ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Agency: Nuclear Regulatory Commission

Activity: **Continued Operation of Salem and Hope Creek Nuclear Generating Stations**
GAR-2020-02842

Conducted by: NOAA's National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office

Date Issued: March 24, 2023

Approved by: ________________________

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1.0 INTRODUCTION

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued in accordance with section 7 of the Endangered Species Act of 1973, as amended, on the effects of the continued operation of Salem Nuclear Generation Station, Units 1 and 2, and Hope Creek Generating Station, Unit 1. These facilities operate pursuant to licenses issued by the U.S. Nuclear Regulatory Commission (NRC) in accordance with the Atomic Energy Act of 1954 as amended (68 Stat. 919) and Title II of the Energy Reorganization Act of 1974 (88 Stat. 1242).

This Opinion is the result of the reinitiation of a consultation that concluded in a July 17, 2014, Biological Opinion. We will keep a complete administrative record of this consultation at the NMFS Greater Atlantic Regional Fisheries Office (GARFO) in Gloucester, Massachusetts.

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 in 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.

2.0 BACKGROUND AND CONSULTATION HISTORY

The Salem and Hope Creek Nuclear generating facilities consist of three units along the Delaware River. These facilities 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. NRC issued the original operating license for Salem Unit 1 on December 1, 1976 and for Salem Unit 2 on May 20, 1981. Salem Units 1 and 2 entered commercial service in June 1977 and October 1981, respectively, and operate with a once-through cooling system. A renewed operating license for Salem Unit 1 was issued on June 30, 2011; this license authorizes operations until August 13, 2036. A renewed operating license for Salem Unit 2 was issued on June 30, 2011; it authorizes operations until April 18, 2040. The license for Hope Creek was issued on July 25, 1986, and the plant became operational later that year. A renewed operating license was issued on June 30, 2011; this license authorizes operations until April 11, 2046. Hope Creek operates with a closed-cycle cooling system (cooling towers). Public Service Enterprise Group Nuclear, LLC (PSEG), operates all three units.

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 and most recently resulted in a July 17, 2014, Biological Opinion. In that Opinion, we concluded that the continued operation of Hope Creek, Salem Unit 1, and Salem Unit 2 was likely to adversely affect but not likely to jeopardize the continued existence any distinct population segment of Atlantic sturgeon, shortnose sturgeon, or loggerhead, green, and Kemp's ridley sea turtles. A complete consultation history between 1979 and 2014 is included in the 2014 Opinion and incorporated by reference here.

The 2014 Opinion included an Incidental Take Statement (ITS) that exempted take of shortnose and Atlantic sturgeon (by distinct population segment) and loggerhead, Kemp's ridley, and green sea turtles. On November 23, 2018, we issued a letter to NRC clarifying the amount of exempted take of loggerhead, Kemp's ridley, and green sea turtles.

In an April, 2020 teleconference, NRC and NMFS discussed the recorded impingement of Atlantic sturgeon at the trash bars since the 2014 Opinion was issued and determined that Salem had exceeded the exempted incidental take limit for causal mortalities of Atlantic sturgeon from impingement at Salem's cooling water intake structure trash bars. Since that time, Salem has also exceeded the limit for total impingement mortalities of Kemp's ridley sea turtles at the trash bars.

On July 2, 2020, NRC requested we reinitiate the 2014 consultation for Salem 1 and 2. Reinitiation of consultation is required because Salem has exceeded the incidental take limits for Atlantic sturgeon from impingement at Salem's cooling water intake structure trash bars. At that time, NRC also noted that Salem was approaching the incidental take limit for Atlantic sturgeon captures during bottom trawl surveys, which PSEG Nuclear, LLC (PSEG), conducts annually pursuant to its Updated Biological Monitoring Work Plan (UBMWP). NRC submitted an updated Biological Assessment (NRC 2020) with their request. NRC staff also requested that we consider effects of the continued operation of Salem and Hope Creek on critical habitat that was designated for the New York Bight distinct population segment (DPS) of Atlantic sturgeon in 2017. On September 28, 2020, PSEG submitted a report on a biological and engineering evaluation of technologies and operating measures that could be considered to potentially reduce effects to Atlantic sturgeon; on November 4, 2020, PSEG presented an overview of this report to NRC and NMFS staff. This report followed a June 10, 2020 submission by PSEG of a pilot study of sonar imaging at the CWIS.

In July 2021, we received timely reports of the collection of six Kemp's ridley sea turtles at the Salem intakes. During a teleconference on July 20, 2021, NRC and NMFS discussed the collection of these six dead Kemp's ridely sea turtles at the Salem trash racks during raking activities between June 17 and July 8, 2021. We determined that Salem had exceeded the exempted incidental take limit for Kemp's ridely sea turtles set forth in the 2014 Opinion. NRC submitted necropsy reports for the Kemp's ridley sea turtles on September 24, 2021. Between June 2022 and September 2022, PSEG submitted additional reports regarding the collection of seven Kemp's ridley sea turtles at the Salem intakes. During a teleconference on October 17, 2022, NRC, PSEG, and NMFS discussed the increasing trend in Kemp's ridley impingement over the last two years, as well as PSEG's plans for necropsy. No additional Kemp's ridleys have been collected since September 2022. This Biological Opinion presents information on take of sea turtles and sturgeon through December 2022.

3.0 DESCRIPTION OF THE PROPOSED ACTIONS

The proposed actions considered in this Opinion are the continued operation of Salem Unit 1, Salem Unit 2, and Hope Creek Unit 1 (HCGS) under the terms of renewed operating licenses.

Salem 1 is authorized to operate through August 13, 2036, Salem 2 through April 18, 2040, and HCGS through April 11, 2046.

Details on the operation of the facilities, as licensed by NRC, are described below. These facilities withdraw water from and discharge water to, the Delaware River. In 1972, Congress assigned authority to administer the Clean Water Act (CWA) to the U.S. Environmental Protection Agency (EPA). The CWA further allowed EPA to delegate portions of its CWA authority to states. On April 13, 1982, EPA authorized the State of New Jersey to issue National Pollutant Discharge Elimination System (NPDES) permits. The Department of Environmental Protection (NJDEP) administers New Jersey's NPDES program. NJDEP issues and enforces NJPDES permits for Salem and Hope Creek.

Section 316(b) of the Clean Water Act of 1977 requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impacts (33 USC 1326). EPA regulates impingement and entrainment under Section 316(b) of the CWA through the NPDES permit process. Administration of Section 316(b) has also been delegated to NJDEP, and that provision is implemented through the NJPDES program.

Salem and Hope Creek cannot operate without cooling water. Intake and discharge of water through the cooling water system would not occur but for the operation of the facility pursuant to a renewed license; therefore, the effects of the cooling water system on listed species are an effectof the continued operation of these facilities. The authority to regulate cooling water intakes and discharges under the CWA lies with EPA, or in this case, NJDEP, as the State has been delegated NPDES authority by EPA. The effects of the proposed Federal actions-- the licensing of the continued operation of Salem Unit 1, Salem Unit 2 and Hope Creek, which necessarily involves the removal and discharge of water from the Delaware River-- are shaped not only by the terms of the renewed operating licenses but also by the SPDES permits as issued by the NJDEP. This Opinion will consider the effects of the operation of Salem Unit 1, Salem Unit 2, and Hope Creek over the term of the extended operating licenses issued by the NRC in 2011 and the NJPDES permits issued by NJDEP in 2016 for Salem 1 and 2 and in 2017 for Hope Creek that are currently in effect.

3.1 Salem Generating Station

Salem is a two-unit plant, which uses pressurized water reactors (PWR) designed by Westinghouse Electric. Each unit has a current licensed thermal power at 100 percent power of 3,459 megawatt-thermal (MW[t]). Salem Units 1 and 2 entered commercial service June 1977 and October 1981, respectively. At 100 percent reactor power, the currently anticipated net electrical output is approximately 1,195 megawatt-electric (MW[e]) for Unit 1 and 1,196 MW(e) for Unit 2. The Salem units have once-through circulating water systems (CWS) for main condenser cooling that withdraws brackish water from the Delaware Estuary through one CWS intake structure located at the shoreline on the south end of the site. There is also a low volume service water intake (SWS) that provides cooling water to the nuclear safety-related heat exchangers.

In the PWR power generation system, reactor heat is transferred from the primary coolant to a lower pressure secondary coolant loop, allowing steam to be generated in the steam supply system. The nuclear steam supply for each unit includes a pressurized water reactor, reactor coolant system (RCS), and associated auxiliary fluid systems. The RCS is arranged as four closed reactor coolant loops connected in parallel to the reactor vessel, each with a reactor coolant pump and a steam generator. Each steam generator is a vertical, U tube-and-shell heat exchanger that produces superheated steam at a constant pressure over the reactor operating power range. From the steam generator, the steam is directed to the turbine, causing it to spin. The spinning turbine is connected to a generator, which generates electricity. The steam is directed to a condenser, where the steam is cooled and condensed back into liquid water. This cooled water is then cycled back to the steam generator, completing the loop.

The containment building serves as a biological radiation shield and a pressure container for the entire RCS. The reactor containment structures are vertical cylinders with 16-feet (4.9-m) thick flat foundation mats and 2- to 5-ft (0.6- to 1.5-m) thick reinforced concrete slab floors topped with hemispherical dome roofs. The side-walls of each containment building are 142 feet (43.3 m) high and the inside diameter is 140 feet (43 m). The concrete walls are 4.5 feet (1.4 m) thick and the containment building dome roofs are 3.5 feet (1.1 m) thick. The inside surface of the reactor building is lined with a carbon steel liner with varying thickness ranging from 0.25 inch (0.64 centimeter [cm]) to 0.5 inch (1.3 cm) (PSEG 2007a).

The nuclear-fueled cores of the Salem reactors are cooled by a moderator, which also slows the speed of neutrons thereby increasing the likelihood of fission of a uranium-235 atom in the fuel. The cooling water is circulated by the reactor coolant pumps. These pumps are vertical, single-stage centrifugal pumps equipped with controlled-leakage shaft seals (PSEG 2007b).

Both Salem units use slightly enriched uranium dioxide (UO2) ceramic fuel pellets in Zircaloy cladding (PSEG 2007b). Fuel pellets are loaded into fuel rods, and fuel rods are joined together in fuel assemblies. The fuel assemblies consist of 264 fuel rods arranged in a square array. Salem uses fuel that is nominally enriched to 5.0 percent (percent uranium-235 by weight). The combined fuel characteristics and power loading result in a fuel burn-up of about 60,000 megawatt-days (MW [d]) per metric ton uranium (PSEG 2009a). The original Salem steam generators have been replaced. In 1997, the Unit 1 steam generators were replaced and in 2008, the Unit 2 steam generators were replaced (PSEG 2009a).

3.2 Hope Creek Generating Station

HCGS is a one-unit station, which uses a boiling water reactor (BWR) with a Mark I containment designed by General Electric. The power plant has a current licensed thermal power output of 3,840 MW (t) with an electrical output estimated to be approximately 1,265 MW(e) (73 FR 13032). HCGS has a closed-cycle circulating water system for condenser cooling that consists of a natural draft cooling tower and associated withdrawal, circulation, and discharge facilities. HCGS withdraws brackish water with the service water system (SWS) from the Delaware Estuary (PSEG 2009b).

In the BWR power generation system, heat from the reactor causes the cooling water, which passes vertically through the reactor core to boil, producing steam. The steam is directed to a turbine, causing it to spin. The spinning turbine is connected to a generator, which generates electricity. The steam is directed to a condenser, where the steam is cooled and is condensed to liquid water. This water is then cycled back to the reactor core, completing the loop.

The reactor building houses the reactor, the primary containment, and fuel handling and storage areas. The primary containment is a steel shell, shaped like a light bulb, enclosed in reinforced concrete, and interconnected to a torus-type steel suppression chamber. The reactor building is capable of containing any radioactive materials that might be released due to a loss-of-coolant accident (PSEG 2009b).

The HCGS reactor uses slightly enriched UO2 ceramic fuel pellets in zircaloy cladding (PSEG 2007b). Fuel pellets are loaded into fuel rods and fuel rods are joined together in fuel assemblies. HCGS uses fuel that is nominally enriched to 5.0 percent (percent uranium-235 by weight), the combined fuel characteristics, and power loading result in a fuel burn-up of about 60,000 MW(d) per metric ton uranium.

3.3 Radiological Environmental Monitoring Program

During normal operations of a nuclear power generating station there are releases of small amounts of radioactive material to the environment. To monitor and determine the effects of these releases, the NRC requires that operating reactors implement a Radiological Environmental Monitoring Program (REMP) in accordance with 10 CFR Parts 20 and 50 to monitor and report measurable levels of radiation and radioactive materials in the site environs. PSEG has established a REMP for the environment around Artificial Island where Salem and Hope Creek are located. The NRC license also includes technical specifications on how PSEG shall implement the REMP. The results of the REMP are published annually, providing a summary and interpretation of the data collected (PSEG 2012). The REMP includes sampling of air particulates, air iodine, milk, surface, ground, and potable (drinking) water, vegetables, fodder crops, fish, crabs, and sediment. External radiation dose measurements are also made in the vicinity of Salem and Hope Creek using optically stimulated luminescence (OSL) dosimeters.

The REMP includes aquatic environment testing. This involves monitoring samples of edible fish (channel catfish, white catfish, bluefish, white perch, summer flounder, striped bass, and black drum), blue crabs (*Callinectes sapidus*), shoreline and riverbed sediments, and surface water. Sampling for fish occurs at three locations (11A1, located 0.2 miles from Salem in the vicinity of the Salem outfall; 12C1 located 2.5 miles from Salem on the west bank of the River, and 7E1, located 4.5 miles from Salem in the River). Fish are captured in gillnets set during two one-day sampling periods per year. Fish are then frozen and transported to a lab where edible tissue is analyzed for the presence of gamma emitters. Crabs are sampled from commercial traps. The REMP has been ongoing since 1968 and will continue over the duration of the licenses.

3.4 Cooling and Auxiliary Water Systems

The Delaware Estuary provides condenser cooling water and service water for both Salem and HCGS (PSEG 2009a, PSEG 2009b). Salem and HCGS use different systems for condenser cooling, but both withdraw from and discharge water to the estuary. Salem Units 1 and 2 use once-through cooling. HCGS uses a closed-cycle system that employs a single natural draft cooling tower. Both sites use groundwater as the source for fresh potable water, fire protection water, industrial process makeup water, and for other sanitary water supplies. Under authorization from the NJDEP (NJDEP 2004) and Delaware River Basin Commission (DRBC) (DRBC 2000), PSEG can service both facilities with up to 43.2 million gallons (164,000 cubic meters [m3]) of groundwater per month.

3.4.1 Salem Nuclear Generating Station

The Salem facility includes two intake structures, one for the circulating water system (CWS), and the other for the SWS. The CWS intake structure is equipped with the following features to prevent intake of debris and biota into the pumps (PSEG 2006c):

<u>Ice Barriers</u>. During the winter, removable ice barriers are installed in front of the intakes to prevent damage to the intake pumps from floating ice formed on the Delaware Estuary. These barriers consist of pressure-treated wood bars and underlying structural steel braces. The barriers are removed early in the spring and replaced in the late fall.

<u>Trash Racks.</u> After intake water passes through the ice barriers (if installed), it flows through fixed trash racks. These racks prevent large organisms and debris from entering the pumps. The racks are made from 0.5-inch (1.3 cm) steel bars placed on 3.5-inch (8.9 cm) centers, creating a 3-inch (7.6 cm) clearance between each bar. The racks are inspected by PSEG employees, who remove any debris caught on them with mechanical, mobile, clamshell-type rakes. These trash rakes include a hopper that stores and transports removed debris to a pit at the end of each intake, where it is dewatered by gravity and disposed of off-site.

<u>Traveling Screens.</u> After the coarse-grid trash racks, the intake water passes through finer vertical travelling screens. There are 11 modified Ristroph screens and 1 Multi-Disc® rotary screen designed to remove debris and biota small enough to have passed through the trash racks while minimizing death or injury. The travelling screens have mesh openings of 0.25 inch x 0.5 inch (0.64 cm x 1.3 cm); and the rotary screen has 9.5 mm perforated plates. The through-screen velocity (TSV) at the Salem CWS has been calculated to range from a minimum velocity value of 1.59 feet per second (fps) to a maximum velocity value of 2.31 fps. The average TSV for the CWS was calculated as 1.86 fps (PSEG 2019).

<u>Fish Return System.</u> Each panel of the travelling screen has a 10-ft (3 m) long fish bucket attached across the bottom support member. As the travelling screen reaches the top of each rotation, the bucket is inverted. A low-pressure water spray washes fish off the screen, and they slide across a flap seal into a fish trough. Debris is then washed off the screen by a high-pressure water spray into a separate debris trough, and the contents of both fish and debris troughs return to the estuary. The troughs and the detritus discharge pipe are designed so that when the fish and debris are released, the tidal flow tends to carry them away from the intake, reducing the likelihood of re-impingement.

The CWS withdraws brackish water from the Delaware Estuary using 12 circulating water pumps through a 12-bay intake structure located on the shoreline at the south end of the site. Water is discharged north of the CWS intake structure via pipes that extend 500 feet (152 m) from the shoreline. No biocides are required in the CWS.

PSEG has an NJPDES permit for Salem issued by the NJDEP (Permit No. NJ0005622; June 2016). The permit sets the maximum water usage from the Delaware Estuary to a 30-day average of 3,024 million gallons per day (MGD; 11.4 million m^3/day) of circulating water. The total permitted flow is 1,110,000 gpm (4,200 m^3/min) through each unit.

Circulating water from each Salem unit is discharged through six adjacent pipes that are 7 feet (2 m) in diameter and spaced 15 feet (4.6 m) apart on center that merge into three pipes 10 feet (3 m) in diameter (PSEG 2006c). The discharge piping extends approximately 500 feet (150 m) from the shore (PSEG 1999). The discharge pipes are buried for most of their length until they discharge horizontally into the water of the estuary at a depth at mean tidal level of about 35 feet (9.5 m). The discharge is approximately perpendicular to the prevailing currents. At full power, Salem is permitted to discharge up to 3,024 MGD (11.4 million m^3/day) at a velocity of about 10 fps (3 m/s) (PSEG, 1999).

The SWS intake is located approximately 400 feet (122 m) north of the CWS intake. The SWS intake has four bays, each containing three pumps. The 12 service water pumps have a total design rating of 130,500 gpm (494 m^3/min). The average velocity throughout the SWS intake is less than 0.8 fps (0.25 m/s) during normal operation (PSEG 2019). The SWS intake structure is equipped with trash racks, traveling screens, and filters to remove debris and biota from the intake water stream. Backwash water is returned to the estuary.

To prevent organic buildup and biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite is injected into the system. SWS water is discharged via the discharge pipe shared with the CWS. Residual chlorine levels are maintained in accordance with the site's NJPDES Permit.

3.4.2 Hope Creek Generating Station

HCGS uses a single intake structure to supply water from the Delaware Estuary to the SWS. The intake structure consists of four active bays that are equipped with pumps and associated equipment (trash racks, traveling screens, and a fish-return system) and four empty bays that were originally intended to service a second reactor, which was never built. Water is drawn into the SWS through trash racks and passes through the traveling screens at a maximum velocity of 0.35 fps (0.11 m/s). The openings in the wire mesh of the screens are 0.375 inches (0.95 cm) square. After passing through the traveling screens, the estuary water enters the service water pumps. Depending on the temperature of the Delaware Estuary water, two or three pumps are normally needed to supply service water. Each pump is rated at 16,500 gpm (62 m^3/min). To prevent organic buildup and biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite is continuously injected into the system.

The SWS also provides makeup water for the CWS by supplying water to the cooling tower basin. The cooling tower basin contains approximately 9 million gallons (34,000 m^3) of water and provides approximately 552,000 gpm (2,090 m^3/min)) of water to the condensers via four CWS pumps. The CWS provides water to the main condenser to condense steam from the turbine and the heated water is returned back to the cooling tower for evaporative cooling. Continuous blowdown controls the build-up of solids in the cooling tower basin resulting from evaporative water loss.

The cooling tower blowdown and other facility effluents are discharged to the estuary through an underwater conduit located 1,500 feet (460 m) upstream of the HCGS SWS intake. The HCGS discharge pipe extends 10 feet (3.0 m) offshore and is situated at mean tide level. The discharge from HCGS is regulated under the terms of NJPDES Permit No. NJ0025411 (NJDEP 2017). The HCGS cooling tower is a 512-foot (156-meter) high single counterflow, hyperbolic, natural draft cooling tower (PSEG 2008b). While the CWS is a closed-cycle system, water is lost due to evaporation. Monthly losses average from 9,600 gpm (36 m^3/min) in January to 13,000 gpm (49 m^3/min) in July. Makeup water is provided by the SWS.

3.4.3 Facility Water Use

The Salem and HCGS facilities rely on the Delaware Estuary as their source of makeup water for their cooling water systems, and they discharge various waste flows to the Estuary. An onsite well system provides groundwater for other site needs. The following sections describe the water use from these resources.

The Salem units both use once-through circulating water systems for main condenser cooling and withdraw brackish water from the Delaware Estuary through a single CWS intake located at the shoreline on the southern end of Artificial Island. The CWS intake structure consists of 12 bays, each outfitted with removable ice barriers, trash racks, traveling screens, circulating water pumps, and a fish return system. The pump capacity of the Salem CWS is 1,110,000 gpm (4,200 m^3/min) for each unit, or a total of 2,220,000 gpm (8,400 m^3/min) for both units combined. Although the initial design included use of sodium hypochlorite biocides, these were eliminated once enough operational experience was gained to indicate that they were not needed. Therefore, the CWS water is used without treatment (PSEG 2009a).

In addition to the CWS intake, the Salem units withdraw water from the Delaware River for the SWS, which provides cooling for auxiliary and reactor safeguard systems. The Salem SWS is supplied through a single intake structure located approximately 400 feet (122 m) north of the CWS intake. The Salem SWS intake is also fitted with trash racks, traveling screens, and filters to remove debris and biota from the intake water stream. The pump capacity of the Salem SWS is 65,250 gpm (247 m^3/min) for each unit, or a total of 130,500 gpm (494 m^3/min) for both units combined (PSEG 2009a).

The discharge to and withdrawal of Delaware River water for the Salem CWS and SWS systems is regulated under the terms of Salem's NJPDES Permit (No. NJ0005622) and is also authorized by the DRBC. The NJPDES permit limits the total withdrawal of Delaware Estuary water to 3,024 MGD (11.4 million m^3/day), for a monthly maximum of 90,720 million gallons (342 million m^3) (NJDEP 2016). The DRBC authorization allows withdrawals not to exceed 97,000 million gallons (367 million m^3/day) in a single 30-day period (DRBC 1977, DRBC 2001). The withdrawal volumes are reported to NJDEP through monthly discharge monitoring reports (DMRs), and copies of the DMRs are submitted to DRBC. Water usage reports are also submitted to the DRBC (DRBC 2001).

Both the CWS and SWS at Salem discharge water back to the Delaware River through a single return that serves both systems. The discharge location is situated between the CWS and Salem

SWS intakes, and consists of six separate discharge pipes; each extending 500 feet (152 m) into the river and discharging water at a depth of 35 feet (11 m) below mean tide. The pipes rest on the river bottom with a concrete apron at the end to control erosion and discharge water at a velocity of 10.5 fps (3.2 m/s) (PSEG 2006c).

The HCGS facility uses a closed-cycle circulating water system, with a natural draft cooling tower, for condenser cooling. Like Salem, HCGS withdraws water from the Delaware Estuary to supply the SWS, which cools auxiliary and other heat exchange systems. The outflow from the HCGS SWS is directed to the cooling tower basin and serves as makeup water to replace water lost through evaporation and blowdown from the cooling tower. The HCGS SWS intake is located on the shore of the river and consists of four separate bays with service water pumps, trash racks, traveling screens, and fish-return systems. The structure includes an additional four bays that were originally intended to serve a second HCGS unit, which was never constructed. The pump capacity of the HCGS SWS is 16,500 gpm (62 m^3/min) for each pump, or a total of 66,000 gpm (250 m^3/min) when all four pumps are operating. Under normal conditions, only two or three of the pumps are typically operated. The HCGS SWS water is treated with sodium hypochlorite to prevent biofouling (PSEG 2009b).

The discharge from the HCGS SWS is directed to the cooling tower basin, where it acts as makeup water for the HCGS CWS. The natural draft cooling tower has a total capacity of 9 million gallons (34,000 m^3) of water, and it circulates water through the condensers at a rate of 552,000 gpm (2,090 m^3/min). Water is removed from the HCGS CWS through both evaporative loss from the cooling tower and from blowdown to control deposition of solids within the system.

Evaporative losses result in consumptive loss of water from the Delaware River. The volume of evaporative losses vary throughout the year depending on the climate but range from approximately 9,600 gpm (36 m3/min) in January to 13,000 gpm (49 m3/min) in July.

Blowdown water is returned to the Delaware Estuary (NJDEP 2002b). The withdrawal of Delaware Estuary water for the HCGS CWS and SWS systems is regulated under the terms of HCGS NJPDES Permit No. NJ0025411 and is also authorized by the DRBC. Although it requires measurement and reporting, the NJPDES permit does not specify limits on the total withdrawal volume of Delaware River water for HCGS operations (NJDEP 2003). Actual withdrawals average 66.8 MGD (253,000 m^3/day), of which 6.7 MGD (25,000 m^3/day) are returned as screen backwash, and 13 MGD (49,000 m3/day) is evaporated. The remainder (approximately 46 MGD [174,000 m^3/day]) is discharged back to the river (PSEG 2009b). The HCGS DRBC contract allows withdrawals up to 16.998 billion gallons (64 million m^3) per year, including up to 4.086 billion gallons (15 million m^3) of consumptive use (DRBC 1984a, 1984b). To compensate for evaporative losses in the system, the DRBC authorization requires releases from storage reservoirs, or reductions in withdrawal, during periods of low-flow conditions at Trenton, NJ (DRBC 2001). To accomplish this, PSEG is one of several utilities that owns and operates the Merrill Creek reservoir in Washington, NJ. Merrill Creek reservoir is used to release water during low-flow conditions, as required by the DRBC authorization (PSEG 2009b).

The SWS and cooling tower blowdown water from HCGS is discharged back to the Delaware River through an underwater conduit located 1,500 ft. (460 m) upstream of the HCGS SWS intake. The HCGS discharge pipe extends 10 ft. (3 m) offshore, and it is situated at mean tide level. The discharge from HCGS is regulated under the terms of NJPDES Permit No. NJ0025411 (NJDEP 2017).

3.4.4 NJPDES Permits

3.4.4.1 Salem

Salem 1 and 2 operate pursuant to a NJPDES permit issued by NJDEP in 2016, with an effective date of August 1, 2016. Information on previous NJPDES permits is included in the 2014 Opinion and incorporated here by reference. The 2016 permit includes limits on the discharge of pollutants, discharge monitoring requirements, and toxicity testing requirements. The permit limits the circulating water system intake flow to a monthly average not to exceed 3,024 MGD. Thermal limits for the discharge are set at a daily maximum of 46.1ºC for June to September and 43.3ºC for October to May, with a year-round daily maximum net thermal limit of 15.3ºC.

The permit requires maintenance and operation of the existing Ristroph traveling screens and the associated fish return system as well as continuation of the wetland/estuary enhancement program, maintenance of fish ladders, and continuation of the Biological Monitoring Program. The Updated Biological Monitoring Work Plan (UBMWP) includes baywide beach seine, bottom trawl, and ichthyoplankton surveys. The NJDEP approved the UBMWP on April 20, 2017 and it was incorporated as a condition of the NJPDES Permit upon final approval.

Impingement and entrainment monitoring and reporting at the circulating water system is required. This includes entrainment sampling three days per week (seven samples per day) in January through March and August through December and four days per week (fourteen samples per day) in April through July. Impingement sampling is required year-round and must take place three days per week with ten samples collected during each 24-hour period. All fish must be identified to species.

3.4.4.2 Hope Creek

The current NJPDES Permit No. NJ0025411 for the HCGS facility was effective on October 1, 2017. The HCGS NJPDES permit regulates water withdrawals (45.38 MGD) and discharges associated with both stormwater and industrial wastewater, including discharges of cooling tower blowdown (NJDEP 2017). The cooling tower blowdown and other effluents are discharged through an underwater pipe located on the bank of the river 1,500 ft. (457 m) upstream of the SWS intake.

3.5 Action Area

Figure 1 shows the location of Salem and HCGS within a 6-mi (10 km) radius, and Figure 2 is an aerial photograph of the site. The action area is defined in 50 CFR 402.02 as “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.” The Salem and HCGS facilities are located at River Mile (RM) 50 (River Kilometer 80 [RKM 80]) and RM 51 (RKM 82) on the Delaware River, respectively, approximately 17 miles (mi) (27 kilometers [km]) south of the Delaware Memorial Bridge.

Philadelphia is about 35 mi (56 km) northeast and the city of Salem, New Jersey is 8 mi (13 km) northeast of the site (AEC 1973). The area affected by operations of the Salem 1, Salem 2 and Hope Creek is related to the intake of water from the Delaware River and the discharge of heated effluent and other pollutants back into the Delaware River. The action area also includes the area where the UBMWP is carried out. The proposed actions have the potential to affect NMFS listed species and designated critical habitat in several ways: impingement of individuals at the intakes; altering the abundance or availability of potential prey items; altering the riverine environment through the discharge of heated effluent and other pollutants; and, capture during UBMWP surveys. The combined action areas for this consultation include the area where UBMWP surveys occur, the intake areas of Salem 1 and 2 and Hope Creek and the region where the thermal plume extends into the Delaware River. The plume is narrow and approximately follows the contour of the shoreline at the discharge; the size of the plume varies seasonally as ambient water temperature changes and daily with the tides. The width of the plume varies from about 4,000 feet (1,200 m) on the flood tide to about 10,000 feet (3,000 m) on the ebb tide. The maximum plume length extends to approximately 43,000 ft. (13,000 m) upstream and 36,000 ft. (11,000 m) downstream (PSEG 1999c).

Therefore, the action area includes the physical footprint of the Salem 1, Salem 2, and HCGS facilities as well as the area within the Delaware River occupied by the maximum extent of the thermal plume (as described above) and the areas of the Delaware River and Delaware Bay where sampling required by the UBMWP is carried out.

Figure 1. Location of Salem and Hope Creek Generating Stations

Figure 2. Aerial photo of facilities

4.0 LISTED SPECIES AND CRITICAL HABITAT IN THE ACTION AREA

The species that occur within the action area and may be affected by the proposed action are listed in Table 1 along with their regulatory status and critical habitat designation. The only critical habitat that overlaps with the action area is the Delaware River unit of critical habitat designated for the New York Bight DPS of Atlantic sturgeon.

Table 1. Endangered Species Act-listed endangered species that occur in the action area

Marine Reptiles			
Species	**ESA Status**	**Critical Habitat**	**Recovery Plan**
Green Turtle (*Chelonia mydas*) – North Atlantic DPS	T – 81 FR 20057	63 FR 46693*	FR Not Available 10/1991 – U.S. Atlantic
Kemp's Ridley Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	-- --	03/2010 – U.S. Caribbean, Atlantic, and Gulf of Mexico 09/2011
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic Ocean DPS	T – 76 FR 58868	79 FR 39855*	74 FR 2995 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 05/1998 – U.S. Pacific 01/2009 – Northwest Atlantic

Fish		
Species	**ESA Status**	**Critical Habitat**

Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Carolina DPS	E – 77 FR 5913	77 FR 5914*
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Chesapeake Bay DPS	E – 77 FR 5879	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Gulf of Maine DPS	T – 77 FR 5879	77 FR 5880*
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – New York Bight DPS	E – 77 FR 5879	77 FR 5880*
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – New York Bight DPS Critical Habitat	-- --	82 FR 39160
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – South Atlantic DPS	E – 77 FR 5913	77 FR 5914*
Shortnose Sturgeon (*Acipenser brevirostrum*)	E – 32 FR 4001	32 FR 4001 and 39 FR 41370 12/1998

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

The action area overlaps with critical habitat designated for the New York Bight DPS of Atlantic sturgeon. As explained below, we have determined that the continued operations of the Salem 1, Salem 2, and Hope Creek nuclear generating facilitites are not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon. A "not likely to adversely affect" determination is appropriate when an effect is expected to be discountable, insignificant, or completely beneficial. As discussed in the FWS-NMFS Joint Section 7 Consultation Handbook (1998), "[b]eneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those effects that are extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

On August 17, 2017, we published a final rule designating critical habitat for all five DPSs of Atlantic sturgeon (82 FR 39160; effective date September 18, 2017). The action area overlaps with a portion of the Delaware River critical habitat unit designated for the New York Bight DPS. This overlap is limited to the lowermost 2 miles of the critical habitat unit. The critical habitat designation for the New York Bight DPS is for habitats that support successful Atlantic sturgeon reproduction and recruitment. In order to determine if the proposed action may affect critical habitat, we consider whether it would impact the habitat in a way that would affect its ability to support reproduction and recruitment. Specifically, we consider the effects of the action on the physical features of the critical habitat. The essential features of critical habitat for the New York Bight DPS of Atlantic sturgeon 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).

For each PBF, we identify the activities that have effects that overlap with the critical habitat physical and biological features (PBFs) and identify those activities that may affect the PBFs. For each feature that may be affected by the action, we then determine whether any effects to the feature are adverse, insignificant, extremely unlikely to occur, or wholly beneficial. In making this determination, we consider the actions' potential to affect how each PBF supports Atlantic sturgeon's conservation needs in the action area.

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

In considering effects to PBF 1, we consider whether the proposed action will have any effects on areas of hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages. Therefore, we consider how the action may affect hard bottom substrate and salinity and how any effects may change the value of this feature in the action area.

Median salinity at the Salem facility is reported as 5 ppt and ranging from 0 to 15 ppt (NRC 2011). Salinity is highest during period of low flow (usually, but not always, in the summer) because salinity is higher during low fresh water flow periods. The USEPA's Delaware Estuary Program Scientific and Technical Advisory Committee (now managed by the Partnership for the

Delaware Estuary) delineated three zones of the Estuary based on patterns of salinity, turbidity, and biological productivity (PSEG 1999): the freshwater Tidal River Zone (or Upper Zone), the Transition Zone, and the Delaware Bay Zone (or Lower Zone). The Delaware Bay Zone extends from RKM 80 to RM 0. The Delaware Bay Zone is characterized by high salinity. The Transition Zone extends from RKM 129 to RKM 80, and includes the site of Salem and Hope Creek Nuclear generating facilities (located near RM 50/RKM 80-82). This zone is characterized by varying salinity. The Tidal River Zone is one of variable, but low, salinity that extends 53 river miles, from the head-of-tide at Trenton, NJ (RM 133, the head of the Estuary (rkm 214)) down to Marcus Hook, PA (RM 80; RKM 129). DRBC describes five salinity zones: polyhaline (> 18 ppt salinity; RKM 0-43.9), polyhaline/mesohaline transition (RKM 43.9-49.8), mesohaline (5 to 18 ppt; RKM 49.8-91.9), mesohaline/oligohaline transition (RKM 91.9-93.9), and oligohaline (0.5 to 5 ppt; RKM 93.9-120.54) areas. Upstream of the oligohaline zone, salinity is typically below 0.5 ppt salinity during seasonally normal hydrological conditions, but exceeds the 250 mg/L chloride definition of the salt line during seasonally low streamflow conditions (Partnership for the Delaware Estuary 2017). While salinity can occasionally fall outside the 5 to 18 ppt range (NRC 2011), the Salem and Hope Creek intakes and discharge locations are located in the DRBC's defined mesohaline zone.

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 (RM 83; RKM 133) and the mouth of the Schuylkill River (RM 92; RKM 148) (Sommerfield and Madsen 2003). Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat exists from Tinicum Island (RM 85; RKM 137) to the fall line in Trenton, NJ (RM 131; RKM 211). Within the action area, substrates include fine-grained silts, clays, and sands (NRC 2011).

Conclusions for PBF 1

As noted above, mean salinity at Artificial Island, where the intakes are located, is around 5 ppt, but ranges from 0 to 15 ppt depending on season and condition (NRC 2006, DRBC 2018). While salinity conditions within the action area are occasionally less than 0.5 ppt during high flow periods, hard bottom substrates and persistent salinity below 0.5, the conditions that are required for egg settlement and development, are not present within the action area. As such, PBF 1 does not occur in the action area and the activities considered here will have no effect on PBF 1.

Feature Two: 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

In considering effects to PBF 2, we consider whether the proposed action will have any effect on areas of soft substrate within transitional salinity zones between the river mouth and spawning sites for juvenile foraging and physiological development; therefore, we consider effects of the action on soft substrate and salinity and any change in the value of this feature in the action area.

In the Delaware River, aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites to support juvenile foraging and physiological development (i.e., PBF 2) occurs from approximately RM 48 (where the final rule describes the mouth of the river) to approximately RM 67, or the downstream median range of the salt front. As described above, salinity levels in the river are dynamic, and the salt front is defined by a lower concentration (0.25 ppt) than the lower level of PBF 2 (0.5 ppt), but RM 67 is a reasonable approximation given the lack of real time data.

Captured sturgeon and subsequent tracking studies have provided evidence of the use of soft substrate habitat in the Delaware River with the salinity gradient matching the criteria for PBF 2. Detections of tagged juvenile Atlantic sturgeon, have been documented in the lower tidal Delaware River, especially between the middle Liston Range (RM 43) to Tinicum Island (RM 88)(Calvo *et al*. 2010). Juveniles tracked in this study ranged in size. Older, larger juveniles (average 716mm, range 505-947mm) moved towards the Bay but were not detected below Liston Range. The smaller juveniles averaged 524 mm (range 485-566 mm).

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

Activities that overlap with the portion of the Delaware River that contains PBF 2 include beach seines, bottom trawl, icthyoplankton sampling, radiological sampling, the intake areas of Salem 1 and 2 and Hope Creek, and a portion (2 miles) of the region where the thermal plume extends into the River until reaching the downstream critical habitat boundary. As described in the *Action Area* section above, the plume is narrow and approximately follows the contour of the shoreline at the discharge; the size of the plume varies seasonally as ambient water temperature changes and daily with the tides. The width of the plume varies from about 4,000 feet (1,200 m) on the flood tide to about 10,000 feet (3,000 m) on the ebb tide (PSEG 1999c). The maximum length of the thermal plume extends past the downstream boundary of designated critical habitat in the Delaware River. The width of the river in the area impacted by the thermal plume ranges from approximately 13,000 -23,000 feet (4,000 – 7,000 m). While the maximum plume length extends to approximately 6.8 miles (11 km) downstream of the Salem and HCGS facilities, critical habitat ends approximately 2 miles (3.2 km) past the site.

River Abundance Monitoring

River abundance monitoring consists of trawl and beach seine surveys. The relative abundance of finfish and blue crabs will be determined by employing 10-minute tows of a 4.9-m otter trawl in the Delaware Estuary. Forty samples will be collected once per month from April through November, conditions permitting, at random stations allocated among eight sampling strata between the mouth of the Delaware Bay (RM 48) and the Delaware Memorial Bridge (RM 67) in all years. Beach seines will also be set in shallow sub-tidal, near shore waters of the Estuary for 15-minute durations. Forty samples will be collected once per month in June and November; and twice per month in July through October, conditions permitting, at fixed stations between the mouth of the Delaware River to the Chesapeake and Delaware Canal in each year of the permit period.

PBF 2 occurs throughout the area where trawl and beach seine surveys will occur. However, neither the trawl or beach seine operations are expected to result in any effects to salinity or changes in water chemistry. Otter trawling will not affect soft substrate or interact with the bottom. Beach seine surveys will have minor, temporary effects on soft substrate as the seine nets are set and have contact with the bottom. The amount of soft substrate that will be disturbed and/or inaccessible during beach seine surveys is small in size and will only be inaccessible for short periods of time (15 minutes). We also considered what effects beach seine surveys would have on the prey species (benthic invertebrates) that occur within the soft substrates. Studies conducted to understand the impact of beach seining on benthic community and sediment structure have indicated no evidence of a reduction in the abundance or availability of benthic species (Lamberth *et al.* 1995, Nemati *et al.* 2015). During dive surveys, Lamberth *et al.* (1995) found no significant differences in abundance or species composition between sites inside and outside seine areas in False Bay, South Africa. Similarly, Nemati *et al.* (2015) found no significant differences in total density, Shannon diversity, or evenness of macroinvertebrate assemblages between impact and control sites affected by the beach seine fishery in the Southwest Caspian Sea. Based on available information (Lamberth *et al.* 1995; Nemati *et al.* 2015) and the minor and temporary impacts to bottom areas, any effects to the value of PBF 2 due to beach seine surveys will be so small that they cannot be meaningfully measured, detected or evaluated and effects to PBF 2 are insignificant.

Radiological Sampling
The Radiological Environmental Monitoring Program (REMP) includes aquatic environment testing. This involves monitoring samples of edible fish, shoreline and riverbed sediments, and surface water. Fish are captured in gillnets set during two one-day sampling periods per year. Sampling for fish occurs at three locations (11A1, located 0.2 miles from Salem in the vicinity of the Salem outfall; 12C1 located 2.5 miles from Salem on the west bank of the River, and 7E1, located 4.5 miles from Salem in the River). PBF 2 occurs throughout the area where gillnetting, riverbed sediment and surface water sampling will occur.

Surface water sampling will have no effect on salinity and sampling procedures will not interact with the soft substate on the river bottom, therefore, there would be no effect on PBF 2. Setting gill nets will have minor and temporary effects on soft substrate at the points the gill nets are anchored to the bottom. While there are very few existing studies on fixed gear (e.g., gill nets) on fish habitat, Grabowski *et al*. (2014) found that geological features impacted by fixed gear types recover more quickly in soft substrates than in hard substrates. Based on this available information and given the very small area of soft substrate that will be temporarily disturbed by setting gill nets at the three sampling locations, any effects to the value of PBF 2 due to beach seine surveys will be so small that they cannot be meaningfully measured, detected or evaluated and effects to PBF 2 are insignificant.

For river bottom sediment sampling, a marine GPS will be used to locate the correct site and the sampling boat will be maneuvered over the area until a square area, measuring one meter on each side can be staked out and the divided into a grid of nine smaller boxes. A one-inch deep scoop from the center of each of the small grids is obtained using a bottom grab sampler (PSEG 2018). River bottom sediment sampling will not have any effect on salinity. Obtaining (grabbing) samples with a bottom grab sampler will result in the disturbance of a small amount of the bottom. However, based on the minuscule amount of bottom sediment collected in relation to the surface area of the river bottom in the action area, any effects to the value of PBF 2 will be so small that they cannot be meaningfully measured, detected, or evaluated and effects to PBF 2 are insignificant.

Intake and Discharge
As noted above, mean salinities in the area affected by the intake and discharge of water range from 0 to 15.0 ppt and average 5 ppt. The discharge to and withdrawal of Delaware River water from Salem and Hope Creek generating facilities has no effect on salinity and will not disturb soft substrate. Therefore, these activities have no effect on PBF 2.

Conclusions for PBF 2
River abundance monitoring, radiological sampling, and the continued intake and discharge of water for the operations of Salem Unit 1, Salem Unit 2, and Hope Creek Unit 1 overlap with PBF 2. None of these activities will affect salinity in the action area. Intake and discharge of waters for facility operations will not disturb soft substrate. Therefore, discharge to and withdrawal of Delaware River water from Salem and Hope Creek generating facilities will have no effect on PBF 2. River bottom sediment sampling, beach seine surveys, and gillnetting will result in temporary disturbances to limited areas of soft substrate in the action area. However, based on the assessment here, any effects of substrate disturbance due to monitoring and sampling activities will be so small that they cannot be meaningfully measured, evaluated, or detected. Based on these considerations, any effects to the value to PBF 2 to the conservation needs of Atlantic sturgeon in the action area will be so small that they cannot be meaningfully measured, detected, or evaluated and effects to PBF 2 are insignificant.

Feature Three: Water absent physical barriers to passage between the river mouth and spawning sites
In considering effects to PBF 3, we consider whether the proposed action will have any effect on water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: unimpeded movements of adults to and from spawning sites; seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and; staging, resting, or holding of subadults or spawning condition adults. We also consider whether the proposed action will affect water depth or water flow, because if water is too shallow it can be a barrier to sturgeon movements, and an alteration in water flow could similarly impact the movements of sturgeon in the river, particularly early life stages that are dependent on downstream drift. Therefore, we consider effects of the action on water depth and water flow and whether the action results in barriers to passage that impede the movements of Atlantic sturgeon.

Water of appropriate depth and absent physical barriers to passage between the river mouth and spawning sites necessary to support: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and, (iii) Staging, resting, or holding of subadults or spawning condition adults, are present throughout the extent of critical habitat designated in the Delaware River. Water depths in the main river channels is also deep enough (*e.g.,* at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river. As previously stated, the maximum plume length extends to approximately 6.8 miles (11 km) downstream of the Salem and HCGS facilities

(PSEG 1999c). Critical habitat for the NYB DPS of Atlantic sturgeon in the waters of the Delaware River starts at the crossing of the Trenton-Morrisville Route 1 Toll Bridge and extends downstream to where the mainstem river discharges at its mouth into Delaware Bay (82 FR 39160; effective date September 18, 2017). The downstream critical habitat boundary is approximately 2 miles (3.2 km) past the Salem and HCGS facilities. Therefore, PBF 3 is only present in the mainstem river portion of the action area (i.e., it does not extend into Delaware Bay). Activities that overlap where PBF 3 occurs include river abundance monitoring, radiological sampling, the intake of water from the Delaware River and the discharge of heated effluent and other pollutants back into the Delaware River. Also as noted above, the plume is narrow and approximately follows the contour of the shoreline at the discharge; the size of the plume varies seasonally as ambient water temperature changes and daily with the tides. The width of the plume varies from about 4,000 feet (1,200 m) on the flood tide to about 10,000 feet (3,000 m) on the ebb tide (PSEG 1999c). The width of the river in the area impacted by the thermal plume ranges from approximately 13,000 -23,000 feet (4,000 – 7,000 m).

River Abundance and Radiological Sampling
River abundance monitoring and radiological sampling overlap with portions of the Delaware River that contain PBF 3. Here we consider whether these activities may affect PBF 3 and if so, whether the effects are adverse, insignificant, extremely unlikely to occur, or entirely beneficial. Trawl surveys associated with river abundance monitoring will have no effect on PBF 3. Similarly, sampling shoreline sediments, riverbed sediments, and surface water associated with the REMP will have no effect on PBF 3. These activities do not result in habitat alterations that impede the movement of Atlantic sturgeon.

The nets used during beach seine surveys and gillnetting will temporarily block access to small portions of the Delaware River that contain PBF 3. Conditions permitting, beach seines will be temporarily (15-minute durations) set in shallow sub-tidal, near shore waters of the Estuary. Forty samples will be collected once per month in June and November; and twice per month in July through October. Gillnets will be set at three locations in the vicinity of Salem during two one-day sampling periods per year during radiological sampling. At Artificial Island, the estuary is approximately 2.5 mi (4 km) wide. Beach seine surveys and gillnetting will not reduce water depth or affect river flow. Because there will always be zone of passage around the nets, and areas will be inaccessible due to the presence of nets for only short, intermittent periods, the barriers to passage associated with river abundance and radiological sampling will not prevent any sturgeon from passing through the action area, and any impediments to the movements of sturgeon will be limited to temporary alterations in the route of passage through the netted areas. Based on the assessment here, these impediments are extremely unlikely to affect the value of PBF 3 to the conservation of the species in the action area. Therefore, we conclude that any effects to the value of PBF 3 related to river abundance and radiological sampling will be so small that they cannot be meaningfully measured, detected, or evaluated and effects to PBF 3 are insignificant.

Intake and Discharge
Salem and HCGS use different systems for condenser cooling, but both withdraw from and discharge water to the Delaware Estuary. The power-generating units at Salem both use once-through circulating water systems. The HCGS facility uses a closed-cycle system that employs a single natural draft cooling tower. PBF 3 occurs in the portion of the action area affected by water intake and discharge from the Salem and HCGS facilities.

The Salem and HCGS facilities 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. Artificial Island is located approximately 2 miles (3.2 km) upstream of the hypothetical line demarking the head of Delaware Bay. More than half of the typical river width in this area is relatively shallow, less than 18 feet (5.5 meters), while the deeper part, including the dredged channel has depths of up to 45 feet (12.2-13.7 meters). The average tidal flow past the facilities at RM 52 ranges between 180,000,000 to 212,000,000 gpm (400,000 and 472,000 cfs).

Intake structures are located parallel to, and nearly flush with, the Delaware Estuary shoreline. Based on the pump capacity of 1,110,000 gpm (4, 200 m^3/min) for each Salem CWS unit, or a total of 2,220,000 gpm (8,400 m^3/min) for both units combined, maximum intake withdrawals for both units represent one percent of the tidal flows which dominate the river in proximity to the Salem and HCGS facilities. In addition to the CWS intake, the Salem units withdraw water from the Delaware River for the SWS. The pump capacity of the Salem SWS is 65,250 gpm (247 m^3/min) for each unit, or a total of 130,500 gpm (494 m^3/min) for both units combined (PSEG, 2009a). At HCGS, the pump capacity of the SWS is 16,500 gpm (62 m^3/min) for each pump, or a total of 66,000 gpm (250 m^3/min) when all four of the HCGS pumps are operating. Under normal conditions, only two or three of the pumps are typically operated. Based on this information, the maximum intake withdrawals for the SWS units at both Salem and HCGS represent less than one percent of the tidal flows past the facilities. Because this withdrawal is negligible in comparison to the average tidal flows, water withdrawals at the Salem and HCGS facilities do not affect water flow in the action area.

Cooling water from Salem is discharged through six adjacent 10 ft. (3 m) diameter pipes spaced 15 ft. (4.6 m) apart on center that extend approximately 500 ft. (150 m) from the shore (PSEG, 1999c in NRC 2011). The discharge pipes are buried for most of their length until they discharge horizontally into the water of the estuary at a depth at mean tidal level of about 35 ft (9.5 m). The discharge is approximately perpendicular to the prevailing currents. At full power, Salem is permitted to discharge 3,024 MGD at a velocity of about 10 fps (3 m/s). Because evaporative losses are minimal in terms of gallons lost, and all water that is withdrawn from the estuary is discharged back to the river, water withdrawals and discharges at the Salem facility do not result in habitat alterations that impede the movement of Atlantic sturgeon.

Cooling tower blowdown and other station effluents from the HCGS are discharged to the Delaware River through an underwater pipe that extends 10 feet (3.0 m) offshore and is situated at mean tide level. The discharge from the HCGS SWS is directed to the cooling tower basin, where it acts as makeup water for the HCGS CWS. The natural draft cooling tower has a total capacity of 9 million gallons (34,000 m^3) of water, and it circulates water through the condensers at a rate of 552,000 gpm (2,090 m^3/min). Water is removed from the HCGS CWS through both evaporative loss from the cooling tower and from blowdown to control deposition of solids within the system. The volume of these evaporative losses vary throughout the year depending on the climate, ranging from approximately 9,600 gpm (36 m^3/min) in January to 13,000 gpm (49 m^3/min) in July. While evaporative losses result in consumptive loss of water from the Delaware River, these losses are negligible (i.e., less than one percent) in comparison to the average tidal flows. Based on this information, water withdrawals and discharges at the HCGS do not result in habitat alterations that impede the movement of Atlantic sturgeon. Laboratory studies suggest that prolonged exposure of juvenile Atlantic sturgeon to temperatures above 28ºC may result in sublethal effects and that such temperatures may be avoided when alternative (cooler) habitats are available (Niklitschek 2001, Niklitschek and Secor 2005, Niklitschek and Secor 2010). However, in southern rivers suitable temperatures for juvenile Atlantic sturgeon habitat range as high as 30 ºC (ASMFC 2017). Little information on thermal tolerances of adult Atlantic sturgeon is available; however, adults have been documented in waters as high as 33.1ºC in South Carolina (ASMFC). In the James River, Balazik *et al.* (2012) reports captures of adult Atlantic sturgeon in water temperatures as high as 30ºC.

No information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. As discussed more fully in the sections that follow and for purposes of considering effects of thermal tolerances, shortnose sturgeon are a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities (see *Thermal Tolerances - Atlantic Sturgeon* section). Lab studies indicate that thermal maxima for juvenile shortnose sturgeon are 33.7 (±0.3) – 36.1°C (±0.1) (92.7-97°F), depending on endpoint (loss of equilibrium or death) and acclimation temperature (19.5 or 24.1°C) (Ziegeweid *et al*. 2008a and 2008b). In the Delaware River, reports for the baywide bottom trawl survey describe captures of subadult Atlantic sturgeon in water temperatures as high as 29.2°C (see for example, August 7, 2019 take report).

As water temperatures above 28°C may affect the movement and distribution of individual Atlantic sturgeon, we consider the potential for the discharge of heated effluent to act as a barrier to the upstream or downstream movement of Atlantic sturgeon. HCGS discharge must meet NJPDES temperature standards. Specifically, the temperature in the river outside of heat dissipation areas (HDAs) may not be raised above ambient by more than 4°F (2.2°C) during non-summer months (September through May) or 1.5°F (0.8°C) during the summer (June through August), and a maximum temperature of 86°F (30.0°C) in the river cannot be exceeded year-round (18 CFR 410; DRBC 2001). HDAs serve as a mixing zone into which thermal effluents may be discharged for the purpose of mixing, dispersing, or dissipating effluents without creating nuisances, hazardous conditions, or violating the provisions NJPDES Surface Water Quality Standards. The HCGS NJPDES permit regulates discharges associated with the cooling tower blowdown, the NJPDES low volume and oily waste treatment system, yard drainage systems, and the domestic sewage treatment plan (NJDEP 2017). The cooling tower blowdown and other effluents are discharged through an underwater pipe located on the bank of the river 1,500 ft (457 m) upstream of the SWS intake. The NJDEP WQS and DRBC Docket define the HDA associated with the HCGS discharge as 2,500 ft upstream or downstream, and 1,500 ft. outshore; thus, the effluent from HCGS must not cause any increases in temperature that cause the river temperature in this area to be greater than 30°C. During the summer months, mean ambient river temperatures may be as high as 26.5°C. During this time, the effluent must not raise temperatures outside the HDA by more than 1.5°C. Ongoing thermal monitoring is performed as part of routine NJPDES permitting requirements for HCGS. Given these circumstances, it is unlikely that the discharge from HCGS would result in any areas where water temperatures are greater than 28°C; thus, the discharge from HCGS is not anticipated to result in water quality conditions (i.e., elevated temperatures) that could potentially present a barrier to Atlantic sturgeon passage through the area.

The effluent discharge from the Salem facility can result in elevated water temperatures in areas that overlap with PBF 3; here, we consider whether those elevated water temperatures result in a barrier to passage. Based on the best available information, including the typical salinity levels in the action area, the presence of adult, subadult, and late-stage juvenile Atlantic sturgeon is possible year round, with younger fish (i.e., eggs, larvae, young of year) expected to be precluded by salinity. Based on available information (Niklitschek 2001), we expect that temperatures above 28°C may affect the movement of Atlantic sturgeon. However, as Atlantic sturgeon are documented in warmer waters, Atlantic sturgeon may still be present in waters with temperatures above 28°C.

In this analysis, we consider data from the most recent thermal modeling that characterize the size and shape of the thermal plume through the tidal cycle. As described in previous sections, the plume is narrow and approximately follows the contour of the shoreline at the discharge. The width of the plume varies from about 4,000 ft (1,200 m) on the flood tide to about 10,000 ft (3,000 m) on the ebb tide. The maximum length of the thermal plume extends past the downstream boundary of designated critical habitat in the Delaware River. While the maximum plume length extends to approximately 6.8 miles (11 km) downstream of the Salem and HCGS facilities, critical habitat ends approximately 2 miles (3.2 km) past the site. The 2-mile downstream limit, in addition to approximately 8 miles (43,000 ft) of upstream waters affected by the plume, results in approximately 10 miles (16.1 km) of critical habitat affected by the thermal discharges; however, as noted below, the area affected does not extend across the entire width of the river. The Delaware River is approximately 13,123 ft (4,000 m) wide at Artificial Island. Based on a maximum-width plume scenario, a sturgeon swimming past Artificial Island would still have a zone of passage at the surface (i.e., river width outside of the thermal plume) approximately 3,281 ft (1,000 m) wide. Within the approximately 10 mile stretch of critical habitat affected by thermal discharge, maximum width conditions at the surface would not last long, as conditions would change with the tidal cycle.We note that thermal effects will be greatest at the surface close to the discharge pipes and effects will decrease with distance away from the discharge point as the plume will become more diluted. Based on this information, we do not anticipate any conditions where water temperatures would be elevated by the thermal plume in a way that would preclude the passage of Atlantic sturgeon moving up or down stream.

Average year-round bottom temperatures in the Delaware Estuary are approximately 14°C. At the depths where discharge occurs, temperatures at the bottom are expected to be at least 3°C lower than at the surface. During the warm summer months (June-September) ambient water temperatures at the bottom could be as high as 23°C. Information provided by NRC on the bottom area where temperatures greater than 4°C above ambient will be experienced indicates that, in the worst case, this area is limited to approximately 80 acres (0.125 square miles) of designated critical habitat within the action area. The area where temperatures greater than 28°C could occur in addition to the gradient of warm temperatures extending from points of discharge, are limited, such that there is ample space for any Atlantic sturgeon to travel around areas impacted by the thermal plume without being exposed to temperatures above 28°C. In summary, there is only a small area near the bottom of the river that may have water temperatures above 28°C during the warmest part of the summer; even during this period, any sturgeon in this location would be able to retreat to adjacent cooler water. At no time do we expect thermal discharges from Salem to result in water temperatures that would be a barrier to the movement of any life stages of sturgeon through any portion of the action area. Based on this analysis, any effects to the value of PBF 3 to the conservation of the species in the action area will be so small that they cannot be meaningfully measured, detected, or evaluated and effects to PBF 3 are insignificant.

Conclusions for PBF 3
Any effects to water depth and water flow will be insignificant. The proposed action will result in temporary temperature increases in a portion of the action area. However, based on the assessment here, any effects of increases in water temperature due to the discharge of heated effluent on the ability of the habitat to support the movement of Atlantic sturgeon through the action area will be so small that they cannot be meaningfully measured, evaluated, or detected. Therefore, any effects to the value of PBF 3 to the conservation of the species in the action area will be so small that they cannot be meaningfully measured, detected, or evaluated and effects to PBF 3 are insignificant.

Feature Four: Water with the temperature, salinity, and oxygen values that, combined, provide for dissolved oxygen values that support successful reproduction and recruitment and are within the temperature range that supports the habitat function
In considering effects to PBF 4, we consider whether the proposed action will have any effect on water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment. Therefore, we consider effects of the action on temperature, salinity and dissolved oxygen needs for Atlantic sturgeon spawning and recruitment. These water quality conditions are interactive and both temperature and salinity influence the dissolved oxygen saturation for a particular area.

As noted above the Salem and HCGS facilities are located at the southern end of Artificial Island, which is approximately 2 miles (3.2 km) upstream of the hypothetical line demarking the head of Delaware Bay. The action area has salinities ranging from 0 – 15 ppt and average 5.0 ppt and contains PBF 4. Activities that overlap where PBF 4 occurs include river abundance monitoring, radiological sampling, the intake of water from the Delaware River and the discharge of heated effluent and other pollutants back into the Delaware River.

River Abundance and Radiological Sampling
As stated above, PBF 4 occurs in the action area until reaching the downstream critical habitat boundary (i.e., 2 miles downstream of the Salem and HCGS facilities). River abundance monitoring and radiological sampling overlap with portions of the Delaware River that contain PBF 4. Bottom trawl and beach seine surveys associated with river abundance monitoring will have no effect on PBF 4. Similarly, sampling shoreline sediments, riverbed sediments, and surface water associated with the REMP will have no effect on PBF 4. These activities do not result in habitat alterations that effect salinity, temperature, or dissolved oxygen; therefore, river abundance and radiological sampling will have no effect on PBF 4.

Intake and Discharge

Here we consider how water withdrawals and effluent discharges may affect PBF 4. Cooling water withdrawals will not have any effect on temperature, salinity, or dissolved oxygen. Discharge of heated effluent will not have any effect on salinity; below we consider effects to dissolved oxygen and water temperature. Atlantic sturgeon are expected to demonstrate avoidance behavior when exposed to waters with stressful temperatures (at or above 28°C, as noted above) or low dissolved oxygen (dissolved oxygen< 4 mg/L). Spawning and larval growth and development does not occur in the action area. Therefore, we focus this analysis on consideration of the effects of the discharge on water in the action area, especially in the bottom meter of the water column, to support juvenile, subadult, and adult survival, growth, and development.

As stated above, the water quality conditions of this feature are interactive, such that both temperature and salinity influence the dissolved oxygen content in a particular area. While discharge of heated effluent does not affect salinity, the action area is tidally influenced, and salinity varies based on the tides and seasons; thus, the dissolved oxygen content present in the action area is variable. However, as reported by NRC (2011), studies completed by PSEG in association with their NJPDES permitting, indicate that the discharge of heated effluent has no discernible effect on dissolved oxygen levels in the area. Therefore, this analysis focuses on effects of the action on water temperature.

Depending on ambient water temperatures, which change seasonally, the area at the water's surface with temperatures greater than 28°C may range from 56.58 acres to as large as 3,725 acres. At its maximum size, the thermal plume extends the entire length of the Delaware River portion of the action area (i.e., up to 8 miles upstream of the discharge point, and 10 miles downstream, with only 2 miles of the downstream extent overlapping with critical habitat); this is equivaluent to approximately 12% of the length of the Delaware River critical habitat unit. However, as noted above, there are no conditions under which the thermal plume is expected to extend across the entire width of the river or through the entire depth of the water column. Due to variable elevated surface water temperatures throughout the year as well as over the course of daily tidal cycles, some areas within the thermal plume would not support the growth, development, or survival of juvenile, subadult, or adult Atlantic sturgeon because water temperatures are too high. However, given that Atlantic sturgeon exposure to this area is limited by their normal behavior as benthic oriented fish which results in limited occurrence near the water surface, any effects to the value of PBF 4 in the action area to support adult, subadult and juvenile survival is so small that it cannot be meaningfully measured, evaluated, or detected. During the warm summer months (June- September), ambient water temperatures in the bottom meter of the water column could be as high as 23°C and are expected to be at least 3°C lower than at the surface. As water is discharged from the outfall below the surface, the heated effluent quickly rises at increasing distances from the outfall; as described in the 2001 NJPDES permit, the plume surfaces within 100 feet of the outfall. The result is a very small area of the river bottom adjacent to the outfall where elevated temperatures may occur. Information provided by NRC on the area at the bottom of the river where temperatures greater than 4°C above ambient will be experienced indicates that in the worst case, this area is limited to approximately 80 acres (i.e., 0.125 square miles) of critical habitat within the action area. Due to elevated water temperatures, during the summer months this area would not support the growth, development, or survival of juvenile, subadult, or adult Atlantic sturgeon because water temperatures are too high. However, given the small size of this area and the high velocity and turbulent mixing in the river, any effects to the value of PBF 4 in the action area to support adult, subadult and juvenile survival is so small that it cannot be meaningfully measured, evaluated, or detected. We have also considered effects of the thermal plume on Atlantic sturgeon prey to consider if any effects of abundance or availability of prey in the action area would affect the value of the habitat for the growth and development of Atlantic sturgeon. In a biothermal study conducted as an assessment of the potential for the thermal plume to adversely affect the survival, growth, and reproduction of Atlantic sturgeon prey items, PSEG concluded that the plume would not likely result in heat-induced mortality for prey species, regardless of mobility (PSEG 1999c in NRC 2011). Based on this, we do not expect the thermal plume to reduce the abundance or availability of Atlantic sturgeon prey. Based on this analysis, effects of these habitat alterations on the PBFs ability to support: (i) Spawning; (ii) Annual and interannual adult, subadult, larval, and juvenile survival; and, (iii) juvenile, and subadult growth, development, and recruitment in the action area, is so small that it cannot be meaningfully measured, evaluated, or detected.

Conclusions for PBF 4

The proposed action will result in temporary temperature increases and in portions of the action area. However, based on the assessment here, any effects to temperature, salinity and dissolved oxygen due to effluent discharges are expected to be so small that they cannot be meaningfully measured, evaluated, or detected and therefore effects to PBF 4 are insignificant.

Summary of effects to critical habitat

We have determined that effects to PBF 2, PBF 3 and PBF 4 are not able to be meaningfully measured, detected or evaluated and are therefore insignificant. PBF 1 does not occur in the action area. Based on this, the action is not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon.

4.2 Loggerhead Sea Turtle (Northwest Atlantic Ocean DPS)

Loggerhead sea turtles are circumglobal and are found in the temperate and tropical regions of the Indian, Pacific, and Atlantic Oceans. The loggerhead sea turtle is distinguished from other turtles by its reddish-brown carapace, large head and powerful jaws. The species was first listed as threatened under the Endangered Species Act in 1978 (43 FR 32800, July 28, 1978). On September 22, 2011, the NMFS and U.S. FWS designated nine distinct population segments of loggerhead sea turtles, with the Northwest Atlantic Ocean DPS listed as threatened (76 FR 58868). The Northwest Atlantic Ocean DPS of loggerheads is found along eastern North America, Central America, and northern South America (Figure 3).

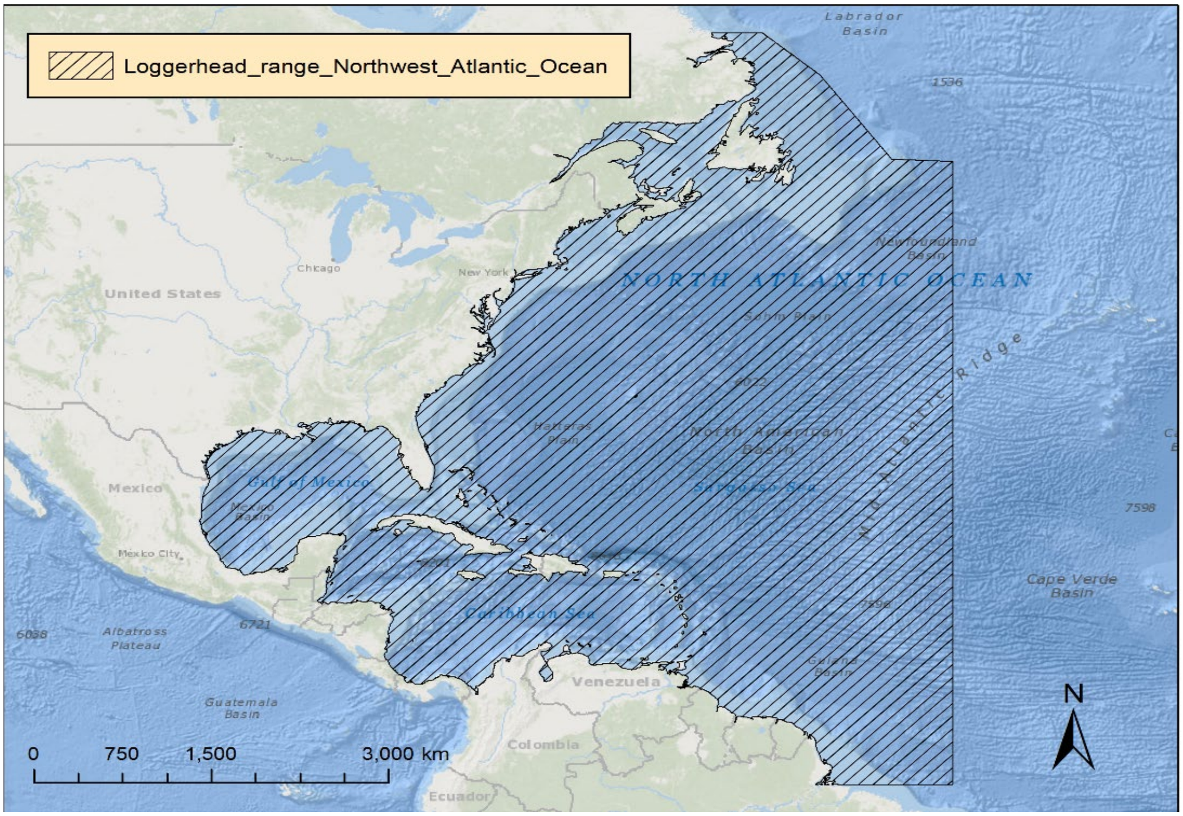

Figure 3: Range of the Northwest Atlantic Ocean DPS of loggerhead sea turtles.

We used information available in the 2009 Status Review (Conant *et al.* 2009), the final listing rule (76 FR 58868, September 22, 2011), the relevant literature, and recent nesting data from the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Nesting occurs on beaches where warm, humid sand temperatures incubate the eggs. Northwest Atlantic females lay an average of five clutches per year. The annual average clutch size is 115 eggs per nest. Females do not nest every year. The average remigration interval is three years (Conant *et al.* 2009). There is a 54% emergence success rate (Conant *et al.* 2009). As with other sea turtles, temperature determines the sex of the turtle during the middle of the incubation period. Turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in coastal waters. Some juveniles may periodically move between the oceanic zone and coastal waters (Witzell 2002, Bolten 2003, Morreale and Standora 2005, McClellan and Read 2007, Mansfield 2006, Eckert *et al*. 2008, Conant *et al.* 2009). Coastal waters provide important foraging, inter-nesting, and migratory habitats for adult loggerheads. In both the oceanic zone and coastal waters, loggerheads are primarily carnivorous, although they do consume some plant matter as well (Conant *et al.* 2009). Loggerheads have been documented to feed on crustaceans, mollusks, jellyfish and salps, and algae (Bjorndal 1997; Seney and Musick 2007; Donaton *et al.* 2019).

Avens *et al.* (2015) used three approaches to estimate age at maturation. Mean age predictions associated with minimum and mean maturation straight carapace lengths were 22.5-25 and 36-38 years for females and 26-28 and 37-42 years for males. Male and female sea turtles have similar post-maturation longevity, ranging from 4 to 46 (mean 19) years (Avens *et al.* 2015).

Loggerhead hatchlings from the western Atlantic disperse widely, most likely using the Gulf Stream to drift throughout the Atlantic Ocean. MtDNA evidence demonstrates that juvenile loggerheads from southern Florida nesting beaches comprise the vast majority (71%-88%) of individuals found in foraging grounds throughout the western and eastern Atlantic: Nicaragua, Panama, Azores and Madeira, Canary Islands and Andalusia, Gulf of Mexico, and Brazil (Masuda 2010). LaCasalla *et al.* (2013) found that loggerheads, primarily juveniles, caught within the Northeast Distant (NED) waters of the North Atlantic mostly originated from nesting populations in the southeast United States and, in particular, Florida. They found that nearly all loggerheads caught in the NED came from the Northwest Atlantic DPS (mean = 99.2%), primarily from the large eastern Florida rookeries. There was little evidence of contributions from the South Atlantic, Northeast Atlantic, or Mediterranean DPSs (LaCasella *et al.* 2013).

More recently, Stewart *et al.* (2019) assessed sea turtles captured in fisheries in the Northwest Atlantic. The analysis included samples from 850 (including 24 turtles caught during fisheries research) turtles caught from 2000-2013 in coastal and oceanic habitats. The turtles were primarily captured in pelagic longline and bottom otter trawls. Other gears included bottom longline, hook and line, gillnet, dredge, and dip net. Turtles were identified from 19 distinct management units; the western Atlantic nesting populations were the main contributors with little representation from the Northeast Atlantic, Mediterranean, or South Atlantic DPSs (Stewart *et al.* 2019). There was a significant split in the distribution of small (≤63 cm SCL) and large (>63 cm SCL) loggerheads north and south of Cape Hatteras, North Carolina. North of Cape Hatteras, large turtles came mainly from southeast Florida (44%±15%) and the northern United States management units (33%±16%); small turtles came from central east Florida (64%±14%). South of Cape Hatteras, large turtles came mainly from central east Florida (52%±20%) and southeast Florida (41%±20%); small turtles came from southeast Florida (56%±25%). The authors concluded that bycatch in the western North Atlantic would affect the Northwest Atlantic DPS almost exclusively ((Stewart *et al.* 2019)).

Population Dynamics
A number of stock assessments and similar reviews (NMFS 2001; Heppell *et al.* 2003; TEWG 1998, 2000, 2009; NMFS and U.S. FWS 2008; Conant *et al.* 2009; NMFS 2009a; Richards *et al.* 2011) have examined the stock status of loggerheads in the Atlantic Ocean, but none have been able to develop a reliable estimate of absolute population size. As with other species, counts of nests and nesting females are commonly used as an index of abundance and population trends, even though there are doubts about the ability to estimate the overall population size. Adult nesting females often account for less than 1% of total population numbers (Bjorndal *et al.* 2005).

Based on genetic analysis of nesting subpopulations, the Northwest Atlantic Ocean DPS is divided into five recovery units: Northern, Peninsular Florida, Dry Tortugas, Northern Gulf of Mexico, and Greater Caribbean (Conant *et al.* 2009). A more recent analysis using expanded mtDNA sequences revealed that rookeries from the Gulf and Atlantic coasts of Florida are genetically distinct (Shamblin *et al.* 2014). The recent genetic analyses suggest that the

Northwest Atlantic Ocean DPS should be considered as ten management units: (1) South Carolina and Georgia, (2) central eastern Florida, (3) southeastern Florida, (4) Cay Sal, Bahamas, (5) Dry Tortugas, Florida, (6) southwestern Cuba, (7) Quintana Roo, Mexico, (8) southwestern Florida, (9) central western Florida, and (10) northwestern Florida (Shamblin *et al.* 2012).

The Northwest Atlantic Ocean's loggerhead nesting aggregation is considered the largest in the world (Casale and Tucker 2017). Using data from 2004-2008, the adult female population size of the DPS was estimated at 20,000 to 40,000 females (NMFS 2009). More recently, Ceriani and Meylan (2017) reported a 5-year average (2009-2013) of more than 83,717 nests per year in the southeast United States and Mexico (excluding Cancun (Quintana Roo, Mexico)). These estimates included sites without long-term (≥10 years) datasets. When they used data from 86 index sites (representing 63.4% of the estimated nests for the whole DPS with long-term datasets, they reported 53,043 nests per year. Trends at the different index nesting beaches ranged from negative to positive. In a trend analysis of the 86 index sites, the overall trend for the Northwest Atlantic DPS was positive (+2%) (Ceriani and Meylan 2017). Uncertainties in this analysis include, among others, using nesting females as proxies for overall population abundance and trends, demographic parameters, monitoring methodologies, and evaluation methods involving simple comparisons of early and later 5-year average annual nest counts. However, the authors concluded that the subpopulation is well monitored, and the data evaluated represents 63.4 % of the total estimated annual nests of the subpopulation and, therefore, are representative of the overall trend (Ceriani and Meylan 2017).

About 80% of loggerhead nesting in the southeast United States occurs in six Florida counties (NMFS and U.S. FWS 2008). The Peninsula Florida Recovery Unit and the Northern Recovery Unit represent approximately 87% and 10%, respectively of all nesting effort in the Northwest Atlantic DPS (NMFS and U.S. FWS 2008; Ceriani and Meylan 2017). As described above, FWRI's Index Nesting Beach Survey (INBS) collects standardized nesting data. The index nest counts for loggerheads represent approximately 53% of known nesting in Florida. There have been three distinct intervals observed: increasing (1989-1998), decreasing (1998-2007), and increasing (2007-2019). At core index beaches in Florida, nesting totaled a minimum of 28,876 nests in 2007 and a maximum of 65,807 nests in 2016 (https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/). In 2019, more than 53,000 nests were documented. The nest counts in Figure 4 represent peninsular Florida and do not include an additional set of beaches in the Florida Panhandle and southwest coast that were added to the program in 1997 and more recent years. Nest counts at these Florida Panhandle index beaches have an upward trend since 2010.

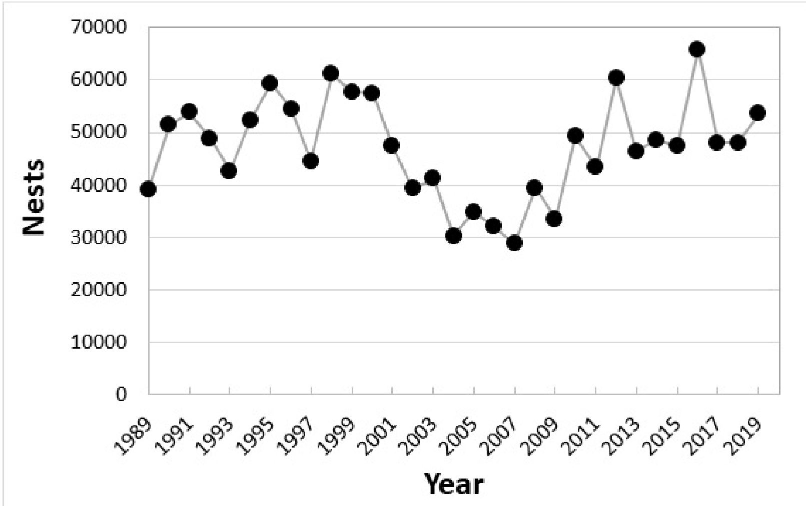

Figure 4. Annual nest counts for loggerhead sea turtles on Florida core index beaches in peninsular Florida, 1989-2019 Source: https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/.

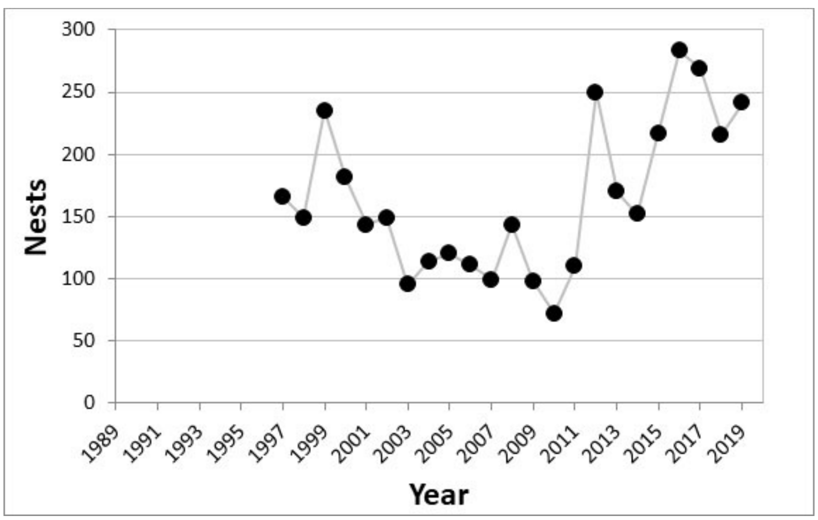

Figure 5. Annual nest counts on index beaches in the Florida Panhandle, 1997-2019. Source: https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/.

The annual nest counts on Florida's index beaches fluctuate widely, and we do not fully understand what drives these fluctuations. In assessing the population, Ceriani and Meylan (2017) and Bolten *et al.* (2019) looked at trends by recovery unit. Trends by recovery unit were variable.

The Peninsular Florida Recovery Unit extends from the Georgia-Florida border south and then north (excluding the islands west of Key West, Florida) through Pinellas County on the west coast of Florida. Annual nest counts from 1989 to 2018 ranged from a low of 28,876 in 2007 to a high of 65,807 in 1998 (Bolten *et al.* 2019). More recently (2008-2018), counts have ranged from 33,532 in 2009 to 65,807 in 2016 (Bolten *et al.* 2019). Nest counts taken at index beaches in Peninsular Florida showed a significant decline in loggerhead nesting from 1989 to 2007, most likely attributed to mortality of oceanic-stage loggerheads caused by fisheries bycatch (Witherington *et al.* 2009). Trend analyses have been completed for various periods. From 2009 through 2013, a 2% decrease for this recovery unit was reported (Ceriani and Meylan 2017). Using a longer time series from 1989-2018, there was no significant change in the number of annual nests (Bolten *et al.* 2019). It is important to recognize that an increase in the number of nests has been observed since 2007. The recovery team cautions that using short term trends in nesting abundance can be misleading and trends should be considered in the context of one generation (50 years for loggerheads) (Bolten *et al*. 2019).

The Northern Recovery Unit, ranging from the Florida-Georgia border through southern Virginia, is the second largest nesting aggregation in the DPS. Annual nest totals for this recovery unit from 1983 to 2019 have ranged from a low of 520 in 2004 to a high of 5,555 in 2019 (Bolten *et al.* 2019). More recently (2008-2019), counts have ranged from 1,289 nests in 2014 to 5,555 nests in 2019 (Bolten *et al.* 2019). Nest counts at loggerhead nesting beaches in North Carolina, South Carolina, and Georgia declined at 1.9% annually from 1983 to 2005 (NMFS and U.S. FWS 2007a). Recently, the trend has been increasing. Ceriani and Meylan (2017) reported a 35% increase for this recovery unit from 2009 through 2013. A longer-term trend analysis based on data from 1983 to 2019 indicates that the annual rate of increase is 1.3% (Bolten *et al.* 2019).

The Dry Tortugas Recovery Unit includes all islands west of Key West, Florida. A census on Key West from 1995 to 2004 (excluding 2002) estimated a mean of 246 nests per year, or about 60 nesting females (NMFS and U.S. FWS 2007a). No trend analysis is available because there was not an adequate time series to evaluate the Dry Tortugas recovery unit (Ceriani and Meyland 2017; Bolten *et al.* 2019), which accounts for less than 1% of the Northwest Atlantic DPS (Ceriani and Meyland 2017).

The Northern Gulf of Mexico Recovery Unit is defined as loggerheads originating from beaches in Franklin County on the northwest Gulf coast of Florida through Texas. From 1995 to 2007, there were an average of 906 nests per year on approximately 300 km of beach in Alabama and Florida, which equates to about 221 females nesting per year (NMFS and U.S. FWS 2008. Annual nest totals for this recovery unit from 1997-2018 have ranged from a low of 72 in 2010 to a high of 283 in 2016 (Bolten *et al.* 2019). Evaluation of long-term nesting trends for the Northern Gulf of Mexico Recovery Unit is difficult because of changed and expanded beach coverage. However, there are now over 20 years of Florida index nesting beach survey data. A number of trend analyses have been conducted. From 1995 to 2005, the recovery unit exhibited a significant declining trend (NMFS and U.S. FWS 2007a; Conant *et al.* 2009). Nest numbers have increased in recent years (Bolten *et al.* 2019; https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/). In the 2009-2013 trend analysis by Ceriani and Meylan (2017), a 1% decrease for this recovery unit was reported, likely due to diminished nesting on beaches in Alabama, Mississippi, Louisiana, and Texas. A longer-term analysis from 1997-2018 found that there has been a non-significant increase of 1.7% (Bolten *et al.* 2019).

The Greater Caribbean Recovery Unit encompasses nesting subpopulations in Mexico to French Guiana, the Bahamas, and the Lesser and Greater Antilles. The majority of nesting for this recovery unit occurs on the Yucatán Peninsula, in Quintana Roo, Mexico, with 903 to 2,331 nests annually (Zurita *et al.* 2003). Other significant nesting sites are found throughout the Caribbean, including Cuba, with approximately 250 to 300 nests annually (Ehrhart *et al.* 2003), and over 100 nests annually in Cay Sal in the Bahamas (NMFS and U.S. FWS 2008). In the trend analysis by Ceriani and Meylan (2017), a 53% increase for this Recovery Unit was reported from 2009 through 2013.

Status

Fisheries bycatch is the highest threat to the Northwest Atlantic DPS of loggerhead sea turtles (Conant *et al.* 2009). Other threats include boat strikes, marine debris, coastal development, habitat loss, contaminants, disease, and climate change. Nesting trends for each of the loggerhead sea turtle recovery units in the Northwest Atlantic Ocean DPS are variable. Overall, short-term trends have shown increases, however, over the long-term the DPS is considered stable.

Critical Habitat

Critical habitat for the Northwest Atlantic Ocean DPS of logger sea turtles was designated in 2014 (79 FR 39855). Specific areas for designation include 38 occupied marine areas within the range of the Northwest Atlantic Ocean DPS. There is no critical habitat designated in the action area.

Recovery Goals

The recovery goal for the Northwest Atlantic loggerhead is to ensure that each recovery unit meets its recovery criteria alleviating threats to the species so that protection under the ESA is not needed. The recovery criteria relate to the number of nests and nesting females, trends in abundance on the foraging grounds, and trends in neritic strandings relative to in-water abundance. The 2008 Final Recovery Plan for the Northwest Atlantic Population of Loggerheads includes the complete downlisting/delisting criteria (NMFS and U.S. FWS 2008). The recovery objectives to meet these goals include:

1. Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females.
2. Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
3. Manage sufficient nesting beach habitat to ensure successful nesting.
4. Manage sufficient feeding, migratory and internesting marine habitats to ensure successful growth and reproduction.
5. Eliminate legal harvest.
6. Implement scientifically based nest management plans.
7. Minimize nest predation.
8. Recognize and respond to mass/unusual mortality or disease events appropriately.
9. Develop and implement local, state, federal and international legislation to ensure long-term protection of loggerheads and their terrestrial and marine habitats.
10. Minimize bycatch in domestic and international commercial and artisanal fisheries.
11. Minimize trophic changes from fishery harvest and habitat alteration.
12. Minimize marine debris ingestion and entanglement.

13. Minimize vessel strike mortality.

No Five-Year review has been completed for the Northwest Atlantic DPS of loggerhead sea turtles that post-dates the 2008 recovery plan.

4.3 Green Sea Turtle (North Atlantic DPS)

The green sea turtle has a circumglobal distribution, occurring throughout tropical, subtropical and, to a lesser extent, temperate waters. They commonly inhabit nearshore and inshore waters. It is the largest of the hardshell marine turtles, growing to a weight of approximately 350 pounds (159 kilograms) and a straight carapace length of greater than 3.3 feet (one meter). The species was listed under the ESA on July 28, 1978 (43 FR 32800) as endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA (81 FR 20057). The North Atlantic DPS of green turtle is found in the North Atlantic Ocean and Gulf of Mexico (Figure 6) and is listed as threatened. Green turtles from the North Atlantic DPS range from the boundary of South and Central America (7.5°N, 77°W) in the south, throughout the Caribbean, the Gulf of Mexico, and the U.S. Atlantic coast to New Brunswick, Canada (48°N, 77°W) in the north. The range of the DPS then extends due east along latitudes 48°N and 19°N to the western coasts of Europe and Africa.

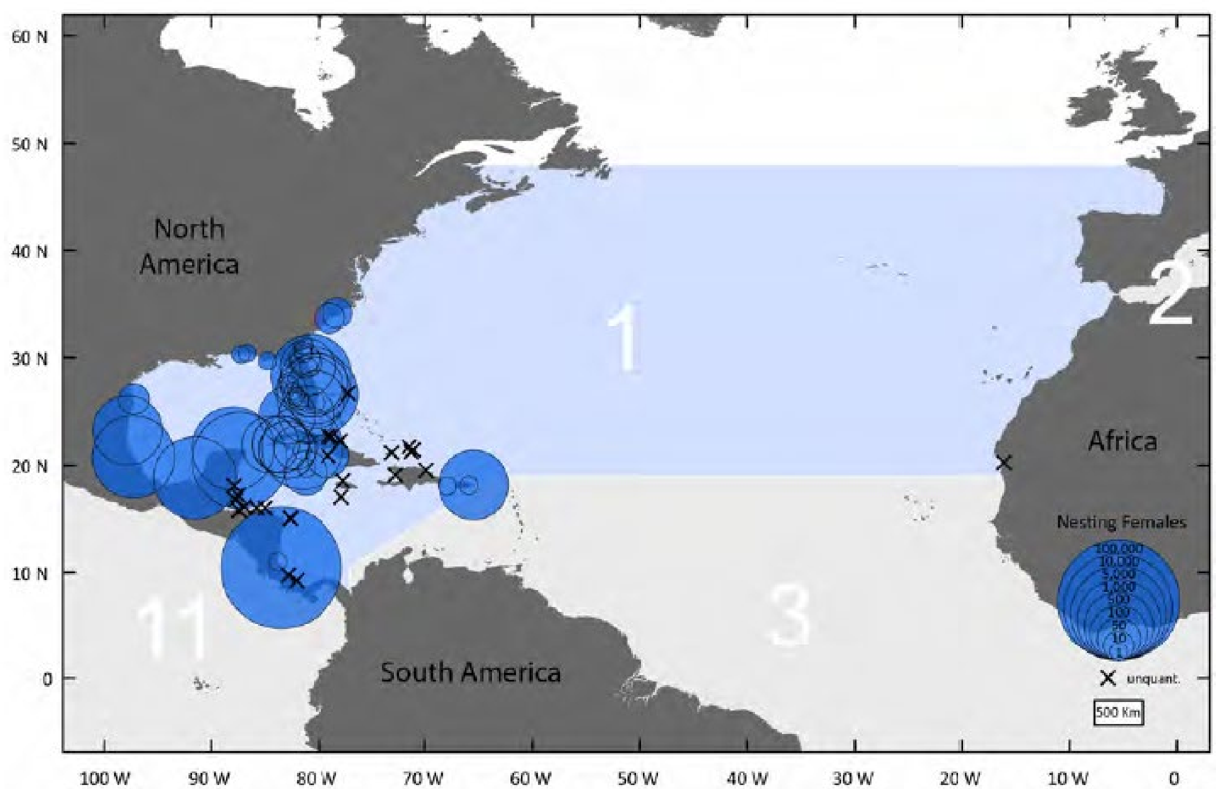

Figure 6. Geographic range of the North Atlantic distinct population segment green turtle (1), with location and abundance of nesting females. From Seminoff *et al.* (2015). We used information available in the 2015 Status Review (Seminoff *et al.* 2015a), relevant literature, and recent nesting data from the Florida FWRI to summarize the life history, population dynamics

and status of the species, as follows.

Life history
Costa Rica (Tortuguero), Mexico (Campeche, Yucatan, Quintana Roo), United States (Florida) and Cuba (Figure 6) support nesting concentrations of particular interest in the North Atlantic DPS (Seminoff *et al.* 2015b). In the southeastern United States, females generally nest between May and September (Seminoff *et al.* 2015b, Witherington *et al.* 2009). Green sea turtles lay an average of three nests per season with an average of one hundred eggs per nest (Hirth 1997, Seminoff *et al.* 2015b). The remigration interval (period between nesting seasons) is two to five years (Hirth 1997); (Seminoff *et al.* 2015b). Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during the summer months.

Sea turtles are long-lived animals. Size and age at sexual maturity have been estimated using several methods, including mark-recapture, skeletochronology, and marked, known-aged individuals. Skeletochronology analyzes growth marks in bones to obtain growth rates and age at sexual maturity (ASM) estimates. Estimates vary widely among studies and populations, and methods continue to be developed and refined (Avens and Snover 2013). Early mark-recapture studies in Florida estimated the age at sexual maturity 18-30 years (Mendonça 1981; Frazer and Ehrhart 1985, Ehrhardt and Witham 1992). More recent estimates of age at sexual maturity are as high as 35–50 years (Goshe *et al.* 2010; Avens and Snover 2013), with lower ranges reported from known age turtles from the Cayman Islands (15–19 years; Bell *et al.* 2005) and Caribbean Mexico (12–20 years; Zurita *et al.* 2012). A study of green turtles that use waters of the southeastern United States as developmental habitat found the age at sexual maturity likely ranges from 30 to 44 years (Goshe *et al.* 2010). Green turtles in the Northwestern Atlantic mature at 85–100+ cm straight carapace lengths (SCL) (Avens and Snover 2013).

Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat other invertebrate prey (Seminoff *et al.* 2015b).

Population dynamics
Compared to other DPSs, the North Atlantic DPS exhibits the highest nester abundance, with approximately 167,424 females at seventy-three nesting sites (using data through 2012), and available data indicated an increasing trend in nesting (Seminoff *et al.* 2015b). Counts of nests and nesting females are commonly used as an index of abundance and population trends, even though there are doubts about the ability to estimate the overall population size. Nesting occurs primarily in Costa Rica, Mexico, Florida, and Cuba. The largest nesting site in the North Atlantic DPS is in Tortuguero, Costa Rica, which hosts 79% of nesting females for the DPS (Seminoff *et al.* 2015a, Seminoff *et al.* 2015b).

The North Atlantic DPS has a globally unique haplotype, which was a factor in defining the discreteness of the DPS. Evidence from mitochondrial DNA studies indicates that there are at least four independent nesting subpopulations in Florida, Cuba, Mexico and Costa Rica

(Seminoff *et al.* 2015b). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin *et al.* 2017).

There are no reliable estimates of population growth rate for the DPS as a whole, but estimates have been developed at a localized level. The status review for green sea turtles assessed population trends for seven nesting sites with more than 10 years of data collection in the North Atlantic DPS. The results were variable with some sites showing no trend and others increasing. However, all major nesting populations (using data through 2011-2012) demonstrated increases in abundance (Seminoff *et al.* 2015b).

More recent data is available for the southeastern United States. The FWRI monitors sea turtle nesting through the Statewide Nesting Beach Survey (SNBS) and Index Nesting Beach Survey (INBS). Since 1979, the SNBS has surveyed approximately 215 beaches to collect information on the distribution, seasonality, and abundance of sea turtle nesting in Florida. Since 1989, the INBS has been conducted on a subset of SNBS beaches to monitor trends through consistent effort and specialized training of surveyors. The INBS data uses a standardized data-collection protocol to allow for comparisons between years and is presented for green, loggerhead, and leatherback sea turtles. The index counts represent 27 core index beaches. The index nest counts represent approximately 67% of known green turtle nesting in Florida (https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/).

Nest counts at Florida's core index beaches have ranged from less than 300 to almost 41,000 in 2019. The nest numbers show a mostly biennial pattern of fluctuation (https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/; Figure 7).

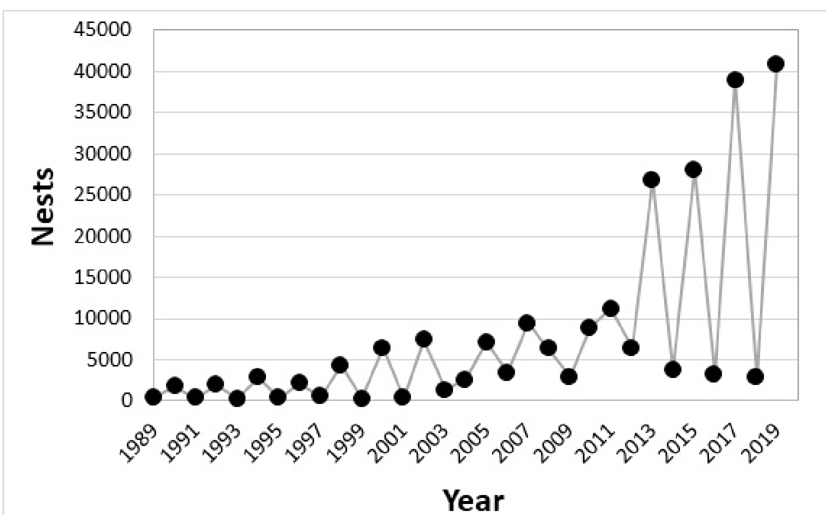

Figure 7. Number of green sea turtle nests counted on core index beaches in Florida from 1989-2019. Source: https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/.

Status

Historically, green sea turtles in the North Atlantic DPS were hunted for food, which was the principal cause of the population's decline. Apparent increases in nester abundance for the

North Atlantic DPS in recent years are encouraging but must be viewed cautiously, as the datasets represent a fraction of a green sea turtle generation which is between 30 and 40 years (Seminoff *et al.* 2015b). While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS appears to be somewhat resilient to future perturbations.

Critical Habitat

Critical habitat for the North Atlantic DPS of green sea turtles surrounds Culebra Island, Puerto Rico (66 FR 20058, April 6, 2016), which is outside the action area.

Recovery Goals

No recovery plan for green sea turtles has been issued since the DPSs were listed in 2016. The goal of the 1991 Recovery Plan for the U.S. population of green sea turtles is to delist the species once the recovery criteria are met (NMFS and U.S.FWS 1991). The recovery plan includes criteria for delisting related to nesting activity, nesting habitat protection, and reduction in mortality.

Priority actions to meet the recovery goals include:

1. Providing long-term protection to important nesting beaches.
2. Ensuring at least a 60% hatch rate success on major nesting beaches.
3. Implementing effective lighting ordinances/plans on nesting beaches.
4. Determining distribution and seasonal movements of all life stages in the marine environment.
5. Minimizing commercial fishing mortality.
6. Reducing threat to the population and foraging habitat from marine pollution.

No Five-Year review has been conducted since the 2016 listing.

4.4 Kemp's Ridley Sea Turtle

The range of Kemp's ridley sea turtles extends from the Gulf of Mexico to the Atlantic coast (Figure 8). They have occasionally been found in the Mediterranean Sea, which may be due to migration expansion or increased hatchling production (Tomas and Raga 2008). They are the smallest of all sea turtle species, with a nearly circular top shell and a pale yellowish bottom shell. The species was first listed under the Endangered Species Conservation Act (35 FR 18319, December 2, 1970) in 1970 and has been listed as endangered under the ESA since 1973.

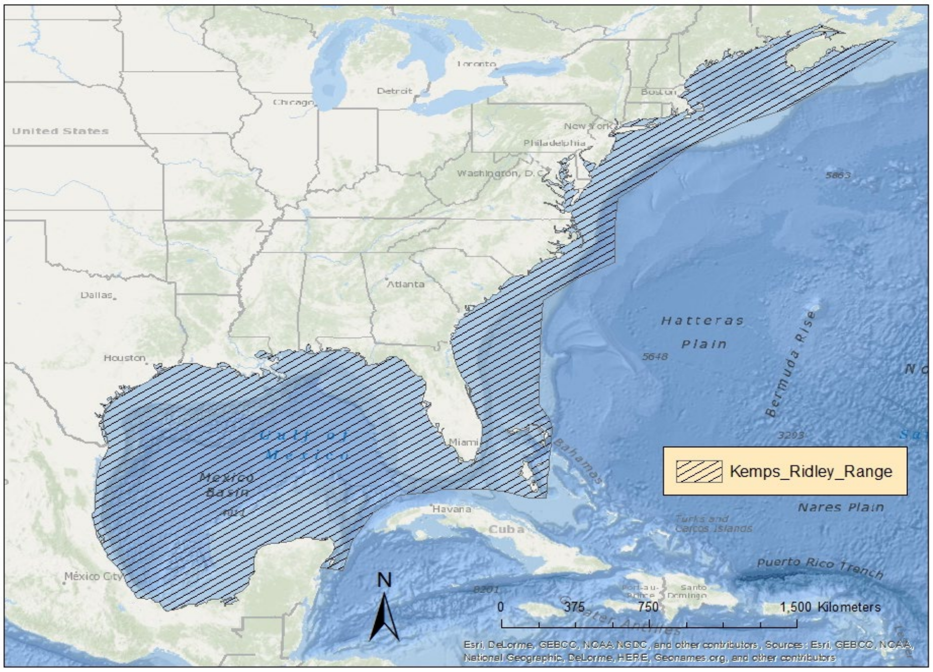

Figure 8. Range of the endangered Kemp's ridley sea turtle.

We used information available in the revised recovery plan (NMFS 2011), the Five-Year Review (NMFS 2015), and published literature to summarize the life history, population dynamics and status of the species, as follows.

Life History

Kemp's ridley nesting is essentially limited to the western Gulf of Mexico. Approximately 97% of the global population's nesting activity occurs on a 146-km stretch of beach that includes Rancho Nuevo in Mexico (Wibbels and Bevan 2019). In the United States, nesting occurs primarily in Texas and occasionally in Florida, Alabama, Georgia, South Carolina, and North Carolina (NMFS and U.S FWS 2015) Nesting occurs from April to July in large arribadas (synchronized large-scale nesting). The average remigration interval is two years, although intervals of 1 and 3 years are not uncommon (TEWG 1998, 2000, NMFS and U.S. FWS 2011). Females lay an average of 2.5 clutches per season (NMFS and U.S. FWS 2011). The annual average clutch size is 95 to 112 eggs per nest (NMFS 2015). The nesting location may be particularly important because hatchlings can more easily migrate to foraging grounds in deeper oceanic waters, where they remain for approximately two years before returning to nearshore coastal habitats (Epperly *et al.* 2013; Snover *et al.* 2007; NMFS and U.S. FWS 2015). Modeling indicates that oceanic-stage Kemp's ridley turtles are likely distributed throughout the Gulf of Mexico into the northwestern Atlantic (Putnam *et al.* 2013). Kemp's ridley nearing the age when recruitment to nearshore waters occurs are more likely to be distributed in the northern Gulf of Mexico, eastern Gulf of Mexico, and the western Atlantic (Putnam *et al.* 2013).

Several studies, including those of captive turtles, recaptured turtles of known age, mark-recapture data, and skeletochronology, have estimated the average age at sexual maturity for Kemp's ridleys between 5 to 12 years (captive only, Bjorndal *et al.* 2014), 10 to 16 years (Chaloupka and Zug 1997; Schmid and Witzell 1997; Zug *et al.*1997; Schmid and Woodhead, 2000), 9.9 to 16.7 years (Snover *et al.*2007), 10 and 18 years (Shaver and Wibbels 2007), 6.8 to 21.8 years (mean 12.9 years) (Avens *et al.* 2017).

During spring and summer, juvenile Kemp's ridleys generally occur in the shallow coastal waters of the northern Gulf of Mexico from south Texas to north Florida and along the U.S. Atlantic coast from southern Florida to the Mid-Atlantic and New England. The NEFSC caught a juvenile Kemp's ridley during a recent research project in deep water south of Georges Bank (NEFSC, unpublished data). In the fall, most Kemp's ridleys migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998). As adults, many turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS *et al.* 2010). Adult habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 120 feet (37 meters) deep (Seney and Landry 2008; Shaver *et al.* 2005; Shaver and Rubio 2008), although they can also be found in deeper offshore waters. As larger juveniles and adults, Kemp's ridleys forage on swimming crabs, fish, jellyfish, mollusks, and tunicates (NMFS 2011).

Population Dynamics

Of the sea turtle species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased at 15% annually (Heppell *et al.* 2005). However, due to recent declines in nest counts, decreased survival of immature and adult sea turtles, and updated population modeling, this rate is not expected to continue, and the overall trend is unclear (NMFS and U.S. FWS 2015; Caillouett *et al.* 2018). In 2019, there were 11,090 nests, a 37.61% decrease from 2018 and a 54.89% decrease from 2017, which had the highest number (24,587) of nests (Figure 9; unpublished data). The reason for this recent decline is uncertain.

Using the standard IUCN protocol for sea turtle assessments, the number of mature individuals was recently estimated at 22,341 (Wibbels and Bevan 2019). The calculation took into account the average annual nests from 2016-2018 (21,156), a clutch frequency of 2.5 per year, a remigration interval of 2 years, and a sex ratio of 3.17 females: 1 male. Based on the data in their analysis, the assessment concluded the current population trend is unknown (Wibbels and Bevan 2019).

Genetic variability in Kemp's ridley turtles is considered to be high, as measured by nuclear DNA analyses (i.e., microsatellites) (NMFS 2011). If this holds true than rapid increases in population over one or two generations would likely prevent any negative effects in the genetic variability of the species (NMFS and U.S. FWS 2011). Additional analysis of the mtDNA taken from samples of Kemp's ridley turtles at Padre Island, Texas, showed six distinct haplotypes, with one found at both Padre Island and Rancho Nuevo (Dutton *et al.* 2006).

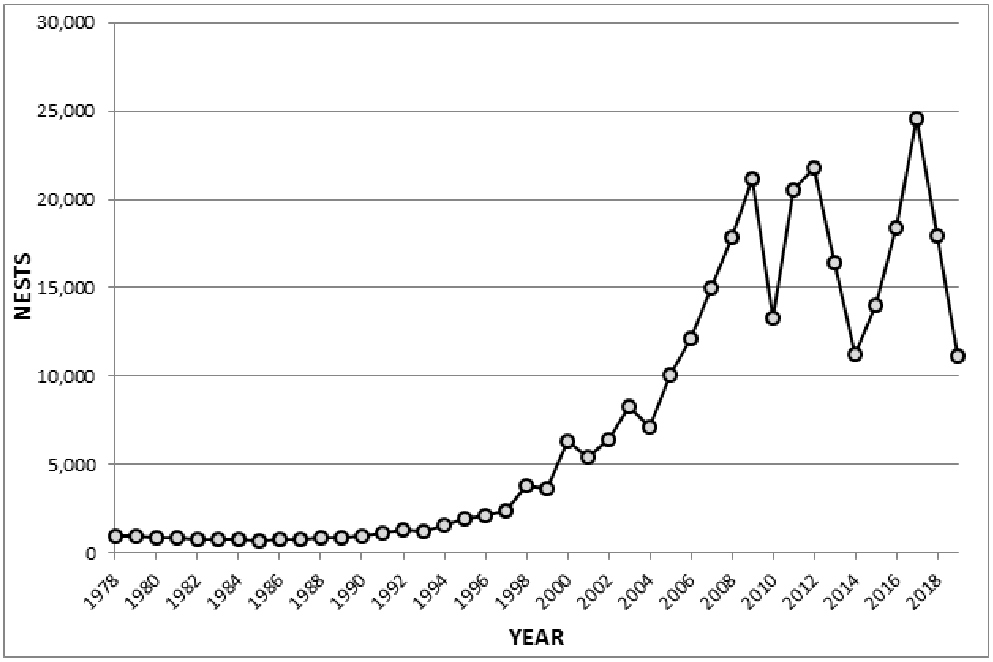

Figure 9. Kemp's ridley nest totals from Mexican beaches (Gladys Porter Zoo nesting database 2019).

Status

The Kemp's ridley was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances in Mexico prohibited the harvest of sea turtles from May to August, and in 1990, the harvest of all sea turtles was prohibited by presidential decree. In 2002, Rancho Nuevo was declared a Sanctuary. Nesting beaches in Texas have been re-established. Fishery interactions are the main threat to the species. Other threats include habitat destruction, oil spills, dredging, disease, cold stunning, and climate change. The current population trend is uncertain. While the population has increased, recent nesting numbers have been variable. In addition, the species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

Critical Habitat

Critical habitat has not been designated for Kemp's ridley sea turtles.

Recovery Goals

As with other recovery plans, the goal of the 2011 Kemp's ridley recovery plan (NMFS, USFWS, and SEMARNAT 2011) is to conserve and protect the species so that the listing is no longer necessary. The recovery criteria relate to the number of nesting females, hatchling recruitment, habitat protection, social and/or economic initiatives compatible with conservation, reduction of predation, TED or other protective measures in trawl gear, and improved information available to ensure recovery. In 2015, the bi-national recovery team published a number of recommendations including four critical actions (NMFS and USFWS 2015). These include: (a) continue funding by the major funding institutions at a level of support needed to run the successful turtle camps in the State of Tamaulipas, Mexico, in order to continue the high level of hatchling production and nesting female protection; (b) increase turtle excluder device (TED) compliance in U.S. and MX shrimp fisheries; (c) require TEDs in U.S. skimmer trawl fisheries and other trawl fisheries in coastal waters where fishing overlaps with the distribution of Kemp's ridleys; (d) assess bycatch in gillnets in the Northern Gulf of Mexico and State of Tamaulipas, Mexico, to determine whether modifications to gear or fishing practices are needed.

The most recent Five-Year Review was completed in 2015 (NMFS and USFWS 2015) with a recommendation that the status of Kemp's ridley sea turtles should remain as endangered. In the Plan, the Services recommend that efforts continue towards achieving the major recovery actions in the 2015 plan with a priority for actions to address recent declines in the annual number of nests.

4.5 Shortnose Sturgeon

Shortnose sturgeon are fish that occur in rivers and estuaries along the East Coast of the U.S. and Canada (SSSRT 2010). They have a head covered in bony plates, as well as protective armor called scutes extending from the base of the skull to the caudal peduncle. Other distinctive features include a subterminal, protractile tube-like mouth, and chemosensory barbels for benthic foraging (SSSRT 2010). Sturgeon have been present in North America since the Upper Cretaceous period, more than 66 million years ago. The information below is a summary of available information on the species. More thorough discussions can be found in the cited references as well as the SSSRT's Biological Assessment (2010). Detailed information on the populations that occur in the action area is provided in section 5.1.2 while details on activities that impact individual shortnose sturgeon in the action area can be found in sections 5.2 and 6.0.

Life History and General Habitat Use

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

Table 2. General life history for shortnose sturgeon throughout its range

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

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

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

Shortnose sturgeon occur in waters between 0 – 34°C (Dadswell *et al.* 1984; Heidt and Gilbert 1978); with temperatures above 28°C considered to be stressful. Depths used are highly variable, ranging from shallow mudflats while foraging to deep channels up to 30 m (Dadswell *et al.* 1984; Dadswell 1979, Kynard *et al.* 2016). Salinity tolerance increases with age; while young of the year must remain in freshwater, adults have been documented in the ocean with salinities of up 30 parts-per-thousand (ppt) (Holland and Yeverton 1973, Squiers and Smith 1978, Kynard *et al.* 2016). Dissolved oxygen affects distribution, with preference for DO levels at or above 5mg/l and adverse effects anticipated for prolonged exposure to DO less than 3.2mg/L (Kynard *et al.* 2016).

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

Following spawning, adult shortnose sturgeon disperse quickly down river to summer foraging grounds and remain in areas downstream of their spawning grounds throughout the remainder of the year (Buckley and Kynard 1981, Dadswell *et al.* 1984, Buckley and Kynard 1985, O'Herron *et al.* 1993, Kynard *et al.* 2016).

In northern rivers, shortnose aggregate during the winter months in discrete, deep (3-10m) freshwater areas with minimal movement and foraging (Kynard *et al.* 2012, Buckley and Kynard 1985, Dadswell 1979, Li *et al.* 2007, Dovel *et al.* 1992, Bain *et al.* 1998, Kynard *et al.* 2016). In the winter, adults in southern rivers spend much of their time in the slower moving waters downstream near the salt-wedge and forage widely throughout the estuary (Collins and Smith 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 (Rogers and Weber 1995). Older juveniles typically occur in the same overwintering areas as adults while young of the year remain in freshwater (Jenkins *et al.* 1993, Jarvis *et al.* 2001).

Listing History

Shortnose sturgeon were listed as endangered in 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Shortnose sturgeon are thought to have been abundant in nearly every large East Coast river prior to the1880s (Kynard *et al.* 2016). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. The species remains listed as endangered throughout its range. While the 1998 Recovery Plan refers to Distinct Population Segments (DPS), the process to designate DPSs for this species has not been undertaken. The SSSRT published a Biological Assessment for shortnose sturgeon in 2010. The report summarized the status of shortnose sturgeon within each river and identified stressors that continue to affect the abundance and stability of these populations.

Current Status

There is no current total population estimate for shortnose sturgeon rangewide. Information on populations and metapopulations is presented below. In general, populations in the Northeast are larger and more stable than those in the Southeast (SSSRT 2010). Population size throughout the species' range is considered to be stable; however, most riverine populations are below the historic population sizes and most likely are below the carrying capacity of the river (Kynard 1996, Kynard *et al.* 2016).

Population Structure

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

Recent developments in genetic research as well as differences in life history support the grouping of shortnose sturgeon into five genetically distinct groups, all of which have unique geographic adaptations (see Grunwald *et al.* 2008, Grunwald *et al.* 2002, King *et al.* 2001, Waldman *et al.* 2002, Walsh *et al.* 2001, Wirgin *et al.* 2010, Wirgin *et al.* 2002, SSSRT 2010). 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[1]. The other two groups (Connecticut/Housatonic and the Hudson River) function as independent populations.

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

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

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

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

Kennebec/Androscoggin/Sheepscot
The estimated size of the adult population (>50cm TL) in this system, based on a tagging and recapture study conducted between 1977-1981, was 7,200 (95% CI = 5,000 - 10,800; Squiers *et*

[1] 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.

al. 1982). A population study conducted 1998-2000 estimated population size at 9,488 (95% CI = 6,942 -13,358; Squiers 2003) suggesting that the population exhibited significant growth between the late 1970s and late 1990s. Spawning is known to occur in the Androscoggin and Kennebec Rivers. In both rivers, there are hydroelectric facilities located at the base of natural falls thought to be the natural upstream limit of the species. The Sheepscot River is used for foraging during the summer months.

Altenritter *et al.* (2017) found that a large proportion of female shortnose sturgeon tagged in the Penobscot River migrated to the Kennebec River during probable spawning windows. They also found that shortnose sturgeon in the Penobscot River were larger and had a higher condition factor than shortnose sturgeon in the Kennebec River. Based on this, they speculated that "increased abundance and resource limitation in the Kennebec River may be constraining growth and promoting migration to the Penobscot River by individuals with sufficient initial size and condition." These individuals then return to spawn in the 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*. (2017) noted that although migrants to the Penobscot River may be a small proportion of the Kennebec River population, they could disproportionately contribute to regional recruitment and facilitate population resilience to disturbance.

Merrimack River

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

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

Connecticut River Population

The Holyoke Dam divides the Connecticut River shortnose population; upstream and downstream fishway improvements were implemented for the 2016 fish passage season. Passage between 1975-1999 was an average of four fish per year and no shortnose sturgeon passed upstream of the dam between 2000 and 2015. From 2016 - 2020, 287 shortnose sturgeon have passed upstream of the dam, at an average rate of 57 per year. The number of sturgeon passing downstream of the Dam is less well known due to difficulties in monitoring downstream passage. However, the 2016 fishway improvements have been shown to significantly reduce the potential for serious injury or mortality. Despite this separation, the populations are not genetically distinct (Kynard 1997, Wirgin *et al.* 2005, Kynard *et al.*2012). The most recent estimate of the number of shortnose sturgeon upstream of the dam, based on captures and tagging from 1990-2005 is approximately 328 adults (CI = 188–1,264 adults; B. Kynard, USGS, unpubl. Data in SSSRT 2010); this compares to a previous Peterson mark-recapture estimate of 370–714 adults (Taubert 1980a). Using four mark-recapture methodologies, the longterm population estimate (1989-2002) for the lower Connecticut River ranges from 1,042-1,580 (Savoy 2004). Comparing 1989-1994 to 1996-2002, the population exhibits growth on the order of 65-138%. The population in the Connecticut River is thought to be stable, but at a small size.

As described in SSSRT (2010), shortnose sturgeon in the Connecticut River inhabit a reach downstream of the Turners Falls Dam (Turners Falls, MA; rkm 198) to Long Island Sound (Fig. 20). Construction of the Turners Falls Dam was completed in 1798 and built on a natural falls-rapids. Turners Falls is believed to be the historic upstream boundary of shortnose sturgeon in the Connecticut River; however, there have been anecdotal sightings of sturgeon upstream of the dam and in the summer of 2017 an angler reported a catch of a shortnose sturgeon upstream of the Turners Falls Dam. This information suggests that occasional shortnose sturgeon are present upstream to the dam; however, we have no information on how shortnose sturgeon accessed this reach or how many sturgeon may be present in this area, if any.

While limited spawning may occur below the Holyoke Dam, until recently successful spawning (i.e., capture of viable eggs and larvae) has only been documented upstream of the Holyoke Dam. Abundance of pre-spawning adults was estimated each spring between 1994–2001 at a mean of 142.5 spawning adults (CI =14–360 spawning adults) (Kynard et al. 2012). Overwintering and foraging occur in both the upper and lower portions of the river. Occasionally, sturgeon have been captured in tributaries to the Connecticut River including the Deerfield River and Westfield River. Additionally, a sturgeon tagged in the CT river was recaptured in the Housatonic River (T. Savoy, CT DEP, pers. comm.). Three individuals tagged in the Hudson were captured in the CT, with one remaining in the river for at least one year (Savoy 2004). In spring 2021, the CT DEEP captured a number of shortnose sturgeon eggs on egg mats below the Holyoke Dam. Young of year shortnose sturgeon were also observed by divers monitoring for listed mussels at a construction site in Springfield, MA. These observations suggest that occasional spawning may occur below the dam; however, we do not have sufficient information to determine how frequently such an occurrence may happen.

Hudson River Population

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

Delaware River-Chesapeake Bay Metapopulation

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

In Chesapeake Bay, shortnose sturgeon have most often been found in Maryland waters of the mainstem bay and tidal tributaries such as the Susquehanna, Potomac, and Rappahannock Rivers (Kynard *et al.* 2016, SSSRT 2010). Spells (1998), Skjeveland *et al.* (2000), and Welsh *et al.* (2002) all reported one capture each of adult shortnose sturgeon in the Rappahannock River. Recent documented use of Virginia waters of Chesapeake Bay is currently limited to two individual shortnose sturgeon: one captured in 2016 (Balazik 2017) and a second sturgeon (a confirmed gravid female) caught in 2018 in the James River (Balazik, pers. comm. 2018). Spawning has not been documented in any tributary to the Bay although suitable spawning habitat and two pre-spawning females with late stage eggs have been documented in the Potomac River. Current information indicates that shortnose sturgeon are present year round in the Potomac River with foraging and overwintering taking place there. Shortnose sturgeon captured in the Chesapeake Bay are not genetically distinct from the Delaware River population.

Southeast Metapopulation

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

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

The only available estimate for the Cooper River is of 300 spawning adults at the Pinoplis Dam spawning site (based on 1996-1998 sampling; Cooke and Leach 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). Available information indicates the Ogeechee River population may be experiencing juvenile mortality rates greater than other southeastern rivers.

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

Threats

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

The small amount of effective movement between populations means recolonization of currently extirpated river populations is expected to be very slow and any future recolonization of any rivers that experience significant losses of individuals would also be expected to be very slow. Despite the significant decline in population sizes over the last century, gene diversity in shortnose sturgeon is moderately high in both mtDNA (Quattro *et al.* 2002, Wirgin *et al.* 2005, Wirgin *et al.* 2000) and nDNA (King *et al.* 2001) genomes.

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

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

The Shortnose Sturgeon Recovery Plan (NMFS 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 5.4). More information on threats experienced in the action area is presented in the Environmental Baseline section of this Opinion.

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

Summary of Status
Shortnose sturgeon remain listed as endangered throughout their range, with populations in the Northeast being larger and generally more stable than populations in the Southeast. All populations are affected by mortality incidental to other activities, including dredging, power plant intakes and shad fisheries where those still occur, and impacts to habitat and water quality that affect the ability of sturgeon to use habitats and impacts individuals that are present in those habitats. While the species is overall considered to be stable (i.e., its trend has not changed recently, and we are not aware of any new or emerging threats that would change the trend in the future), we lack information on abundance and population dynamics in many rivers. We also do not fully understand the extent of coastal movements and the importance of habitat in non-natal rivers to migrant fish. While the species has high levels of genetic diversity, the lack of effective movement between populations increases the vulnerability of the species should there be a significant reduction in the number of individuals in any one population or metapopulation as recolonization is expected to be very slow. All populations, regardless of size, are faced with threats that result in the mortality of individuals and/or affect the suitability of habitat and may restrict the further growth of the population. Additionally, there are several factors that combine

to make the species particularly sensitive to existing and future threats; these factors include: the small size of many populations, existing gaps in the range, late maturation, the sensitivity of adults to very specific spawning cues which can result in years with no recruitment, and the impact of losses of young of the year and juveniles to population persistence and stability.

4.6 Atlantic Sturgeon

Atlantic sturgeon are listed as five distinct population segments (DPS) under the ESA (77 FR 5880 and 77 FR 5914, February 6, 2012). The oceanic range of the five DPSs extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida (ASMFC 2006, Stein *et al.* 2004) (Figure 10). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the species. Therefore, sturgeon originating from any of the five DPSs may occur in the action area.

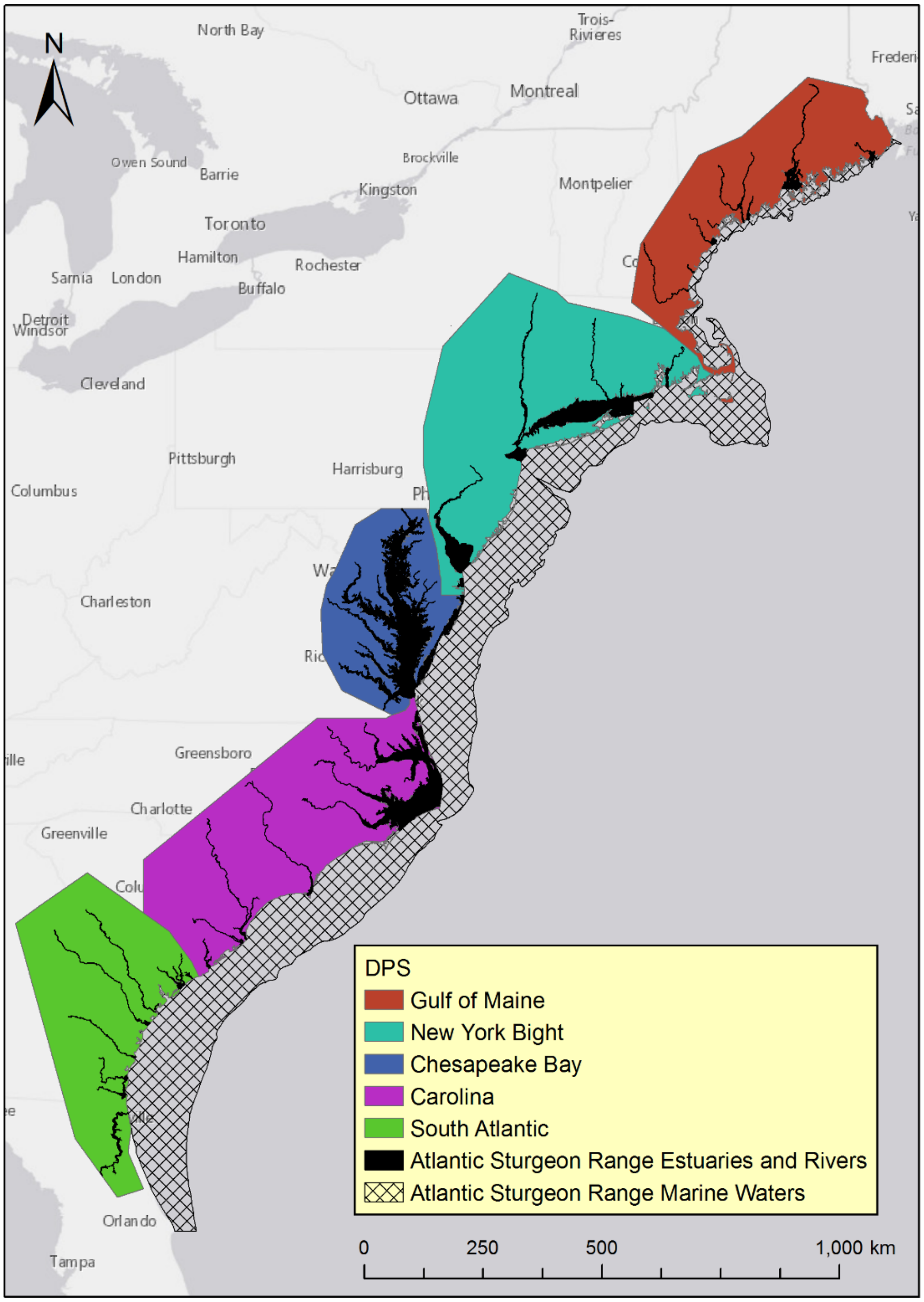

Figure 10. Geographic range for all five Atlantic sturgeon DPSs.

Critical habitat has been designated for each DPS (82 FR 39160, August 17, 2017). The action area for the proposed action considered in this Opinion covers the physical footprint of the Salem 1, Salem 2, and HCGS facilities as well as the region where the thermal plume extends into the Delaware River and the areas of the Delaware River and Delaware Bay where sampling required by the UBMWP is carried out. The maximum length of the thermal plume extends past the downstream boundary for the Delaware River critical habitat unit designated for the New York Bight DPS. While the maximum plume length extends to approximately 6.8 miles (11 km) downstream of the Salem and HCGS facilities, critical habitat ends approximately 2 miles (3.2 km) past the site. As such, the overlap between the action area and the Delaware River Critical Habitat Unit is limited to the lowermost 2 miles of the critical habitat unit. While the critical habitat unit contains all four of the physical features (referred to as physical or biological features (PBF)) described in the critical habitat designation, they do not all occur in the action area. Information on the PBFs within the action area is contained in the *Designated Critical Habitat* section above (section 4.1).

The Atlantic sturgeon is a long-lived, late maturing, anadromous species. Atlantic sturgeon attains lengths of up to approximately 14 feet, and weights of more than 800 pounds. They are bluish black or olive brown dorsally with paler sides and a white ventral surface and have five major rows of dermal scutes (Colette and Klein-MacPhee 2002). Five DPSs were listed under the Endangered Species Act on February 6, 2012. The Gulf of Maine DPS was listed as threatened, and the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs were listed as endangered (Table).

Table 3. Atlantic sturgeon information bar provides species' common name, and current Federal Register notice of listing status, designated critical habitat, Distinct Population Segment, recent status review, and recovery plan.

Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Gulf of Maine	Threatened	2007	77 FR 5880	No	82 FR 39160
New York Bight	Endangered	2007	77 FR 5880	No	82 FR 39160
Chesapeake	Endangered	2007	77 FR 5880	No	82 FR 39160
Carolina	Endangered	2007	77 FR 5914	No	82 FR 39160
South Atlantic	Endangered	2007	77 FR 5914	No	82 FR 39160

Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 of them. Individuals are currently present in 36 rivers, and spawning occurs in at least 20 of these (ASSRT 2007). The decline in abundance of Atlantic sturgeon has been attributed primarily to the large U.S. commercial fishery, which existed for the Atlantic sturgeon from the 1870s through the mid-1990s. The fishery collapsed in 1901 and landings remained at between one to five percent of the pre-collapse peak until ASMFC placed a two generation moratorium on the fishery in 1998 (ASMFC 1998). The majority of the populations show no signs of recovery, and new information suggests that stressors such as bycatch, ship strikes, and low dissolved oxygen can and do have substantial impacts on populations (ASSRT 2007). Additional threats to Atlantic sturgeon include habitat degradation from dredging, damming, and poor water quality (ASSRT 2007). Climate change related impacts on water quality (e.g., temperature, salinity, dissolved oxygen, contaminants) have the potential to affect Atlantic sturgeon populations using impacted river systems. These effects are expected to be more severe for southern portions of the U.S. range of Atlantic sturgeon (Carolina and South Atlantic DPSs).

Life history

Atlantic sturgeon size at sexual maturity varies with latitude with individuals reaching maturity in the Saint Lawrence River at 22 to 34 years (Scott and Crossman 1973). Atlantic sturgeon spawn in freshwater but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in May through July in Canadian systems (Bain 1997, Caron *et al.* 2002, Murawski and Pacheco 1977, Smith 1985, Smith and Clugston 1997). Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers at depths of three to 27 meters (Bain *et al.* 2000, Borodin 1925, Crance 1987, Leland 1968, Scott and Crossman 1973). Atlantic sturgeon likely do not spawn every year; spawning intervals range from one to five years for males (Caron *et al.* 2002, Collins *et al.* 2000, Smith 1985) and two to five years for females (Stevenson and Secor 2000, Van Eenennaam *et al.* 1996, Vladykov and Greeley 1963).

Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (Gilbert 1989, Smith and Clugston 1997) between the salt front and fall line of large rivers (Bain *et al.* 2000, Borodin 1925, Crance 1987, Scott and Crossman 1973). Following spawning in northern rivers, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks (Savoy and Pacileo 2003). Hatching occurs approximately 94 to 140 hours after egg deposition at temperatures of 20 and 18 degrees Celsius, respectively (Theodore *et al.* 1980).

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

Studies suggest that age-0 (i.e., young-of-year), age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Hilton *et al.* 2016) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Hilton *et al.* 2016, Collins *et al.* 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (ASSRT 2007, Dadswell 2006, Dovel and Berggren 1983, Hilton *et al.* 2016). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other benthic invertebrates (ASSRT 2007, Guilbard *et al.* 2007, Bigelow and Schroeder 1953).

Upon reaching the subadult phase, individuals move to coastal and estuarine habitats (Dovel and Berggren 1983, Murawski and Pacheco 1977, Smith 1985, Stevenson 1997). Tagging and genetic data indicate that subadult and adult Atlantic sturgeon travel widely once they emigrate from rivers. Despite extensive mixing in coastal waters, Atlantic sturgeon exhibit high fidelity to their natal rivers (Grunwald *et al.* 2008, King *et al.* 2001, Waldman *et al.* 2002). Because of high natal river fidelity, it appears that most rivers support independent populations (Grunwald *et al.* 2008, King *et al.* 2001, Waldman and Wirgin 1998, Wirgin *et al.* 2002, Wirgin *et al.* 2000). Atlantic sturgeon feed primarily on polychaetes, isopods, American sand lances and amphipods in the marine environment, while in fresh water they feed on oligochaetes, gammarids, mollusks, insects, and chironomids (Guilbard *et al.* 2007, Johnson *et al.* 1997,Moser and Ross 1995, Novak *et al.* 2017, Savoy 2007).

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

In the marine range, several marine aggregation areas occur adjacent to estuaries and/or coastal features formed by bay mouths and inlets along the U.S. eastern seaboard (*i.e.*, waters off North Carolina, Chesapeake Bay; Delaware Bay; New York Bight; Massachusetts Bay; Long Island Sound; and Connecticut and Kennebec River Estuaries). Depths in these areas are generally no greater than 25 meters (Bain *et al.* 2000, Stein *et al.* 2004a, Laney *et al.* 2007, Dunton *et al.* 2010, Erickson *et al.* 2011, Oliver *et al*. 2013, Waldman *et al.* 2013, O'Leary *et al.* 2014, Wippelhauser *et al.* 2012, Wippelhauser *et al*. 2015, Savoy and Pacileo 2003). 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 (Stein *et al.* 2004a, Dunton *et al.* 2010, Erickson *et al.* 2011).

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 (Smith *et al.* 1982, Dovel and Berggren 1983, Smith 1985, Bain 1997, Bain *et al.* 2000, Greene *et al.* 2009, Balazik *et al.* 2012, Breece *et al.* 2013, NMFS 2017, Hatin *et al.* 2002). Following spawning, males move downriver to the lower estuary and remain there until outmigration in the fall (Smith *et al.* 1982, Dovel and Berggren 1983, Smith 1985, Bain 1997, Bain *et al.* 2000, Hatin *et al.* 2002, Greene *et al.* 2009, Balazik *et al.* 2012, Breece *et al.* 2013, Ingram *et al.* 2019).

Population dynamics
A population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) trawl surveys (Kocik *et al.* 2013).[2] For this Opinion, we are relying on the population estimates derived from the NEAMAP swept area biomass assuming a 50 percent catchability (*i.e.*, net efficiency x availability) rate. We consider that the NEAMAP surveys sample an area utilized by Atlantic sturgeon, but do not sample all the locations and times where Atlantic sturgeon are present. We also consider that the trawl net captures some, but likely not all, of the Atlantic sturgeon present in the sampling area. Therefore, we assume that net efficiency and the fraction of the population exposed to the NEAMAP surveys in combination result in a 50 percent catchability (NMFS 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 is estimated to be 67,776 fish (see Table 16 in Kocik *et al.* 2013). Based on genetic frequencies of occurrence in the sampled area, this overall population estimate was subsequently partitioned by DPS (Table 4). 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 (YOY) fish and juveniles in the rivers. The NEAMAP surveys are conducted in waters that include the preferred depth ranges of subadult and adult Atlantic sturgeon and take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. However, the estimated number of subadults in marine waters is a minimum count because it only considers those subadults that are captured in a portion of the area where Atlantic sturgeon are present in the marine environment, which is only a fraction of the total number of subadults. In regard 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 areas where Atlantic sturgeon are present, and therefore a portion of the Atlantic sturgeon's range.

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[2]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.

Table 4. Calculated population estimates based upon the NEAMAP survey swept area model, assuming 50 percent efficiency.

DPS	Estimated Ocean Population Abundance	Estimated Ocean Population of Adults	Estimated Ocean Population of Subadults (of size vulnerable to capture in fisheries)
GOM	7,455	1,864	5,591
NYB	34,567	8,642	25,925
CB	8,811	2,203	6,608
Carolina	1,356	339	1,017
SA	14,911	3,728	11,183
Canada	679	170	509

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

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

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

Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. The proposed action takes place in the Delaware River. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Delaware River, and thereby, in the action area, will have originated from the Delaware River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Delaware River generally, and the action area specifically would not be limited to just individuals originating from the NYB DPS. Genetic analysis of fin clip samples sent to the Sturgeon Tissue Repository from Atlantic sturgeon incidentally captured at Salem was completed in November 2020. Tissue samples were assigned to one of 18 baseline populations, which were subsequently aggregated into DPSs. Of the 150 samples that underwent genetic assignment testing, the majority of samples assigned to the Delaware (57) and Hudson (49). A smaller number of individuals were assigned to the James Fall Run (19), Ogeechee Spring Run (5), Pee Dee Spring Run (4), Satilla (4), York (4), Edisto Spring Fall (2), Pee Dee Fall Run (2), Albemarle Complex (1), James Spring Run (1), Kennebec (1), and St. John (1). Most of these assignments were made with a high degree of likelihood (mean 91.7% to the assigned population; range 48.3-100.0%). Of the 43 individuals who were assigned with less than 95% likelihood, the runner up population was in the same DPS 67.4% of the time. There was a reasonable probability that each assigned individual could have originated in its assigned population given reference allele frequencies (mean 44.3%; range 0.01-99.1%). These assignments and the data from which they are derived are described in detail in Kazyak *et al.* (2021).

Because these samples were from fish collected at the Salem intakes, we consider these results as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. All juvenile Atlantic sturgeon in the action area originate from the Delaware River and belong to the New York Bight DPS. For subadult and adult Atlantic sturgeon, we expect them to occur in proportions represented in the 150 samples noted above. As such, we anticipate sub-adult and adult Atlantic sturgeon in the action area from the five DPSs as follows: 71% New York Bight DPS, 16% Chesapeake Bay DPS, 7% South Atlantic DPS, 5% Carolina DPS, and 1% Gulf of Maine DPS.

Status

Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 of them. Individuals are currently present in 36 rivers, and spawning occurs in at least 20 of these (ASSRT 2007). The decline in abundance of Atlantic sturgeon has been attributed primarily to the large U.S. commercial fishery which existed for the Atlantic sturgeon from the 1870s through the mid 1990s in some states. Based on management recommendations in the interstate fishery management plan (ISFMP), adopted by the Atlantic States Marine Fisheries Commission (the Commission) in 1990, commercial harvest in Atlantic coastal states was severely restricted and ultimately eliminated from all states (ASMFC 1998). In 1998, the Commission placed a 20-40 year moratorium on a coastwide basis to allow 20 consecutive cohorts of females to reach sexual maturity and spawn, which will facilitate restoration of the age structure. The 20- to 40-year moratorium was put in place because they considered the median maturity of female Atlantic sturgeon to be about age 18 and, therefore, it was expected that it could take up to 38 years before 20 subsequent year classes of adult females is established (ASMFC 1980). 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.* 2016).

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

Climate Change

Hare *et al.* (2016) assessed the vulnerability to climate change of a number of species that occur along the U.S. Atlantic coast. The authors define vulnerability as "the extent to which abundance or productivity of a species in the region could be impacted by climate change and decadal variability." Atlantic sturgeon were given a Vulnerability Rank of Very High (99% certainty from bootstrap analysis) as well as a Climate Exposure rank of Very High. Three exposure factors contributed to this score: Ocean Surface Temperature (4.0), Ocean Acidification (4.0) and Air Temperature (4.0). The authors concluded that Atlantic sturgeon are relatively invulnerable to distribution shifts and that while the effect of climate change on Atlantic sturgeon is estimated to be negative, there is a high degree of uncertainty with this prediction.

Secor and Gunderson (1998) found that juvenile metabolism and survival were impacted by increasing hypoxia in combination with increasing temperature. Niklitschek and Secor (2005) used a multivariable bioenergetics and survival model to generate spatially explicit maps of potential production in the Chesapeake Bay; a 1°C temperature increase reduced productivity by 65% (Niklitschek and Secor, 2005). These studies highlight the importance of the availability of water with suitable temperature, salinity and dissolved oxygen; climate conditions that reduce the amount of available habitat with these conditions would reduce the productivity of Atlantic sturgeon. Changes in water availability may also impact the productivity of populations of Atlantic sturgeon in areas where water availability is limited. Spawning and rearing habitat may be restricted by increased saltwater intrusion in rivers with dams or other barriers that limit access to upstream freshwater reaches; however, no estimates of the impacts of such change are currently available. Hare *et al.* conclude that most climate factors have the potential to decrease productivity (sea level rise; reduced dissolved oxygen, increased temperatures) but that understanding the magnitude and interaction of different effects is difficult.

Recovery Goals
A Recovery Plan has not been completed for any DPS of Atlantic sturgeon. In 2018, NMFS published a Recovery Outline to serve as an initial recovery planning document (see https://www.fisheries.noaa.gov/resource/document/recovery-outline-atlanticsturgeon-distinct-population-segments). In this, the recovery vision is stated, "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 Outline also includes steps that are expected to serve as an initial recovery action plan. These include protecting extant subpopulations and the species' habitat through reduction of threats; gathering information through research and monitoring on current distribution and abundance; and addressing vessel strikes in rivers, the effects of climate change and bycatch.

4.6.1 Gulf of Maine DPS of Atlantic sturgeon

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

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

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine

Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (ASMFC 1998, NMFS (National Marine Fisheries Service) and U.S. FWS (U.S. Fish and Wildlife Service) 1998, Wippelhauser *et al.* 2017). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (*i.e.*, expressing milt) in July 1994 below the (former) Edwards Dam; (2) capture of 31 adult Atlantic sturgeon from June 15, 1980, through July 26, 1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least four ripe males and one ripe female captured on July 26, 1980; (3) capture of nine adults during a gillnet survey conducted from 1977-1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, ME (ASMFC (Atlantic States Marine Fisheries Commission) 2007, NMFS (National Marine Fisheries Service) and U.S. FWS (U.S. Fish and Wildlife Service) 1998); and (4) the capture of three Atlantic sturgeon larvae between rkm 72 and rkm 75 in July 2011 (Wippelhauser *et al.* 2017). The low salinity values for waters above Merrymeeting Bay are consistent with values found in rivers where successful Atlantic sturgeon spawning is known to occur.

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

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

Connectivity is disrupted by the presence of dams on some rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin, and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon are known to occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. While not expected to be killed or injured during passage at the dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The tracking of spawning condition Atlantic sturgeon downstream of the Brunswick Dam in the Androscoggin River suggests however, that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. Until it was breached in July 2013, the range of Atlantic sturgeon in the Penobscot River was limited by the presence of the Veazie Dam. Since the removal of the Veazie Dam and the Great Works Dam, sturgeon can now travel as far upstream as the Milford Dam. Atlantic sturgeon primarily occur within the mesohaline reach of the river, particularly in areas with high densities of sturgeon prey which means that the Penobscot River is likely an important foraging area for Atlantic sturgeon belonging to the Gulf of Maine DPS (Altenritter *et al.* 2017). There is no current evidence that spawning is occurring in the Penobscot River. Acoustic tag detections suggest that the adults that forage in the Penobscot River travel to the Kennebec River to spawn (Altenritter *et al.* 2017). The Essex Dam on the Merrimack River blocks access to approximately 58 percent of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

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

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

We described in the listing rule that potential changes in water quality as a result of global climate change (temperature, salinity, dissolved oxygen, contaminants, etc.) in rivers and coastal waters inhabited by Atlantic sturgeon will likely affect riverine populations, and we expected these effects to be more severe for southern portions of the U.S. range. However, new information shows that the Gulf of Maine is one of the fastest warming areas of the world as a result of global climate change (Brickman *et al.* 2021, Pershing *et al.* 2015). Markin and Secor

(2020) further demonstrate the effects 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, 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 2017) and 67 (95% CI=52.0–89.1) (Waldman *et al.* 2019).

Summary of the Gulf of Maine DPS

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

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (*e.g.*, directed fishing), or reduced as a result of improvements in water quality and removal of dams (*e.g.*, the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC 2007). Atlantic sturgeon from the Gulf of Maine DPS are not commonly taken as bycatch in areas south of Chatham, Massachusetts, with only 8 percent (*e.g.*, 7 of 84 fish) of interactions observed in the New York region being assigned to the Gulf of Maine DPS (Wirgin and King 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin *et al.* 2012). Thus, a significant number of the GOM DPS fish appear to migrate north into Canadian waters where they may be subjected to a variety of threats including bycatch. Dadswell *et al.* (2016) describes characteristics of the seasonal aggregation of sturgeon in the Bay of Fundy. Dadswell *et al.* does not identify the natal origin of each of the 1,453 Atlantic sturgeon captured and sampled for their study. However, based on Wirgin *et al.* (2012) and Stewart *et al.* (2017), NMFS considers the results of Dadswell *et al.* as representative of the movement of the Gulf of Maine DPS of Atlantic sturgeon. Dadswell *et al.* determined subadult and adult Atlantic sturgeon occur seasonally (approximately May to September) in the Bay of Fundy for foraging, and many return in consecutive years. Fork length (FL) of the 1,453 sampled sturgeon ranged from 45.8 to 267 cm, but the majority (72.5 percent) were less than 150 cm FL. The age of the sturgeon (*i.e.*, 4 to 54 years old) is also indicative of the two different life stages. Detailed seasonal movements of sturgeon to and from the Bay of Fundy are described in Beardsall *et al.* (2016).

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

In 2018, we announced the initiation of a 5-year review for the Gulf of Maine DPS. We reviewed and considered new information for the Gulf of Maine DPS that has become available since this

DPS was listed as threatened in February 2012. We completed the 5-year review for the Gulf of Maine DPS in February 2022. Based on the best scientific and commercial data available at the time of the review, we concluded that no change to the listing status is warranted.

4.6.2 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay (CB) DPS of Atlantic sturgeon includes Atlantic sturgeon spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters (including bays and sounds) from the Delaware-Maryland border at Fenwick Island to Cape Henry, Virginia. The marine range of Atlantic sturgeon from the CB DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the CB DPS and the adjacent portion of the marine range are shown in Figure 10. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (*i.e.*, dams) are located upriver of where spawning is expected to have historically occurred (ASSRT 2007). Spawning still occurs in the James River, amongst the additional spawning populations for the Chesapeake Bay DPS, and there is evidence that most of the Chesapeake Bay DPS spawning populations spawn in the late summer to fall (hereafter referred to as "fall spawning") rather than in the spring. Fall spawning activity has been documented in the newly discovered spawning populations in the Pamunkey River, a tributary of the York River, and in Marshyhope Creek, a tributary of the Nanticoke River (Hager *et al.* 2014, Richardson and Secor 2016, Secor *et al.* 2021). The James River is currently the only river of the Chesapeake Bay DPS where evidence suggests there is both spring and fall spawning with separate spawning populations. The results of genetic analyses show that there is some limited gene flow between the populations but, overall, the spawning populations are genetically distinct (Balazik *et al.* 2017b, Balazik *et al.* 2012a, Balazik and Musick 2015). New detections of acoustically-tagged adult Atlantic sturgeon along with historical evidence suggests that Atlantic sturgeon belonging to the Chesapeake Bay DPS may be spawning in the Mattaponi and Rappahannock rivers as well (ASMFC 2017, Hilton *et al.* 2016, Kahn 2019). However, information for these populations is limited and the research is ongoing.

Age to maturity for CB DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit variation across their geographic range 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.* 1998). Therefore, age at maturity for Atlantic sturgeon of the CB DPS likely falls within these values.

Several threats play a role in shaping the current status of CB DPS Atlantic sturgeon. Historical records provide evidence of the large-scale commercial exploitation of Atlantic sturgeon from the James River and Chesapeake Bay in the 19th century (Hildebrand and Schroeder 1928; Vladykov and Greeley 1963; ASMFC 1998b; Secor 2002; Bushnoe *et al.* 2005; ASSRT 2007) as well as subsistence fishing and attempts at commercial fisheries as early as the 17th century

(Secor 2002; Bushnoe *et al.* 2005; ASSRT 2007; Balazik *et al.* 2010). Habitat disturbance caused by in-river work, such as dredging for navigational purposes, have reduced available spawning habitat in the James River (Holton and Walsh 1995; Bushnoe *et al.* 2005; ASSRT 2007). At this time, we do not have information to quantify this loss of spawning habitat.

Decreased water quality also threatens Atlantic sturgeon of the CB DPS, especially since the Chesapeake Bay system is vulnerable to the effects of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface-to-volume ratio, and strong stratification during the spring and summer months (Pyzik *et al.* 2004; ASMFC 1998a; ASSRT 2007; EPA 2008). These conditions contribute to reductions in dissolved oxygen levels throughout the Bay. The availability of nursery habitat, in particular, may be limited given the recurrent hypoxia (low dissolved oxygen) conditions within the Bay (Niklitschek and Secor 2005, 2010). 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 2020, the Chesapeake Bay Foundation gave the overall health index of the Bay a grade of 32 percent (D+) based on the best available information about the Chesapeake Bay for indicators representing three major categories: pollution, habitat, and fisheries (Chesapeake Bay Foundation 2020). While 32 percent is one percent lower than the state of the Bay score in 2018, this was 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 modest gain in the health score was due to a relatively stable adult blue crab population, promising results from oyster reef restoration, less nitrogen and phosphorous in the water, a smaller dead zone, and improvements in water clarity as highlighted below:

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

At this time, we do not have sufficient information to quantify the extent that degraded water quality affects habitat or individuals in the Chesapeake Bay watershed.

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

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

Summary of the Chesapeake Bay DPS
There are no abundance estimates for the entire Chesapeake Bay DPS or for the spawning populations in the James River or the Nanticoke River system. Spawning for the CB DPS is known to occur in only the James and Pamunkey Rivers and in Marshyhope Creek. Spawning may be occurring in other rivers, such as the York, Rappahannock and Potomac, but has not been confirmed for any of those. There are anecdotal reports of increased sightings and captures of Atlantic sturgeon in the James River. However, this information has not been comprehensive enough to develop a population estimate for the James River or to provide sufficient evidence to confirm increased abundance.

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

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

There are several estimates of effective population size for Atlantic sturgeon that are spawned in the James River although only one study examined the effective population size of both the spring and fall spawning populations. Nevertheless, the estimates of effective population size from separate studies and based on different age classes are similar. These are: 62.1 (95% CI=44.3-97.2) based on sampling of subadults captured off of Long Island across multiple years; 32 (95% CI=28.8-35.5) based on sampling of natal juveniles and adults in multiple years (Waldman *et al.* 2019); 40.9 (95% CI=35.6-46.9) based on samples from a combination of juveniles and adults, (ASMFC 2017); and, 44 (95% CI=26–79) and 46 (95% CI=32–71) for the spring and fall spawning populations, respectively, based on sampling of adults (Balazik *et al.* 2017b). There is a single estimate of 12.2 (95% CI = 6.7– 21.9) for the Nanticoke River system (Secor *et al.* 2021), and also a single estimate of 7.8 (95% CI=5.3-10.2) for the York River system based on samples from adults captured in the Pamunkey River (ASMFC 2017).

Some of the impact from the threats that facilitated the decline of the CB DPS have been removed (*e.g.*, directed fishing) or reduced as a result of improvements in water quality since passage of the CWA. Areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in U.S. state and federally-managed fisheries, Canadian fisheries, and vessel strikes remain significant threats to the CB DPS of Atlantic sturgeon. Of the 35% of Atlantic sturgeon incidentally caught in the Bay of Fundy, about 1% were CB DPS fish (Wirgin *et al.* 2012). Studies have shown that Atlantic sturgeon can only sustain low levels of bycatch mortality (Boreman 1997, ASMFC 2007, Kahnle *et al.* 2007). The CB DPS is currently at risk of extinction given (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect the potential for population recovery.

In 2018, we announced the initiation of a 5-year review for the Chesapeake Bay DPS. We reviewed and considered new information for the Chesapeake Bay DPS that has become available since this DPS was listed as endangered in February 2012. We completed the 5-year review for the Chesapeake Bay DPS in February 2022. Based on the best scientific and commercial data available at the time of the review, we concluded that no change to the listing status is warranted.

4.6.3 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 10. Sturgeon are commonly captured 40 miles offshore (D. Fox, Delaware State University, pers. comm.). Records providing fishery bycatch data by depth show the vast majority of Atlantic sturgeon bycatch via gillnets is observed in waters less than 50 meters deep (ASMFC 2007, Stein *et al.* 2004b), but Atlantic sturgeon are recorded as bycatch out to 500 fathoms.

Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Pee Dee Rivers. We determined spawning was occurring if YOY were observed or mature adults were present in freshwater portions of a system (Table 5). 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 5. Major rivers, tributaries, and sounds within the range of the Carolina DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

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

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

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in

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

Though there are statutory and regulatory provisions that authorize reducing the impact of dams on riverine and anadromous species, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Water quality continues to be a problem in the Carolina DPS, even with existing controls on some pollution sources. Current regulatory regimes are not effective in controlling water allocation issues (*e.g.*, no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution, etc.).

Summary of the Status of the Carolina DPS

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.

4.6.4 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 SA DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the SA DPS and the adjacent portion of the marine range are shown in Figure 10.

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, and Satilla Rivers. We determined spawning was occurring if YOY were observed, or mature adults were present, in freshwater portions of a system (Table 6). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. Historically, both the Broad-Coosawatchie and St. Marys Rivers were documented to have spawning populations at one time; there is also evidence that spawning may have occurred in the St. Johns River or one of its tributaries. Recent evidence shows that a small number of fish have returned to the St. Mary's River, and may use the river for spawning. Both the St. Marys and St. Johns Rivers are used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. The use of the Broad-Coosawatchie by sturgeon from other spawning populations is unknown at this time. The presence of historical and current spawning populations in the Ashepoo River has not been documented; however, this river may currently be used for nursery habitat by young Atlantic sturgeon originating from other spawning populations. Fish from the SA DPS likely use other river systems than those listed here for their specific life functions.

Table 6. Major rivers, tributaries, and sounds within the range of the SA DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

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

Altamaha River, GA	Yes	74 captured/308 estimated spawning adults (2004); 139 captured/378 estimated spawning adults (2005)
Satilla River, GA	Yes	4 YOY and spawning adults (1995-1996)
St. Marys River, GA/FL	Unknown	
St. Johns River, FL	Extirpated	

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

The directed Atlantic sturgeon fishery caused initial severe declines in southeast Atlantic sturgeon populations. Although the directed fishery is closed, bycatch in other commercial fisheries continues to impact the SA DPS. Statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species such as Atlantic sturgeon, but these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Further, water quality continues to be a problem in the SA DPS, even with existing controls on some pollution sources. Current regulatory regimes are not effective in controlling water allocation issues (e.g., no permit requirements for water withdrawals under 100,000 gpd in Georgia, no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution.)

Summary of the Status of the South Atlantic DPS

Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. Their late age at maturity provides more opportunities for individuals to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, this is hampered within the SA DPS by habitat alteration, bycatch, and from the inadequacy of existing regulatory mechanisms to address and reduce habitat alterations and bycatch.

Dredging is contributing to the status of the SA DPS by modifying spawning, nursery, and foraging habitat. Habitat modifications through reductions in water quality and dissolved oxygen are also contributing to the status of the SA DPS, particularly during times of high water temperatures, which increase the detrimental effects on Atlantic sturgeon habitat. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch also contributes to the SA DPS's status. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may use multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (*e.g.*, exposure to toxins). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality. While many of the threats to the SA DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch and habitat alteration are currently not being addressed through existing mechanisms. Further, access to habitat and good water quality continues to be a problem even with NMFS's authority under the Federal Power Act to prescribe fish passage and existing controls on some pollution sources. There is a lack of regulation for some large water withdrawals, which threatens sturgeon habitat. Existing water allocation issues will likely be compounded by population growth, drought, and, potentially, climate change. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the SA DPS.

4.6.5 New York Bight DPS of Atlantic sturgeon

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco 1977, Secor 2002, ASSRT 2007). Spawning still occurs in the Delaware and Hudson Rivers. There is no recent evidence (within the last 15 years) of spawning in the Taunton River (ASSRT 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT 2007, Savoy 2007, Wirgin and King 2011).

In 2014, several presumed age-0 Atlantic sturgeon were captured in the Connecticut River; the available information indicates that successful spawning took place in 2013 by a small number of adults. Genetic analysis of the juveniles indicates that the adults were likely migrants from the South Atlantic DPS (Savoy *et al.* 2017). As noted by the authors, this conclusion is counter to prevailing information regarding straying of adult Atlantic sturgeon. As these captures represent the only contemporary records of possible natal Atlantic sturgeon in the Connecticut River and the genetic analysis is unexpected, more information is needed to establish the frequency of spawning in the Connecticut River and whether there is a unique Connecticut River population of Atlantic sturgeon.

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800s is unknown but has been conservatively estimated at 10,000 adult females (Secor, 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor 2002, ASSRT 2007, Kahnle *et al.* 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007). Kahnle *et al.* (1998; 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. A decline in the abundance of young Atlantic sturgeon appeared to occur in the mid to late 1970s followed by a secondary drop in the late 1980s (Kahnle *et al.* 1998, Sweka *et al.* 2007, ASMFC 2010). 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 (Sweka *et al.* 2007, ASMFC, 2010). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s while the CPUE is generally higher in the 2000s as compared to the 1990s. Given the significant annual fluctuation, it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. Standardized mean catch per net set from the NYSDEC juvenile Atlantic sturgeon survey have had a general increasing trend from 2006 – 2015, with the exception of a dip in 2013.

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

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800s indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman 1999, Secor 2002). Sampling in 2009 to target young-of- the year (YOY) Atlantic sturgeon in the Delaware River (i.e., natal sturgeon) resulted in the capture of 34 YOY, ranging in size from 178 to 349 mm TL (Fisher 2009) and the collection of 32 YOY Atlantic sturgeon in a separate study (Brundage and O'Herron in Calvo *et al.*, 2010). Genetics information collected from 33 of the 2009-year class YOY indicates that at least 3 females successfully contributed to the 2009-year class (Fisher 2011). Therefore, while the capture of YOY in 2009 provides evidence that successful spawning is still occurring in the Delaware River, the relatively low numbers suggest the existing riverine population is limited in size. As part of a recent study to estimate the number of adults that successfully reproduced to create a cohort of offspring (N_s), White *et al*. (2022) collected juvenile Atlantic sturgeon from the lower tidal Delaware River. A total of 1,165 fish were collected in 2009, 2011, and 2013 to 2019. Fish were collected from October to December each year and consisted only of individuals <450 mm (i.e., individuals less than 1 year of age; Hale *et al*. 2016). White *et al.* (2022) noted that cohort sample size was variable among years, with sample sizes from 2009 to 2014 being smaller (range = 27-59) compared to those from 2015 to 2019 (range = 106-301). Based on genetic pedigrees constructed for each cohort, White *et al*. (2022) concluded that the (N_s) for Delaware River Atlantic sturgeon is between 125 and 250 adults. Using these estimates, and assuming a modest sex ratio of 2:1 male: female, contemporary population sizes for Delaware River Atlantic sturgeon are up to three orders of magnitude lower than historic highs (White *et al*., 2022).

Several threats play a role in shaping the current status and trends observed in the Delaware

River and Estuary. In-river threats include habitat disturbance from dredging and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River. Data from Delaware's Department of Natural Resources and Environmental Control (DNREC) from recovered carcasses in the Delaware River and Estuary indicate that from 2005 through 2017, 112 Atlantic sturgeon mortalities were attributable to vessel strikes (an additional 80 had an unknown cause of death) in the Delaware River and Delaware Bay. At this time, we do not have information to quantify this threat or its impact to the population or the New York Bight DPS. During 2018 and 2019, Fox *et al*. (2020) attempted to estimate reporting rates for Atlantic sturgeon carcasses along the Delaware River in an effort to advance understanding of the role of commercial shipping in influencing the conservation and recovery of Atlantic Sturgeon in the Delaware River. Findings of the study suggested that overall reporting rates were low and all reports across both years of the study occurred in areas that were easily accessible to the general public. Fox *et al.* (2020) acknowledge that the lack of a statistically valid carcass reporting rate is a limitation to estimating the true mortality attributable to vessel strikes. Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

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

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

Riverine habitat may be impacted by dredging, blasting, 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. Deepening the main navigation channel of the Delaware River required the blasting and removal of rock outcrops within the Marcus Hook, Chester, Eddystone, and Tinicum ranges of the channel. The first season of blasting was conducted during December 23, 2015 through March 12, 2016, the second during December 1, 2016 through March 13, 2017, the third during December 1, 2017 through February 25, 2018, the fourth during February 17 through March 15, 2019, and the fifth during January 20 through February 2, 2020. Blasting during the fourth and fifth seasons consisted of small, highly targeted blasts designed to break up small pinnacles of rock in the channel that exceeded the design elevation, compared to the much larger production blasts of the first three seasons. Sturgeon relocation trawling procedures to protect sturgeon during blasting were implemented prior to and during each blasting season (see ERC 2015, NMFS 2014, NMFS 2017, NMFS 2019). When blasting Season 5 concluded in February 2020, a total of 228 Atlantic sturgeon (59 acoustically tagged) were captured and relocated with no mortalities or injuries. At this time, we do not have any additional information to quantify the number of Atlantic sturgeon killed or disturbed during dredging, blasting, or other in-water construction projects. We are also not able to quantify any effects to habitat.

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

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

Vessel strikes occur in the Delaware River and Bay. One-hundred and one mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2005 to 2019, and at least 64 of these fish were large adults and subadults. Based on evidence of Atlantic sturgeon vessel strikes since the listing, it is now apparent that vessel strikes are also occurring in the Hudson River. For example, the New York DEC reported that at least 17 dead Atlantic sturgeon with vessel strike injuries were found in the river in 2019 of which at least 10 were adults (NMFS, 2022). Additionally, 138 sturgeon carcasses were observed on the Hudson River and reported to the NYSDEC between 2007 and 2015. Of these, 69 are suspected of having been killed by vessel strike. Genetic analysis has not been completed on any of these individuals to date, given that the majority of Atlantic sturgeon in the Hudson River belong to the New York Bight DPS, we assume that the majority of the dead sturgeon reported to NYSDEC belonged to the New York Bight DPS. Given the time of year in which the fish were observed (predominantly May through July), it is likely that many of the adults were migrating through the river to the spawning grounds (NMFS, 2016).

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

In 2018, we announced the initiation of a 5-year review for the New York Bight DPS. We reviewed and considered new information for the New York Bight DPS that has become available since this DPS was listed as endangered in February 2012. We completed the 5-year review for the New York Bight DPS in February 2022. Based on the best scientific and commercial data available at the time of the review, we concluded that no change to the listing status is warranted.

5.0 ENVIRONMENTAL BASELINE

The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action are ath have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. (50 CFR 402.02). The environmental baseline, therefore, includes the past impacts of the operation of the Salem and Hope Creek facilities.

There are a number of existing activities that regularly occur in various portions of the action area, including maintenance of the federal navigation channel, operation of vessels, and state authorized fisheries. There are also environmental conditions caused or exacerbated by human activities (i.e., water quality) that may affect listed species in the action area. Some of these stressors may result in mortality or serious injury to individual animals (e.g., vessel strike, fisheries), whereas others result in more indirect or non-lethal impacts. For all of the listed species considered here, the status of the species in the action area is the same as the rangewide status presented in the Status of the Species section of this Opinion. Below, we describe the conditions of the action area, present a summary of the best available information on the use of the action area by listed species, and address the impacts to listed species of federal, state, and private activities in the action area.

As described above, the action area is limited to a portion of the Delaware River and Delaware Bay. The Salem and Hope Creek facilities are located in the lowermost reach of the Delaware River at Artificial Island. The facilities are located at River Mile (RM) 51 on the Delaware River. The entirety of the action area is tidally influenced. The Delaware Estuary supports an abundance of aquatic resources in a variety of habitats. Open water habitats include salt water, tidally-influenced water of variable salinities, and tidal freshwater areas. Moving south from the Delaware River to the mouth of the bay, there is a continual transition from fresh to salt water. Additional habitat types occur along the edges of the estuary in brackish and freshwater marshes. The bottom of the estuary provides many different benthic habitats, with their characteristics dictated by salinity, tides, water velocity, and substrate type. Sediments in the estuary near Artificial Island are primarily mud, muddy sand, and sandy mud (PSEG 2006c). At Artificial Island, the estuary is tidal with a net flow to the south and a width of approximately 2.5 mi (4 km).

The U.S. Army Corps of Engineers (USACE) maintains a dredged navigation channel near the center of the estuary and about 6,600 ft (2,000 m) west of the shoreline at Salem and HCGS. The navigation channel is 40-45 ft (12-13 m) deep and 1,300 ft (400 m) wide. On the New Jersey side of the channel, water depths in the open estuary at mean low water are fairly uniform at about 20 ft (6 m). Predominant tides in the area are semi-diurnal, with a period of 12.4 hours and a mean tidal range of 5.5 ft (1.7 m). The maximum tidal currents occur in the channel, and currents flow more slowly over the shallower areas (NRC, 1984; Najarian Associates, 2004). Salinity is an important determinant of biotic distribution in estuaries, and salinity near the Salem and HCGS facilities depends on river flow. Salinity in the vicinity of Salem and HCGS typically ranges from 5 to 12 ppt during periods of low flow (usually, but not always, in the summer) and from 0 to 5 ppt during periods of high flow because salinity will be lower during high freshwater flow periods (NRC 2006, DRBC 2018).Within these larger patterns, salinity at any specific location also varies with the tides (NRC 2007).

Monthly average surface water temperatures in the Delaware Estuary vary with season. Between 1977 and 1982, water temperatures ranged from -0.9°C (30°F) in February 1982 to 30.5°C (86.9°F) in August 1980. Although the estuary in this reach is generally well mixed, it can occasionally stratify, with surface temperatures 1° to 2°C (2° to 4°F) higher than bottom temperatures and salinity increasing as much as 2 ppt per meter of water depth (NRC 1984).

5.1 Summary of Information on Listed Species in the Action Area

5.1.1 Sea Turtles

Three ESA-listed species of sea turtles (North Atlantic DPS of green, Northwest Atlantic Ocean DPS of loggerhead, Kemp's ridley) are seasonally present in Delaware Bay and occur at least occasionally in the action area between May and November each year.

Sea turtles are highly migratory and typically occur in areas of warmer water (≥15°C), as they are susceptible to cold stunning if water temperature is too low. Sea turtles most frequently occur in the action area during summer and fall months when water temperatures are the warmest. Sea turtles typically use these waters for foraging and resting (Standora and Spotila 1985).

Sea turtles in the action area are adults or juveniles; due to the distance from any nesting beaches, no hatchlings occur in the action area. Similarly, no reproductive behavior is known or suspected to occur in the action area. Sea turtles feed on a variety of both pelagic and benthic prey and change diets through different life stages. Adult loggerhead and Kemp's ridley sea turtles are carnivores that feed on crustaceans, mollusks, and occasionally fish. Green sea turtles are herbivores and feed primarily on algae, seagrass, and seaweed. As juveniles, loggerhead and green sea turtles are omnivores (Wallace *et al.* 2009, Dodge *et al.* 2011, Eckert *et al.* 2012, *https://www.seeturtles.org/sea-turtle-diet,* Murray *et al.* 2013, Patel *et al.* 2016). The distribution of pelagic and benthic prey resources is primarily associated with dynamic oceanographic processes, which ultimately affect where sea turtles forage (Polovina *et al.* 2006). One of the main factors influencing sea turtle presence in mid-Atlantic waters is seasonal temperature patterns (Ruben and Morreale 1999). The distribution of sea turtles is limited geographically and temporally by water temperatures (Epperly *et al.* 1995a, Braun-McNeill *et al.* 2008b, Mansfield *et al.* 2009, James *et al.* 2006), with warmer waters in the late spring, summer, and early fall being the most suitable. Water temperatures too low or too high may affect feeding rates and physiological functioning (Milton and Lutz 2003); metabolic rates may be suppressed when a sea turtle is exposed for a prolonged period to temperatures below 8-10° C (Morreale *et al.* 1992; George 1997; Milton and Lutz 2003). That said, loggerhead sea turtles have been found in waters as low as 7.1-8 ° C (review in Braun-McNeill *et al.* 2008, Smolowitz *et al.* 2015). However, in assessing critical habitat for loggerhead sea turtles, the review team considered the water-temperature habitat range for loggerheads to be above 10° C (NMFS 2013). Sea turtles are most likely to occur in the action area when water temperatures are above this temperature, although depending on seasonal weather patterns and prey availability, they could be also present in months when water temperatures are cooler. If the range of these sea turtle species shifts further north due to warming waters in the mid-Atlantic and Northeast, it is possible that the number of sea turtles in the action area could increase. It is also possible that as waters warm earlier in the spring and cool later in the fall that the time of year that sea turtles occupy the action area could increase. Any such change is expected to be gradual and incremental over time.

Sea turtles are most likely to occur in the action area between June and October when water temperatures are above 11°C and depending on seasonal weather patterns, could be present in May and early November. In the Delaware River, sea turtles occur as far upstream as Artificial Island, where the Salem and Hope Creek facilities are located. Stetzar (2002) reports that temporal occurrence of sea turtles in Delaware Bay was found to be linked to the water temperature regime within the estuary and live turtles were sighted June-October. Mean surface temperatures during June when turtles first started immigrating into the Estuary was about 21°C. The majority of turtles had emigrated from the estuary during October when mean surface water temperatures approached 15°C. Loggerheads and Kemp's ridley were distributed throughout the estuary but were most often associated with channel and shoal habitats in water depths >9m.

5.1.2 Shortnose Sturgeon

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. In recent years, shortnose sturgeon have been routinely captured below Philadelphia and shortnose sturgeon are documented nearly every year at the Salem intakes.

Although they have been documented in waters with salinities as high as 31 parts per thousand (ppt), shortnose sturgeon are typically concentrated in areas with salinity levels of less than 3 ppt

(Dadswell *et al.* 1984). Jenkins *et al.* (1993) demonstrated in lab studies that 76 day old shortnose sturgeon experienced 100% mortality in salinity greater than 14 ppt. One year old shortnose sturgeon were able to tolerate salinity levels as high as 20 ppt for up to 18 hours but experienced 100% mortality at salinity levels of 30 ppt. A salinity of 9 ppt appeared to be a threshold at which significant mortalities began to occur, especially among the youngest fish (Jenkins *et al.* 1993). The distribution of salinity in the Delaware estuary exhibits significant variability on both spatial and temporal scales, and at any given time reflects the opposing influences of freshwater inflow from tributaries versus saltwater inflow from the Atlantic Ocean. Based on this information and the known tolerances and preferences of shortnose sturgeon to salinity, shortnose sturgeon are most likely to occur upstream of RKM 70 where salinity is typically less than 5ppt.As explained above, salinity in the area of the Salem and Hope Creek intakes averages 5 ppt but can range from 0 to 15 ppt, with periods of lower salinity coinciding with occasional periods of high freshwater input.

Shortnose sturgeon eggs and larvae do not occur in the action area. Due to the benthic, adhesive nature of the eggs, they only occur in the immediate vicinity of the spawning area, located at least 80 miles upstream of the action area. Immobile larvae are also limited to an area close to the spawning grounds, and therefore, do not occur in the action area. Free-swimming larvae occur only in freshwater and do not occur in the action area.

In other river systems, older juveniles (3-10 years old) occur in the saltwater/freshwater interface (NMFS 1998). In these systems, juveniles moved back and forth in the low salinity portion of the salt wedge during summer. In the Delaware River the salt front can range from as far south as Wilmington, Delaware, north to Philadelphia, Pennsylvania, depending upon meteorological conditions such as excessive rainfall or drought. The salt front location varies throughout the year, with the median monthly salt front ranging from RM 67 to RM 76 (DRBC 2017). As a result, it is possible that in the Delaware River, juveniles could range from Artificial Island (RM 54) to the Schuylkill River (RM 92) (O’Herron 2000, pers. comm). Acoustic tracking of tagged juveniles indicates that juveniles are likely overwintering in the lower Delaware River from Philadelphia to below Artificial Island (ERC 2007). The distribution of juveniles in the river is likely highly influenced by flow and salinity. In years of high flow (for example, due to excessive rains or a significant spring runoff), the salt wedge will be pushed seaward, and the low salinity reaches preferred by juveniles will extend further downriver. In these years, shortnose sturgeon juveniles are likely to be found further downstream in the summer months. In years of low flow, the salt wedge will be higher in the river and in these years juveniles are likely to be concentrated further upstream.

O’Herron believes that if juveniles are present within this range they would likely aggregate closer to the downstream boundary in the winter when freshwater input is normally greater (O’Herron 2000, pers. comm.). Research in other river systems indicates juvenile sturgeon primarily feed in 10 to 20 meter deep river channels, over sand-mud or gravel-mud bottoms (Pottle and Dadswell 1979). However, little is known about the specific feeding habits of juvenile shortnose sturgeon in the Delaware River.

Distribution of adult and juvenile shortnose sturgeon in the action area is influenced by seasonal water temperature, the distribution of forage items, and salinity. Adult and juvenile shortnose sturgeon are likely to occur in the action area any time water temperatures are greater than 10°C (the trigger for movement to overwintering areas); these temperatures are typically experienced between April and November[3]. Shortnose sturgeon have been removed from the Salem Nuclear Generating Facility intakes in all months except August and September. One dead shortnose sturgeon was observed at the intake in January 1978 and one in late November 2007. However, due to the level of decomposition observed with these fish, it is unlikely that they died at the intakes; it is likely that they died further upstream and drifted down river to the intakes. Salinity is lowest in the action area during the winter months when shortnose sturgeon are known to occur at overwintering locations further upstream; this reduces the number of shortnose sturgeon likely to occur in the action area. Shortnose sturgeon in this reach are likely to be using it for migration and for foraging.

5.1.3 Atlantic sturgeon in the Action Area

The Delaware Estuary is used by sturgeon from multiple DPSs. Based on mixed-stock analysis, we have determined that Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%. Atlantic sturgeon are well distributed throughout the Delaware River and Bay and spawning is thought to occur between RM 75-93 and 106-118. Eggs are only likely to be present within these reaches and not in the action area. Because of low tolerance to salinity, larvae are not present in the action area. During times of year when salinity in the action area is low (i.e., winter) some young of the year (YOY) could be present and would only originate from the New York Bight DPS because these life stages are restricted to their natal river.

Brundage and O'Herron (in Calvo *et al.* 2010) tagged 26 juvenile Atlantic sturgeon, including six YOY. For non-YOY fish, most detections occurred in the lower tidal Delaware River from the middle Liston Range (RM 43) to Tinicum Island (RM 88). For non-YOY fish, these researchers also detected a relationship between the size of individuals and the movement pattern of the fish in the fall. The fork length of fish that made defined movements to the lower bay and ocean averaged 815 mm (range 651-970 mm) while those that moved towards the bay but were not detected below Liston Range averaged 716 mm (range 505-947 mm), and those that appear to have remained in the tidal river into the winter averaged 524 mm (range 485-566 mm) (Calvo *et al.* 2010).

Subadults from any of the five DPSs could be present in the action area in the proportions noted above; this life stage is most likely to immigrate into the estuary in mid-April, establish home range in the summer months in the river, and emigrate from the estuary in mid-November (Fisher 2011). However, some subadults may overwinter in the river and be present year round. 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

[3] For example, in 2012 water temperatures fell to 10°C on November 9 and rose above 10°C on April 11, 2013. In the Fall of 2013, water temperatures fell to 10°C on November 14. Water temperatures reached 10°C on April 12, 2014. This information is based on water temperature taken at PORTS 8537121 at Ship John Shoal, NJ. Water temperature is measured at 12.4' below MLLW. Data is available at: http://tidesandcurrents.noaa.gov/stationhome.html?id=8537121 (last accessed on July 2, 2014).

have found a similar movement pattern of upstream movement in the spring-summer and downstream movement to overwintering areas in the lower estuary or nearshore ocean in the fall-winter (Brundage and Meadows 1982; Lazzari *et al.* 1986; Shirey *et al.* 1997, 1999; Brundage and O'Herron 2009; Brundage and O'Herron in Calvo *et al.*, 2010). Breece *et al.* (2016) reported subadults using the Bay between April and June.

Adults are likely to be present in the river from mid-April to mid-June, dependent on annual water temperature. Adult Atlantic sturgeon captured in marine waters off of Delaware Bay in the spring were tracked in an attempt to locate spawning areas in the Delaware River, (Fox and Breece 2010). Over the period of two sampling seasons (2009-2010) four of the tagged sturgeon were detected in the Delaware River. The earliest detection was in mid-April while the latest departure occurred in mid-June (Fox and Breece 2010); supporting the assumption that adults are most likely to be present in the river during spawning. The sturgeon spent relatively little time in the river each year, generally about 4 weeks, and used the area from New Castle, DE (RKM 100) to Marcus Hook (RKM 130) (Fox and Breece 2010). A fifth sturgeon tagged in a separate study was also tracked and followed a similar timing pattern but traveled farther upstream (to RKM 165) before exiting the river in early June (Fox and Breece 2010). Nearly all adults in the river are likely to originate from the New York Bight DPS, but tracking indicates that occasionally adults are present in rivers outside their DPS of origin.

Based on the best available information, including the salinity levels in the action area (i.e., average 5 ppt), the presence of adult, subadult, and late-stage juvenile Atlantic sturgeon is possible year round. As explained above, adults and subadults are most likely to be present from April to November, as they spend winter months in the lower estuary/bay, or other ocean aggregation areas.

5.2 Summary of Past Impacts of Operation of the Hope Creek and Salem NGS

As noted above, Salem 1 has been operational since 1976, Salem 2 since 1981, and Hope Creek since 1986. Detailed information on past interactions of ESA listed sturgeon and sea turtles is included in the Effects of the Action section of this Opinion. Here, we provide a brief summary of past impacts of these facilities on these species and their habitat.

Hope Creek

As a closed cycle facility, Hope Creek withdraws and discharges a relatively small amount of water from the Delaware River. There has been no recorded impingement or entrainment of any sturgeon or sea turtles at this facility since it began operation. Effects on prey and habitat are not known to have impacted the abundance or distribution of sea turtles or sturgeon or had a significant effect on behaviors such as migration, foraging, spawning, or rearing.

Salem Units 1 and 2

The Salem units withdraw and discharge a significant amount of water from the Delaware River. Through December 2021, the impingement and capture/collection of 104 sea turtles (36 Kemp's ridley, 66 Loggerhead. 2 Green), 48 shortnose sturgeon, and 195 Atlantic sturgeon has been recorded at the Salem intakes. The discharge of heated effluent affects the distribution of sturgeon in the action area; however, as detailed below, the thermal plume does not block passage through the action area and adverse effects on behaviors such as migration, foraging, spawning, or rearing have not been documented.

5.3 Consideration of Federal, State, and Private Activities in the Action Area

Dredging of the Delaware River Federal Navigation Channel
Maintenance dredging occurs in the action area to maintain navigational channels at safe depths. These activities are authorized by the U.S. Army Corps of Engineers and the State of New Jersey. Dredging typically occurs with a cutterhead or hydraulic hopper dredge. While sea turtles have been killed in dredging operations in Delaware Bay, no interactions have been recorded in the action area. Atlantic and shortnose sturgeon have been killed in hopper dredging operations in the action area. Dredging results in the removal of bottom sediments and as such results in a temporary disruption of benthic resources; however, the dredged areas are expected to be recolonized from nearby undredged areas resulting in only a temporary reduction in the availability of potential sea turtle and sturgeon prey. The effects of these occasional, temporary reductions in the amount of prey in the action area are likely to be so small that they cannot be meaningfully measured, evaluated, or detected.

New Jersey Wind Port
On February 25, 2022, we issued a biological opinion to the USACE for the development by the PSEG of a marshalling facility in support of offshore wind projects in New Jersey and other U.S. East Coast states. The New Jersey Wind Port (NJWP) is anticipated to 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 Port will be co-located with the Salem and HCGS facilities at the northwestern edge within the 740-acre parcel of the existing PSEG property. 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), 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.

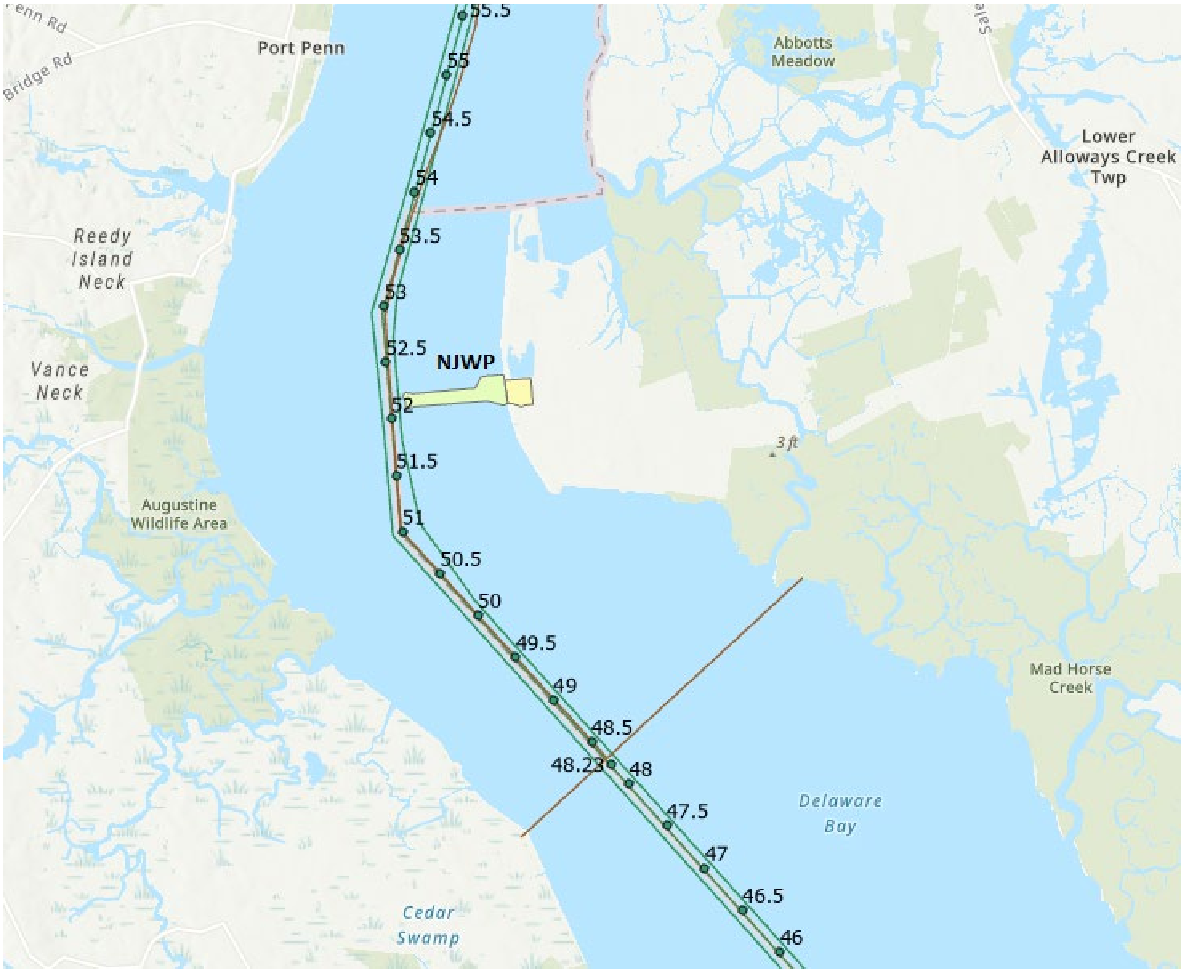

Figure 11. New Jersey Wind Port Development Boundary. The line across the channel is the location of the Delaware River mouth.

In the February 2022 biological opinion, we concluded that the proposed action may adversely affect, but is not likely to jeopardize the continued existence of the shortnose sturgeon, the GOM, NYB, CB, or SA DPSs of Atlantic sturgeon. We concurred that the effects 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 NYB 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 NYB, GOM, CB, and SA DPSs as well as shortnose sturgeon. We expect cutterhead dredging to kill up to two sturgeon. These may be two juvenile shortnose sturgeon, two juvenile NYB DPS Atlantic sturgeon, or one of each. In addition, we expect that sturgeon struck by construction vessels during construction of the NJWP will result in the mortality of one shortnose sturgeon and one Atlantic sturgeon. The shortnose sturgeon may be a juvenile or an adult. The Atlantic sturgeon will be either a juvenile or an adult of the NYB DPS. Finally, we expect up to 39 lethal vessel strikes over the operational life of the NJWP. Of these:

- Up to 4 shortnose sturgeon juveniles, adults, or mix of the two;
- Up to 7 juvenile Atlantic sturgeon from NYB DPS;
- Up to 16 adult Atlantic sturgeon from NYB DPS;
- Up to 5 adult Atlantic sturgeon from CB DPS;
- Up to 5 adult Atlantic sturgeon from SA DPS; and,
- Up to 2 adult Atlantic sturgeon from GOM DPS.

On July 20, 2022, we notified the USACE that the NJWP consultation would need to be reinitiated to incorporate new information related to vessel strikes. To date, we have not reinitiated the consultation.

Fishing Activity in the Action Area
Commercial and recreational fishing occurs in the action area. The action area is within New Jersey state waters. To date, New Jersey has not had a comprehensive program to capture data on bycatch or incidental capture of protected species such as sea turtles. We are not aware of any reports of the capture of sea turtles or Atlantic sturgeon in commercial or recreational fisheries in the action area. However, given that fisheries operate in the area that have the potential to interact with these species (e.g., hook and line, trawls, gillnets) we anticipate that there is at least occasional capture of individuals in the action area and that some percentage of these interactions would result in serious injury or mortality. A variety of commercial and recreational fisheries occur in the action area including blue crab, striped bass, and bluefish. Throughout their range, sea turtles have been taken in different types of gear, including gillnet, pound net, rod and reel, trawl, pot and trap, longline, and dredge gear. Sturgeon are vulnerable to capture in trawl gear, rod and reel, and gillnets. Given the use of fishing gear that is known to interact with sea turtles and sturgeon in areas and at times of year when these species are present, at least occasional interactions are likely to occur in the action area.

Vessel Operations
The Delaware River Navigation Channel is heavily trafficked by commercial, recreational, fishing, and military vessels. As turtles may be in the area where high vessel traffic occurs, the potential exists for collisions with vessels transiting within the action area. Vessel traffic is identified as a threat to Atlantic sturgeon in the Delaware River and sturgeon are known to be struck and killed by vessels in the action area. There is currently no quantitative estimate of the extent of vessel strikes for sea turtles or sturgeon in the action area.

Private and commercial vessels, including fishing vessels, operating in the action area of this consultation also have the potential to interact with sea turtles. Approximately 3,000 cargo vessels transit the Delaware River annually as well as numerous smaller commercial and recreational vessels. The effects of fishing vessels, recreational vessels, or other types of commercial vessels on listed species may involve disturbance or injury/mortality due to collisions or entanglement in anchor lines.

While vessel struck sea turtles have been observed throughout their range, including in the action area, as noted in NRC 1990, the regions of greatest concern for vessel strike are outside the action area and include areas with high concentrations of recreational-boat traffic such as the eastern Florida coast, the Florida Keys, and the shallow coastal bays in the Gulf of Mexico. In general, the risk of strike for sea turtles is considered to be greatest in areas with high densities of sea turtles and small, fast moving vessels such as recreational vessels or speed boats (NRC 1990). Similarly, Foley *et al.* (2019) concluded that in a study in Florida, vessel strike risk for sea turtles was highest at inlets and passes. Stetzar (2002) reports that 24 of 67 sea turtles stranded along the Atlantic Delaware coast from 1994-1999 had evidence of boat interactions (hull or propeller strike); however, it is unknown how many of these strikes occurred after the sea turtle died. If we assume that all were struck prior to death, this suggests a minimum of four strikes per year in this area. Stetzar (2002) reports that 33 of 109 sea turtles stranded along the Delaware Estuary from 1994 - 1999 had evidence of boat interactions (hull or propeller strike); however, it is unknown how many of these strikes occurred after the sea turtle died. If we assume that all were struck prior to death, this suggests 5 to 6 strikes per year in the Delaware Estuary. The Marine Mammal Stranding Center responds to stranded sea turtles in New Jersey. In 2015, they responded to 62 sea turtles. Of these, 12 (9 loggerhead, 1 leatherback and 2 green) had evidence of interactions with vessels (boat or propeller strike).[4]

As evidenced by reports and collections of Atlantic and shortnose sturgeon with injuries consistent with vessel strike (NMFS unpublished data[5]), both species are struck and killed by vessels in the Delaware River. Vessel strikes are a significant threat to Atlantic sturgeon in the Delaware River. As described in the 2021 5-Year Review for the New York Bight DPS of Atlantic sturgeon (NMFS 2021), there is new information to show that vessel strikes of Atlantic sturgeon occur more frequently and in more areas than what NMFS anticipated when the New York Bight DPS was listed as endangered. Additionally, multiple studies have shown that Atlantic sturgeon are unlikely to move away from vessels or avoid areas with vessel activity (Reine *et al.* 2014, Barber 2017, Balazik *et al.* 2017, DiJohnson 2019, Balazik *et al*. 2020).

NMFS has only minimum counts of the number of Atlantic sturgeon that are struck and killed by vessels because not all vessel struck sturgeon are detected and/or reported. As described in NMFS 2021, new research, including a study that intentionally placed Atlantic sturgeon carcasses along the Delaware River 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 state agencies (Balazik *et al.* 2012, Balazik, pers. comm. in ASMFC 2017; Fox *et al.* 2020). Based on the reporting rates in their study, Fox *et al.* estimated that a total of 199 and 213 carcasses were present along the Delaware Estuary shoreline in 2018 and 2019, respectively.

Brown and Murphy (2010) reported on 28 Atlantic sturgeon carcasses found in the Delaware River and Bay between 2005 and 2008 of which 14 mortalities were identified as the result of vessel strike. The remaining fish where too decomposed to determine cause of death but the authors believed that the majority most likely died after interaction with vessels. Brown and Murphy (2010) reported that a majority of mortalities in the River were adult Atlantic sturgeon greater than 150 cm (5 ft) total length with 39% of the mortalities reported being juveniles. The

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[4] https://mmsc.org/strandings/stranding-stats. Last accessed 10/18/2019
[5] The unpublished data are reports received by NMFS and recorded as part of the sturgeon salvage program authorized under ESA permit 17273

majority (71%) of sturgeon carcasses showed sign of interaction with large commercial vessels with large propellers and deep draft (Brown and Murphy 2010). This corresponds to conclusions drawn from other rivers (Balazik *et al.* 2012). 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.

In 2005, the Delaware Division of Fish and Wildlife started a reporting program where the public can report sturgeon carcasses they find in the Delaware River and Bay (https://dnrec.alpha.delaware.gov/fish-wildlife/fishing/sturgeon/). The data does not represent a scientific or dedicated survey. All of the sturgeon mortalities are reported by the public or by agency biologists who encountered the carcasses while conducting surveys on other species (personal communication, Ian Park, DENRC, 2017). Thus, while it represents the best available data on the number of carcasses reported to the state, it cannot be used to compare mortality rates between years and is not a total count of mortalities. We also note that this data includes sturgeon reported from coastal areas as well as from the Delaware River and the Delaware Bay and therefore overestimates vessel strikes in the action area. From 2005 through 2019[6], 242 sturgeon carcasses were reported (data provided by Ian Park, DNREC, 2019). Of these, 222 were identified as Atlantic sturgeon, 13 were identified as shortnose sturgeon, and seven were not identified to species.

Of all sturgeon carcasses reported, 128 showed injuries consistent with interaction with boat propellers and 19 were identified as having died by other causes. Cause of death could not be determined for 94 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, which is consistent with injury patterns resulting from propeller strike.

Information on the number of shortnose sturgeon struck and killed by vessels in the Delaware River is currently limited to reports provided to NMFS through our sturgeon salvage permit. A review of the database indicates that of the 53 records of salvaged shortnose sturgeon (2008-2016), 11 were detected in the Delaware River. Of these 11, 6 had injuries consistent with vessel strike. This is considerably less than the number of records of Atlantic sturgeon from the Delaware River with injuries consistent with vessel strike (15 out of 33 over the same time period). From 2017 to 2021, salvage program participants from Delaware and New Jersey reported 32 salvaged sturgeon in the Delaware River. Of these 32, two were shortnose sturgeon, neither of which had injuries consistent with vessel strike. Of the 30 records of salvaged Atlantic sturgeon in the Delaware River (2017-2021), 11 had injuries consistent with vessel strikes. Based on this, we assume that more Atlantic sturgeon are struck by vessels in the Delaware River than shortnose sturgeon.

Scientific Research

There are a number of survey and research activities that occur in the action area. These include

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

scientific surveys that target sturgeon and/or sea turtles and operate pursuant to permits issued under section 10 of the ESA and surveys that result in the bycatch of turtles or sturgeon. Surveys carried out by the State of New Jersey that receive federal funding, have underwent section 7 consultation. Capture in any of these surveys is largely expected to result in short-term stress and minor injury, with serious injury or mortality expected to be rare.

Water Quality
Sea turtles and sturgeon are exposed to a number of other stressors in the action area that are widespread and not unique to the action area which makes it difficult to determine to what extent these species may be affected by past, present, and future exposure within the action area. These stressors include water quality and aquatic trash. Aquatic trash in some form is present in nearly all of the world's riverways, including the action area. While the action area is not known to aggregate aquatic trash, aquatic trash, including plastics that can be ingested and cause health problems in sea turtles is expected to occur in the action area. Sea turtles and sturgeon can also become entangled in abandoned fishing gear or other discarded materials.

Significant efforts have been made to improve water quality in the Delaware River, with a major focus on improving dissolved oxygen levels and resolving conditions that led to seasonal areas of hypoxia in areas upstream of the action area. The Delaware River Basin Commission (DRBC) reports that in 2020, zone 5 (which overlaps with the action area) of the Delaware River met the 6 mg/l dissolved oxygen standard over 96% of the time, when measured on a daily basis, and 100% of the time when measured on a seasonal basis (DRBC 2020). However, despite significant improvements to water quality since the 1970s, the lower Delaware River is still considered impaired when considering the following factors: PCB in Fish Tissue; Aluminum; Mercury in Fish Tissue; pH; DDT in Fish Tissue; Chlordane in Fish Tissue; Turbidity; Water/Flow Variability; Siltation; Other Habitat Alterations; and, Impaired Biota (Wild and Scenic Rivers, 2018). These pollutants could affect the abundance and distribution of sea turtle or sturgeon prey in the action area. Similarly, uptake of contaminants could negatively affect turtles or sturgeon that use the action area; however, the extent and frequency of such effects are currently unknown.

Climate Change
There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://climate.gov).

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

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Evans and Bjørge 2013, IPCC 2021, Kintisch 2006, Learmonth *et al.* 2006, MacLeod *et al.* 2005, McMahon and Hays 2006, Robinson *et al.* 2005). Though predicting the precise effects of climate change on highly mobile marine species is difficult (Simmonds and Isaac 2007), recent research has indicated a range of effects already occurring. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35 degrees Celsius (Ackerman 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007a, NMFS and USFWS 2007b, NMFS and USFWS 2013a, NMFS and USFWS 2013b, NMFS and USFWS 2015). These impacts will be exacerbated by sea level rise with the loss of nesting habitat. This loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis *et al.* 2006, Baker *et al.* 2006).

Regarding the effects of climate change in the action area, available information largely focuses on effects that rising water levels may have on the human environment (Barnett and Dobshinsky 2008) and the availability of water for human use (e.g., Ayers *et al.* 1994).

Kreeger *et al.* (2010) considers effects of climate change on the Delaware Estuary. Using the average of 14 models, an air temperature increase of 1.9 to 3.7 degrees Celsius (3.4 to 6.7 degrees Fahrenheit) over this century is anticipated, with the amount dependent on emissions scenarios. No predictions related to increases in river water temperature are provided. There is also a 7 to 9 percent increase in precipitation predicted as well as an increase in the frequency of short term drought, a decline in the number of frost days, and an increase in growing season length predicted by 2100.

The report notes that the Mid-Atlantic states are anticipated to experience sea level rise greater than the global average (Karl *et al.* 2009). While the global sea level rise is largely attributed to melting ice sheets and expanding water as it warms, there is regional variation because of gravitational forces, wind, and water circulation patterns. In the Mid-Atlantic region, changing water circulation patterns are expected to increase sea level by approximately 10 centimeters over this century (Kreeger *et al.* 2010). Subsidence and sediment accretion also influence sea level rise in the Mid-Atlantic, including in the Delaware estuary. As described by Kreeger *et al.* (2010), postglacial settling of the land masses has occurred in the Delaware system since the last Ice Age. This settling causes a steady loss of elevation, which is called subsidence. Through the next century, subsidence is estimated to hold at an average 1 to 2 millimeters of land elevation loss per year (Kreeger *et al.* 2010). Rates of subsidence and accretion vary in different areas around the Delaware Estuary, but the greatest loss of shoreline habitat is expected to occur where subsidence is naturally high in areas that cannot accrete more sediment to compensate for elevation loss plus absolute sea-level rise. The net increase in sea-level compared to the change in land elevation is referred to as the rate of relative sea-level rise (RSRL). Kreeger *et al.* (2010) states that the best estimate for RSLR by the end of the century is 0.8 to 1.7 meters in the Delaware Estuary.

Sea level rise combined with more frequent droughts and increased human demand for water has been predicted to result in a northward movement of the salt wedge in the Delaware River (Collier 2011). Currently, the normal average location of the salt wedge is at approximately RKM 114 (median monthly salt front ranges from RKM 107.8 to RKM 122.3; DRBC 2017). Collier (2011) predicts that without mitigation (e.g., increased release of flows into downstream areas of the river), at high tide in the peak of the summer during extreme drought conditions, the salt line could be as far upstream as RKM 183 in 2050 and RKM 188 in 2100. The farthest north the salt line has historically been documented was approximately RKM 166 during a period of severe drought in 1965; thus, she predicts that over time, during certain extreme conditions, the salt line could shift up to 17 kilometers further upstream by 2050 and 22 kilometers further upstream by 2100.

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

A hydrologic model for the Delaware River, incorporating predicted changes in temperature and precipitation was compiled by Hassell and Miller (1999). The model results indicate that when only the temperature increase is input to the hydrologic model, the mean annual streamflow decreased, the winter flows increased due to increased snowmelt, and the mean position of the salt front moved upstream. When only the precipitation increase was input to the hydrologic model, the mean annual streamflow increased, and the mean position of the salt front moved further downstream. However, when both the temperature and precipitation increase were input to the hydrologic model the mean annual streamflow changed very little, with a small increase during the first four months of the year. Ross *et al.* (2015) found that regardless of any change in streamflow, future sea-level rise will cause salinity to increase.

Water temperature in the Delaware River varies seasonally. For the period from 1964 to 2000, thelowest temperatures were recorded in April (10 to 11 degrees Celsius (50 to 51.8 degrees Fahrenheit)) and peak temperatures were observed in August (approximately 26 to 27 degrees Celsius (78.8 to 80.6 degrees Fahrenheit)). Kaushal *et al.* (2010) found that water temperatures are increasing in many streams and rivers throughout the US with the Delaware River near Chester, Pennsylvania, having the most rapid rate of increase (of 0.077 degrees Celsius (0.14 degrees Fahrenheit) per year; 1965 to 2007). There was also a significant increase ($P < 0.05$) at the Ben Franklin Bridge (near Philadelphia, Pennsylvania; 1965-2007; Kaushal *et al.* 2010). However, not every site along the Delaware River showed significant increases, and those sites with the most rapid increase rates were located in downstream urban areas (Kaushal *et al.* 2010). Moberg and DeLucia (2016) compiled recent literature and information including USGS data from 2005-2014 showing higher river temperatures (27 to 29 degrees Celsius (80.6 to 84.2 degrees Fahrenheit)) in the Delaware in recent years.

Information from a recent effort to develop high-resolution future projections of air temperature and surface water temperature for the Chesapeake Bay out to 2100 can be used to provide insights for the Delaware Bay (Muhling *et al.* 2017). Muhling *et al.* (2017) also projected salinity, but these conclusions would likely be specific to just the Chesapeake Bay based on the complexities noted above (e.g., Ross *et al.* 2015). Air temperature has been used for coastal and freshwater water temperature trends (Tommasi *et al.* 2015) so may be more easily applied to a regional scale, including the Delaware River. Projected annual air temperature increase between 1979 and 2008 versus 2071 and 2100 indicates that future warming between the Chesapeake and Delaware and their major watersheds will be reasonably similar (see air temperature including RCP 8.5 and all models at NOAA's Climate Change Web Portal; https://www.esrl.noaa.gov/psd/ipcc/cmip5/).

Expected effects of climate change for river systems could be a decrease in the amount of dissolved oxygen in surface waters (Murdoch *et al.* 2000). Moberg and DeLucia (2016) compiled recent studies and information including USGS data showing a relationship between increasing temperature and decreasing dissolved oxygen in the Delaware River. For example, Moberg and DeLucia (2016) highlighted that dissolved oxygen levels less than 4.0 milligrams per liter occurred when temperatures were greater than 25 degrees Celsius (77 degrees Fahrenheit) and dissolved oxygen levels less than 5.0 milligrams per liter occurred when temperatures were greater than 23 degrees Celsius (73.4 degrees Fahrenheit) during observations in July and August 2005 to 2014.

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

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on sea turtles, shortnose and Atlantic sturgeon. We have analyzed the available information, however, to consider likely impacts to sturgeon and their habitat in the action area. The proposed action under consideration is the continued operation of the Salem and Hope Creek generating stations through 2036 (Salem 1), 2040 (Salem 2) and 2046 (Hope Creek); thus, we consider here, likely effects of climate change during the period from now through 2046.

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

If sea level rise was great enough to consistently shift the salt wedge far enough north which would restrict the range of juvenile sturgeon and may affect the development of these life stages (affecting Atlantic sturgeon critical habitat PBFs 1, 2, and 4). Upstream shifts in spawning or rearing habitat (PBF 1) in the Delaware River are not limited by any impassable falls or manmade barriers. Habitat that is suitable for spawning is known to be present upstream of the areas that are thought to be used by shortnose and Atlantic sturgeon suggesting that there may be some capacity for spawning to shift further upstream to remain ahead of the saltwedge. Based on predicted upriver shifts in the saltwedge, areas where Atlantic sturgeon currently spawn could, over time, become too saline to support spawning and rearing. Modeling conducted the USACE (2019) indicates that this is unlikely to occur before 2040 but modeling conducted by Collier (2011) suggests that by 2100, some areas within the range where spawning is thought to occur (RKM 125-212), may be too salty and spawning would need to shift further north. Breece *et al.* (2013) used habitat modeling to consider where adult Atlantic sturgeon would be located under various scenarios including the location of the salt front due to changes in sea level rise in 2100 (i.e., occurring RKM 122-137 based on a 1986 EPA report for the Delaware Estuary) and under extreme historic drought (i.e., restricted to RKM 125, 130 and 153 based on drought conditions observed in the 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 or nursery habitat. Shortnose sturgeon spawning habitat (RKM 214-238) is approximately 90 km upstream of the current median range of the salt front

(RKM 122). Atlantic sturgeon spawning habitat (RKM 125-212) is at greater risk from encroaching salt water, with some of the best potential spawning habitat at the downstream end of that range (i.e., Marcus Hook Bar area). However, without an upstream barrier to passage, and spawning habitat extending to Trenton, NJ, it is unlikely that salt front movement upstream would significantly limit spawning and nursery habitat. The available habitat for juvenile sturgeon of both sturgeon species could decrease over time; however, even if the salt front shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon. The areas in the Delaware River critical habitat unit containing PBF 2 (aquatic habitat with soft substrate and a gradual downstream salinity gradient of 0.5-30 ppt for juvenile foraging and physiological development) may also shift upstream but would not necessarily be diminished in size or quality.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations through the area as sturgeon move throughout the river. Atlantic sturgeon prefer water temperatures up to approximately 28 °C (82.4 °F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28 °C are experienced in larger areas, Atlantic sturgeon may be excluded from some habitats. Additionally, temperature cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey.

Spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change). It is difficult to predict how any change in water temperature or river flow will affect the seasonal movements of sturgeon through the action area. However, it seems most likely that spawning would shift to earlier in the year. Moberg and DeLucia (2016) noted that low flow conditions influence the salt front location and available freshwater habits that are suitable for early life stages. DO concentrations between 2005 and 2014 were often in ranges identified as impaired or lethal for Atlantic sturgeon early life stages (Moberg and DeLucia 2016).

Any forage species that are temperature dependent may also shift in distribution as water temperatures warm. However, because we do not know the adaptive capacity of these individuals or how much of a change in temperature would be necessary to cause a shift in distribution, it is not possible to predict how these changes may affect foraging sturgeon. If sturgeon distribution shifted along with prey distribution, it is likely that there would be minimal, if any, impact on the availability of food. Similarly, if sturgeon shifted to areas where different forage was available and sturgeon were able to obtain sufficient nutrition from that new source of forage, any effect would be minimal. The greatest potential for effect to forage resources would be if sturgeon shifted to an area or time where insufficient forage was available; however, the likelihood of this happening is low because sturgeon feed on a wide variety of species and in a wide variety of habitats.

Limited information on the thermal tolerances of Atlantic and shortnose sturgeon is available. Atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010); in the wild, shortnose sturgeon are typically found in waters less than 28°C. In the laboratory, juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). Tolerance to temperatures is thought to increase with age and body size (Ziegeweid *et al.* 2008 and Jenkins *et al.* 1993), however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. Muhling *et al.* (2018) noted that the predicted increase in summer surface temperatures may increase to between 27 - 29 °C and > 30°C depending on the climate model, in the Chesapeake Bay, which represents a moderate to potentially lethal change in conditions for species such as Atlantic sturgeon. It is possible that these values may be similar to the Delaware Bay (see above). Shortnose sturgeon, have been documented in the lab to experience mortality at temperatures of 33.7°C (92.66°F) or greater and are thought to experience stress at temperatures above 28°C. For purposes of considering thermal tolerances, we consider shortnose sturgeon to be a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities. Mean monthly ambient temperatures in the Delaware estuary range from 11-27°C from April – November, with temperatures lower than 11°C from December-March. As noted above, there are various studies looking at temperature in the Delaware Bay (Moberg and DeLucia 2016). Rising temperatures could meet or exceed the preferred temperature of shortnose and Atlantic sturgeon (28°C) on more days and/or in larger areas. This could result in shifts in the distribution of sturgeon out of certain areas during the warmer months. Information from southern river systems suggests that during peak summer heat, sturgeon are most likely to be found in deep water areas where temperatures are coolest. Thus, we could expect that over time, sturgeon would shift out of shallow habitats on the warmest days. This could result in reduced foraging opportunities if sturgeon were foraging in shallow waters.

As described above, over the long term, global climate change may affect shortnose and Atlantic sturgeon by affecting the location of the salt wedge, distribution of prey, water temperature and water quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which shortnose or Atlantic sturgeon will be able to successfully adapt to any such changes. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect shortnose and Atlantic sturgeon in the action area. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species which may allow them to deal with change better than predicted. When we designated the Delaware River as critical habitat for the New York Bight DPS of Atlantic sturgeon, we did not extend any areas upstream because of anticipated impacts of climate change. Rather, we determined that the areas designated would accommodate any changes in distribution of the PBFs that may result from climate change.

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

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

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

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on sea turtles; however, we have considered the available information to consider likely impacts to these species in the action area. Sea turtles are most likely to be affected by climate change due to increasing sand temperatures at nesting beaches which in turn would result in increased female:male sex ratio among hatchlings, sea level rise which could result in a reduction in available nesting beach habitat, increased risk of nest inundation, changes in the abundance and distribution of forage species which could result in changes in the foraging behavior and distribution of sea turtle species, and changes in water temperature which could possibly lead to a northward shift in their range.

Over the time period considered in this Opinion, sea surface temperatures are expected to rise less than 1°C. It is unknown if that is enough of a change to contribute to shifts in the range or distribution of sea turtles. Theoretically, we expect that as waters in the action area warm, more sea turtles could be present or sea turtles could be present for longer periods of time. However, if temperature affected the distribution of sea turtle forage in a way that decreased forage in the action area, sea turtles may be less likely to occur in the action area. It has been speculated that the nesting range of some sea turtle species may shift northward. Given existing nesting locations and the relatively short duration of time considered in this Opinion (2013-2046, a period of 33 years), it seems extremely unlikely that the range of Kemp's ridley sea turtle nesting would shift enough so that nesting would occur on beaches in Delaware Bay. Kemp's ridleys only nest in Mexico. It is more likely that any shift in nesting to Delaware Bay beaches would be from loggerheads (which nest as far north as Virginia) and/or green sea turtles (which normally nest as far north as North Carolina.

Nesting in the mid-Atlantic generally is extremely rare. As reported by the Conserve Wildlife Foundation of New Jersey (Egger 2011), in 2010, one green sea turtle came up on the beach in Sea Isle City, New Jersey; however, it did not lay any eggs. In August 2011, a loggerhead came up on the beach in Stone Harbor, New Jersey but did not lay any eggs. On August 18, 2011, a green sea turtle laid one nest at Cape Henlopen Beach in Lewes, Delaware near the entrance to Delaware Bay. The nest contained 190 eggs and was transported indoors to an incubation facility on October 7. A total of twelve eggs hatched, with eight hatchlings surviving. In December, seven of the hatchlings were released in Cape Hatteras, North Carolina (DNREC 2012). In September 2017, about 100 loggerhead hatchlings successfully emerged from nests on the Maryland side of Assateague Island. It is important to consider that in order for nesting to be successful in the mid-Atlantic, fall and winter temperatures need to be warm enough to support the successful rearing of eggs and sea temperatures must be warm enough for hatchlings to survive when they enter the water. The predicted increases in water temperatures between now and 2046 are not great enough to allow successful rearing of sea turtle eggs in the action area. However, if increased nesting activity were to begin occurring, that would constitute new information that may require reinitiation of this Opinion.

5.6 Reducing Threats to ESA-listed Sea Turtles

Handling and Resuscitation Requirements

NMFS has developed and published sea turtle handling and resuscitation techniques for sea turtles that are incidentally caught during scientific research or fishing activities (66 FR 67495, December 31, 2001). Persons participating in fishing activities or scientific research are required to handle and resuscitate (as necessary) sea turtles as prescribed in the final rule. These measures help to prevent mortality of hard-shelled turtles caught in fishing or scientific research gear.

Exception for injured, dead, or stranded specimens

Any agent or employee of NMFS, the USFWS, the U.S. Coast Guard, or any other Federal land or water management agency, or any agent or employee of a state agency responsible for fish and wildlife, when acting in the course of his or her official duties, is allowed to take threatened or endangered sea turtles encountered in the marine environment if such taking is necessary to aid a sick, injured, or entangled endangered sea turtle, or dispose of or salvage a dead endangered or threatened sea turtle (50 CFR 223.206(b); 50 CFR 222.310). This take exemption extends to NMFS' Sea Turtle Stranding and Salvage Network.

6.0 EFFECTS OF THE ACTION

This section of the biological opinion assesses the effects of the proposed action on threatened or endangered species. Effect of the action "are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action." (50 CFR §402.02). This Opinion examines the effects of the continued operation of Salem 1, Salem 2, and Hope Creek on five DPSs of Atlantic sturgeon, shortnose sturgeon, loggerhead, Kemp's ridley and green sea turtles in the action area and their habitat within the context of the species current status, the environmental baseline, and cumulative effects.

As described above, the proposed actions are the continued operation of the Salem Unit 1, Salem Unit 2, and Hope Creek facilities as authorized by NRC pursuant to their respective licenses issued under the authority of the Atomic Energy Act. Carrying out the fish sampling component of the REMP is considered to be part of the proposed Federal action as it is a required component of the operating licenses and interactions with listed species are a direct effect of the proposed actions. The NJPDES permit issued for the two Salem facilities requires the completion of the annual UBMWP. Note that the UBMWP requirement replaces an older requirement to complete an annual IBMWP. The new UBMWP continues the requirement for bottom trawl and beach seine surveys in the Delaware Bay. We consider the effects of the annual UBMWP, trawl surveys, beach seine surveys, and other activities required by the NJPDES permits to be effects of the action because the UBMWP, and the NJPDES permits, are interdependent actions that have no independent utility apart from the continued operation of the Salem facilities;; that is, but for the continued operation of Salem Unit 1 and Salem Unit 2, these effects would not occur. The UBMWP is a required component of the NJPDES permit issued for the operations of Salem, which has no independent utility apart from the NRC operating licenses.

The proposed actions considered in this Opinion have the potential to affect Atlantic sturgeon, shortnose sturgeon, and sea turtles in several ways: impingement or entrainment at the intakes; altering the abundance or availability of potential prey items; altering water quality through the discharge of heated effluent and other pollutants; handling during PIT tagging and tissue sampling procedures; and, incidental capture during the sampling required by the Salem and Hope Creek REMPs and the UBMWP activities required by the Salem NJPDES permit.

6.1 Entrainment at Salem and Hope Creek

Entrainment occurs when small aquatic life forms are carried into and through the cooling system during water withdrawals. Entrainment primarily affects organisms with limited swimming ability that can pass through the screen mesh used on the intake systems. Once entrained, organisms pass through the circulating pumps and are carried with the water flow through the intake conduits toward the condenser units. They are then drawn through one of the many condenser tubes used to cool the turbine exhaust steam (where cooling water absorbs heat) and then returned to the Delaware River. As entrained organisms pass through the intake, they may be injured from abrasion or compression. Within the cooling system, they can encounter physical impacts in the pumps and condenser tubing; pressure changes and shear stress throughout the system; thermal shock within the condenser; and exposure to chemicals, including chlorine and residual industrial chemicals discharged at the diffuser ports (Mayhew *et al.* 2000). Death can occur immediately or later from the physiological effects of heat, or it can occur after organisms are discharged if stresses or injuries result in an inability to escape predators, a reduced ability to forage, or other impairments.

A rack system is in place in front of the intakes to screen out large debris; this consists of vertical bars spaced 3-inches apart. There is also a ¼-inch by ½-inch mesh traveling screen system (NRC 2011). To be entrained in the facility, an organism must be small enough to pass through the trash bars and the small mesh.

Studies to evaluate entrainment at Salem and HCGS have been ongoing since 1978. The 2016 NJPDES permit for Salem contained a requirement for entrainment sampling to be carried out three days per week at a frequency of seven samples per day from January – March and August – December and four days per week at a frequency of fourteen samples per day from April through July. NRC reports that based on examination by NRC staff of entrainment data provided by PSEG, no NMFS-listed species have been entrained at Salem or HCGS; as addressed below, this is consistent with our expectation that no sea turtles, shortnose or Atlantic sturgeon small enough to be vulnerable to entrainment occur in the action area.

6.1.1 Entrainment of Shortnose Sturgeon

The southern extent of the shortnose sturgeon spawning area in the Delaware River is approximately RM 133 (RKM 214*),* more than 80 RM upstream of the Salem or Hope Creek intakes. The eggs of shortnose sturgeon are demersal, sinking, and adhere to the bottom of the river. Upon hatching, the larvae in both yolk-sac and post-yolk-sac stages remain on the bottom of the river, within the bottom 1 meter of the water column. Shortnose sturgeon larvae grow rapidly and after a few weeks are too large to be entrained by the cooling water intake; additionally, larvae are intolerant to saline conditions and are unlikely to occur in the lower

Delaware River where the intakes are located. Any shortnose sturgeon in the action area are too big to be entrained at the Salem or Hope Creek intakes.

Based on the life history of the shortnose sturgeon, the location of spawning grounds within the Delaware River, and the patterns of movement for eggs and larvae, it is extremely unlikely that any shortnose sturgeon early life stages would be entrained at the Salem or Hope Creek intakes. We do not anticipate any entrainment of shortnose sturgeon eggs or larvae over the period of the extended operating license because these life stages do not occur in the action area. This conclusion is supported by the lack of any sturgeon eggs or larvae documented during over 40 years of entrainment monitoring at any of the intakes All other life stages of shortnose sturgeon are too big to pass through the screen mesh and cannot be entrained at the facility. We do not expect any entrainment of any life stage of shortnose sturgeon in the future at Salem 1, Salem 2, or HCGS.

6.1.2 Entrainment of Atlantic sturgeon

The southern extent of the Atlantic sturgeon spawning area in the Delaware River is near Marcus Hook Bar approximately RKM 125*),* more than 45 RKM upstream of the Salem or Hope Creek intakes. The eggs of Atlantic sturgeon are demersal, sinking, and adhering to the bottom of the river. Upon hatching, the larvae in both yolk-sac and post-yolk-sac stages remain on the bottom of the river. Atlantic sturgeon larvae grow rapidly and after a few weeks are too large to be entrained by the cooling water intake; additionally, larvae are intolerant to saline conditions and are unlikely to occur in the lower Delaware River where the intakes are located. Any Atlantic sturgeon in the action area are too big to be entrained at the Salem or Hope Creek intakes.

Based on the life history of Atlantic sturgeon, the location of spawning grounds within the Delaware River, and the patterns of movement for eggs and larvae, it is extremely unlikely that any Atlantic sturgeon early life stages would be entrained at the Salem or Hope Creek intakes. We do not anticipate any entrainment of Atlantic sturgeon eggs or larvae over the period of the extended operating license because these life stages do not occur in the action area. This conclusion is supported by the lack of any sturgeon eggs or larvae documented during over 40 years of entrainment monitoring at any of the intakes. All other life stages of Atlantic sturgeon are too big to pass through the screen mesh and cannot be entrained at the facility. We do not expect any entrainment of Atlantic sturgeon in the future at Salem 1, Salem 2 or HCGS.

6.1.3 Entrainment of Sea Turtles

Entrainment of sea turtles would only be possible if individuals were smaller than the mesh size of the screens. As even hatchling sea turtles, which do not occur in the action area, are too big to be entrained at the intakes, it is not possible for juvenile or adult sea turtles which may occur in the action area, to be entrained at these intakes. Therefore, there is no risk of entrainment of sea turtles in the intakes for Salem 1, Salem 2 or HCGS.

6.2 Impingement of Atlantic sturgeon, shortnose sturgeon and sea turtles – Hope Creek

Generally speaking, impingement occurs when organisms are trapped against cooling water intake screens or racks by the force of moving water. Impingement can kill organisms immediately or contribute to death resulting from exhaustion, suffocation, injury, or exposure to air when screens are rotated for cleaning. The potential for injury or death is generally related to the amount of time an organism is impinged, its susceptibility to injury, and the physical characteristics of the screenwashing and fish return system that the plant operator uses.

Hope Creek operates with a closed cycle cooling system, withdrawing approximately 66.8 MGD, approximately 2% of the volume of water withdrawn by Salem. The intake velocity at Hope Creek is 0.35 fps, approximately 1/3 the intake velocity of the Salem intakes. Since HCGS began operations, no Atlantic sturgeon, shortnose sturgeon, or sea turtles have been documented to be impinged at Hope Creek. This is likely due to the low intake velocity and the relatively small amount of water withdrawn. As there are no operational changes proposed that would change the likelihood of impingement, it is reasonable to expect that the risk of impingement will be the same in the future as it has been in the past. As such, we do not expect any Atlantic sturgeon, shortnose sturgeon, or sea turtles to be impinged at Hope Creek through the remainder of the term of the license.

6.3 Impingement of Atlantic sturgeon, shortnose sturgeon and sea turtles – Salem

The Salem intakes are located along the eastern shoreline of the Delaware River. The face of the intakes is screened with vertical metal bars (trash racks). The racks are made from 0.5 inch (1.3 cm) steel bars placed on 3.5-inch (8.9 cm) centers, creating a 3-inch (7.6 cm) clearance between each bar. The trash racks are cleaned on a set schedule with automated trash rakes. The trash rakes include a hopper that stores and transports removed debris to a pit at the end of each intake, where it is dewatered by gravity and disposed of off-site. During the winter, removable ice barriers are installed in front of the trash racks to prevent damage to the intake pumps from floating ice formed on the Delaware Estuary. These barriers consist of pressure-treated wood bars and underlying structural steel braces. The barriers are removed early in the spring and replaced in the late fall.

PSEG carries out monitoring of impingement at the trash racks and the traveling screens. Trash racks are visually inspected at least once per 12-hour shift and are cleaned one to several times per week, depending on the time of year. All material removed from the racks is inspected and any sturgeon or sea turtles are recorded and reported to NRC and NMFS.

Organisms that pass through the trash bars can become impinged on the traveling screens or captured in the traveling fish buckets. These organisms are washed off the CWS intake screens and returned to the Delaware Estuary through a fish return system. Impingement monitoring occurs 10 times per day, three days per week. Impingement samples are collected in fish counting pools constructed for this purpose that are located adjacent to the fish return system discharge troughs at both the northern and southern ends of the CWS intake structure. Screen-wash water is diverted into the counting pools for an average sample duration of 3 minutes (depending on debris load, sampling time varies from 1 to 15 min). Water is then drained from the pools, and organisms are sorted by species, counted, measured, and weighed (PSEG 1984).

Impingement monitoring of the traveling screens has been carried out since May 1977. As currently specified in the UBMWP, CWS impingement abundance samples are collected at a sampling frequency of 10 samples per day three days a week. Information on historical impingement sampling is included in the 2014 Opinion and incorporated here by reference.

As discussed below, sea turtles, shortnose sturgeon and Atlantic sturgeon have been observed impinged at the trash bars. To date, no sea turtles or shortnose sturgeon have been observed during impingement sampling at the traveling screens and eight Atlantic sturgeon have been observed during sampling at the traveling screens.

6.3.1 Impingement of Sea Turtles

In order to pass through the trash racks and be potentially impinged on the traveling screens, an organism would need to be small enough to pass between the bars (3" clear spacing). Sea turtles in the action area are too large to pass through the trash racks. Therefore, there is no potential for impingement on the traveling screens. Sea turtles can become impinged on the trash racks if they are unable to swim away. Sea turtles close to the rack can also be captured by the trash rake during cleaning operations.

From 1976- 2022, a total of 114 sea turtles have been removed from the Salem intakes, with 55 dead upon removal from the water or dying shortly after. Of these 114 sea turtles, there have been 68 loggerheads, 2 green, and 44 Kemp's ridleys (see Table 5). Prior to 1993, when the ice barriers were left on the trash bars year round, the number of loggerheads removed from the trash bars each year ranged from 0-23. From 1993 – 2022, 6 loggerheads have been impinged with no more than 2 impinged in any year. No loggerheads have been impinged since 2001. Only two green sea turtles have been impinged at the intakes since 1978 (1 in 1991 (alive), and 1 in 1992 (dead)). Prior to 1993, 23 Kemp's ridleys were impinged at Salem (11 dead); 21 Kemp's ridleys have been impinged between 1993-2022 (18 dead) with 13 of those occurring in 2021 and 2022.

Table 7. **Total number of sea turtles captured or impinged at Salem from 1976 – 2022.** Please note that two of the live turtles in 1991 were recaptures and one of the live turtles in 1992 was a recapture.

	Kemp's ridley		Loggerhead		Green		Annual Total		
	Alive	Dead	Alive	Dead	Alive	Dead	Total Alive	Total Dead	**TOTAL**
1976	0	0	0	0	0	0	0	0	**0**
1977	0	0	0	0	0	0	0	0	**0**
1978	0	0	0	0	0	0	0	0	**0**
1979	0	0	0	0	0	0	0	0	**0**
1980	1	0	0	2	0	0	1	2	**3**
1981	0	1	1	2	0	0	1	3	**4**
1982	0	0	0	1	0	0	0	1	**1**
1983	0	1	0	2	0	0	0	3	**3**
1984	1	0	0	2	0	0	1	2	**3**
1985	1	1	1	5	0	0	2	6	**8**
1986	0	1	0	0	0	0	0	1	**1**

1987	1	2	3	0	0	0	4	2	**6**
1988	1	1	2	6	0	0	3	7	**10**
1989	4	2	2	0	0	0	6	2	**8**
1990	0	0	0	0	0	0	0	0	**0**
1991	1	0	22	1	1	0	24	1	**25**
1992	2	2	10	0	0	1	12	3	**15**
1993	1	0	0	0	0	0	1	0	**1**
1994	0	0	1	0	0	0	1	0	**1**
1995	0	0	0	1	0	0	0	1	**1**
1996	0	0	0	0	0	0	0	0	**0**
1997	0	0	0	0	0	0	0	0	**0**
1998	0	0	0	1	0	0	0	1	**1**
1999	0	0	0	0	0	0	0	0	**0**
2000	0	0	1	1	0	0	1	1	**2**
2001	0	0	0	1	0	0	0	1	**1**
2002	0	0	0	0	0	0	0	0	**0**
2003	0	0	0	0	0	0	0	0	**0**
2004	0	0	0	0	0	0	0	0	**0**
2005	0	0	0	0	0	0	0	0	**0**
2006	0	0	0	0	0	0	0	0	**0**
2007	0	0	0	0	0	0	0	0	**0**
2008	0	0	0	0	0	0	0	0	**0**
2009	0	0	0	0	0	0	0	0	**0**
2010	0	0	0	0	0	0	0	0	**0**
2011	0	0	0	0	0	0	0	0	**0**
2012	0	0	0	0	0	0	0	0	**0**
2013	1	1	0	0	0	0	1	1	**2**
2014	0	1	0	0	0	0	0	1	**1**
2015	0	0	0	0	0	0	0	0	**0**
2016	0	0	0	0	0	0	0	0	**0**
2017	0	1	0	0	0	0	0	1	**1**
2018	0	1	0	0	0	0	0	1	**1**
2019	0	0	0	0	0	0	0	0	**0**
2020	0	1	0	0	0	0	0	1	**1**
2021	0	7	0	0	0	0	0	7	**7**
2022	1	6	0	0	0	0	1	6	**7**
TOTAL	**15**	**29**	**43**	**25**	**1**	**1**	**59**	**55**	**114**
% dead	**66%**		**37%**		**50%**		**48%**		

The removal of the ice barriers during turtle season (May – October), which began in 1993, has resulted in a dramatic reduction in the number of sea turtles impinged at Salem. It appears that the presence of the ice barriers was affecting sea turtles in some way that made them more vulnerable to impingement, likely by reducing sea turtles' ability to easily exit the immediate intake area. In 1993, PSEG began removing the ice barriers between May 1 and October 24 of each year. This seasonal schedule will be maintained in the future. From 1993- 2022, 27 sea turtles (6 loggerheads, 21 Kemp's) have been removed from the Salem trash bars. Only six sea turtles (all Kemp's) were impinged at Salem between January 2002 and December 2020. Between June 17, 2021, and July 8, 2021, PSEG personnel collected six dead Kemp's ridleys from the Salem trash racks during raking activities; an additional dead Kemp's ridley was collected on August 10, 2021. Between June 28, 2022, and September 23, 2022, six dead Kemp's ridleys and one live Kemp's ridely were collected by PSEG personnel at the Salem trash racks during raking activities. There are no known environmental or operational changes that can be attributed to the increase in Kemp's ridley collections during this period.

Given the low velocity at the intakes (less than 1 foot per second), it is possible that live, uninjured sea turtles removed from the intakes do not get stuck on the racks, but rather are close enough to the racks to be captured or removed with the trash rake. This is because the intake velocity is slower than the current that sea turtles are known to swim against during normal behaviors such as while migrating and foraging. Sea turtles typically cruise at speeds of 0.9-1.4 miles per hour (3.3-4.4 fps) and juvenile sea turtles forage in areas with currents of up to 2 knots (3.4 fps).

Except for the Kemp's ridleys collected in 2022, necropsies have been conducted on nearly all of the turtles removed dead from the intakes. One loggerhead was alive when removed from the water but died shortly after. One of the Kemp's ridleys removed from the trash racks in 2013 was alive when captured but had a significant head injury. It was transported to a rehabilitation facility for further examination and treatment. The turtle was euthanized due to the extent of its injury which affected its brain; it was determined that the turtle was injured prior to impingement. One of the Kemp's ridleys removed from the trash racks in 2022 was alive and in excellent condition when captured. After processing, the turtle was taken to the New Jersey Marine Mammal Stranding Facility and later released.

Of the 55 dead sea turtles, 36 were determined to have died prior to impingement (8 boat strikes, 6 illness or internal injury and 22 unknown cause of death but significant decomposition indicating death prior to impingement). Six turtles were reported as "fresh dead" with the cause of death likely to be impingement/drowning. Six turtles (including the second Kemp's ridley impinged in 2013 and one of the Kemp's ridley impinged in 2021) had no apparent signs of trauma and necropsy did not reveal a cause of death. Four of the turtles impinged in 2021 were reported as "fresh dead" and had apparent signs of trauma. However, necropsy did not reveal a cause of death for these individuals. No necropsy report is available for the Kemp's ridley collected in August 2021; this turtle was considered "fresh dead" and had no external signs of injury or illness. Two of the turtles impinged in 2022 were reported as "fresh dead" and had apparent signs of trauma. As previously stated, no necropsy reports are available for the Kemp's ridleys collected in 2022.

Of the 25 dead loggerheads removed from the intakes, 19 were determined to have died prior to impingement. The remaining six (just over 25%), had the cause of death identified as drowning (due to impingement at the trash bars) or were fresh dead with no signs of decomposition and considered likely to have drowned at the trash bars.

Of the 29 dead Kemp's ridleys, 10 (34%) had the cause of death identified as drowning (due to impingement at the trash bars) or were fresh dead with no signs of decomposition (including the second 2013 Kemp's, two of the 2021 Kemp's, and one of the 2022 Kemp's) and we consider it likely that they drowned at the trash bars. The higher mortality rate for Kemp's ridleys (compared to loggerheads) may be due to differences in physiology between Kemp's ridleys and loggerheads. Kemp's ridleys cannot survive underwater as long as other sea turtle species and have been found to drown faster in trawl nets compared to other species (Magnuson *et al.* 1990). Necropsies for four of the seven Kemp's ridleys collected from the trash bars in 2021 revealed that all of these individuals had trauma and bruising. Examination did not provide a definitive cause of death for any of these turtles, however bruising suggest that these individuals were alive prior to impingement. All four of the turtles were in "poor nutritional condition" during the immediate antemortem period (MMSC 2021). Inspection of the gastrointestinal tract of two of the four turtles indicated that they were not eating well; and despite ingestion of abundant food prior to death, histopathology results for a third turtle exhibited signs that its body had been eating away at its fat stores (i.e., hepatic lipidosis). The one dead green sea turtle removed from the intakes had a cause of death attributable to a massive head injury and was determined to have died prior to impingement.

Anticipated Future Impingement of Sea Turtles
Besides the seasonal removal of the ice barriers, no other changes in operations are known to have taken place that would change the rate of sea turtle impingement at Salem. There have been no long-term studies of sea turtles in Delaware Bay so there is no information to determine whether the change in numbers of impingement at the Salem intakes is related to a change in numbers of sea turtles in the Bay generally.

In water abundance studies in other Mid-Atlantic coastal waters, including Long Island Sound (Morreale *et al.* 2005) and Chesapeake Bay (Mansfield 2006) indicate that there were reductions in the numbers of sea turtles in these waters in the early 2000s. Morreale *et al.* (2005) observed a decline in the percentage and relative numbers of loggerhead sea turtles incidentally captured in pound net gear fished around Long Island, New York during the period 2002-2004 in comparison to the period 1987-1992, with only two (2) loggerheads (of a total 54 turtles) observed captured in pound net gear during the period 2002-2004. This is in contrast to the previous decade's study where numbers of individual loggerheads ranged from 11 to 28 per year (Morreale *et al.* 2005). Potential explanations for this decline include major shifts in loggerhead foraging areas and/or increased mortality in pelagic or early benthic stage/age classes (Morreale *et al.* 2005). Using aerial surveys, Mansfield (2006) also found a decline in the densities of loggerhead sea turtles in Chesapeake Bay over the period 2001-2004 compared to aerial survey data collected in the 1980s. Significantly fewer loggerheads ($p<0.05$) were observed in both the spring (May-June) and the summer (July-August) of 2001-2004 compared to those observed during aerial surveys in the 1980s (Mansfield 2006). A comparison of median densities from the 1980s to the 2000s suggested that there had been a 63.2% reduction in densities during the spring residency period and a 74.9% reduction in densities during the summer residency period (Mansfield 2006). The decline in observed loggerhead populations in Chesapeake Bay may be related to a significant decline in prey, namely horseshoe crabs and blue crabs, with loggerheads redistributing outside of Bay waters (NMFS and USFWS 2008). It is possible that there have been similar shifts in the distribution of sea turtles that have resulted in a decrease in sea turtles in Delaware Bay; however, as noted above, there are no current studies of sea turtles in Delaware Bay on which to base any determinations.

We have considered the potential that the reduction in sea turtle impingements at Salem is related to a reduction in sea turtles associated with a reduction in blue crabs in the Bay (as this relationship has been speculated in the Chesapeake Bay). A review of available stock assessment data for blue crabs in Delaware Bay (Wong 2010) indicates that from 1978-2009, model estimates of annual blue crab abundance have ranged from 31 to 660 million, with a mean and median of 165 and 140 million crabs. The assessments indicate a period of generally low abundance, with numbers beginning to rise after 2002. We considered whether the number of sea turtles in the Bay, and therefore the number of sea turtles impinged at Salem, is influenced by the stock size of blue crabs in a particular year. However, there does not appear to be a correlation between blue crab stock size and the number of sea turtles impinged; in fact, the highest year of sea turtle impingement (1991, with 25 impingements) was one of the years with the lowest number of blue crabs in the Bay (67.8 million). Numbers of blue crabs in the Bay were low in 2002 (88.5 million) and 2008 (66.3 million) and below the mean in all years since 2001. However, high levels of crabs were available in the mid to late 1990s and there were very few impingements during this time period; the stock size was the largest in 1997, a year when no sea turtles were impinged at Salem. Based on this information, there is no apparent relationship between the numbers of blue crabs in the Bay and sea turtle impingement.

The approach velocity at the Salem intakes (0.9 fps) is significantly less than the velocity of local currents within the estuary that may reach speeds of 3.3 to 4.3 feet per second and is within the range of water velocities where sea turtles are likely to forage (less than 2 knots or 3.37 fps). Although sea turtles have been observed swimming against currents stronger than those encountered at the intake, sea turtles tracked in the Long Island sound area seem to take advantage of currents when traveling (Morreale, pers. comm. l990 in NMFS 1999). Passive drifting and the resultant susceptibility to impingement may occur at night, when sea turtles are less active. However, documented discovery times of sea turtles at the Salem intakes did not show a clear temporal pattern, and while many of the noted times coincided with shift changes, early morning recoveries were no more common than recoveries at other times of the day. Therefore, it is not possible to determine if nighttime drifting turtles are more likely to be impinged at the intakes.

As noted above, many of the sea turtles impinged at the facility have been determined to be previously dead or suffering from previously inflicted injuries. Of the 23 turtles (3 loggerheads, 20 Kemp's) recovered from the intakes from 2000- 2022, two loggerheads and eight of the Kemp's collected were moderately to severely decomposed, indicating that death occurred prior to impingement (the trash racks are inspected at least once per 12-hour shift and cleaned multiple times a week). One Kemp's ridley was suffering from a serious head injury that occurred prior to impingement, another was in a state of early decomposition. One Kemp's ridley was discovered floating outside of the CWIS. One loggerhead was retrieved alive during trash rack cleaning and had been apparently foraging along the bottom of the racks and may not have actually been impinged on the rack, but rather captured by the cleaning equipment. This turtle was released apparently unharmed. One Kemp's ridley was removed from the racks dead with no visible signs of injury or trauma. No cause of death was identified in the necropsy (MMSC 2013) and it is assumed to have died prior to impingement. Four of the most recent Kemp's were decomposed and in a condition indicating that death was unlikely to have been related to plant operation.

We have considered whether the operation of Salem attracts sea turtles to the area of the CWS intake trash bars. Information on stomach contents of incidentally captured sea turtles recovered at Salem indicate that many are actively feeding on blue crabs and other common prey species prior to their death. No quantitative diet study has been conducted and species listed under stomach contents on necropsy reports include only those most easily identified. Dead fish and other material returned to the river with the traveling screen wash water may provide food for the turtles or scavenging prey species. The water depth in this area is 7.6 to 9 meters; which is the typical feeding depth for Kemp's ridleys in Long Island sound waters (Morreale, pers comm 1990) and is thought to be within the normal depths for sea turtle foraging in Mid-Atlantic coastal waters. However, even if sea turtles were attracted to the area where impinged material was discharged, the distance between the area where material is discharged, and the intakes makes it unlikely that this would concentrate sea turtles at the intakes. As evidenced by the live capture during rack cleaning, sea turtles may use the racks for opportunistic foraging. Blue crabs, a preferred prey of loggerhead and Kemp's ridley sea turtles, are commonly impinged on the intakes; however, given the size of individual crabs, they do not get stuck on the trash bars, but pass through them and are impinged on the traveling screens. It is possible that sea turtles forage opportunistically in the vicinity of the intakes; however, the facility does not concentrate sea turtle forage items on the trash bars, making it unlikely that sea turtles are attracted to the area for foraging.

No operational changes or changes at the intakes are proposed for the future that are likely to cause a different rate of impingement or capture of sea turtles than has been observed in the past. As noted above, the number of sea turtles in the action area is variable each year depending on environmental factors such as water temperature, weather patterns, and prey availability and this variability is likely to continue.

Over time, there has been a general decrease in the number of sea turtles impinged at the facility (with the exception of 2021 and 2022); this change has likely been largely facilitated by the seasonal removal of ice barriers which we assume allows sea turtles to more readily escape from the intake area. From 1976 - 2022, an annual average of less than 2 loggerheads (average 1.45/year), less than 1 green (average 0.04/year) and less than 1 Kemp's ridley (0.9/year) have been impinged at the facility. Since the beginning of 1993, when the ice barriers were removed during the warmer months when sea turtles are present in the action area, 21 Kemp's ridley, six loggerheads and no green sea turtles have been impinged. Outside of the effects of removing the ice barriers during the warmer months, it is impossible to determine what has caused this reduction in sea turtles at Salem; there have been no operational changes at the facility that would account for this shift. It may be linked to factors affecting these species globally (i.e., outside of the action area) or may be related to a change in distribution of prey species or climate related factors. Up until 2021, the reduction in the number of sea turtles impinged at this facility had been sustained since 1993. It is impossible to determine what caused the increased incidence of Kemp's ridley impingements between June 17, 2021, and September 23, 2022, however, it is reasonable to expect that conditions that resulted in higher rates of impingement are likely to continue through the extended operating period. As stated above, there have been no operational changes and PSEG has not changed its raking practices (i.e., raking once per week in the summer months because there is typically not a lot of debris at this time of the year). Given the different conditions at the facility prior to 1993 (i.e., the year-round ice barrier that is thought to have made it harder for sea turtles to swim away from the intakes), we consider the period between 1993 and 2022 to be the best reasonable predictor of trends in impingement for loggerhead and green sea turtles through the remainder of the license period.

Over time, there has been a general increase in the number of Kemp's ridleys captured at the Salem facility. From 1993-2012, an average of 0.05 Kemp's ridleys were captured at the facility each year, with a total of one Kemp's ridley captured over this 20-year period. From 2013-2022, an average of two Kemp's ridley per year were captured at the facility, with a total of 20 Kemp's ridley over this 10-year time period. There is not enough information about specific conditions in the action area to see if there is a relationship between environmental factors and the high number of Kemp's ridley sea turtles taken at Salem in 2021 and 2022. The increase in the number of Kemp's ridelys may be linked to factors affecting the species globally (i.e., outside of the action area) or may be related to a change in distribution of prey species or climate related factors, such as increased water temperatures. However, as the shift in Kemp's ridley sea turtles observed at Salem has been sustained over at least the last 10 years, it is reasonable to consider the period between 2013 and 2022 to be the best reasonable predictor of trends in impingement for Kemp's ridley sea turtles through the remainder of the license period.

When predicting the number of loggerhead and green sea turtles likely to be impinged at the Salem intakes in the future, we have excluded data prior to 1993. This is because the change in the deployment of the ice barriers resulted in a dramatic change in the impingement rate following the 1992 season. As the seasonal use of the ice barriers will continue in the future, we consider the impingement rate from 1993-2022 to be the best predictor of the likely impingement rate for loggerhead and green sea turtles in the remainder of the extended operating period. As explained above, there has been a general increase in the number of Kemp's ridley sea turtles captured at the facility in the last 10 years. Therefore, we considered if the average impingement rate during 1993-2022 would underestimate future impingement for Kemp's ridleys. The lack of information on the relative health of individuals captured in 2022 and not knowing the degree to which annual environmental fluctuations (e.g., water temperatures, seasonal weather temperature, prey availability) contributed to species shifts makes predictions of future impingement more difficult. We consider the impingement rate from 2013-2022, however, to be the best predictor of the likely impingement rate for Kimp's ridley sea turtles in the remainder of the extended operating period because that period reflects a general increasing trend of captures and includes the two most recent years where higher than average numbers of Kemp's ridleys have been collected. The mean number of Kemp's ridley sea turtles captured or impinged at Salem from January 2013-December 2022 is 2 Kemp's ridleys/year. The mean number of loggerhead and green sea turtles captured or impinged at Salem from January 1993- December 2022 is: 0.2 loggerheads/year, and 0 greens/year.

The impingement rate calculated above is based on the operation of both Salem 1 and Salem 2. Prior to 2013, PSEG did not maintain records to determine from which intakes the turtles had been removed. While that information is available for 2013-2022, we do not have other data necessary to inform an accurate assessment of any differences in impingement rate (i.e., daily operational and water intake data). We also note that there are not any differences in the configuration or locations of the intakes that would suggest that the risk of impingement is greater at one unit than the other. As such, given the available data, it is reasonable to assume that it is equally probable that a turtle would be impinged at the intakes for Unit 1 as it is for Unit 2. As such, it is reasonable to determine that the impingement rate for one unit would be half as for two units. By multiplying the estimated annual impingement rate per unit (1/2 of the average 1993-2022 impingement rate calculated above; 0.1 loggerheads/year and 1 Kemp's ridley/year) and multiplying it by the number of years remaining in the license for each unit (14 for Unit 1 and 18 for Unit 2) we can calculate an estimate of impingement over the remaining term of the licenses. Using this impingement rate (0.1 loggerheads/year per Unit * 14 years) we anticipate that no more than two loggerheads would be impinged at the Salem Unit 1 intakes between now and the expiration of the operating license (i.e., August 2036). The operating license for Salem Unit 2 will expire in April 2040. Using this same impingement rate, we anticipate that no more than two loggerheads (0.1 loggerheads per unit per year * 18 years) would be impinged at the Salem Unit 2 intakes between now and the expiration of the extended operating license. We expect that no more than 14 Kemp's ridley sea turtle will be impinged or captured at Salem 1 (1 Kemp's per unit per year * 14 years) and no more than 18 Kemp's ridleys (1 Kemp's per unit per year * 18 years) will be impinged or captured at Salem 2 over the duration of the operating licenses. Note that in all cases we have rounded up any calculations of fractions of sea turtles to whole individuals.

No green sea turtles have been impinged at Salem since 1992; however, because this species have been impinged at Salem in the past and occurs in the action area, it is possible that greens may be impinged in the future. However, given the low rate of impingement in the past (2 individuals, 1976-2022), we expect that the rate of impingement in the future would be very low. As such, we expect that no more than one green sea turtle will be impinged at Salem 1 or Salem 2 over the remaining duration of the operating licenses.

Based on the observation of sea turtles captured at the facility in the past, it is likely that nearly all of the sea turtles impinged will suffer from some degree of injury, likely abrasions and bruising, due to interactions with the trash bars and/or the trash rake used to clean the bars. However, if rescued alive and without previously inflicted injuries or illness, these injuries are not expected to be life threatening and sea turtles are expected to make a complete recovery with no impact on fitness or future health.

Using information on the number of dead sea turtles of each species captured or impinged at the facility we have calculated a mortality rate for loggerheads (using 1993-2022 impingements of which four of the six loggerheads were dead when removed from the water: 0.67). Necropsy data indicates that approximately 21% of mortalities will be attributable to drowning at the trash racks. As noted above, we expect a total of four loggerheads to be impinged at the Salem trash racks between now and April 2040. Assuming that we will see a similar pattern of mortality in the future (i.e., 67% of loggerheads removed will be dead), we expect no more than three of these turtles will be dead with no more than one (i.e., 21% of 3) of those deaths due to drowning at the trash bars. The other dead loggerhead removed from the intakes is likely to have been killed prior to impingement at the intakes.

Existing monitoring data (1993-2022; 21 Kemp's with 3 alive, 1 with massive pre-impingement head injury that would have been fatal, 1 with severe damage to plastron with exposed internal organs and tissue and presumed to die due to interactions with the trash rake, 10 with evidence of moderate to severe decomposition and presumed to have died at earlier dates, and 6 with no apparent cause of death and presumed to die due to drowning) indicates that 86% of the Kemp's ridleys removed from the intakes will be dead (here, we consider the Kemp's with the head injury to be dead) with 33% of mortalities attributable to drowning at the intakes. We expect the impingement of 32 Kemp's ridleys between now and when the operating licenses expire. Using the past mortality rates, we expect 28 of the 32 turtles to be dead with no more than 10 of those deaths due to impingement at the intakes.

Existing monitoring data indicates that 50% of the green sea turtles removed from the intakes will be dead. However, because the data set is so small (only two impingements, one of which was determined to have died prior to impingement) and we only anticipate one impingement of a green sea turtle prior to expiration of the operating licenses, it is possible that the one green sea turtle will be dead or alive and that the cause of death could be due to impingement at the intakes.

6.3.2 Impingement of Sturgeon – Salem 1 and 2

Below, we consider the available data on the impingement of shortnose and Atlantic sturgeon at Salem 1 and 2 and then consider the likely rates of mortality associated with this impingement. We then use this information to predict the number of individuals of each species likely to be impinged at the intakes over the extended operating period and the amount of mortality associated with these impingements. We consider impingement at the trash bars and on the traveling screens.

Some studies have been carried out to examine the swimming ability of sturgeon and their vulnerability to impingement. Generally speaking, fish swimming ability, and therefore ability to avoid impingement and entrainment, are affected not just by the flow velocity into the intakes, but also fish size and age, water temperature, level of fatigue, ability to remain a head-first orientation into current, and whether the fish is sick or injured. As indicated below, because the intakes at Salem 1 and 2 are fitted with Ristroph screens that also have rotating buckets, in this case, we consider impingement to include not just the trapping of fish against the screens, but also the collection of fish in the rotating buckets.

As noted in Alden 2020, information on the behavior of sturgeon when they encounter water intakes is limited. Several laboratory studies have investigated entrainment and/or bypass use of juveniles but observed behaviors in test flumes may not be representative of wild fish in the field. Additionally, most laboratory studies have been conducted with underyearling or yearling fish, which are not often encountered at the Salem intakes.

As reported in Alden 2020, Reading (1982) evaluated impingement and entrainment of White Sturgeon larvae and juveniles (17 to 63 mm in length) with varying screen opening sizes (4.0 mm diameter perf plate and 2.4 mm wedgewire) and approach velocities (0.2, 0.4, and 0.6 ft/s). Impingement occurred for 20% of sturgeon at an approach velocity of 0.2 ft/s and total impingement occurred within 5 minutes at a velocity 0.6 ft/s. Another study found approach velocities ranging from 0.6 to 1.2 ft/s resulted in 16.8% of juvenile Green Sturgeon (average 28 cm FL) and 1.6% of White Sturgeon (average 27 cm FL) being impinged (Poletto *et al.* 2014a). Overall, fish were found to make more contacts with the screen during the day than the night. However, this differed slightly between species as White Sturgeon were found to have more contacts during the night. Green Sturgeon were found to spend 34.8% of the experimental period near the screens compared to only 18.7% by White Sturgeon.

Evaluations of bar racks and louvers have provided some behavioral information for several sturgeon species, including Shortnose, Lake, White, and Pallid Sturgeon (EPRI 2000; Kynard and Horgan 2001; Amaral *et al.* 2002; Kynard *et al.* 2005, 2006; Alden 2009, 2010). Most of these studies have been conducted in laboratory flumes, with one evaluation conducted at a field site. The flume studies indicate juvenile and sub-adult sturgeon will typically stay near the bottom and exhibit positive rheotaxis as they move downstream towards a bar rack angled or perpendicular to the flow at channel velocities of about 1 to 3 ft/s. When encountering these structures some sturgeon will rise in the water column, but generally will remain in the lower half of the water column. Radio telemetry tracking of juvenile Shortnose Sturgeon approaching and interacting with the angled louver array in the Holyoke canal also provided evidence of fish moving up and down in the water column as they moved downstream along the structure. Observations from these studies indicate that most sturgeon likely approach water intakes near the bottom but may begin to search or explore vertically when they encounter bar racks or other types of intake screening.

Kynard *et al.* (2005) conducted tests in an experimental flume of behavior, impingement, and entrainment of yearlings (minimum size tested 280mm FL, 324mm TL), juveniles (minimum size tested 516mm FL, 581mm TL) and adult shortnose sturgeon (minimum size tested 600mmFL, 700mm TL). Impingement and entrainment were tested in relation to a vertical bar rack with 2 inch clear spacing. The authors observed that after yearlings contacted the bar rack, they could control swimming at 1 and 2 feet/sec, but many could not control swimming at 3 feet/sec velocity. After juveniles or adults contacted the rack, they were able to control swimming and move along the rack at all three velocities. During these tests, no adults or juveniles were impinged or entrained at any approach velocity. No yearlings were impinged at velocities of 1 ft/sec, but 7.7-12.5% were impinged at 2 ft/sec, and 33.3-40.0% were impinged at 3 ft/sec. The range of entrainment of yearlings (measured as passage through the rack) during trials at 1, 2, and 3 ft/sec approach velocities follow: 4.3-9.1% at 1 ft/sec, 7.1-27.8% at 2 ft/sec, and 66.7-80.0% at 3 ft/sec. From this study, we can conclude that shortnose sturgeon that are yearlings and older (at least 280mm FL) would have sufficient swimming ability to avoid impingement at an intake with velocities of 1 fps or less, as long as conditions are similar to those in the study (e.g., fish are healthy and no other environmental factors in the field, such as heat stress, pollution, and/or disease, operate to adversely affect their swimming ability).

In addition to behavior, which would primarily be influenced by hydraulic cues as fish approach an intake, sturgeon swimming capability is another important aspect of avoiding entrainment and impingement at water intakes. The swimming capabilities of sturgeon have been evaluated for multiple species and life stages. Maximum sustained and critical swim speed estimates range from 2.1 to 18 cm/s (0.07 to 0.60 ft/s) for larvae and 15 to 172 cm/s (0.5 to 5.6 ft/s) for juveniles, with increasing speeds for larger sub-adults and adults (Table 2). Although not evaluated, Atlantic Sturgeon would be expected to have similar swimming speeds as those reported for other species.

The swimming speed that causes juvenile shortnose sturgeon to experience fatigue was investigated by Deslauriers and Kieffer (2012). Juvenile shortnose sturgeon (19.5 cm average total length) were exposed to increasing current velocities in a flume to determine the velocity that caused fatigue. Fish were acclimated for 30 minutes to a current velocity of 5 cm/sec (0.16 fps). Current velocities in the flume then were increased by 5 cm/sec increments for 30 minutes per increment until fish exhibited fatigue. Fish were considered fatigued when they were impinged on the down-stream plastic screen for a period of 5 seconds (Deslauriers and Kieffer 2012).

The current velocity that induced fatigue was reported as the critical swimming speed (“U_{crit}”) under the assumption that the fish swam at the same speed as the current. The effect of water temperature on U_{crit} for juvenile shortnose sturgeon was determined by repeating the experiment at five water temperatures: 5°C, 10°C, 15°C, 20°C and 25°C. Shortnose sturgeon in this study swam at a maximum of 2.7 body lengths/second (BL/s) at velocities of 45 cm/s (1.47 fps). In this study, the authors developed a prediction equation to describe the relationship between U^{crit} and water temperature. The authors report that amongst North American sturgeon species, only the pallid and shovelnose sturgeon have higher documented U_{crit} values (in BL/s) than shortnose sturgeon at any given temperature.

Boysen and Hoover (2009) conducted swimming performance trials in a laboratory swim tunnel with hatchery-reared juvenile white sturgeon to evaluate entrainment risk in cutterhead dredges. The authors observed that 80% of individuals tested, regardless of size (80-100mm TL) were strongly rheotactic (i.e., they were oriented into the current), but that endurance was highly variable. Small juveniles (< 82 mm TL) had lower escape speeds (< 40 cm/s (1.31fps)) than medium (82–92 mm TL) and large (> 93 mm TL) fish (42–45 cm/s (1.47 fps)). The authors concluded that the probability of entrainment of juvenile white sturgeon could be minimized by maintaining dredge head flow fields at less than 45 cm/s (1.47 fps).

Hoover *et al.* (2011) used a Blazka-type swim tunnel, to quantify positive rheotaxis (head-first orientation into flowing water), endurance (time to fatigue), and behavior (method of movement) of juvenile sturgeon in water velocities ranging from 10 to 90 cm/s (0.3-3.0 fps). The authors tested lake and pallid sturgeon from two different populations in the U.S. Rheotaxis, endurance, and behavioral data were used to calculate an index of entrainment risk, ranging from 0 (unlikely) to 1.00 (inevitable), which was applied to hydraulic models of dredge flow fields. The authors concluded that at distances from the draghead where velocity had decreased to 40cm/s (1.31 fps) entrainment was unlikely.

6.3.2.1 Impingement of Shortnose sturgeon
Between 1977 and the 2022, 48 shortnose sturgeon were removed from the Salem intakes (see Table 6). All of these fish have been observed at the trash racks. No shortnose sturgeon have been observed during impingement monitoring at the traveling screens. This is consistent with our expectation that shortnose sturgeon small enough to pass through the trash rack bars are unlikely to occur in the action area as they remain further upstream in the Delaware River.

Fish that are narrower than 3-inches can pass through the trash bars. Fish wider than 3-inches would be impinged on the trash racks if they were not able to swim away. Once inside the trash racks, fish that do not swim back out through the racks into the river would be impinged at the screens in front of the intakes or captured in the moving buckets that are part of the Ristroph screens. Information on length-width relationships for sturgeon indicates that sturgeon longer than 85cm would be excluded from a 4-inch opening (UMaine, unpublished data). While we do not have information on the body lengths that would have widths sufficiently large to prevent passage through a 3-inch opening, because fish get wider as they get longer, we expect that the length of fish that could possibly pass through a 3-inch opening would be smaller than 85 cm. Assuming that length and width are proportional, we can estimate that fish longer than 64 cm (approximately 25”) would be too wide to pass through a 3” opening. Body lengths of the 42 (out of 48) impinged shortnose sturgeon for which length data is available ranged from 63-152cm, with an average length of approximately 81cm.

6.3.2.1.1 Impingement of shortnose sturgeon at the trash racks
If through-rack velocity at the trash racks in front of Salem 1 and 2 is 1.0 fps, as reported by PSEG, and assuming the condition of the fish and environmental factors in the river are similar to those in the laboratory studies previously discussed, we would not anticipate any impingement of healthy, unimpaired shortnose sturgeon at the trash racks. This is because sturgeon that are big enough to not be able to pass through the racks (i.e., those that have body widths greater than three inches) would be large enough to have sufficient swimming ability to avoid impingement. If their swimming ability is not compromised, these fish should be able to avoid impingement at velocities of up to 3 feet per second and should be able to readily avoid getting stuck on the trash racks. Based on these lab studies, the only impingement at the trash racks that we would anticipate is adult or large juvenile shortnose sturgeon that are dead, injured, or otherwise impaired in a way that makes them unable to avoid the current caused by the facility’s water intake and swim away from the trash racks.

Table 8. Shortnose sturgeon removed from the Salem trash bars, 1976-2022.

Date	Length (total, mm)	Length (FL, mm)	Condition	Unit
1/12/1978	645	545	dead – decomposing	
6/26/1978	725	625	alive, then died	

5/1/1981	658	648	dead; decomposing; fish seen floating in area previous day	
10/22/1991	802	720	dead	
10/28/1991	828	743	Dead	
11/6/1991	782	668	alive, then died; impinged near top of rack, partially exposed to air as tide went out	
11/2/1992	840	745	dead; signs of decomp	
11/16/1992	824	720	Dead	
5/19/1994	820	720	dead - signs of decomposition; significant injuries present	
5/20/1994	800	708	appeared fresh dead	
5/6/1998	~610		Alive	
5/14/1998	855	775	Alive	
5/16/1998		639	dead	
3/31/1999	630	590	Alive	
4/18/2000	850	760	dead - 3 large existing wounds	
4/9/2003	800	about 690	removed alive then died; had severe wound near tail	
10/1/2004	737	646	removed alive then died	
11/28/2007	674		dead – decomposing	
7/31/2008	508 but back of fish missing		dead – decomposing	
3/21/2011	831		dead, decomp, injuries	
9/9/2011	715	615	dead, decomp, injuries	
1/12/2013	787	685	Alive	
1/14/2013	776	686	moderately decomposed	
2/11/2013	871	802	Alive	
7/28/2013	835	758	Alive but died shortly after	
3/13/2014	889	946	Dead – severely decomposed	
3/20/2014	673	635	Alive-older healed injuries	
4/15/2014	889	-	Alive	
11/21/2014	836	722	Alive-minor injuries	Unit 1
12/10/2014	771	708	Alive	Unit 1
12/10/2014	760	667	Dead – moderately decomposed	Unit 1
12/11/2015	831	738	dead – fresh	Unit 1
5/12/2017	770	731	Dead –moderately decomposed	Unit 1
5/12/2017	720	635	Dead – moderately decomposed	Unit 1
12/19/2017	806	700	Alive – minor injuries	Unit 2

1/16/2018	~889	-	Alive – healthy but cold shocked		Unit 1
1/30/2018	832	727	Alive – minor injuries		Unit 1
2/6/2018	723	635	Dead – moderately decomposed		Unit 2
1/18/2019	710	620	Alive –minor injuries		Unit 1
2/28/2019	872	764	Alive – injuries		Unit 1
3/27/2020	1524	1346	Dead – fresh		Unit 1
4/24/2020	927	826	Dead –fresh		Unit 1
11/13/2020	844	749	Dead- moderately decomposed		Unit 2
1/8/2021	840	743	Alive - injuries		Unit 1
3/10/2021	705	610	Dead - fresh		
4/22/2021	-	-	Dead – moderately decomposed		Unit 2
12/2/2021	1061	914	Dead – moderately decomposed		Unit 1
12/28/2021	-	-	Dead – severely decomposed		Unit 1
TOTAL	**48**		**Total Dead: 33 (18 determined dead prior to impingement)**	**Total alive: 15**	

Of the 48 shortnose sturgeon removed from the Salem trash bars (see Table 6), eight were alive with no apparent injuries or indications of stress or disease. Given the size of these fish (greater than 64cm) and their condition (healthy), it is likely that they were close enough to the trash racks to be captured by the traveling rake during cleaning and were not actually stuck to the rack. Another seven shortnose sturgeon were alive with minor injuries or indications of stress or disease when they were removed from the Salem trash bars. Several of these minor injuries consisted of minor abrasions on the stomachs or sides of the fish. One of these fish was described as “cold-shocked” which would have affected its swimming ability. Shortnose sturgeon are known to successfully overwinter in the Delaware River, thus it is unlikely that cold temperatures impaired its movements. It is possible it had some other impairment that was not recorded.

Five shortnose sturgeon have been removed from the intakes alive but quickly died. One of these fish was suffering from a major injury (large gash in front of tail) which would have affected its swimming ability. Another one of these fish was impinged near the top of the rack and as the tide went out and was partially exposed to the air; while alive when removed from the water, it died shortly after, likely due to a lack of air during its time out of the water. No additional information is available on the cause of death for the other three sturgeon that died after removal from the water; no cause of death has been identified, we assume that impingement and capture was a cause or contributor to their death.

Twenty-eight sturgeon were dead upon removal from the intakes. Eighteen of these fish were at least moderately decomposed. Given the frequency of rack cleaning, it was determined that these fish died prior to impingement. One of the dead fish had major traumatic injuries of an unknown cause and it was determined to have died as a result of these injuries prior to impingement. The records available for the remaining 10 impingements do not note any signs of decomposition or existing injury. However, we do not know if that is because these conditions were not present or because they were just not recorded.

In summary, seventeen-percent (8 of 48) of the shortnose sturgeon removed from the Salem trash bars were alive and apparently uninjured; based on the available information, it is likely that these individuals were not impinged on the rack but were close enough to it to be captured by the automated trash rake. Fifteen-percent (7 of 48) of the shortnose sturgeon removed from the Salem trash bars were alive but showed signs of minor injuries or stress. The remaining 69% (33 of 48) were dead or dying. Of the dead or dying fish, 55% (18 of 33) had injuries or levels of decomposition that indicated they were dead prior to impingement. While we cannot rule out the possibility that at least some of the remaining fifteen shortnose sturgeon were killed prior to impingement, the available information does not allow us to make any conclusions regarding the cause of death of these fish. Therefore, we have made the assumption that the cause of death for the remaining fish may have been impingement or that impingement was at least a factor in the death (this seems to be the case for at least the five fish that died after removal from the trash bars). Therefore, we estimate that for approximately 45% of the shortnose sturgeon (18 of 33 fish) removed from the intakes impingement was a factor in their death.

Predicted Future Impingement of Shortnose sturgeon – Trash Racks

From 1976 - 2022, an average of one shortnose sturgeon per year has been removed from the Salem trash racks (average of 1.02/year). Prior to 1993, the impingement rate was 0.47 fish/year (8 in 17 years). The rate for 1993-2022 was 1.33 fish/year (40 in 30 years). We have considered whether the seasonal removal of the ice barriers (beginning in 1993) would have affected the likelihood of impingement of shortnose sturgeon. In previous Opinions, we concluded that because the ice barriers are present near the water surface and because shortnose sturgeon are benthic fish that remain below the water, the ice barriers were not likely to affect shortnose sturgeon. However, a report commissioned by PSEG in 2020 (Alden 2020) suggests that the ice barriers may make it more difficult for sturgeon to move away from the intakes when the trash rake is operating. In that case, the reduced period of time per year that the ice barriers were deployed post-1993 would have been more likely to reduce impingement rates rather than increase them. Based on the available information, the change in ice barrier deployment is not likely to have contributed to the apparent change in the frequency of sturgeon removal from the trash racks. We considered whether this change in impingement rate is reflective of a change in the number of shortnose sturgeon in the Delaware River population. However, the size of the Delaware River population has been stable at approximately 12,000 adults since 1981; this determination is based on a comparison of population estimates generated from maruk-recapture data collected in 1981-1984 and again in 1999-2003. Because of this, it may be that the apparent "change" in the impingement rate from 1976-1992 compared to 1993- 2022 is an artifact of the low number of impingements and annual variability. For example, in the 47 years of monitoring, interactions have been recorded in only 21 years with the number of interactions ranging from 1 to 6 in those years. It is possible that environmental factors, potentially a combination of water temperature and salinity and/or prey distribution, affect the distribution of shortnose sturgeon in the action area and as these environmental conditions vary annually, the distribution of shortnose sturgeon in the action area varies. Available information indicates that as water quality improved in the Philadelphia area of the Delaware River in the late 1970s and into the 1980s, shortnose sturgeon became more common downstream of Philadelphia. This may explain why the impingement rate is higher from 1991- 2022 (45 shortnose sturgeon in 32 years; average 1.4/year) compared to 1976-1990 (3 shortnose sturgeon in 15 years; average 0.2/year). Based on the available information, the impingement rate for 1991- 2022 (approximately 2 shortnose sturgeon/year) appears to be the best predictor of future impingement. Because the Delaware River population of shortnose sturgeon has been stable since 1981 and we expect that stable trend to continue and as there are no proposed changes to project operations, we expect that impingement will occur in the future at the same rate it has since 1991. We also expect the number of shortnose impinged annually to continue to be variable; based on past impingements, we expect an annual range of 0-6 shortnose sturgeon impinged per year.

Under the terms of the renewed operating license, Salem Unit 1 will continue to operate from now through August 2036, a period of 14 years. The impingement rate calculated above (2 shortnose sturgeon/year) is based on the operation of both Salem 1 and Salem 2. Prior to 2015, records had not been maintained to determine which intakes the impinged shortnose sturgeon had been removed from. Based on the available information, approximately 88% (15 of 17 fish) of shortnose sturgeon impinged from 2015 to 2022 were removed from intakes for Unit 1. One of the seventeen sturgeon was removed from intakes from Unit 2. Location data was not available for one of the sturgeon collected since 2015. Despite records now being maintained to determine which intakes the impinged sturgeon have been removed from, we still do not have sufficient information to predict impingement rates at the individual units. This is due to the small number of impingements that have occurred since location has been recorded as well as the lack of analysis on operating conditions; this information would be necessary to determine if any apparent difference in impingement rate was "real" or an artifact of different operating schedules. As such, and given the adjacent locations of the intakes, and the lack of information indicating that impingement would be more or less likely at one unit than that other, we assume that it is equally probable that a fish would be impinged at the intakes for Unit 1 as it is for Unit 2. Therefore, it is reasonable to determine that the impingement rate for one unit would be half that as for two units. Using this impingement rate, (1 fish/unit/year) it is likely that no more than 14 shortnose sturgeon would be impinged at the Salem Unit 1 intakes between now and the expiration of the extended operating license (i.e., August 2036). The extended operating license for Salem Unit 2 will expire in April 2040. Using this same impingement rate and considering an operational period of 18 years, it is likely that no more than 18 shortnose sturgeon would be impinged at the Salem Unit 2 intakes between now and the expiration of the extended operating license.

Long-term mortality data (1976- 2022) indicate that approximately 69% of the shortnose sturgeon removed from the intakes will be dead or dying and that 45% of these mortalities may be attributable to impingement at the trash racks. As noted above, we expect a total of 14 shortnose sturgeon to be impinged at the Salem 1 trash racks between now and license expiration in 2036. We expect 10 of these shortnose sturgeon to be dead with five of those deaths due to impingement at the trash bars. At Salem 2, we expect the impingement of 18 shortnose sturgeon prior to license expiration in 2040. We expect 13 of those sturgeon to be dead, with six of those deaths due to impingement at the trash bars. The remaining dead shortnose sturgeon are likely to have been killed prior to impingement at the intakes.

6.3.2.1.2 Impingement of Shortnose sturgeon – Traveling Screens

As explained above, because of the salinity levels in the action area, it is unlikely that any yearling (young of the year) or small juvenile shortnose sturgeon will be present in the action area. Shortnose sturgeon adults and large juveniles that are likely to occur in the action area are too wide to pass through the bars. Based on the size of shortnose sturgeon in the action area, we do not anticipate that any shortnose sturgeon would be small enough to pass between the trash bars. Therefore, we do not anticipate any impingement of shortnose sturgeon the traveling screens. To date, no shortnose sturgeon have been observed during any impingement monitoring conducted at the Salem traveling screens which has been ongoing since 1976.

6.3.2.2 Impingement of Atlantic sturgeon

Prior to the proposed ESA listing of Atlantic sturgeon published in February 2011, PSEG did not record or report the impingement of Atlantic sturgeon at the trash racks. However, any incidence of Atlantic sturgeon observed during impingement monitoring at the traveling screens was recorded. To date, nine Atlantic sturgeon have been observed during impingement monitoring at the traveling screens; one each in 2006, 2007, 2011, 2013 (Strait, PSEG, Personal Communication 2014), 2017, 2018, and 2022, and two in 2019 (NRC 2020). From February 2011 through 2022, 190 Atlantic sturgeon were removed from the trash bars (see Table 7).

Table 9. Impingement of Atlantic sturgeon at the Salem trash bars February 2011–2022.

Date Found	Length	Condition	Unit
3/18/2011	NA	Live	Unit 1
4/20/2011	NA	Live	Unit 1
4/24/2011	NA	Live	Unit 1
9/7/2011	180mm TL	Live	Unit 1
11/14/2012	425mm FL; 485mm TL	Dead; no signs of injury or decomposition	Unit 1
11/30/2012	522mm FL; 593mm TL	Live; abrasions on fins and scutes	Unit 1
1/16/2013	446mm FL; 522mm TL	Live	Unit 1
2/11/2013	542mm FL; 643mm TL	Live; minor injuries near tail that were beginning to heal	Unit 2
2/19/2013	665mm FL; >760mm TL	Live; minor abrasions	Unit 1
3/13/2013	406mm FL; 446mm TL	Live	Unit 1
3/15/2013	473mm FL; 546mm TL	Live	Unit 1
3/18/2013	449mm FL; 518mm TL	Live	Unit 1
3/20/2013	660mm FL; 742mm TL	Live; injured - large abrasion in front of tail	Unit 1

3/25/2013	677mm FL; 784mm TL	Live; injured - large, deep gash in front of tail	Unit 1
4/3/2013	666mm FL; 773mm TL	Dead; large, deep gash in front of tail. Signs of decomposition. Possibly the same fish observed on March 20 and 25	Unit 1
8/7/2013	910mm FL; 1067mm TL	Dead; DENRC confirmed died prior to impingement	Unit 1
10/28/2013	611mm FL; 713mm TL	Dead. Extensive decomposition. Determined to have died prior to impingement	Unit 1
10/28/2013	NA	Dead. Extensive decomposition. Determined to have died prior to impingement.	Unit 1
12/13/2013	570mm TL	Live	Unit 2
12/20/2013	570mm TL	Live	Unit 1
12/26/2013	625mm FL; 732mm TL	Live	Unit 1
12/26/2013	548mm FL; 621mm TL	Dead – fresh; no signs of injury or decomposition	Unit 2
12/26/2013	1900mm FL; 2100mm TL	Live	Unit 2
12/27/2013	595mm FL; 679mm TL	Dead-partly decomposed; DENRC confirmed died prior to impingement	Unit 2
1/6/2014	523mm FL; 611mm TL	Dead – fresh	Unit 1
1/8/2014	535mm FL; 622mm TL	Live/injured	Unit 2
1/27/2014	647.7mm TL	Live	Unit 2
1/27/2014	660.4mm TL	Live/injured	Unit 2
2/12/2014	605mm FL; 702mm TL	Live/injured	Unit 2
2/19/2014	580mm FL; 684mm TL	Dead	Unit 1
2/20/2014	591mm FL; 664mm TL	Dead	Unit 1
3/27/2014	584mm FL; 672mm TL	Live	Unit 2
3/31/2014	664mm FL; 770mm TL	Live	Unit 1
4/3/2014	540mm FL; 630mm TL	Live/injured	Unit 2
4/7/2014	609mm FL; 702mm TL	Dead	Unit 1
4/7/2014	611mm FL; 702mm TL	Live	Unit 1
4/7/2014	590mm FL; 676mm TL	Live	Unit 1

4/9/2014	606mm FL; 693mm TL	Dead- slightly decomposed; Determined to have died prior to impingement.	Unit 1
4/18/2014	590mm FL; 673mm TL	Dead- moderately decomposed; Determined to have died prior to impingement.	Unit 1
8/5/2014	~760mm	Dead- head and tail portions missing; minor decomposition; Determined to have died prior to impingement.	Unit 1
12/22/2014	610mm FL; 701mm TL	Dead- moderately decomposed; Determined to have died prior to impingement.	Unit 1
3/25/2015	737mm FL; 813mm TL	Live	Unit 1
11/24/2015	641mm FL; 746mm TL	Dead- fresh, small laceration	Unit 1
12/4/2015	532mm FL; 615mm TL	Live	Unit 1
12/18/2015	526mm FL; 619mm TL	Live	Unit 1
1/21/2016	562mm FL; 653mm TL	Live	Unit 1
1/26/2016	454mm FL; 531mm TL	Dead	Unit 1
2/2/2016	927mm FL; 1060 mm TL	Live	Unit 1
2/2/2016	224mm FL; 248mm TL	Live	Unit 1
2/2/2016	551mm FL; 642mm TL	Live	Unit 1
3/23/2016		Live, but later died from injuries	Unit 1
3/23/2016	~620mm FL; ~710mm TL	Dead- fresh, tail portion missing	Unit 1
4/8/2016	210 mm FM; 213 mm TL	Dead	Unit 2
5/26/2016	844mm FL; 984mm TL	Dead- moderate decomposition; Determined to have died prior to impingement.	Unit 2
12/9/2016	560mm FL; 647mm TL	Live	Unit 2
12/30/2016	620mm FL; 727mm TL	Live	Unit 2
2/23/2017	831mm FL; 940mm TL	Dead	Unit 2
2/23/2017	NA	Dead	Unit 2
5/12/2017	675mm FL; 740mm TL	Dead- severely decomposed; Determined to have died prior to impingement.	Unit 1

5/12/2017	NA	Dead- severely decomposed; Determined to have died prior to impingement.	Unit 1
3/14/2018	682mm FL; 810mm TL	Live	Unit 1
3/28/2018	NA	Dead	Unit 1
4/11/2018	763mm FL; 834mm TL	Live	Unit 2
4/11/2018	675mm FL; 780mm TL	Dead/fresh	Unit 1
11/4/2018	486mm FL; 570mm TL	Dead/fresh	Unit 1
11/13/2018	713mm FL; 851mm TL	Dead/fresh	Unit 1
11/20/2018	764mm FL; 863mm TL	Dead/fresh	Unit 1
11/20/2018	813mm FL; 104mm TL	Dead	
11/29/2018	621mm FL; 723mm TL	Dead	Unit 1
12/1/2018	630mm FL; 738 mm TL	Dead	Unit 2
12/24/2018	835mm FL; 935mm TL	Dead – severely decomposed; DENRC confirmed that this was a fish that had been collected alive but severely injured on 11-20-18	Unit 1
1/1/2019	623mm FL; 686mm TL	Dead – fresh	Unit 1
1/7/2019	616mm FL, 720mm TL	Dead – fresh	Unit 2
1/18/2019	NA	Dead – fresh	Unit 1
2/7/2019	609mm FL; 709mm TL	Dead- moderately decomposed; Determined to have died prior to impingement.	Unit 1
2/15/2019	542mm FL; 638mm TL	Dead- dried carcass	Unit 1
2/19/2019	690mm FL; 701mm TL	Dead	Unit 2
3/8/2019	630mm FL; 741mm TL	Live	Unit 1
3/8/2019	543mm FL; 630mm TL	Live/injured – small laceration	Unit 1
3/18/2019	710mm FL; 815mm TL	Live	Unit 1
4/1/2019	706mm FL; 789mm TL	Live/injured – severe laceration to dorsal fin, minor laceration along dorsal scutes	Unit 1
4/2/2019	550mm FL; 685mm TL	Live	Unit 1
4/15/2019	768mm FL; 895mm TL	Dead/fresh – severe laceration	Unit 2

4/23/2019	730mm FL; 965mm TL	Live, but later died from injuries	Unit 2
12/11/2019	NA; 665mm TL	Dead- moderately decomposed; Determined to have died prior to impingement.	Unit 1
12/13/2019	610mm FL; 714mm TL	Dead – moderately decomposed; Determined to have died prior to impingement.	Unit 1
12/13/2019	578mm FL;670mm TL	Dead/fresh- large laceration mid-torso	Unit 1
12/13/2019	620mm FL; 718mm TL	Dead/fresh – large laceration posterior pectoral fin	Unit 2
12/13/2019	740mm FL; 863mm TL	Dead – moderately decomposed; no wounds or damage; Determined to have died prior to impingement.	Unit 2
12/17/2019	597mm FL; 686mm TL	Dead/fresh – large deep laceration on torso	Unit 1
12/27/2019	710mm FL; 805mm TL	Live	Unit 2
12/27/2019	630mm FL; 727mm TL	Dead/fresh – large laceration near head and minor bruising	Unit 2
12/30/2019	632mm FL; 720mm TL	Dead/fresh – minor skin laceration posterior to dorsal fin, minor bruising	Unit 1
1/17/2020	580mm FL; 660mm TL	Live	Unit 2
1/24/2020	439mm FL; 507mm TL	Dead/fresh – two large flesh wounds	Unit 2
1/31/2020	1048mm FL; 1188mm TL	Live, but later died from injuries	Unit 1
3/14/2020	680mm FL; 800mm TL	Dead	Unit 2
3/16/2020	838mm FL; 952mm TL	Live	Unit 2
3/16/2020	NA	Dead – caudal fin missing	Unit 2
3/16/2020	609mm FL; 686mm TL	Live	Unit 2
3/24/2020	705mm FL; 775mm TL	Dead – minor bruising, small laceration or puncture	Unit 2
3/24/2020	686mm FL; 787mm TL	Dead – two large lacerations	Unit 2
3/24/2020	647mm FL; 737mm TL	Dead – fresh bruising	Unit 2
3/24/2020	660mm FL; 749mm TL	Dead – fresh bruising	Unit 1
3/28/2020	692mm FL; 806mm TL	Live/injuries	Unit 1
3/28/2020	787mm FL; 870mm TL	Live	Unit 1
4/2/2020	700mm FL, 810mm TL	Live	Unit 1

4/2/2020	730mm FL, 826mm TL	Live	Unit 1
4/2/2020	736mm FL, 825mm TL	Live	Unit 1
4/2/2020	571mm FL, 653mm TL	Live	Unit 1
4/2/2020	580mm FL, 670mm TL	Live	Unit 2
4/2/2020	770mm FL, 870mm TL	Live	Unit 2
4/2/2020	650mm FL, 751mm TL	Live	Unit 2
4/2/2020	NA	Dead	Unit 1
4/2/2020	744mm FL, 840mm TL	Dead	Unit 1
4/2/2020	617mm FL, 704mm TL	Dead	Unit 2
4/2/2020	680mm FL, 772mm TL	Dead	Unit 2
4/2/2020	591mm FL, 650mm TL	Dead	Unit 2
4/2/2020	577mm FL, 680mm TL	Dead	Unit 2
4/2/2020	650mm FL, 744mm TL	Dead	Unit 2
4/2/2020	604mm FL, 696mm TL	Dead	Unit 2
4/2/2020	720mm FL, 825mm TL	Dead	Unit 2
4/2/2020	730mm FL, 840mm TL	Dead	Unit 2
4/2/2020	595mm FL, 680mm TL	Dead	Unit 2
4/2/2020	820mm FL, 942mm TL	Live	Unit 2
4/2/2020	770mm FL, 853mm TL	Live	Unit 2
4/2/2020	710mm FL, 820mm TL	Live	Unit 2
4/2/2020	740mm FL, 860mm TL	Live	Unit 2
4/2/2020	670mm FL, 762mm TL	Live	Unit 2
4/2/2020	660mm FL, 693mm TL	Live	Unit 2
4/2/2020	820mm FL, 924mm TL	Live	Unit 2
4/10/2020	833mm FL; 962mm TL	Dead – moderately decomposed; Determined to have died prior to impingement.	Unit 2
4/10/2020	589mm FL; 680mm TL	Dead – moderately decomposed; Determined to have died prior to impingement.	Unit 1
4/10/2020	706mm FL; 830mm TL	Dead – moderately decomposed; Determined to have died prior to	Unit 1

		impingement.	
4/21/2020	730mm FL; 813mm TL	Dead	Unit 1
4/21/2020	654mm FL; 730mm TL	Dead	Unit 1
4/24/2020	622mm FL; 699mm TL	Dead/fresh – two small lacerations	Unit 1
4/24/2020	591mm FL; 699mm TL	Dead - moderately decomposed; Determined to have died prior to impingement.	Unit 1
4/24/2020	552mm FL; 610mm TL	Dead – severely decomposed; Determined to have died prior to impingement.	Unit 1
5/13/2020	1136mm FL; 1290mm TL	Live	Unit 1
5/13/2020	641mm FL; 698mm TL	Live	Unit 1
6/9/2020	604mm FL; 684 TL	Live	Unit 1
7/8/2020	650mm FL; 740mm TL	Dead/fresh – severe laceration above head and moderate abrasions	Unit 1
7/13/2020	450mm FL; 518mm TL	Dead - moderately decomposed; missing head. Determined to have died prior to impingement.	Unit 1
7/21/2020	609mm FL; 699mm TL	Dead - moderately decomposed; Determined to have died prior to impingement.	Unit 1
9/15/2020	670mm FL; 720mm TL	Dead – moderately decomposed	Unit 2
11/13/2020	698mm FL; 838mm TL	Dead – fresh	Unit 2
1/8/2021	572mm FL; 662mm TL	Live	Unit 2
1/8/2021	806mm FL; 900mm TL	Dead/fresh - surface bruising, abrasions, and a deep laceration on torso	Unit 2
1/13/2021	650mm FL; 740mm TL	Dead/fresh – shallow puncture wound on torso	Unit 1
1/13/2021	635mm FL; 750mm TL	Dead – moderately decomposed	Unit 2
1/13/2021	724mm FL; 825mm TL	Dead/fresh – punctured eye, minor bruising	Unit 2
1/28/2021	460mm FL; 504mm TL	Dead – moderately decomposed	Unit 2
3/10/2021	648mm FL; 716mm TL	Dead – dried carcass	Unit 1
3/19/2021	1440mm FL; 1710mm TL	Live – severe injuries	Unit 1
3/23/2021	717mm FL; 854mm TL	Live – minor injuries	Unit 1

3/23/2021	724mm FL; 826mm TL	Dead – moderately decomposed	Unit 1
3/23/2021	565mm FL; 699mm TL	Dead/fresh	Unit 1
3/24/2021	762mm FL; 876mm TL	Dead/fresh – minor injuries	Unit 2
3/25/2021	750mm FL; 840mm TL	Live – minor injuries	Unit 1
4/6/2021	762mm FL; 863mm TL	Dead/fresh – severe laceration on torso	Unit 1
4/6/2021	673mm FL; 787mm TL	Dead/fresh – severe laceration on torso	Unit 2
4/6/2021	711mm FL; 838mm TL	Live – small puncture wound on torso	Unit 2
4/6/2021	724mm FL; 838mm TL	Live	Unit 2
4/6/2021	670mm FL; 777mm TL	Live – minor injuries, punction wounds and minor bruising	Unit 2
4/6/2021	665mm FL; 795mm TL	Dead/fresh – severe laceration on torso	Unit 2
4/8/2021	707mm FL; 813mm TL	Live – minor bruising on torso	Unit 1
4/13/2021	889mm FL; 1016mm TL	Dead/fresh – severe laceration	Unit 1
4/13/2021	762mm FL; 864mm TL	Live	Unit 2
4/15/2021	762mm FL; 812mm TL	Dead/fresh – moderate injuries (same specimen collected live two days earlier)	Unit 1
4/15/2021	685mm FL; 787mm TL	Live – minor bruising	Unit 1
4/22/2021	1422mm FL; 1613mm TL	Dead – severely decomposed	Unit 2
5/6/2021	638mm FL; 723mm TL	Dead/fresh – minor bruising	Unit 1
5/14/2021	656mm FL; 744mm TL	Dead – moderately decomposed	Unit 1
5/14/ 2021	NA	Dead – severely decomposed	Unit 1
6/3/2021	546mm FL; 648mm TL	Dead – moderately decomposed	Unit 1
6/8/2021	591mm FL; 686mm TL	Dead – moderately decomposed	Unit 1
6/15/2021	NA	Dead – moderately decomposed, missing caudal fin	Unit 2
6/24/2021	711mm FL; 813mm TL	Dead/fresh – severe injuries	Unit 1
7/20/2021	711mm FL; 787mm TL	Dead – moderately decomposed	Unit 2
7/27/2021	495mm FL; 597mm TL	Dead - moderately decomposed	Unit 1
9/7/2021	685mm FL; 787mm TL	Dead/fresh – minor bruising	Unit 1

10/4/2021	750mm FL; 876mm TL	Dead/fresh – laceration on head	Unit 1
10/12/2021	NA	Dead – severely decomposed	Unit 1
12/2/2021	442mm FL; 500mm TL	Dead – moderately decomposed	Unit 1
12/2/2021	647mm FL; 730mm TL	Dead/fresh	Unit 2
12/2/2021	743mm FL; 851mm TL	Dead/fresh – dorsal lacerations at midpoint and on caudal fin	Unit 2
12/2/2021	597mm FL; 692mm TL	Dead/fresh	Unit 1
3/22/2022	710 mm FL; 770 mm TL	Dead – moderately decomposed	Unit 2
3/29/2022	NA	Live – missing entire caudal fin, including the caudal peduncle	Unit 1
Total: 190		**Total Alive: 77** **Total Dead: 113(41 died prior to impingement)**	

6.3.2.2.1 Predicted Future Impingement on the Trash Bars

Reporting of Atlantic sturgeon removed from the trash bars has been occurring for over ten years (February 2011 – 2022). During this time, 190 Atlantic sturgeon have been removed from the trash bars (four in 2011, two in 2012, 18 in 2013, 17 in 2014, four in 2015, 11 in 2016, four in 2017, 11 in 2018, 22 in 2019, 54 in 2020 (three of these are suspected to be the same fish), 41 in 2021, and two in 2022). While monitoring of the trashbars predates 2011, any Atlantic sturgeon observed prior to February 2011 were not recorded. There is likely to be annual variability in the number of impingements, as is seen for shortnose sturgeon. Assuming that the 2011- 2022 period is representative of typical impingement rates, we would predict an average of 16 impingements per year, with a range of 2 – 54 impingements annually.

Under the terms of the renewed operating license, Salem Unit 1 will continue to operate from now through August 2036, a period of 14 years. The average impingement rate calculated above (16 fish/year) is based on the operation of both Salem 1 and Salem 2. Prior to 2014, records had not been maintained to determine which intakes the impinged Atlantic sturgeon had been removed from. Based on the available information, 190 Atlantic sturgeon were impinged at Salem trash racks from 2014 to 2022. Location data was available for all of these fish. Based on these data, approximately 59% (113 of 190 fish) of Atlantic sturgeon impinged from 2014 to July 2022 were removed from intakes for Unit 1. Seventy-seven of the 190 (41%) sturgeon were removed from Unit 2. Despite records now being maintained to determine which intakes the impinged sturgeon have been removed from, we still do not have sufficient information to predict impingement rates at the individual units. However, assuming that it is equally probable that a fish would be impinged at the intakes for Unit 1 as it is for Unit 2, it is reasonable to determine that the impingement rate for one unit would be half that as for two units. Using this impingement rate (8 fish/unit/year * 14 years) it is likely that no more than 112 Atlantic sturgeon would be impinged at the Salem Unit 1 intakes between now and the expiration of the extended operating license (i.e., April 2036). The extended operating license for Salem Unit 2 will expire in April 2040. Using this same impingement rate and considering an operational period of 18 years, it is likely that no more than 144 Atlantic sturgeon would be impinged at the Salem Unit 2 intakes between now and the expiration of the extended operating license.

Seventy-seven of the 190 Atlantic sturgeon removed from the Salem intakes were alive (approximately 41%). With the exception of seven live fish that had significant lacerations, the other live fish exhibited minor injuries (abrasions), but these did not likely affect the fishes swimming ability. Given the size of these fish and the minor injuries exhibited, we expect that these fish were not actually stuck on the racks but were close enough to be captured by the trash rake as it moved down the rack.

Of the 113 dead Atlantic sturgeon, 41 were determined to have died prior to impingement (due to traumatic injury). The other 72 fish (64% of the dead Atlantic sturgeon) had no signs of decomposition. Of these 72 fish, 49 had signs of injury ranging from minor bruising to severe lacerations and it is possible that impingement caused or contributed to their death; however, without a necropsy we do not know the cause of death and cannot determine whether or to what extent impingement contributed to the death. For purposes of predicting future mortality, we assume that impingement caused or contributed to the death of these fish. However, we recognize, that based on laboratory evaluations of swimming performance of sturgeon, it is likely that these fish suffered some stress or impairment prior to impingement that affected their ability to escape from the rack.

Using the 2011–2022 information to predict future conditions, we expect 59% of the Atlantic sturgeon removed from the trash racks will be dead, with impingement causing or contributing to the death of 64% of those dead fish.

As calculated above, we expect a total of 112 Atlantic sturgeon to be impinged at the Salem Unit 1 trash racks between now and license expiration in 2036. Using the percentages just discussed, we expect 67 of these fish to be dead, with impingement causing or contributing to the death of 43 of these fish. At Unit 2, we expect the impingement of 144 Atlantic sturgeon prior to license expiration in 2040, with 85 of these fish being removed from the water dead and impingement causing or contributing to the death of 55 of those fish.

Here, we predict the DPS of origin for the 256 Atlantic sturgeon anticipated to be impinged at the Salem Unit 1 and Unit 2 trash racks. Of the 190 Atlantic sturgeon removed from the trash racks between 2011 and 2022, 102 were in the 441-760 mm total length range. Fish of these size are not likely to have begun migrations outside of their natal river (ASSRT 2007); thus, these fish likely originated from the Delaware River and were NYB DPS fish. Genetic analysis to confirm this assumption was completed in November 2020. A total of 150 tissue samples were assigned to one of 18 baseline populations, which were subsequently aggregated into DPSs. Of the samples that underwent genetic assignment testing, all of the samples taken from individuals that were less than 500 mm TL (i.e., river-resident juveniles) were assigned to the Delaware River (Kazyak *et al*. 2021). Two adult Atlantic sturgeon were removed from the racks (alive) in December 2013 and February 2016. This occurrence is considered highly unusual as we do not expect adult Atlantic sturgeon to be in the Delaware River during December or February (see for example, Breece *et al.* 2013 which indicate that acoustically tagged adults are only present in the river in April, May and June). Based on genetic assignment analysis, the Atlantic sturgeon removed from the trash racks in February 2016 originated in the Savannah River. Using the size classes of the 190 fish recorded from 2011-2022 to predict future impingement, we would expect 54% of impinged sturgeon to be non-migrant subadults or juveniles (102/190 from 2011-2022) and 46% (88/190 from 2011- 2022) to be a migrant subadult or adult. All juveniles would originate from the Delaware River and belong to the NYB DPS. Subadults or adults could originate from any of the five DPSs. Based on the genetic assignment analysis mentioned above we expect Atlantic sturgeon larger than 760 mm (i.e., migrant subadults and adults) in the action area to originate from all five DPSs at the following frequencies: NYB 71%; Chesapeake Bay 16%; South Atlantic 7%; Gulf of Maine 1%; and Carolina 5%.

Using the analysis presented above, we expect the Atlantic sturgeon removed from the intakes to consist of:

	Salem Unit 1	Salem Unit 2	Total Unit 1 and 2[7]
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 dead due to impingement)	66 (39 dead, 25 dead due to impingement)	117 (70 dead, 45 dead due to impingement)
Subadult or adult NYB DPS	37 (22 dead, 15 dead due to impingement)	47 (28 dead, 18 dead due to impingement)	84 (50 dead, 32 dead due to impingement)
Subadult 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 Carolina DPS	3 dead or alive	4 dead or alive	7 dead or alive
Subadult or adult GOM DPS	1 dead or alive	1 dead or alive	2 dead or alive

Table 10. Expected Impingement of Atlantic sturgeon at Salem 1 and 2 Trash Bars (including capture of live sturgeon with the trash rake). Dead "due to impingement" are a subset of the total dead sturgeon removed from the intakes.

6.3.2.2.2 Atlantic sturgeon impingement – Traveling Screens

The intensity of monitoring at the traveling screens has varied over time. From 1976- 2022, only nine Atlantic sturgeon have been observed during impingement sampling. Seven of the nine individuals were alive with no apparent injuries. In order to contact the traveling screens, Atlantic sturgeon would need to be small enough to pass between the 3" spacing of the trash bars. Young of the year, which we expect to be 410 mm or less in length and the life stage that would be most likely to be small enough to pass between the trash bars, are unlikely to be

[7] Due to rounding, some totals may not correspond with the sum of the separate figures.

present in the action area given the salinity in the action area. The length of the 2006 Atlantic sturgeon was 441-mm. The Atlantic sturgeon observed during impingement sampling on March 14, 2013 had a total length of 443 mm (382 mm Fork Length). The May 21, 2018 Atlantic sturgeon was 415 mm (355 mm Fork Length). The April 24, 2019 Atlantic sturgeon was 444 mm (377 mm Fork Length). These fish were alive and had no signs of injury. Juvenile and adult shortnose sturgeon (body lengths greater than 58.1cm) have been demonstrated to avoid impingement and entrainment at intakes with velocities as high as 3.0 feet per second (Kynard *et al.* 2005). Yearling shortnose sturgeon (body lengths greater than 28 cm) have been observed to avoid impingement at intakes with velocities of 1.0 fps. If there are Atlantic sturgeon in the action area that are small enough to pass between the trash bars, they could become impinged on the traveling screens at intakes with a velocity of 1.0 fps; lab studies indicate an impingement rate at this intake velocity of 4.3-9.1%. Small sturgeon could also be collected in the buckets and not actually "stuck" to the traveling screens. As discussed above, we expect the 3" trash bars to exclude sturgeon with body lengths greater than 63cm from the forebays; therefore, the only fish that could be impinged on the traveling screens or collected by the traveling buckets would be smaller than 63cm in length. As Atlantic sturgeon do not leave their natal river until they are approximately 76 cm in length, we would expect only Delaware River origin fish from the NYB DPS would be impinged or collected at the traveling screens.

Since 1997, PSEG has carried out a monitoring program that diverted impinged fish to a sampling pool ten times per day on three days each week. The duration of the sampling effort is between 1 and 8 minutes. Approximately 300 minutes of sampling occurs each week which represents approximately 1.5% of the total operational period each week. In 1995-1996, impingement sampling occurred 10 times per day but only during one 24-hour period per week. Between 1980 and 1994, sampling occurred for an average of 3-minutes 4-times per day, 6-days per week. In 1978 and 1979, 10 samples per day were taken on six days per week. From May 1977 to September 1978, samples were taken every six hours (four times per day) during three 24-hour periods each week. Over time, the intensity of sampling has ranged from 0.7% to 3% of operations time.

In 1995, modified Ristroph screens were installed at the facility. Because no Atlantic sturgeon were recorded prior to 1995 we do not know if the rate of impingement for Atlantic sturgeon would be different on the old screens. Sampling effort has been consistent since 1997. During this time, nine Atlantic sturgeon have been observed during routine impingement sampling. An additional Atlantic sturgeon was observed during supplemental sampling carried out in 2013 to estimate the density of river grass in Delaware River water entering the plant (Wagner, 2013). If we make the assumption that the samples that have been taken over the last 26 years (i.e., 1997-2022) are representative of the total impingement that has occurred at the traveling screens, we can calculate a total number of Atlantic sturgeon that were likely impinged at the traveling screens over this period. Nine Atlantic sturgeon have been collected in 26 years of routine sampling. This equates to 0.35 sturgeon/year for 1.5% sampling which can be extrapolated to a total of 24 sturgeon/year likely to be collected on the traveling screens.

Under the terms of the renewed operating license, Salem Unit 1 will continue to operate from now through August 2036, a period of 14 years. The impingement rate calculated above (24 fish/year) is based on the operation of both Salem 1 and Salem 2. Records have not been maintained to determine which intakes the impinged sturgeon have been removed from. However, assuming that it is equally probable that a fish would be impinged at the intakes for Unit 1 as it is for Unit 2, it is reasonable to determine that the impingement rate for one unit would be half that as for two units. Using this impingement rate, (12 fish/year) it is likely that no more than 168 Atlantic sturgeon would be impinged at the Salem Unit 1 traveling screens between now and the expiration of the extended operating license (i.e., April 2036). The extended operating license for Salem Unit 2 will expire in April 2040. Using this same impingement rate and considering an operational period of 18 years, it is likely that no more than 216 Atlantic sturgeon would be impinged at the Salem Unit 2 traveling screens between now and the expiration of the extended operating license.

Seven of the nine Atlantic sturgeon observed during impingement sampling were alive. One of the dead sturgeon was collected in the north discharge bypass sluice, where it would have been routed for return to the estuary after being sprayed off the traveling screens with a low-pressure spray wash. When collected, the individual appeared to be in good condition and was only recently deceased. The other most recent dead sturgeon was collected from the south fish counting pool. When collected, a rubber band was observed stretched over the individual's head, with a portion of the band piercing through the tissue of the outer edges of its mouth and appearded to be recently deceased. Given the small sample size and the known impacts of passing through the traveling screen system on other fish species, it is unlikely that all Atlantic sturgeon impinged in the future will survive. PSEG has studied latent impingement mortality for many species of fish. The impingement survival rates form Salem's modified Ristroph traveling screens vary by species. PSEG 2006 includes pooled estimates of latent impingement mortality from studies conducted during 1995 through 2003. Latent impingement mortality values are reported by month. When these are averaged to provide an annual estimate, the mortality values range from 5.9% (striped bass) to 47.1% (bay anchovy). Given that seven of the nine collected Atlantic sturgeon have been alive with no signs of injury or distress, we expect survival of Atlantic sturgeon at the Salem screens to be high. We conducted a search and were unable to find any studies or reports that documented impingement survival rates for any species of sturgeon at modified Ristroph screens. We do not know which, if any, of the species that have been studied at Salem would be the most appropriate surrogate for Atlantic sturgeon. However, given the condition of the seven live collected Atlantic sturgeon, it is not reasonable to use the species with the highest latent impingement mortality value (bay anchovy) to predict future mortality of Atlantic sturgeon impinged or collected on the Salem screens. Survival for striped bass and white perch during the months when Atlantic sturgeon have been impinged range from 80 to 100 percent, with annual averages of 94.1% and 89.4%, respectively. Based on the available information, it appears that mortality rates of impinged Atlantic sturgeon are most likely to be similar to those of striped bass and white perch. We do not currently have enough information to determine which months Atlantic sturgeon are most likely to be impinged in the future; therefore, it is reasonable to use the annual average latent impingement mortality values. If we use the midpoint of the annual values for striped bass and white perch, we predict an annual latent impingement mortality value for Atlantic sturgeon of 8.25%.

Applying this mortality rate to the estimated total of 24 Atlantic sturgeon impinged on the traveling screens each year, we would anticipate that no more than 2 juvenile Atlantic sturgeon would be killed or injured due to impingement at the traveling screens each year. Over the life of the Salem 1 operating license, where we anticipate the impingement of no more than 168 Atlantic sturgeon at the traveling screens, we would anticipate no more than 14 of those fish to be injured or killed. For Salem 2, where we anticipate the impingement of 216 Atlantic sturgeon, we would anticipate the injury or mortality of no more than 18 Atlantic sturgeon. Given the small size necessary to pass through the trash bars and contact the traveling screens, we expect that all of these individuals would be juveniles originating from the Delaware River (and therefore, belonging to the New York Bight DPS).

	Salem Unit 1	Salem Unit 2	Total
NYB DPS	168 (14 injury or mortality)	216 (18 injury or mortality)	384 (32 injury or mortality)

6.4 Effects on Prey – Impingement and Entrainment

6.4.1 Salem

The Salem facility began operation in 1977. Monitoring of the aquatic community has been ongoing since the late 1960s. Since 1977, monitoring has been performed on an annual basis to evaluate the impacts on the aquatic environment of the Delaware Estuary from entrainment of organisms through the cooling water system. Methods and results of these studies are summarized in several reports, including the 1984 316(b) Demonstration (PSEG 1984), the 1999 316(b) Demonstration (PSEG 1999a), and the 2006 316(b) Demonstration (PSEG 2006c). In addition, biological monitoring reports have been submitted to NJDEP on an annual basis from 1995 through the present (PSEG 1996, PSEG 1997, PSEG 1998, PSEG1999b, PSEG 2000, PSEG 2001, PSEG 2002, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006a, PSEG 2007a, PSEG 2008a, PSEG 2009c). PSEG has performed annual impingement monitoring at the Salem plant since 1977 in order to determine the impacts that impingement at Salem might have on the aquatic environment of the Delaware Estuary. Results of these monitoring studies are summarized in the FSEIS (NRC 2011).

6.4.1.1 Effects of Impingement and Entrainment on Shortnose and Atlantic sturgeon prey

In the action area, shortnose and Atlantic sturgeon feed on benthic invertebrates. Limited diet studies of sturgeon in the Delaware River are available; however, *Corbicula* clams are considered to be a primary forage of sturgeon in the river. *Gemma gemma* clams, as well as other benthic invertebrates, are also preyed upon by sturgeon in the Delaware River.

Sturgeon prey species are found on the bottom and are generally immobile or have limited mobility and are not within the water column; they are less vulnerable to potential impingement or entrainment because they do not occur within the water column. No *Corbicula* or *Gemma gemma* clams have been recorded in impingement and entrainment monitoring. Impingement and entrainment studies have included at least two macroinvertebrates, scud and opossum shrimp, as focus species. Assessments completed on these species concluded that Salem does not and will not have an adverse environmental impact on these macroinvertebrates (PSEG 1999a). Based on the determination that the past and continued operation of Salem is likely to have only insignificant impacts on species chosen to represent the macroinvertebrate community, and given the life history characteristics (sessile, benthic, occurring outside of the water column) of shortnose and Atlantic sturgeon forage items which make impingement and entrainment unlikely, any loss of potential shortnose sturgeon prey due to impingement or entrainment is insignificant.

6.4.1.2 Effects of Impingement and Entrainment on sea turtle prey
Green turtles are herbivorous, feeding primarily on seagrasses while in the Delaware estuary. There is no sea grass in the action area; thus, none will be affected by operations of Salem or Hope Creek.

Loggerhead turtles feed on benthic invertebrates such as gastropods, mollusks and crustaceans. Kemp's ridleys are largely cancrivirous (crab eating), with a preference for portunid crabs including blue crabs. Both species may also forage on fish, particularly if crabs are unavailable. The EIS provides information on the likely mortality of aquatic life associated with the cooling water intakes. Studies conducted over the life of the facility have indicated that there has been no change in the species composition or population trends in the action area that can be attributable to the operation of the intakes. Given that (1) the numbers of fish killed as a result of impingement is extremely small compared to the population numbers for these species, and, (2) there has been no change in species composition or abundance in the action area in the more than 30 years that the facilities have been operating, it is likely that any mortality of fish that may serve as prey for Kemp's ridley or loggerhead sea turtles resulting from impingement or entrainment is undetectable at a population level and has an insignificant effect on foraging sea turtles.

Blue crabs are a significant prey species for loggerhead and Kemp's ridley sea turtles. Impingement studies completed from 2002-2004, as well as between 1978-1998, indicate that there is a large amount of variability in the number of blue crabs impinged at the facility each year. From 2002-2004, the number of blue crabs killed at the facility ranged from 27,483 to 172,725. In 2005, the size of the blue crab stock in Delaware Bay was approximately 115 million crabs; the amount of blue crabs lost at the facility is a small fraction of the blue crabs available in the action area or the Delaware estuary as a whole. Using data available from 1978-2009, the average annual stock size of blue crabs in Delaware Bay is approximately 164.8 million (Wong 2010). In 2004, the loss of 172,725 blue crabs at Salem (NRC 2011) represented approximately 0.09% of the Delaware Bay stock of blue crabs.

While the continued operation of Salem is likely to result in the loss of some potential forage items for sea turtles (fish, jellyfish and crabs), this loss is likely to be undetectable compared to the availability of prey in the action area and in the Delaware Bay as a whole. Based on the best available information outlined above, while the operation of Salem may result in a reduction of forage items available for loggerhead and Kemp's ridley sea turtles in the action area, this loss is likely to insignificant or extremely unlikely.

6.4.2 Hope Creek - Impact of Impingement and Entrainment on Shortnose sturgeon and sea turtle prey

Hope Creek has a closed cycle cooling system; thus, it withdraws far less cooling water than Salem (approximately 2%). As the effects to Atlantic sturgeon, shortnose sturgeon and sea turtle prey from the Hope Creek intakes would be proportionally less than from the Salem intakes, all effects are anticipated to be insignificant or extremely unlikely as explained for Salem above.

6.5 Discharge of Heated Effluent

6.5.1 Salem

Extensive studies were conducted at Salem between 1968 and 1999 to determine the effects of the thermal plume on the biological community of the Delaware Estuary. The results of these studies are summarized in the FSEIS (NRC 2011).

6.5.1.1 Regulatory Background

The Delaware River Basin Commission (DRBC) is a federal interstate compact agency charged with managing the water resources of the Delaware River Basin without regard to political boundaries. It regulates water quality in the Delaware River and Delaware Estuary through DRBC Water Quality Regulations, including temperature standards. The temperature standards for Water Quality Zone 5 of the Delaware Estuary, where the Salem discharge is located, state that the temperature in the river outside of designated heat dissipation areas (HDAs) may not be raised above ambient by more than 4 degrees Fahrenheit (°F; 2.2 degrees Celsius [°C]) during non-summer months (September through May) or 1.5°F (0.8°C) during the summer (June through August), and a maximum temperature of 86°F (30.0°C) in the river cannot be exceeded year-round (18 CFR 410; DRBC 2001). HDAs are zones within which maximum temperature is governed by the DRBC. HDAs are established on a case-by case basis. The thermal mixing zone requirements and HDAs that had been in effect for Salem since it initiated operations in 1977 were modified by the DRBC in 1995 and again in 2001 (DRBC 2001), and the 2001 requirements were included in the 2001 NJPDES permit. The HDAs at Salem are seasonal. In the summer period (June through August), the Salem HDA extends 25,300 ft (7,710 m) upstream and 21,100 ft (6,430 m) downstream of the discharge and does not extend closer than 1,320 ft (402 m) from the eastern edge of the main river channel. In the non-summer period (September through May), the HDA extends 3,300 ft (1,000 m) upstream and 6,000 ft (1,800 m) downstream of the discharge and does not extend closer than 3,200 ft (970 m) from the eastern edge of the shipping channel (DRBC 2001).

Section 316(a) of the CWA pertains to the regulation of thermal discharges from power plants. This statutory provision includes a process by which a discharger can obtain a variance from thermal discharge limits when it can be demonstrated that the limits are more stringent than necessary to protect aquatic life (33 USC 1326). PSEG submitted a comprehensive Section 316(a) study for Salem in 1974, filed three supplements through 1979, and provided further review and analysis in 1991 and 1993. In 1994, NJDEP granted PSEG's request for a thermal variance and concluded that the continued operation of Salem in accordance with the terms of the NJPDES permit "would ensure the continued protection and propagation of the balanced indigenous population of aquatic life" in the Delaware Estuary (NJDEP 1994). The 1994 permit continued the same thermal limitations that had been imposed by the prior NJPDES permits for Salem. This variance has been continued through the current NJPDES permit. PSEG subsequently provided comprehensive Section 316(a) Demonstrations in the 1999 and 2006 NJPDES permit renewal applications for Salem. NJDEP reissued the Section 316(a) variance in the 2001 NJPDES Permit (NJDEP 2001).

The Section 316(a) variance for Salem limits the temperature of the discharge, the difference in temperature (ΔT) between the thermal plume and the ambient water, and the rate of water withdrawal from the Delaware Estuary (NJDEP 2001). During the summer period, the maximum permissible discharge temperature is 115°F (46.1°C). In non-summer months, the maximum permissible discharge temperature is 110°F (43.3°C). The maximum permissible temperature differential year round is 27.5°F (15.3°C). The permit also limits the amount of water that Salem withdraws to a monthly average of 3,024 MGD (11 million m^3/day) (NJDEP 2001).

In 2015, PSEG submitted an NJPDES permit renewal application (NJDEP 2015) with a request for renewal of the Section 316(a) variance. The variance renewal request summarized studies that were conducted at the Salem plant, including the 1999 Section 316(a) Demonstration, and evaluated the changes in the thermal discharge characteristics, facility operations, and aquatic environment since the time of the 1999 Section 316(a) Demonstration. PSEG concluded that Salem's thermal discharge had not changed significantly since the 1999 application and that the thermal variance should be continued. NJDEP agreed with that conclusion citing a predictive and retrospective assessment of two decades of data collected between 1991 and 2011. In 2016, NJPDES reissued the Section 316(a) variance in Salem's NJPDES Permit (NJ0005622).

6.5.1.2 Characteristics of the Thermal Plume

Cooling water from Salem is discharged through six adjacent 10 ft (3 m) diameter pipes spaced 15 ft (4.6 m) apart on center that extend approximately 500 ft (150 m) from the shore (PSEG, 1999c in NRC 2011). The discharge pipes are buried for most of their length until they discharge horizontally into the water of the estuary at a depth at mean tidal level of about 31 ft (9.5 m). The discharge is approximately perpendicular to the prevailing currents. At full power, Salem is permitted to discharge 3,024 MGD (11.4 million m^3/day) at a velocity of about 10 fps (3 m/s).

The location of the discharge and its general design characteristics have remained essentially the same over the period of operation of the Salem facility (PSEG, 1999c in NRC 2011). The thermal plume at Salem can be defined by the regulatory thresholds contained in the DRBC water quality regulations, consisting of the 1.5°F (0.83°C) isopleth of ΔT during the summer period and the 4°F (2.2°C) isopleth of ΔT during non-summer months. Thermal modeling, to characterize the thermal plume, has been conducted numerous times over the period of operation of Salem. Since Unit 2 began operation in 1981, operations at Salem have been essentially the same and studies have indicated that the characteristics of the thermal plume have remained relatively constant (PSEG 1999c in NRC 2011).

The most recent thermal modeling was conducted during the 1999 Section 316(a) Demonstration. Three linked models were used to characterize the size and shape of the thermal plume: an ambient temperature model, a far-field model (RMA-10), and a near-field model (CORMIX). The plume is narrow and approximately follows the contour of the shoreline at the discharge. The width of the plume varies from about 4,000 ft (1,200 m) on the flood tide to about 10,000 ft (3,000 m) on the ebb tide. The maximum plume length extends to approximately 43,000 ft (13,000 m) upstream and 36,000 ft (11,000 m) downstream (PSEG 1999c). Figures 12 through 15 depict the expansion and contraction of the surface and bottom plumes through the tidal cycle (figures 4-3 through 4-6 in NRC 2011). Table 9 includes the surface area occupied by the plume within each ΔT isopleth through the tidal cycle (adapted from Table 4-18 in NRC 2011).

Table 11. Surface area occupied by the plume within each ΔT isopleth through the tidal cycle (adapted from Table 4-18 in NRC 2011).

	Ebb: 6/2/1998 at 0830 hrs		End of Ebb: 6/2/1998 at 0000 hrs		Flood: 6/4/1998 at 1630 hrs		End of Flood: 5/31/1998 at 1600 hrs	
ΔT (°F)	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area
>13	0.08	0.00002	0	0	0	0	0	0
>12	0.46	0.0001	0.47	0.0001	0.21	0.00004	0	0
>11	0.98	0.0002	2.15	0.00045	0.61	0.00013	0	0
>10	1.66	0.00034	2.15	0.00045	1.15	0.00024	0.85	0.00018
>9	2.22	0.00046	2.15	0.00045	1.82	0.00038	1.93	0.0004
>8	3.19	0.00066	2.15	0.00045	2.64	0.00055	1.93	0.0004
>7	4.32	0.0009	5.1	0.00106	3.59	0.00075	1.93	0.0004
>6	5.61	0.00116	11.32	0.00235	4.68	0.00097	1.93	0.0004
>5	36.6	0.0076	21.43	0.00445	56.58	0.01174	2.14	0.00044
>4	150.08	0.03115	45.11	0.00936	245.94	0.05105	205.37	0.04263
>3	631.42	0.13106	739.88	0.15357	585.78	0.12158	920.75	0.19111
>2	1947.91	0.4043	2519.94	0.52303	2212.75	0.45927	2093.04	0.43442
>1.5	3156.56	0.65517	3725.19	0.77319	3703.61	0.76871	3596.95	0.74657

Plant Conditions: Low flow (140,000 gpm/pump), high ΔT (18.6°F). Total surface area of the estuary is 481,796 acres.

Reasonable worst-case tide phases were selected based on analysis of time-temperature curves. Running tides (e.g., ebb and flood) include area approximation of the intermediate field.

Source: Table 4-18 from NRC 2011

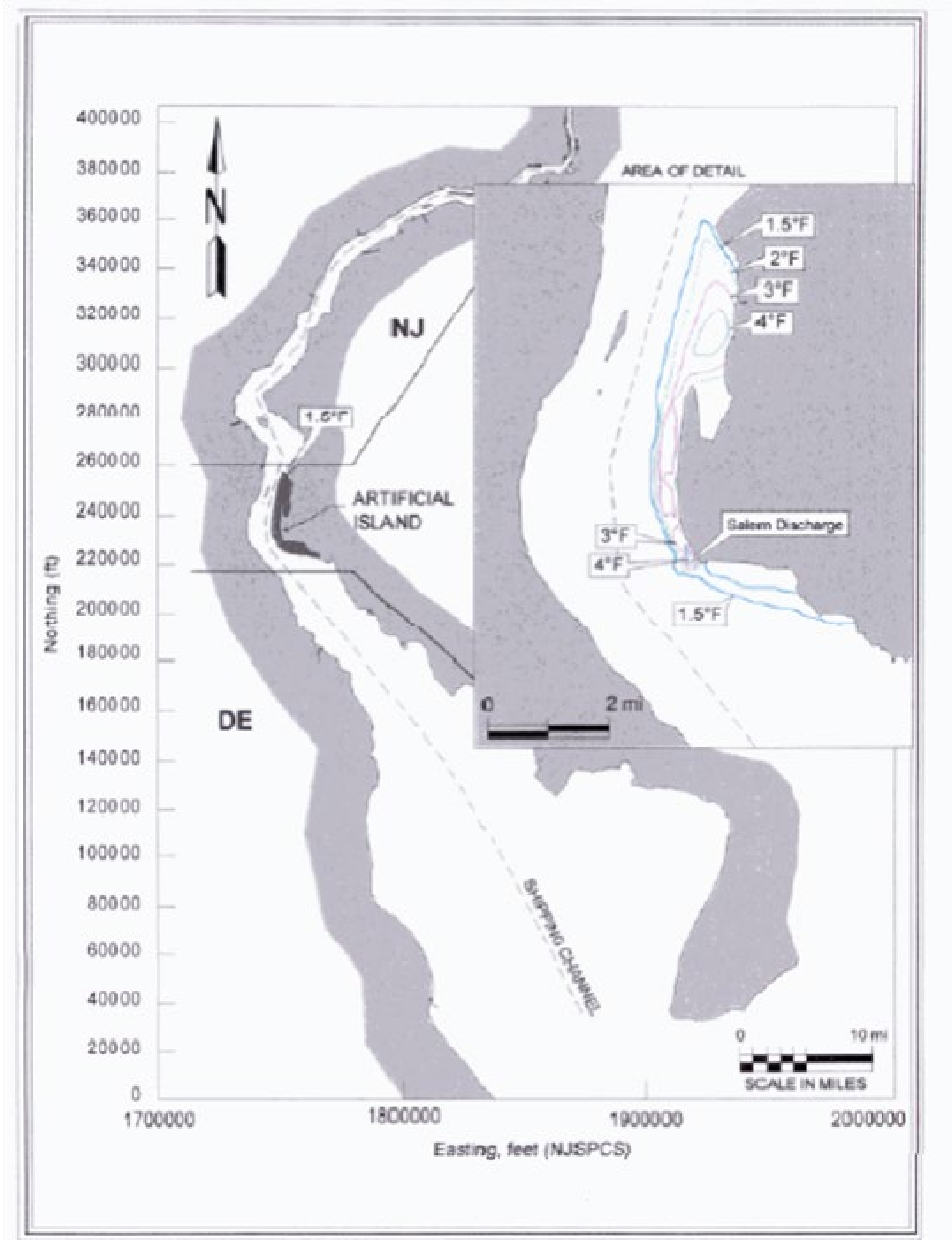

Figure 12. Surface ΔT isotherms for Salem's longest plume at the end of flood on May 31, 1998 (Source: NRC 2011).

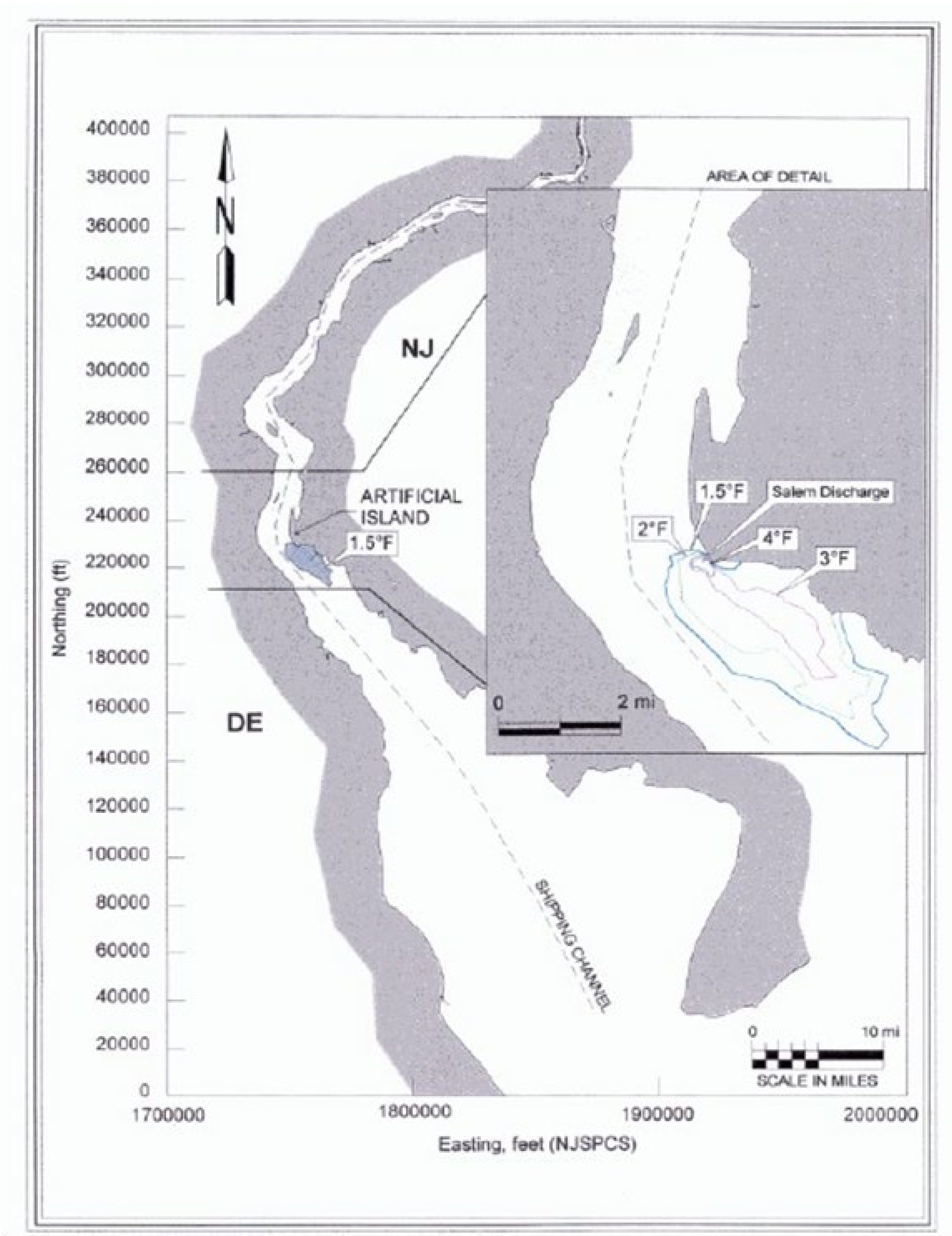

Figure 13. Surface ΔT isotherms for Salem at the end of ebb on June 2, 1998 (Source: NRC 2011).

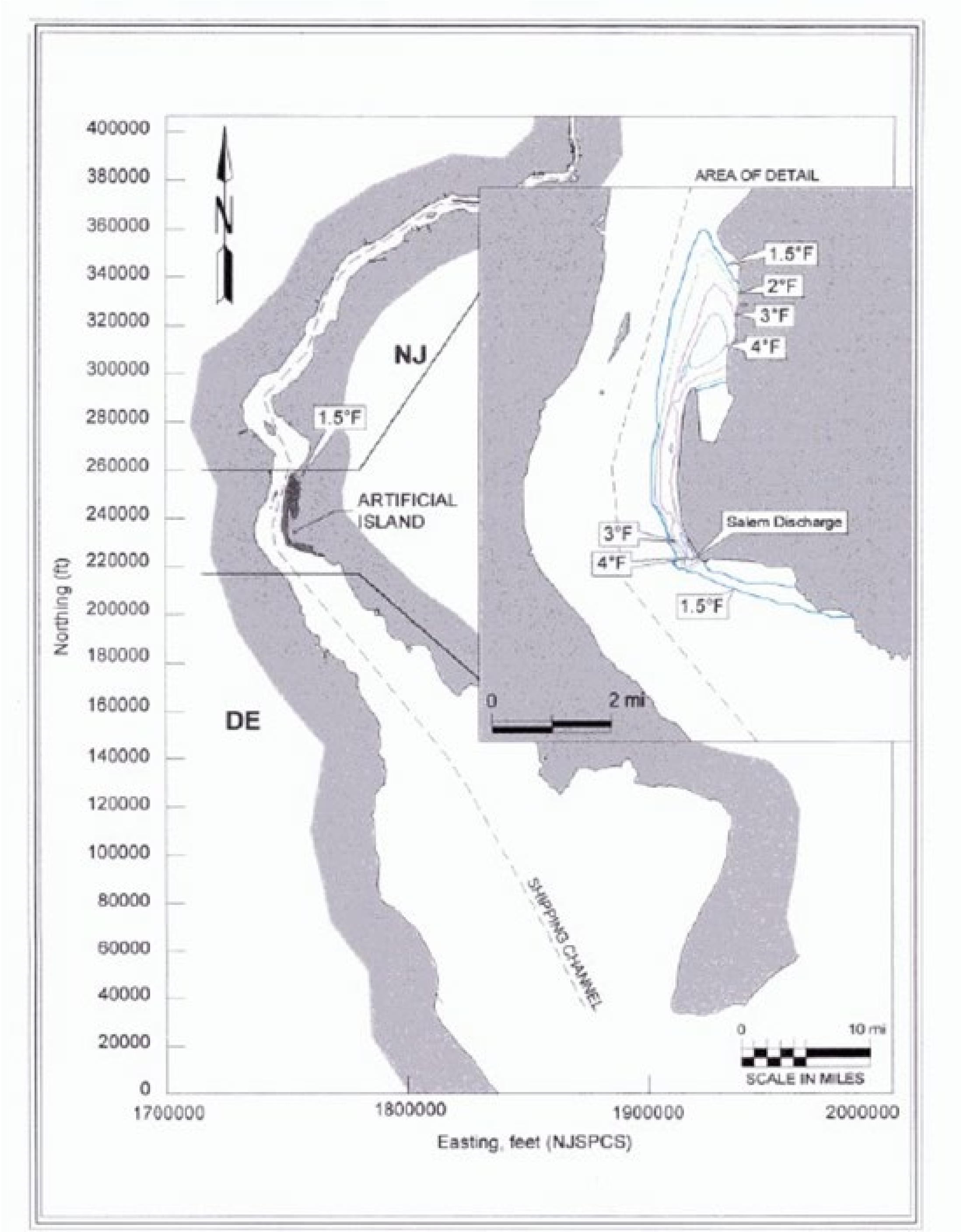

Figure 14. Bottom ΔT isotherms for Salem's longest plume at the end of the flood on May 31, 1998 (Source: NRC 2011).

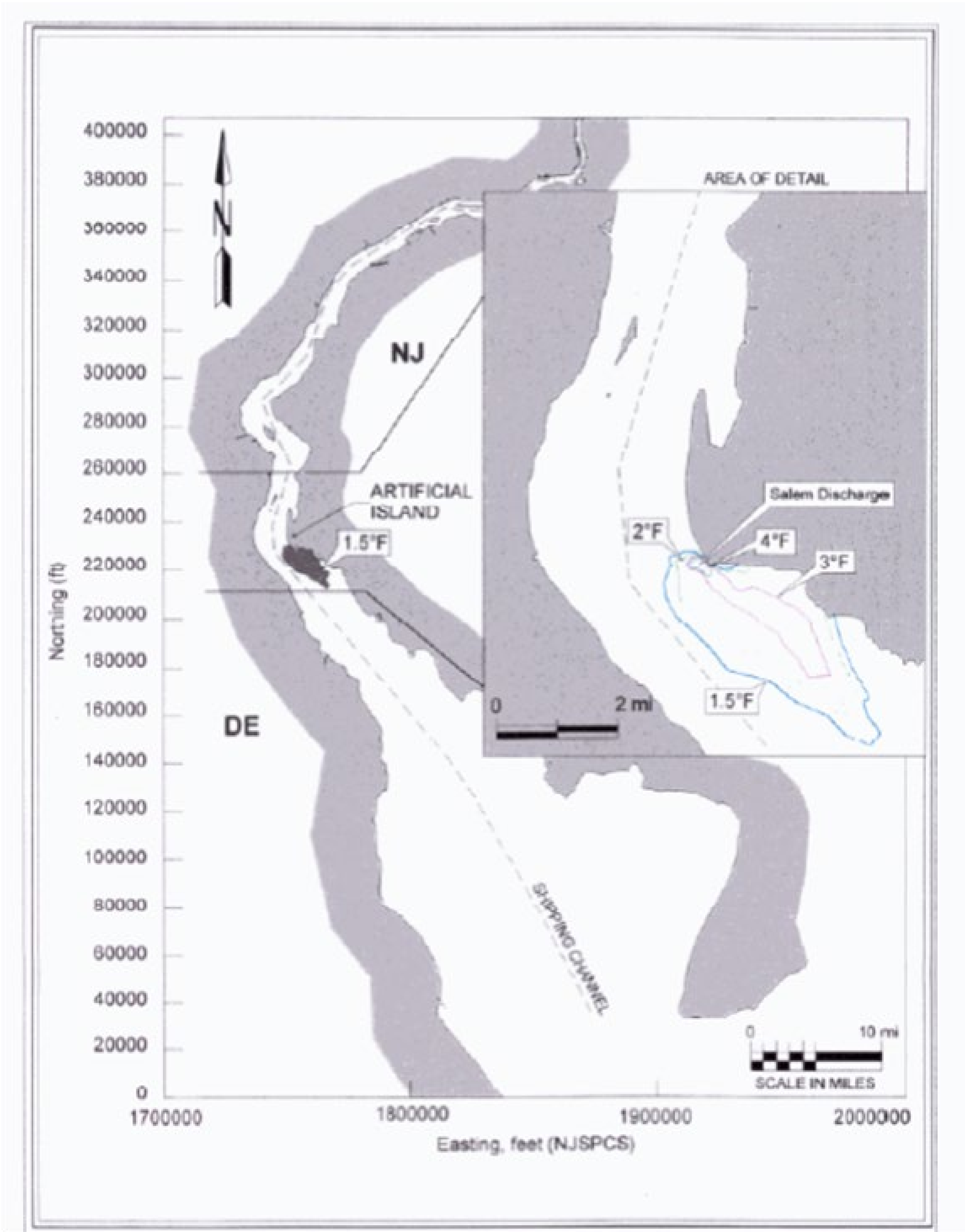

Figure 15. Bottom ΔT isotherms for Salem at the end of the ebb on June 2, 1998 (Source: NRC 2011).

The thermal plume consists of a near-field region, a transition region, and a far-field region. The near-field region, also referred to as the zone of initial mixing, is the region closest to the outlet of the discharge pipes where the mixing of the discharge with the waters of the Delaware Estuary is induced by the velocity of the discharge itself. The length of the near-field region is approximately 300 ft (90 m) during ebb and flood tides and 1,000 ft (300 m) during slack tide. The transition region is the area where the plume spreads horizontally and stratifies vertically due to the buoyancy of the warmer waters. The length of the transition region is approximately 700 ft (200 m). In the far-field region, mixing is controlled by the ambient currents induced mainly by the tidal nature of the receiving water. The ebb tide draws the discharge downstream, and the flood tide draws it upstream. The boundary of the far-field region is delineated by a line of constant ΔT (PSEG, 1999c).

6.5.1.3 Thermal Tolerances – Shortnose sturgeon

Most organisms can acclimate (i.e., metabolically adjust) to temperatures above or below those to which they are normally subjected. Bull (1936) demonstrated, from a range of marine species, that fish could detect and respond to a temperature front of 0.03 to 0.07°C (0.05 – 0.13°F). Fish will therefore attempt to avoid stressful temperatures by actively seeking water at the preferred temperature.

The temperature preference for shortnose sturgeon is not known (Dadswell *et al.* 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2 to 3ºC (35.6-37.4°F) (Dadswell *et al.* 1984) and as high as 34ºC (93.2°F) (Heidt and Gilbert 1978). Foraging is known to occur at temperatures greater than 7°C (44.6°F) (Dadswell 1979). In the Altamaha River, temperatures of 28-30ºC (82.4-86°F) during summer months are correlated with movements to deep cool water refuges. Ziegeweid *et al.* (2008a) conducted studies to determine critical and lethal thermal maxima for YOY shortnose sturgeon acclimated to temperatures of 19.5 and 24.1°C (67.1 – 75.4°F). Lethal thermal maxima were 34.8°C (±0.1) and 36.1°C (±0.1) (94.6°F and 97°F) for fish acclimated to 19.5 and 24.1°C (67.1°F and 75.4°F), respectively. The study also used thermal maximum data to estimate upper limits of safe temperature, final thermal preferences, and optimum growth temperatures for YOY shortnose sturgeon. Visual observations suggest that fish exhibited similar behaviors with increasing temperature regardless of acclimation temperature. As temperatures increased, fish activity appeared to increase; approximately 5–6°C (9-11°F) prior to the lethal endpoint, fish began frantically swimming around the tank, presumably looking for an escape route. As fish began to lose equilibrium, their activity level decreased dramatically, and at about 0.3°C (0.54°F) before the lethal endpoint, most fish were completely incapacitated. Estimated upper limits of safe temperature (ULST) ranged from 28.7 to 31.1°C (83.7-88°F) and varied with acclimation temperature and measured endpoint. Upper limits of safe temperature (ULST) were determined by subtracting a safety factor of 5°C (9°F) from the lethal and critical thermal maxima data. Final thermal preference and thermal growth optima were nearly identical for fish at each acclimation temperature and ranged from 26.2 to 28.3°C (79.16-82.9°F). Critical thermal maxima (the point at which fish lost equilibrium) ranged from 33.7 (±0.3) to 36.1°C (±0.2) (92.7-97°F) and varied with acclimation temperature. Ziegeweid *et al.* (2008b) used data from laboratory experiments to examine the individual and interactive effects of salinity, temperature, and fish weight on the survival of young-of-year shortnose sturgeon. Survival in freshwater declined as temperature increased, but temperature tolerance increased with body size. The authors conclude that temperatures above

29°C (84.2°F) substantially reduce the probability of survival for young-of-year shortnose sturgeon. However, previous studies indicate that juvenile sturgeons achieve optimum growth at temperatures close to their upper thermal survival limits (Mayfield and Cech 2004, Allen *et al.* 2006, Ziegeweid *et al.* 2008a), suggesting that shortnose sturgeon may seek out a narrow temperature window to maximize somatic growth without substantially increasing maintenance metabolism. Ziegeweid (2006) examined thermal tolerances of young of the year shortnose sturgeon in the lab. The lowest temperatures at which mortality occurred ranged from 30.1 – 31.5°C (86.2-88.7°F) depending on fish size and test conditions. For shortnose sturgeon, dissolved oxygen (DO) also seems to play a role in temperature tolerance, with increased stress levels at higher temperatures with low DO versus the ability to withstand higher temperatures with elevated DO (Niklitchek 2001).

6.5.1.4 Thermal Tolerances – Atlantic sturgeon
Limited information on the thermal tolerances of Atlantic sturgeon is available. Juvenile atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010; ASMFC 2017) and adult Atlantic sturgeon have been documented in waters as warm as 33.1 in South Carolina (ASMFC 2017) and as high as 30C in the James River (Balazik *et al.* 2012).

In the laboratory, Atlantic sturgeon larvae survived considerably longer at lower rearing temperatures (13°C and 15°C), with mortality increasing rapidly following the full absorption of the yolk. The acceleration of mortality in yolk-sac larvae in higher temperatures is often attributed to higher metabolic rates, which result in faster absorption of endogenous energy sources (Kamler 1992). Laboratory studies involving 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). These tests were carried out with fish reared at the U.S. Fish and Wildlife Service's Northeast Fishery Center (Lamar, PA) and are progeny of Hudson River broodstock. It is important to note that there may be physiological differences in sturgeon originating from different river systems; however, given the geographic proximity and similar environmental conditions between the Hudson and Delaware rivers as well as genetic similarities, it is reasonable to expect that Hudson River and Delaware River sturgeon would have similar thermal tolerances. Tolerance to temperatures is thought to increase with age and body size (Ziegeweid *et al.*. 2008 and Jenkins *et al.*. 1993), however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. For purposes of considering effects of thermal tolerances, shortnose sturgeon are a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities. Information on thermal tolerances of shortnose sturgeon is presented in 6.5.1.3 above.

6.5.1.5 Effect of Thermal Discharge on Shortnose and Atlantic Sturgeon
Mean monthly ambient temperatures in the Delaware estuary range from 11-27°C from April – November, with temperatures lower than 11°C from December-March. As noted above, mortality of shortnose and Atlantic sturgeon could occur after exposure to temperatures greater than 33.7°C (92.7°F). Using information on Delaware estuary temperatures (Krejmas *et al.* 2011) and information on the thermal plume presented in NRC 2011, the potential to exceed 33.7°C (92.7°F) only exists from June-September. During this time period, depending on

ambient river temperature, in worst case conditions (low flow, maximum ΔT, worst-case ebb tide), an area of 2.15-5.10 acres could have temperatures of 33.7°C (92.7°F) or higher. However, fish are known to avoid areas with unsuitable conditions and shortnose and Atlantic sturgeon are likely to actively avoid heated areas, as evidenced by sturgeon moving to deep cool water areas during the summer months in southern rivers. Laboratory studies using shortnose sturgeon (progeny from Savannah River broodstock) and Atlantic sturgeon (progeny from Hudson River broodstock) demonstrate that these species are able to identify and select between water quality conditions that significantly affect growth and metabolism, including temperature. Based on field observations and laboratory studies, we expect that sturgeon would actively avoid areas where temperatures are intolerable. Assuming that there is a gradient of temperatures decreasing with distance from the Salem discharge (as illustrated in NRC 2011); we expect shortnose and Atlantic sturgeon to begin avoiding areas with temperatures greater than 28°C (82.4°F). We do not expect individuals to remain within the heated surface waters to swim towards the discharge and be exposed to temperatures that could result in mortality. As such, provided that conditions allow for sturgeon to detect changes in temperature (i.e., that there is a gradual gradient of temperatures decreasing with increasing distance from the Salem discharge as reported in NRC 2011) and escape from the area prior to prolonged exposure to critical temperatures, it is extremely unlikely that any sturgeon would remain within the area where surface temperatures are elevated to 33.7°C (92.7°F) and be exposed to potentially lethal temperatures. This gradient of temperatures that decreases from the surface to the bottom is also expected to deter sturgeon from moving high enough up into the water column to encounter surface waters that have stressful or lethal temperatures. The risk is further reduced by the limited amount of time shortnose and Atlantic sturgeon spend near the surface, the small area where such high temperatures will be experienced and the gradient of warm temperatures extending from the Salem discharge. Near the bottom where shortnose and Atlantic sturgeon most often occur, water temperatures will not be elevated by more than 4°C, creating no risk of exposure to temperatures likely to be lethal near the bottom of the river.

We have also considered the potential for shortnose and Atlantic sturgeon to be exposed to water temperatures greater than 28°C (82.4°F). Available information from field observations (primarily in southern systems; however this may be related to the prevalence of temperatures greater than 28°C in those areas compared to the rarity of ambient temperatures greater than 28°C in northern rivers) and laboratory studies (using progeny of fish from southern and northern rivers) suggests that water temperatures of 28°C (82.4°F) or greater can be stressful for sturgeon and that shortnose and Atlantic sturgeon are likely to actively avoid areas with these temperatures. This temperature (28°C; (82.4°F)) is close to both the final thermal preference and thermal growth optimum temperatures that Ziegeweid *et al.* (2008) reported for juvenile shortnose sturgeon acclimated to 24.1 °C (75.4 °F), and thus is consistent with observations that optimum growth temperatures are often near the maximum temperatures fish can endure without experiencing physiological stress. Based on the available information, it is reasonable to anticipate that shortnose and Atlantic sturgeon will actively avoid areas with temperatures greater than 28°C (82.4°F).

In the summer months (June – September), temperature increases as small as 1-4°C may cause water temperatures within the plume to be high enough to be avoided by sturgeon (greater than 28°C (82.4°F)). The width of the plume varies from about 0.76 miles (4,000 ft) on the flood tide to about 1.89 miles (10,000 ft) on the ebb tide. The Delaware River is approximately 2.49 miles (13,123 ft) wide at Artificial Island. Based on a maximum-width plume scenario, sturgeon would still have a zone of passage approximately 0.62 miles (3,281 ft) wide. To be outside of heated areas during the maximum plume length, sturgeon need to be more than 8.14 miles (43,000 ft) upstream and more than 6.82 miles (36,000 ft) downstream of the Salem discharge. Depending on ambient temperatures, the surface area with temperatures greater than 28°C (82.4°F) may range from 56.58 acres to as large as 3,725 acres. Shortnose and Atlantic sturgeon exposure to this area is limited by their normal behavior because they are benthic oriented fish which results in limited occurrence near the water surface. Assuming that there is a gradient of water temperatures that decreases with increasing distance from the discharge and decreases with depth from the surface, reactions to surface waters with temperatures greater than 28°C (82.4°F) are expected to consist of swimming away from heated surface waters by traveling deeper in the water column or by swimming around bottom waters heated by the plume.

Bottom water temperatures near the outfall will also be elevated. The discharge occurs below the surface; however, as heated water is more buoyant than cool water, heated effluent rapidly rises at increasing distances from the outfall; as described in the 2001 NJPDES permit, the plume surfaces within 100 feet of the outfall. The result is a very small area of the river bottom adjacent to the outfall where elevated temperatures may occur. Average year-round bottom temperatures in the Delaware estuary are approximately 14°C. At the depths where the outfall is located, temperatures at the bottom are expected to be at least 3°C lower than at the surface. As explained above, bottom temperatures are not likely to be sufficiently elevated to expose shortnose sturgeon to any temperatures high enough to result in mortality. During the warm summer months (June-September) ambient water temperatures at the bottom could be as high as 23°C; thus, temperatures would have to be at least 5°C above ambient for there to be any potential to cause any effects to shortnose or Atlantic sturgeon. Information provided by NRC on the bottom area where temperatures greater than 4°C above ambient will be experienced indicates that in the worst case, this area is limited to approximately 80 acres (0.125 square miles). Given that sturgeon are known to actively seek out cooler waters when temperatures rise to 28°C, any sturgeon encountering this area are likely to avoid it. Reaction to this elevated temperature is expected to be limited to swimming away from the plume by swimming around it. Given the limited time it would take to avoid water above 28 C (i.e., seconds to minutes) there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effects on growth, reproduction, or general health. As such, it is extremely unlikely that these minor changes in behavior will preclude any shortnose or Atlantic sturgeon from completing any normal behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. Additionally, given the extremely small area of the bottom that may have temperatures elevated above 28°C (80 acres) and that this is an extremely small portion of the action area and an even smaller portion of the Delaware River estuary as a whole, it is extremely unlikely that avoidance of this area will result in any lost foraging opportunities or other detectable or measurable effects on any Atlantic sturgeon.

At no time do water temperatures exceed 28°C in an area that would block the passage of any sturgeon moving up or downstream. At all times, there is an area of cooler water temperatures below (i.e., near the river bottom where sturgeon are most likely to occur) or along the warmer parts of the thermal plume, this means that there is always a zone of passage for sturgeon in the action area. Given that sturgeon will have a true zone of passage adjacent to the thermal plume at all times at least 1,000 m wide, it is extremely unlikely that any minor avoidance behaviors (e.g. detecting changes in temperature and moving several meters away from the warmest waters to remain in cooler areas) will preclude any Atlantic or shortnose sturgeon from completing any normal behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. Additionally, there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health.

Water temperature and dissolved oxygen levels are related, with warmer water generally holding less dissolved oxygen. As such, NMFS has considered the potential for the discharge of heated effluent to affect dissolved oxygen in the action area. However, as reported by NRC (2011), studies completed by PSEG in association with their NJPDES permitting, indicate that the discharge of heated effluent has no discernible effect on dissolved oxygen levels in the area. As the thermal plume is not affecting dissolved oxygen, it will not cause changes in dissolved oxygen levels that could affect any shortnose or Atlantic sturgeon.

6.5.1.6 Effect of Thermal Discharge on Sea Turtles

Excessive heat exposure (hyperthermia) is a stress to sea turtles but is a rare phenomenon when sea turtles are in the ocean (Milton and Lutz 2003). As such, limited information is available on the impacts of hyperthermia on sea turtles. Environmental temperatures above 40°C can result in stress for green sea turtles (Spotila *et al.* 1997); given that all sea turtles spend time in tropical waters with high ambient temperatures, it is reasonable to expect that other sea turtle species would have similar thermal tolerances as green sea turtles. Given the known ambient temperatures in the Delaware estuary at the time of year when sea turtles are likely to be present (April – November; maximum 27°C), even in the warmest months (July and August), surface temperatures would have to be warmed by at least 13°C to reach the temperatures that may be stressful to sea turtles (i.e., 40°C). Even in the worst case conditions, the area where temperatures are raised more than 13°C (i.e., within the HDAs) is limited to 0.08 acres (approximately 0.00002% of the surface area of the estuary). Given the very small area where temperatures would be potentially stressful and the ability of sea turtles to avoid this area by normal swimming or diving, it is extremely unlikely that any sea turtle would experience stress due to exposure to elevated temperatures. Given the extremely small area that would be avoided by sea turtles, any effects of this avoidance are likely to be insignificant or extremely unlikely.

We have considered whether the thermal effluent discharged from the plant may represent an attraction for turtles. If turtles are attracted by this thermal plume, they could remain there late enough in the fall to become cold-stunned. Cold stunning occurs when water temperatures drop quickly and turtles become incapacitated. The turtles lose their ability to swim and dive, lose control of buoyancy, and float to the surface (Spotila *et al.* 1997). If sea turtles are attracted to the heated discharge or remain in surrounding waters heated by the discharge and move outside of this plume into cooler waters (approximately less than 8-10°C), they could become cold stunned. While no one has studied the distribution of sea turtles in Delaware Bay to determine whether the thermal effluent associated with Salem or Hope Creek affects sea turtle distribution; existing data from other nuclear power plants in the NMFS Northeast Region do not support the concern that warm water discharge may keep sea turtles in the area until surrounding waters are too cold for their safe departure. For example, extensive data is available on sea turtles at the Oyster Creek facility in New Jersey (OCNGS; NMFS NERO 2011). We expect cold-stunning to occur around mid-November in New Jersey waters. No incidental captures of sea turtles have been reported at the OCNGS later than October 30. The minimum recorded temperature at time of capture of a sea turtle at OCNGS was 11.7°C (this turtle was alive and healthy, not cold stunned). This information suggests that the thermal effluent is not increasing the risk of cold stunning.

There are several factors that may make it unlikely that the thermal effluent from Salem or Hope Creek increases the risk of cold-stunning of sea turtles. During the winter, when water temperatures are low enough for cold stunning to occur, the area where the water temperatures would be suitable for sea turtles is transient, small and localized. In order to stay in the action area once ambient waters cool in the Fall, sea turtles would need to find areas where temperatures higher than at least 11°C would consistently be found. While there is warm water discharged from Salem and Hope Creek year round and there are nearly always areas where water is heated to above 11°C, the amount of water that is at this temperature is highly variable and because of tidal influences on the distribution of the thermal plume in the water column, this heated area is transient in surface area and depth. The space and time when the water would be warmed to above 11°C throughout the water column is extremely limited. Given the transient nature of the thermal plume and the small size of the area that would have temperatures that would support sea turtles, it is extremely unlikely that sea turtles would seek out and use the thermal plume for refuge from falling temperatures in the action area. Because of this, it is extremely unlikely that sea turtles would remain unseasonably long in the action area because of the presence of heated water from Salem or Hope Creek. The lack of any impingement of sea turtles at Salem at the time of year when cold stunning could occur (i.e., all captures have occurred between June and September) supports this determination. Based on the best available information, it is extremely unlikely that the discharge of heated effluent increases the vulnerability of sea turtles in the action area to cold stunning.

6.5.1.7 Effect on Atlantic sturgeon, Shortnose sturgeon and Sea turtle Prey

For the 1999 Section 316(a) Demonstration PSEG conducted an assessment of the potential for the thermal plume to adversely affect survival, growth, and reproduction of the selected RIS, including species that may be shortnose sturgeon and sea turtle prey (e.g., blue crab, opossum shrimp and gammarus spp.). For each of the selected species, temperature requirements and preferences as well as thermal limits were identified and compared to temperatures in the thermal plume to which these species may be exposed (PSEG 1999c in NRC 2011).

In this assessment, PSEG concluded that Salem's thermal plume would not have substantial effects on the survival, growth, or reproduction of the selected species from heat-induced mortality. Scud, blue crab, and juvenile and adult American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, and spot have higher thermal tolerances than the temperature of the plume regardless of where each species might be exposed to elevated temperatures in the water column. PSEG also concluded that juvenile and adult weakfish and bay anchovy could come into contact with plume waters that exceed their thermal tolerances during the warmer months, but the mobility of these organisms should allow them to avoid sustained contact with these temperatures

The biothermal assessment also concluded that less-mobile organisms, such as scud, juvenile blue crab, and fish eggs, would not be likely to experience mortality from being transported through the plume. American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, spot, and weakfish are not likely to spawn in the vicinity of the discharge. Scud, juvenile blue crab, and eggs and larvae that do occur in the vicinity of the discharge have higher temperature tolerances than the maximum temperature of the centerline of the plume in average years. PSEG concluded that opossum shrimp, weakfish, and bay anchovy may experience a small amount of mortality during peak summer water temperatures in warm years (approximately 1 to 3 percent of the time).

As described in the FSEIS, PSEG has completed an analysis of the biological community in the Delaware Estuary to determine whether there has been evidence of changes within the community that could be attributable to the thermal discharge at Salem. PSEG concluded that there was no indication that the thermal plume was affecting the distribution or abundance of any species. Additionally, there was no indication of increases in populations of nuisance species or stress-tolerant species. Thus, it appears that effects from the thermal discharge from Salem to the prey of shortnose sturgeon and Atlantic sturgeon, as well as loggerhead, Kemp's ridley, and green sea turtles are so small that they cannot be meaningfully detected and are therefore insignificant.

6.5.2 Discharge of Heated Effluent – Hope Creek

Hope Creek has a closed cycle cooling system; thus, it discharges far less heated water than Salem. The temperature standards that the Hope Creek discharge must meet state requirements that the temperature in the river outside of HDAs may not be raised above ambient by more than 4°F (2.2°C) during non-summer months (September through May) or 1.5°F (0.8°C) during the summer (June through August), and a maximum temperature of 86°F (30.0°C) in the river cannot be exceeded year-round (18 CFR 410; DRBC 2001). The NJDEP WQS and DRBC Docket define the HDA as 2,500 ft upstream or downstream, and 1,500 ft. outshore; thus, the effluent from Hope Creek must not cause any increases in temperature that cause the river temperature in this area to be greater than 30°C. As such, there is no potential for stress to sea turtles or mortality of shortnose or Atlantic sturgeon within these temperatures. During the summer months, mean ambient river temperatures may be as high as 26.5°C. During this time, the effluent must not raise temperatures more than 1.5°C. Given these circumstances, it is unlikely that the discharge from Hope Creek would result in any areas where water temperatures are greater than 28°C; thus, no effects to shortnose or Atlantic sturgeon are likely to result from the discharge of heated effluent from Hope Creek.

As the effects to shortnose sturgeon, Atlantic sturgeon and sea turtle prey from the Hope Creek discharge would be proportionally less than from the Salem outfall, any effects are anticipated to be insignificant or extremely unlikely as explained above for Salem.

6.6 Other Pollutants Discharged from the Facility

Pollutants discharged from Salem are regulated under the facility's NJPDES permit (NJ0005622; NJDEP 2016). Pollutants discharged from Hope Creek are regulated under NJPDES permit no. NJ0025411 effective October 1, 2017. Limits on the concentration of pollutants in effluent are included when required for a specific type of facility or when a reasonable potential analysis indicates that there is a reasonable potential for an excursion from a water quality standard (then, a water quality based limit is required). The NJPDES permit also regulates thermal discharges (see above), chlorine produced oxidants (sodium hypochlorite is used to control biofouling), pH, Oil and Grease, Total Suspended Solids (TSS), Ammonia, Total organic carbon, and fecal coliform (Hope Creek only as outfall 461A receives sewage treatment plant effluent). To prevent organic buildup and biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite is injected into the system at both Salem and Hope Creek. No other biocides are used at the SWS and no biocides are introduced into the CWS at Salem. All pollutant limits authorized by the NJPDES permit to be discharged at Salem and Hope Creek are at levels at or below EPA's aquatic life criteria.

Water quality criteria are developed by EPA for protection of aquatic life (see http://water.epa.gov/scitech/swguidance/standards/current/index.cfm for current criteria table; last accessed May 1, 2012). Both acute (short term exposure) and chronic (long term exposure) water quality criteria are developed by EPA based on toxicity data for plants and animals. Often, both saltwater and freshwater criteria are developed, based on the suite of species likely to occur in the freshwater or saltwater environment. For aquatic life, the national recommended toxics criteria are derived using a methodology published in *Guidelines for Deriving Numeric National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (EPA 1985). Under these guidelines, criteria are developed from data quantifying the sensitivity of species to toxic compounds in controlled chronic and acute toxicity studies. The final recommended criteria are based on multiple species and toxicity tests. The groups of organisms are selected so that the diversity and sensitivities of a broad range of aquatic life are represented in the criteria values. To develop a valid criterion, toxicity data must be available for at least one species in each of eight families of aquatic organisms. The eight taxa required are as follows: (1) salmonid (e.g., trout, salmon); (2) a fish other than a salmonid (e.g., bass, fathead minnow); (3) chordata (e.g., salamander, frog); (4) planktonic crustacean (e.g., daphnia); (5) benthic crustacean (e.g., crayfish); (6) insect (e.g., stonefly, mayfly); (7) rotifer, annelid (worm), or mollusk (e.g., mussel, snail); and (8) a second insect or mollusk not already represented. Where toxicity data are available for multiple life stages of the same species (e.g., eggs, juveniles, and adults), the procedure requires that the data from the most sensitive life stage be used for that species.

The result is the calculation of acute (criteria maximum concentration (CMC)) and chronic (criterion continuous concentration (CCC)) criteria. CMC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly (i.e., for no more than one hour) without resulting in an unacceptable effect. The CCC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. EPA defines "unacceptable acute effects" as effects that are lethal or immobilize an organism during short term exposure to a pollutant and defines "unacceptable chronic effects" as effects that will impair growth, survival, and reproduction of an organism following long term exposure to a pollutant.

The CCC and CMC levels are designed to ensure that aquatic species exposed to pollutants in compliance with these levels will not experience any impairment of growth, survival or reproduction.

Data on toxicity as it relates to sea turtles and sturgeon is extremely limited. In the absence of species specific chronic and acute toxicity data, the EPA aquatic life criteria represent the best available scientific information. Absent species specific data, NMFS believes it is reasonable to consider that the CMC and CCC criteria are applicable to NMFS listed species as these criteria are derived from data using the most sensitive species and life stages for which information is available. As explained above, a suite of species is utilized to develop criteria and these species are intended to be representative of the entire ecosystem, including marine mammals and sea turtles and their prey. These criteria are designed to not only prevent mortality but to prevent all "unacceptable effects," which, as noted above, is defined by EPA to include not only lethal effects but also effects that impair growth, survival and reproduction.

For the Salem and Hope Creek facilities, the relevant water quality criteria are the New Jersey water quality criteria, which must be certified by EPA every three years. This certification process is designed to ensure that the NJDEP water quality standards are consistent with, or more protective than, the EPA national recommended aquatic life criteria. Based on this reasoning outlined above and provided the Salem and Hope Creek facilities are compliant with the NJDEP water quality standards, for the purposes of this consultation, NMFS considers that pollutants that are discharged with no reasonable potential to cause excursions in water quality standards, will not cause effects that impair growth, survival and reproduction of any NMFS listed species and their prey. Therefore, the effect of the discharge of these pollutants at levels that are less than the relevant water quality standards, which by design are consistent with, or more stringent than EPA's aquatic life criteria, will be insignificant on NMFS listed species.

6.7 Capture during REMP Aquatic Sampling

Since 1968, gillnet sampling has taken place twice a year at three locations within 5 miles of Salem in order to capture fish for testing of edible flesh for gamma emitters. This sampling is required by NRC for the Salem 1, Salem 2, and Hope Creek facilities. On May 16, 2013, one Atlantic sturgeon was captured during REMP sampling. This is the first recorded sturgeon captured during this sampling. After retrieval from the net, the fish was measured and returned immediately back to the river alive. The total length was 510 mm and fork length was 440 mm. Reports provided by the sampling biologists and photographs indicate there were no injuries to the fish. No sea turtles have been captured in REMP sampling.

Given the location of the sampling in areas where shortnose and Atlantic sturgeon are known to occur and because shortnose and Atlantic sturgeon are known to be vulnerable to capture in gillnets, we anticipate that future capture of these species in the REMP fish sampling is possible. However, the rate of capture is likely to be low given that sampling only occurs on two -days per year. As noted above, only one sturgeon has been captured in 52 years of sampling. Annual REMP sampling will continue each year that Salem or Hope Creek is operational. Therefore, sampling will continue through the expiration of the Hope Creek operating license in 2046, a period of 24 years. Given the very low rate of past interactions with sturgeon (1 since 1968), we expect the capture of no more than one shortnose or Atlantic sturgeon over the remaining 24 years of REMP sampling. If an Atlantic sturgeon is captured, it is most likely to originate from the NYB DPS; however, given the mixed-stock analysis for the action area (see Section 4.6), it is possible that the fish could originate from any of the five DPSs.

The duration of the net sets (no more than 12 hours), constant monitoring/tending of the gear and careful handling of any sturgeon once the net is hauled is likely to result in a low potential for mortality. Information available from the Northeast Fisheries Observer Program (NEFOP) database suggests that mortality of Atlantic sturgeon in commercially fished sink gillnets is, on average, approximately 20%; however, mortality of sturgeon in gillnets set for fisheries research is much lower, on average around 1% (see Damon-Randall *et al.* 2010; Kahn and Mohead 2010). Gill nets are constantly observed/tended during the REMP sampling. Based on the duration of net sets and the constant observation/tending of the net, and past monitoring in similar short-set research activities where few mortalities have occurred, we expect that the likelihood of an Atlantic or shortnose sturgeon captured in future REMP sampling to suffer serious injury or mortality is very low (around 1% based on other research using gillnets to capture sturgeon); therefore, we do not expect that a captured shortnose or Atlantic sturgeon will die during REMP sampling.

Sea turtles are also vulnerable to capture and entanglement in gillnets. However, because no sea turtles have been captured in 52 years of sampling, we do not expect any future capture of sea turtles during REMP sampling.

6.8 Radiological Impacts

We have reviewed the information presented in the FEIS and the available reports of the Radiological Evaluation Monitoring Report ((REMP) PSEG 2008, 2009, 2010, 2011, 2012 and 2017) as well as the Radiological Effluent Release Reports for those same years to assess any radiological impacts to listed species or their prey.

As described in the REMP, radioactivity released from the liquid effluent system to the environment is limited, controlled, and monitored by a variety of systems and procedures. Effluent is tested for radioactivity before being released and is only released if the radioactivity levels are below the federal release limits. Thus, releases would only occur to the Delaware River after it is determined that the amount of radioactivity in the wastewater is diminished to acceptable levels that meet NRC criteria.

The REMP includes aquatic environment testing. This involves monitoring samples of edible fish (channel catfish, white catfish, bluefish, white perch, summer flounder, striped bass and black drum), blue crabs, shoreline and riverbed sediments, and surface water. As reported by PSEG, all levels of radioactivity in samples were comparable to pre-operational testing (i.e., testing of these same aquatic species and areas prior to operation of Salem or Hope Creek). The conclusion of these reports is that the operation of Salem and Hope Creek is not having an impact on levels of radionuclides in the environment and that levels are what would be expected in an estuarine environment.

It is important to note that no sea turtles, shortnose sturgeon or Atlantic sturgeon have been tested to determine levels of radionuclides. However, the species tested either serve as prey for these species (e.g., blue crabs serve as primary prey for loggerhead and Kemp's ridley sea turtles) or use similar habitats as these species (e.g., channel catfish occupy similar benthic habitats to sturgeon). Additionally, because there has been no detectable change in radionuclide levels in the aquatic environment as compared to pre-operational levels, it is reasonable to anticipate that similar results would be seen if these listed species were sampled. Based on this information, we do not expect that any sea turtles, shortnose sturgeon or Atlantic sturgeon contain any detectable levels of radionuclides attributable to Salem or Hope Creek. As such, radiological impacts to these species are extremely unlikely. Thus, NMFS considers the effects to critical habitat, listed species and their prey from radionuclides to be extremely unlikely.

In 2002, operations personnel at Salem identified a release of tritium from the Unit 1 Spent Fuel Pool to the environment. PSEG developed a Remedial Action Work Plan (RAWP). NRC and the NJDEP approved the RAWP. In accordance with the RAWP, PSEG installed a Groundwater Recovery System (GRS), and it is in operation to remove the groundwater containing tritium. This system was designed to prevent the migration of the tritium plume towards the plant boundary. No tritium has been detected in the Delaware River and it is not thought that the leak has affected water quality in the river. As such, it is extremely unlikely that any shortnose sturgeon, Atlantic sturgeon, sea turtles, Atlantic sturgeon critical habitat have been exposed to tritium resulting from the Spent Fuel Pool leak.

6.9 Non-routine and Accidental Events

By their nature, non-routine and accidental events that may affect the marine environment are unpredictable and typically unexpected. In the FSEIS, NRC considers design-basis accidents (DBAs); these are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents, without undue hazard to the health and safety of the public. NRC states that "a number of these postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility" (NRC 2011). NRC states that the environmental impacts of these DBAs will be "small" (i.e., insignificant), because the plant is designed to withstand these types of accidents including during the extended operating period.

NRC also states that the risk of severe accidents initiated by internal events, natural disasters or terrorist events is small. As noted by Thompson (2006) in a report regarding the risks of spent-fuel pool storage at nuclear power plants in the U.S., the available information does not allow a statistically valid estimate of the probability of an attack-induced spent-fuel-pool fire. However, Thompson states that "prudent judgment" indicates that a probability of at least one per century within the U.S. is a reasonable assumption. There have been very few instances of accidents or natural disasters that have affected nuclear facilities and none at Salem or Hope Creek that have led to any impacts to the Delaware River. While the experience at Fukishima in Japan provides evidence that natural disaster induced problems at nuclear facilities can be severe and may have significant effects to the environment, the risk of non-routine and accidental events at Salem or Hope Creek that would affect the marine environment, and subsequently affect listed species and critical habitat, is extremely low. Because of this, effects to listed species and critical habitat are extremely unlikely. We expect that in the unlikely event of any accident or disaster that affects the marine environment, reinitiation of consultation, or an emergency consultation, would be necessary.

6.10 Other Effects of the Continued Operation of Salem and Hope Creek

6.10.1 Updated Biological Monitoring Work Plan required by the NJPDES permit

The UBMWP, approved by NJDEP in 2016, requires the completion of several tasks, including: impingement and entrainment monitoring; and bay-wide abundance monitoring. Here, we consider the effects of the implementation of these activities on NMFS listed species. Note that a number of activities that were required by previous versions of the Plan and assessed in the 2014 Opinion are no longer required and as such are not addressed here.

6.10.1.1 River Bottom Trawl Survey

The relative abundance of finfish and blue crabs will be determined by employing 10-minute tows of a 4.9-m otter trawl in the Delaware Estuary. Forty samples will be collected once per month from April through November, conditions permitting, at random stations allocated among eight sampling strata between the mouth of the Delaware Bay and the Delaware Memorial Bridge in all years of the permit period.

During three years (2002, 2003, and 2004) of the NJPDES permit period, an additional 30 samples were collected once per month from April through November, conditions permitting, at random stations allocated among six strata between the Delaware Memorial Bridge and near the Fall Line in Trenton, NJ. This intensive sampling was limited to this three-year period and is not expected to be required in the future.

Fish and blue crabs collected are identified to the lowest practicable taxonomic level, sorted by species, and counted. The length distribution of target species are determined in a representative subsample of each target species. Lengths are measured to the nearest millimeter. In addition, sampling information as well as water temperature, dissolved oxygen, salinity, and water clarity is recorded for each sample.

Interactions with Shortnose and Atlantic sturgeon

From 1995- 2022, 35 Atlantic sturgeon and 26 shortnose sturgeon have been captured during PSEG's NJPDES Permit-required baywide bottom trawl monitoring program (Table 10). These captured sturgeon consisted of juveniles, sub-adults and adult fish. All sturgeon were quickly removed from the net for measurement with minimal handling and released alive at the point of capture.

Table 12. Atlantic and shortnose sturgeon captured during bottom trawl surveys carried out pursuant to the Salem NJPDES permit.

YEAR	ATLANTIC STURGEON	SHORTNOSE STURGEON
1995	1	0
1996	0	0
1997	0	0
1998	1	1
1999	0	0
2000	0	0
2001	0	0
2002	2	2
2003	4	2
2004	6	4
2005	0	0
2006	1	0
2007	0	0
2008	0	2
2009	1	0
2010	0	1
2011	0	0
2012	0	1
2013	2	1
2014	0	1
2015	1	1
2016	2	2
2017	2	3
2018	2	2
2019	3	0
2020	1	0
2021	3	2
2022	3	1
Total	**35**	**26**

As noted above, additional sampling was carried out in 2002, 2003 and 2004. This more intensive sampling resulted in more captures of shortnose and Atlantic sturgeon in those years. PSEG does not anticipate this intense sampling to happen in the future. Outside of the 2002-2004 period, captures of Atlantic and shortnose sturgeon averaged 0.92 and 0.72 fish per year, respectively. Since the issuance of our 2014 biological opinion, the capture rate (2.13 Atlantic sturgeon per year over the eight sample years (2015-2022)) is higher than the 0.38 sturgeon per year anticipated in the 2014 Opinion. The spike in interactions with Atlantic sturgeon during bottom trawl sampling may be correlated with the 2017 year class size, which was very large according to reports from local researchers (NRC, 2020).

Given the rate of historical capture, it is reasonable to assume that some level of capture during bottom trawling will continue for both species. Under terms of the renewed operating license, Salem Units 1 and 2 will continue to operate through August 2036 and April 2040, respectively. The bottom trawl monitoring program is expected to continue as a condition of the NJPDES Permit issued for the operation of Salem. We assume here that it will continue to be required over the entirety of the operational period (i.e., through April 2040). Applying the average annual rate of historical capture (0.92 Atlantic sturgeon/year and 0.72/shortnose sturgeon/year), based on captures from 1995-2022), we expect the capture of 17 Atlantic sturgeon and 13 shortnose sturgeon in the trawl survey between now and April 2040.

Given the location of the trawl survey, we expect captured Atlantic sturgeon to be juveniles, subadults or adults. Based on mixed-stock analysis (see Section 4.6), we anticipate the 17 Atlantic sturgeon to consist of 13 individuals from the New York Bight DPS, 3 from the Chesapeake Bay DPS, and 1 from the South Atlantic, the Gulf of Maine or Carolina DPS.

Capture in trawl gear can result in injury and mortality, reduced fecundity, and delayed or aborted spawning migrations of sturgeon (Moser and Ross 1995, Collins *et al.* 2000, Moser *et al.* 2000). Trawling to capture sturgeon is a safe and reliable method provided that trawling duration is limited. Most negative effects resulting from trawling capture of sturgeon typically are related to the speed and duration of the trawl (Moser *et al.* 2000).

Atlantic sturgeon captured in trawl gear as bycatch of commercial fishing operations have a mortality rate of approximately 5% (based on information in the NEFOP database). Short tow duration and careful handling of any sturgeon once on deck is likely to result in a very low potential for mortality. We reviewed records from 11 long-term trawl surveys carried out by Northeast States (ME/NH, MA, RI, CT, NY, NJ, DE, MD, VA) that capture sturgeon, including two surveys that occur in the Delaware River. In the Hudson River, a trawl survey that incidentally captures shortnose and Atlantic sturgeon has been ongoing since the late 1970s. To date, no injuries or mortalities of any sturgeon have been recorded. These surveys have collectively operated for thousands of hours with some dating back as far as the 1960s. A total of nearly 950 Atlantic and shortnose sturgeon have been captured during these surveys, with no recorded injuries or mortalities. All of these surveys operate with tow times of thirty minutes or less. Similarly, The NEFSC and NEAMAP surveys have recorded the capture of hundreds of Atlantic sturgeon since their inceptions, and to date, there have been no recorded serious injuries or mortalities in those similar surveys.

The only non-fisheries trawl mortalities of Atlantic sturgeon that we are aware of are a result of relocation trawling associated with the Delaware River deepening project. The Delaware River deepening project involved five years of intensive relocation trawling before and during blasting seasons. A total of 5,031 Atlantic sturgeon and 1,097 shortnose sturgeon were captured during the first four seasons of relocation trawling. Three Atlantic sturgeon mortalities occurred in 2015-2016 (886 total sturgeon relocated), there was no mortality in 2016-2017 (691 total sturgeon relocated), two Atlantic sturgeon mortalities occurred in 2017-2018 (3,045 total sturgeon relocated), and no mortality occurred in 2019 (1,506 sturgeon relocated). Reloaction trawling associated with the deepening project has not caused the mortality or injury of any shortnose sturgeon. Four of the five Atlantic sturgeon mortalities were associated with large woody debris in the trawl net. The fifth mortality occurred after an Atlantic sturgeon was injured by a catfish spine while in the net. The injured sturgeon had difficulty swimming and was presumed to have succumbed to its injuries after being released. The catfish spine-related mortality appears to be an extremely rare occurrence as there is no other evidence of such an interaction. We expect that the occurrence of large woody debris in the relocation trawl net is attributable to the large size of the otter trawl used during relocation trawling (i.e., 30.5 m /100 ft); river bottom trawl surveys through the remainder of the license period for Salem and Hope Creek will employ a 4.9 m (16 ft) otter trawl.) and the location of the relocation trawling. It is also important to note that the relocation trawling is distinguishable from the trawling required by the UBMWP not only by net size, location (significantly further upstream), and time of year (winter months as opposed to April through November) but also because the relocation trawl is targeting times and areas where sturgeon are known to congegrate with the purpose of collecting those fish. These factors, in addition to the lack of any mortality of sturgeon in the 28 years that the trawl survey has taken place, make it unreasonable to assume that even the very low mortality rate in the relocation trawl (0.08%) would be expected in the trawl survey considered here. TBased on this information, we do not anticipate the injury or mortality of any shortnose or Atlantic sturgeon captured in the trawl operating for the UBMWP survey.

Sea Turtles
Six sea turtles have been captured in the Bay-wide trawl survey since 1979 (one each in 1979, 1980, 1981, 1984, 1987 and 2004; see PSEG reports to NMFS). With the exception of one green sea turtle in 1980, the remainder have been loggerheads. The turtle captured in 1984 was dead when removed from the trawl and was determined to have died prior to capture. The remaining turtles were alive with no apparent injury. Captures have occurred in June, July, August and September.

The capture rate for sea turtles (1979-2021) is an average of 0.14 sea turtles per year (6 captures in 42 years). Locations and trawl methodology will be unchanged in the future; therefore, it is reasonable to expect this trend to continue. Therefore, assuming that these surveys are required over the duration of the Salem operating licenses (18 years), we anticipate the capture of three sea turtles. We expect the majority of these turtles will be loggerheads; however, given that green and Kemp's ridley sea turtles are present in the action area, we expect that these species may also be captured. We expect the capture of two loggerheads and one green or Kemp's ridley between now and the expiration of the Salem 2 operating license in 2040.

Based on the analysis by Sasso and Epperly (2006) and Epperly *et al.*(2002) as well as information on captured sea turtles from past trawl surveys carried out by States, as well as the NEAMAP and NEFSC trawl surveys and information from the NEFSC FSB observer program, tow times less than 30 minutes will likely eliminate the risk of death from forced submergence for sea turtles caught in the bottom otter trawl survey gear. Given the short tow time (10 minutes), we do not anticipate any mortality.

6.10.1.2 Beach Seine Survey

Finfish and blue crabs are sampled by deploying a 100-ft x 6-ft beach seine in the near shore waters of the Delaware Estuary. Forty samples will be collected once per month in June and November; and twice per month in July through October, conditions permitting, at fixed stations between the mouth of the Delaware River to the Chesapeake and Delaware Canal in each year of the permit period.

Finfish and blue crabs collected are identified to the lowest practicable taxon and counted. Length measurements will be determined in a representative subsample of each target species. Sampling information, as well as water temperature, dissolved oxygen, and salinity, will be recorded for each sample.

Beach seine surveys have occurred for over 30 years. No shortnose sturgeon have been encountered during past beach seine surveys. One Atlantic sturgeon and one Green sea turtle have been captured.

The Green sea turtle captured on August 1, 2016, was in good condition and appeared healthy at the time of collection. Capture of sea turtles in beach seines is rare. Beach seines will be set in shallow sub-tidal waters near the shore. These nearshore habitats, which may contain seagrass, are known foraging areas for sea turtle species. Given the area to be sampled, the short duration of the net sets (15 minutes) and the limited amount of spatial area covered, there is a low likelihood of an encounter with a sea turtle. This is consistent with the low number of encounters that have occurred in the study to date. In the future, we expect captures to be rare and anticipate that no more than one sea turtle will be captured over the life of the licenses.

Direct effects from handling and capture in the seine net will result in some physical damage and physiological stress, which may extend post-capture. Captured sea turtles will be minimally handled and released immediately; however released turtles may experience minor abrasions on their flippers due to chafing on the net. These injuries are expected to be minor and full recovery is expected to be rapid and complete. No lethal injuries or mortality are anticipated.

Capture of sturgeon in beach seines is rare. We are aware of many nearshore seine studies that occur annually in rivers and coastal waters where sturgeon are present with very few observations of sturgeon recorded. The type of habitat where beach seining occurs somewhat overlaps with preferred sturgeon habitat; however, shortnose and Atlantic sturgeon are a benthic species typically found in deeper river channels near the bottom. Shortnose and Atlantic sturgeon are known to forage on tidal mud flats where an abundance of preferred prey items are found. Typically, beach seines will be set in shallow sub-tidal waters near the shore on sandy, gravel or mud substrates. Even though sampling will occur in preferred foraging habitat, the short duration of the net sets (15 minutes) and the limited amount of spatial area covered, will decrease the likelihood of an encounter with a sturgeon. This is consistent with the low number of encounters that have occurred in the study over a period of more than 30 years. In the future, we anticipate that no more than one shortnose or Atlantic sturgeon will be captured in this beach seine survey. Based on mixed stock analysis, we anticipate that the Atlantic sturgeon captured is most likely to originate from the New York Bight DPS.

Direct effects from handling and capture in the seine net will result in some physical damage and physiological stress, which may extend post-capture. Captured sturgeon will be minimally handled and released immediately; however released fish may experience minor abrasions due to chafing on the net. These injuries are expected to be minor and full recovery is expected to be rapid and complete. No lethal injuries or mortality are anticipated.

Beach seine net sampling involves sets of up to 15 minutes. This will cause sturgeon to be temporarily withheld from normal behaviors. However, based on results of gill net studies in other river systems where the same fish have been repeatedly captured, the stress related to this capture is likely to be temporary and sturgeon are expected to be able to rapidly recover and resume their normal behaviors. Accordingly, if handling procedures for captured fish are consistent with our protocols (Kahn and Mohead 2010), we expect the level of stress to be low enough to result in no long term physiological effects, behavioral change or changes to normal migratory behaviors.

6.10.2.1 Entrainment Abundance Monitoring

To estimate the number and size distribution of ichthyoplankton entrained, abundance samples will be collected over 24-hour periods with a pump. In all years of the permit cycle, sampling will be conducted three days per week at a frequency of seven samples per day during January through March and August through December (non-peak entrainment periods), conditions permitting. In addition, sampling will be conducted four days per week at a frequency of fourteen samples per day during the period April through July (peak entrainment periods), conditions permitting. Specimens collected will be identified to the lowest practical taxon and life stage and counted. In addition, total length will be measured to the nearest millimeter for a representative subsample of each target species and life stage per sample. For each sample, additional data collected will include circulator status (on/off), air temperature, water temperature, and salinity.

As explained above, no entrainment of any NMFS listed species is anticipated. Therefore, we do not anticipate any effects to these species from the required entrainment abundance monitoring.

6.10.2.2 Impingement Abundance Monitoring

To estimate the number and size distribution of target species impinged, collections of traveling screen wash water will be made on three days per week during all years of the permit cycle. Ten samples will be collected per 24-hour period.

All fish collected will be sorted by species and counted, and the condition (live, dead, or damaged) of each specimen will be recorded. Length of each specimen will be measured for a subset of each target species, along with the total aggregate weight for all specimens of each species and condition code. For each sample, additional data collected will include circulator status (on/off), air temperature, water temperature, and salinity.

As explained above, we do not anticipate the impingement or capture of any sea turtles or shortnose sturgeon on the traveling screens. Therefore, we do not anticipate any effects to these species from the impingement abundance monitoring.

We estimate that an average of 24 Atlantic sturgeon will be captured or impinged at the traveling screens each year. These individuals could be affected by impingement monitoring. If they were captured or impinged when sampling was taking place, they would be diverted to the fish counting pool and subject to short term holding and handling. However, given that the pools are monitored by trained personnel during the entire sampling period and that the sampling period is short (no more than 8 minutes), we do not anticipate any injury or mortality to result from this diversion and handling. Diversion to the sampling pools will cause sturgeon to be temporarily withheld from normal behaviors. However, based on the results of other studies of sturgeon (gill net, trawl, etc.), the stress related to this monitoring is likely to be temporary and sturgeon are expected to be able to rapidly recover and resume their normal behaviors once returned to the river. Accordingly, if captured fish are handled correctly, we expect the level of stress to be low enough to result in no long term physiological effects, behavioral change or changes to normal migratory behaviors.

6.11 Effects of Handling, Tissue Sampling, and PIT Tagging on Sturgeon

Guidelines developed by sturgeon researchers in cooperation with NMFS staff (Moser *et al.* 2000, Damon-Randall *et al.* 2010, Kahn and Mohead 2010) provide standardized research protocols that minimize the risk to sturgeon species from capture, handling, and sampling. All sturgeon collected at the Salem intakes or captured during radiological sampling or river abundance monitoring will be handled, weighed, measured, visually assessed for injury, and photographed. All sturgeon will be scanned for existing Passive Integrated Transponder (PIT) tags using a tag reader. For sturgeon that do not already have a PIT tag, a tissue sample will be taken for genetic analyses and a PIT tag will be inserted.

We estimate that the continued operation of Salem and Hope Creek will result in the non-lethal capture or collection of a total of 500 sturgeon (475 Atlantic sturgeon and 25 shortnose sturgeon) over the life of the three licenses considered in this consultation. We therefore expect that as many as 500 sturgeon may be affected by handling, tissue sampling, and tagging procedures. The handling, holding, weighing, measuring, and photographing procedures will follow our protocols (Moser *et al.* 2000; Damon-Randall *et al*. 2010; Kahn and Mohead 2010). We expect that individual fish would normally experience no more than short-term stresses as a result of these activities. Researchers have taken measurements and weights of thousands of sampled animals in the proposed manner with no apparent ill effect. No injury would be expected from these activities, and individuals would be worked up as quickly as possible to minimize stress. The proposed methods of handling fish will minimize effects resulting from routine handling and holding.

Tissue sampling

Genetic samples will be taken from all captured fish. This will be done by taking a small (1 cm^2) tissue sample, clipped with surgical scissors from a section of soft fin rays. This procedure does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact (Kahn and Mohead 2010). Thousands of shortnose and Atlantic sturgeon have been sampled in this way with no apparent ill effect; therefore, we do not anticipate any long-term adverse effects to the sturgeon from this activity.

Passive Integrated Transponder (PIT) Tags

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

PIT tags have been used with a wide variety of animal species that include fish (Clugston 1996, Skalski *et al.* 1998, Dare 2003), amphibians (Thompson 2004), reptiles (Cheatwood *et al.* 2003, Germano and Williams 2005), birds (Boisvert and Sherry 2000, Green *et al.* 2004), and mammals (Wright *et al.* 1998, Hilpert and Jones 2005). Problems from PIT tags result from the insertion of tags too big for the size of the animal or from pathogen infection (Muir *et al.* 2001; Henne *et al.,* unpublished). When tag size is appropriate for the animal, no adverse effect on the growth, survival, reproductive success, or behavior of individual animals are anticipated (Brännäs *et al.* 1994, Elbin and Burger 1994, Keck 1994, Jemison *et al*. 1995, Clugston 1996, Skalski *et al.* 1998, Hockersmith *et al.* 2003). PIT tags are biologically inert and have not been shown to cause scarring or tissue damage or otherwise adversely affect growth or survival (Brännäs *et al.* 1994). As the recommended procedures contain limits on the size of the tags based on the size of the fish, and proper sterilization protocols, we do not anticipate problems related to tag size or introduction of pathogens. Therefore, we do not anticipate any injury or mortality to result from insertion of PIT tags.

6.12 Effects of Operation in light of Anticipated Future Climate Change

In the future, global climate change is expected to continue and may impact listed species and their habitat in the action area. The period considered for the continued operation of Salem 1 is 2036, Salem 2 through 2040 and HCGS through 2046.

In section 5.0 above we considered effects of global climate change on sea turtles, shortnose and Atlantic sturgeon. It is possible that there will be effects to sturgeon and sea turtles from climate change over the time that Salem and Hope Creek continue to operate. As explained above, based on currently available information and predicted habitat changes, these effects are most likely to be changes in distribution and timing of seasonal migrations of sturgeon throughout the Delaware River including the action area. There may also be shifts in the seasonal distribution of sea turtles in the action area. However, because we expect only a small increase in water temperature (1°C) and a small change in the location of the salt wedge (shifting further upstream from the action area), there are not likely to be major shifts in abundance, distribution or seasonal use of the action area by Atlantic sturgeon, shortnose sturgeon or sea turtles.

The greatest potential for climate change to impact our assessment would be if (1) ambient water temperatures increased enough such that a larger portion of the thermal plume had temperatures that were stressful for listed species or their prey or if (2) the status, distribution and abundance of listed species or their prey changed significantly in the action area. Given the small predicted increase in ambient water temperatures in the action area during the time period considered (1°C), it is not likely that over the remainder of the operating period that any water temperature changes would be significant enough to affect the conclusions reached by us in this consultation. If new information on the effects of climate change becomes available, then reinitiation of this consultation may be necessary.

7.0 CUMULATIVE EFFECTS

Cumulative effects, as defined in 50 CFR 402.02, are those effects of future State or private activities, not involving Federal activities, which are reasonably certain to occur within the action area. Future Federal actions are not considered in the definition of "cumulative effects."

Actions carried out or regulated by the States of New Jersey and Delaware within the action area that may affect critical habitat, sea turtles, shortnose and Atlantic sturgeon include the authorization of state fisheries and the regulation of point and non-point source pollution through the National Pollutant Discharge Elimination System. We are not aware of any local or private actions that are reasonably certain to occur in the action area that may affect listed species or Atlantic sturgeon critical habitat. 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[8]. The activities discussed in the Cumulative Effects section of NRC's final EIS for the relicensing of Salem and Hope Creek do not all meet the definition of "cumulative effects" under the ESA. In the Cumulative Effects discussion in the EIS, NRC considers the proposed addition of a new nuclear generating facility (two units, closed cycle cooling) at Artificial Island, other existing water withdrawals and discharges from the river near the project site, fisheries, habitat loss and restoration, water quality and climate change. Climate change is addressed in sections 5.4 and 5.5 above.

On May 25, 2010, PSEG filed an application with the NRC for an early site permit (ESP), for approval of a site for up to two nuclear units with closed cycle cooling at Artificial Island. The NRC provided comments to PSEG on the ESP when it was proposed in 2010. The NRC issued the ESP in 2016, but no applications for an operating license have been submitted to NRC. ESPs are valid for 20 years; PSEG's ESP is valid through May 5, 2036. No section 7 consultation has occurred to date, but we expect that any necessary consultation would occur following the receipt by NRC of a complete application for an operating license and prior to any NRC approval of the project. In order to construct and operate additional nuclear units on the site, PSEG would have to apply for, and the NRC would have to grant, either a construction permit and operating licenses under 10 CFR Part 50 or a combined license under 10 CFR Part 52. These permits and/or licenses would be Federal actions that would require section 7 consultation as part of the NRC's environmental review. Because the construction and operation of new nuclear reactors by PSEG is considered a future Federal action, it is not considered to meet the definition of "cumulative effects" under the ESA. In addition, because the construction and operation of these new nuclear reactors is not dependent on the continued operation of Salem 1, Salem 2, or HCGS, it cannot be considered a effect of this proposed 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

[8] 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."

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

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

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

8.0 INTEGRATION AND SYNTHESIS OF EFFECTS

In the effects analysis outlined above, we considered potential effects from the continued operation of Salem 1, Salem 2, and Hope Creek on shortnose sturgeon, five DPSs of Atlantic sturgeon, critical habitat for the NYB DPS of Atlantic sturgeon, and loggerhead, Kemp's ridley, and green sea turtles. We concluded that the proposed actions were not likely to adversely affect critical habitat designated for the NYB DPS of Altnatic sturgeon.

We anticipate the mortality of some green, loggerhead and Kemp's ridley sea turtles, shortnose sturgeon, and Atlantic sturgeon from all five DPSs. Mortality will occur as a result of impingement at Salem; we note that not all dead or injured sturgeon and sea turtles that are collected at the intakes have a cause of death attributable to operation of Salem 1 or 2, where possible, we have distinguished between our estimates of the amount of previously dead individuals that we expect to be collected and the amount of mortality expected to result from impingement at the intakes. We also anticipate the capture of Atlantic and shortnose sturgeon and Kemp's ridley, green and loggerhead sea turtles during surveys required by the NJPDES permit issued for Salem. We also expect the capture of shortnose and Atlantic sturgeon during REMP fish sampling required by NRC, which will result in the mortality of no more than 1 shortnose and 1 Atlantic sturgeon (from any of the 5 DPSs). We anticipate that all sturgeon captured during required sampling or collected at Salem intakes will undergo handling, tissue sampling, and tagging procedures if necessary.. As explained in the *Effects of the Action* section, other effects of operations including effects to prey and the discharge of heated effluent will be insignificant or extremely unlikely. We do not anticipate any take of any listed species due to impingement or entrainment at Hope Creek.

In the discussion below, we consider whether the effects of the proposed actions 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 the listed species. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." Below, for the listed species that may be affected by the proposed action, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of these species and then 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 federal Endangered Species Act.

8.1 Shortnose sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard *et al.* (2016), adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for five 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 exists of the size of either the shortnose sturgeon population in the Northeastern U.S. or of the species throughout its range, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of some populations, such as that in the Chesapeake Bay, add uncertainty to any determination on the status of this species as a whole. Based on the best available information, we consider the status of shortnose sturgeon throughout their range to be stable.

As described in the Status of the Species, Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Delaware River are affected by impingement at water intakes, habitat alteration, dredging, bycatch in commercial and recreational fisheries, water quality, in-water construction activities, and vessel traffic (e.g., data from Delaware's Department of Natural Resources and Environmental Control (DNREC), indicate that from 2005 through 2017, 8 sturgeon mortalities were attributable to vessel strikes (an additional 3 had an unknown cause of death)). It is difficult to quantify the number of shortnose sturgeon that may be killed in the Delaware River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions, we obtain some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Delaware River each year, with little if any mortality. With the exception of the five shortnose sturgeon observed during cutterhead dredging activities in the 1990s, the three shortnose sturgeon killed by hopper dredge in 2017 - 2019, the shortnose sturgeon injured during the pilot relocation study, and the six shortnose sturgeon killed during blasting (for the deepening project) we have no reports of interactions or mortalities of shortnose sturgeon in the Delaware River resulting from dredging or other in-water construction activities. We have no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Delaware River since the 1970s when the CWA was implemented, with significant improvements below Philadelphia which was previously considered unsuitable for shortnose sturgeon and is now well used. Shortnose sturgeon in the Delaware River have full, unimpeded access to their historic range in the river and appear to be fully utilizing all suitable habitat; this suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. In high water years, there is some impingement and entrainment of larvae at facilities with intakes in the upper river; however, these instances are rare and involve only small numbers of larvae. Bycatch in the shad fishery, primarily hook and line recreational fishing, historically may have impacted shortnose sturgeon, particularly because it commonly occurred on the spawning grounds. However, little to no mortality was thought to occur and due to decreases in shad fishing, impacts are expected to be less now than they were in the past. Despite these ongoing threats, the Delaware River population of shortnose sturgeon is stable at high numbers. Over the life of the action, shortnose sturgeon in the Delaware River will continue to experience anthropogenic and natural sources of mortality. However, we are not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Delaware River population. If the salt line shifts further upstream as is predicted in climate change modeling, the range of juvenile shortnose sturgeon is likely to be restricted. However, because there is no barrier to upstream movement it is not clear if this will impact the stability of the Delaware River population of shortnose sturgeon as there appears to be potential for the species to shift its range further up river; 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.

In the *Effects of the Action* section above, we determined that 32 shortnose sturgeon are likely to be captured or impinged while Salem 1 and 2 continue to operate (14 at Salem 1 and 18 at Salem 2). We anticipate that 9 of the shortnose sturgeon will be removed from the water alive and 23 will be dead. Of the 23 dead shortnose sturgeon, we expect that a necropsy would indicate that impingement was a cause of death or a factor in the death of 11 of these sturgeon. The remaining 12 dead sturgeon are likely to have died prior to impingement. We expect that the shortnose sturgeon killed would be large juveniles or adults. We also anticipate the non-lethal capture of up to 13 shortnose sturgeon during the bottom trawl survey and the non-lethal capture of 1 shortnose or Atlantic sturgeon during the beach seine survey to be carried out pursuant to the UBMWP required by the NJPDES permit. We also anticipate the non-lethal capture of 1 shortnose or Atlantic sturgeon during REMP gillnet sampling required by NRC over the duration the Salem 1, Salem 2 and Hope Creek operating licenses. In total, we expect the continued operation of Salem 1, Salem 2, and Hope Creek, to result in the mortality of no more than 11 shortnose sturgeon before the last license expires in 2046. As described above, we also anticipate the non-lethal take of an additional 25 shortnose sturgeon. We determined that all other effects to this species of the actions considered in this Opinion would be insignificant or extremely unlikely.

Live sturgeon captured at the facility or during the bottom trawl survey, beach seine or REMP gillnet sampling may have minor injuries and may experience no more than short-term stresses as a result of handling, tissue sampling, and tagging procedures; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these individuals from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the sturgeon are returned to the wild. The capture of live sturgeon will not reduce the numbers of shortnose sturgeon in the action area, the numbers of shortnose sturgeon in the Delaware River or the species as a whole. Similarly, as the capture of live shortnose sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated over the course of the action. The capture of live shortnose sturgeon is also not likely to affect the distribution of shortnose sturgeon in the action area or affect the distribution of shortnose sturgeon throughout their range. As any effects to individual live shortnose sturgeon removed from the intakes or trawl will be minor and temporary, we do not anticipated any population level impacts over the course of the action.

Existing monitoring data indicates that of the 23 dead shortnose sturgeon we expect to be removed from the Salem intakes, 12 will have died prior to impingement. The operation of Salem will cause the impingement and the “capture” or “collection” of these individuals given the presence of the trash bars, the flow of water through them into the facilities’ service and cooling water systems. The capture and collection of sturgeon killed prior to impingement would not affect the numbers, reproduction or distribution of shortnose sturgeon in the action area or throughout their range.

The number of shortnose sturgeon that are likely to die as a result of the ongoing operations of Salem 1 and Salem 2 (11), represents an extremely small percentage of the shortnose sturgeon population in the Delaware River, which is believed to be stable at high numbers, and an even smaller percentage of the total population of shortnose sturgeon rangewide, which is also stable. We expect this stable trend to continue over the life of the action. The best available population estimates indicate that there are approximately 12,047 adult shortnose sturgeon in the Delaware River (ERC 2006). While the death of 11 shortnose sturgeon between now and 2040 will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this population or its stable trend as this loss represents a very small percentage of the population (approximately 0.09% of adult estimate, a much smaller percentage of the total population which includes all life stages). The effect of this loss is also lessened as it will be experienced slowly over time, with the death of an average of less than one shortnose sturgeon per year over the course of the action.

Reproductive potential of the Delaware population is not expected to be affected in any other way other than through a reduction in numbers of individuals. A reduction in the number of shortnose sturgeon in the Delaware River would have the effect of reducing the amount of potential reproduction in this system as the fish killed would have no potential for future reproduction. However, it is estimated that on average, approximately 1/3 of adult females spawn in a particular year and approximately ½ of males spawn in a particular year. Given that the best available estimates indicate that there are more than 12,000 adult shortnose sturgeon in the Delaware River, it is reasonable to expect that there are at least 5,000 adults spawning in a particular year. It is unlikely that the loss of 11 shortnose sturgeon over an 18-year period at a rate of less than one per year would affect the success of spawning in any year. Additionally, this small reduction in potential spawners is expected to result in a small reduction in the number of eggs laid or larvae produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be very small and would not change the stable trend of this population. Additionally, the proposed action will not affect spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution over the course of the action because the action will not impede shortnose sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Delaware River. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed action is approximately 0.09% of the Delaware River population, there is not likely to be a loss of any unique genetic haplotypes and therefore, it is unlikely to result in the loss of genetic diversity.

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

Based on the information provided above, the death of up to 11 shortnose sturgeon over a 18-year period, will not reduce appreciably the likelihood of survival of this species (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect shortnose sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent shortnose sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter (i.e., it will not increase the risk of extinction faced by this species). This is the case because: given that: (1) the population trend of shortnose sturgeon in the Delaware River is stable; (2) the death of up to 11 shortnose sturgeon represents an extremely small percentage of the number of shortnose sturgeon in the Delaware River and an even smaller percentage of the species as a whole; (3) the loss of these shortnose sturgeon is likely to have such a small effect on reproductive output of the Delaware River population of shortnose sturgeon or the species as a whole that the loss of these shortnose sturgeon will not change the status or trends of the Delaware River population or the species as a whole; (4) the action will have only a minor and temporary effect on the distribution of shortnose sturgeon in the action area (related to movements around the thermal plume) and no effect on the distribution of the species throughout its range; and, (5) the action will have no effect on the ability of shortnose sturgeon to shelter and only an insignificant effect on individual foraging shortnose sturgeon.

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

A Recovery Plan for shortnose sturgeon was published in 1998 pursuant to Section 4(f) of the ESA (NMFS 1998). 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, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the Delaware River population of shortnose sturgeon in a way that would affect the species' likelihood of recovery.

The Delaware River population of shortnose sturgeon is stable at high numbers. This action will not change the status or trend of the Delaware River population of shortnose sturgeon or the species as a whole. This is because the reduction in numbers will be small and the impact on reproduction and future year classes over the course of the action will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant or extremely unlikely, and the area of the river that sturgeon will be precluded from (due to high temperatures) is small. The proposed action will not affect shortnose sturgeon outside of the Delaware River. Therefore, 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.

Despite the threats faced by individual shortnose sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions 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 actions, resulting in the mortality of 11 shortnose sturgeon over 18 years, is not likely to reduce appreciably the survival and recovery of this species. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

8.2 Atlantic sturgeon

In the *Effects of the Action* section above, we determined that 256 Atlantic sturgeon are likely to be captured or impinged at the trash racks while Salem 1 and 2 continue to operate (112 at Salem 1 and 144 at Salem 2). We anticipate that 104 of these Atlantic sturgeon will be removed from the water alive and 152 will be dead. Of the 152 dead Atlantic sturgeon, we expect that a necropsy would indicate that impingement caused or contributed to the death of 98 of these sturgeon. The remaining dead sturgeon (54) are likely to have died prior to impingement. We also anticipate the non-lethal capture of 17 Atlantic sturgeon during the bottom trawl survey and one non-lethal capture during the beach seine survey; both surveys are carried out pursuant to the UBMWP required by the NJPDES permit. We anticipate the non-lethal capture of one Atlantic sturgeon during the REMP gillnet sampling required by NRC over the duration the Salem 1, Salem 2 and Hope Creek operating licenses. We anticipate the impingement or capture of 384 non-migrant subadults or juveniles Delaware River origin New York Bight DPS Atlantic sturgeon at the traveling screens (168 at Salem 1 and 216 at Salem 2); we conservatively anticipate that up to 32 of these individuals may be injured or killed. We also anticipate the non lethal take described above in connection with handling, sampling and tagging of fish. All other effects of the continued operation of Salem 1, Salem 2 and Hope Creek will be insignificant or extremely unlikely.

8.2.1 New York Bight DPS

The NYB DPS is listed as endangered, and while Atlantic sturgeon occur in several rivers in the New York Bight, recent spawning has only been physically documented in the Hudson and Delaware Rivers. The essential physical features necessary to support spawning and recruitment are also present in the Connecticut and Housatonic Rivers (82 FR 39160; August 17, 2017). However, there is no current evidence that spawning is occurring nor are there studies underway to investigate spawning occurrence in those rivers; except one recent study where YOY fish of were captured in the Connecticut River (Savoy *et al.* 2017). Genetic analysis suggests that the YOY belonged to the SA DPS and at this time we do not know if these fish were the result of a single spawning event due to unique straying of the adults from the South Atlantic DPS's spawning rivers. Because juvenile Atlantic sturgeon do not leave their natal rivers, we expect all juvenile Atlantic sturgeon (less than 76cm; see ASSRT 2007) to originate from the Delaware River and therefore, belong to the NYB DPS.

Based on existing data, we expect that 71% of the subadult and adult Atlantic sturgeon in the action area will originate from the NYB DPS. We have limited information from which to determine the percentage of NYB DPS fish in the Delaware River that are likely to originate from the Delaware vs. the Hudson River. Given the sizes of the two populations (i.e., the Delaware River population is thought to be considerably smaller than the Hudson River population), the worst case scenario is that all NYB fish that are killed are Delaware River fish; however, that appears to be unlikely. Of the 150 fish captured in the Delaware River for which genetic assignments are available, 106 were from the New York Bight DPS, with 57 originating from the Delaware River and 49 from the Hudson River. This suggests that within the action area, the composition of New York Bight fish is approximately 54% Delaware and 46% Hudson. Thus, if a NYB subadult Atlantic sturgeon is killed, it is about equally likely that it originated from the Delaware or Hudson River.

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

There are no abundance estimates for the entire NYB DPS or for the entirety of either the Hudson or Delaware River spawning populations. There are, however, some abundance estimates for specific life stages (*e.g.*, natal juvenile abundance, spawning run abundance, and effective population size). Using side scan sonar technology in conjunction with detections of previously tagged Atlantic sturgeon, Kazyak *et al.* (2020, 2021) estimated the 2014 Hudson River spawning run size to be 466 sturgeon (95 percent CRI = 310-745). White *et al.* (2021a) recently estimated the number of adults (N_S) in the Delaware River that successfully reproduced in order to create a cohort of offspring by using genetic pedigrees constructed from progeny genotypes. *Ns* estimates the number of successful breeders and is not synonymous with effective population size (N*e*) or effective number of breeders (Nb) as these metrics describe genetic processes (e.g. inbreeding and genetic drift see Jamieson and Allendorf 2012, Wang *et al.* 2016, Waldman *et al*. 2019). White *et al.* (2021a) estimated that *Ns* ranged from 42 (95% CI: 36-64) spawners in 2014 to 130 (95% CI: 116-138) spawners in 2017 during the years from 2013 to 2019. Because N_S only includes adults that generate at least one offspring during a single breeding season, it sets a lower bound on the size of the spawning run. Nevertheless, the genetics information indicates that at least 42 to 130 adults successfully contributed to the 2014- and 2017-year classes. White *et al.* (2021a) concluded, when considering bias in the data when sample size of offspring is small may result in the Ns being underestimated, that the N_S for Delaware River Atlantic sturgeon is likely between 125 and 250.

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

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

For this biological opinion, we have estimated adult and sub-adult abundance of the NYB DPS based on available information for the genetic composition and the estimated abundance of Atlantic sturgeon in marine waters (Kazyak *et al.* 2021, Kocik *et al.* 2013). Kocik *et al.* (2013), estimated sub-adult and adult abundance of the NYB DPS at 34,566 sturgeon based upon the NEAMAP data. This number encompasses many age classes since sub-adults can be as young as two years old when they first enter the marine environment, and adults can live as long as 60 years (Hilton *et al.* 2016). For example, a study of Atlantic sturgeon captured in the geographic NYB determined that 742 of the Atlantic sturgeon captured represented 21 estimated age classes and that, individually, the sturgeon ranged in age from 2 to 35 years old (Dunton *et al.* 2016). The 2017 ASMFC stock assessment determined that abundance of the NYB DPS is "depleted" relative to historical levels (ASMFC 2017). The assessment also determined there is a relatively high probability (75 percent) that the NYB DPS abundance has increased since the implementation of the 1998 fishing moratorium, and a 31 percent probability that mortality for the NYB DPS exceeds the mortality threshold used for the assessment (ASMFC 2017). The Commission noted, however, there is significant uncertainty in relation to the trend data. Moreover, new information suggests that the Commission's conclusions primarily reflect the status and trend of only the DPS's Hudson River spawning population.

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

In the *Effects of the Action* section above, we determined that 139 non-migrant subadults or juveniles NYB DPS Atlantic sturgeon are likely to be captured or impinged at the trash bars while Salem 1 and 2 continue to operate (61 at Salem 1 and 78 at Salem 2). We anticipate that 56 of these sturgeon will be removed from the water alive and 83 will be dead. Of the 83 dead Atlantic sturgeon, we expect that a necropsy would indicate that impingement was a cause or contributor to the death of 55 of these sturgeon. The remaining 28 dead sturgeon are likely to have died prior to impingement. Additionally, we anticipate the capture or impingement of 84 subadult or adult Atlantic sturgeon from the NYB DPS. We expect 32 of these subadults or adults would be dead, with impingement or collection causing or contributing to the death. We also anticipate the impingement or capture of 384 juvenile NYB DPS Atlantic sturgeon at the Salem 1 and 2 traveling screens (168 at Salem 1 and 216 at Salem 2). We anticipate that 32 of these sturgeon will be injured or killed. We also anticipate the non-lethal capture of 13 NYB DPS Atlantic sturgeon during the UBMWP bottom trawl survey and one Atlantic sturgeon during the beach seine survey (originating from any of the five DPSs, but most likely from the NYB DPS) to be carried out pursuant to the UBMWP required by the NJPDES permit. We also anticipate the non-lethal capture of one Atlantic sturgeon during the REMP gillnet sampling required by NRC for the duration of the operation of Salem 1, Salem 2 and Hope Creek; this fish could originate from the NYB DPS. In addition to the non lethal capture, we anticipate the non lethal, non injurious handling, tissue sampling and tagging of these fish. We determined that all other effects of these actions on this species would be insignificant or extremely unlikely.

In total, we anticipate the continued operation of Salem 1 and 2 will result in the mortality of up to 119 NYB DPS Atlantic sturgeon (87 Delaware River origin juveniles, 32 Hudson or Delaware River subadult or adult) between now and the expiration of the Salem 2 operating license in 2040.

Live sturgeon captured at the intakes or during the bottom trawl or beach seine survey or the REMP gillnet sampling may have minor injuries and may experience no more than short-term stresses as a result of handling, tissue sampling, and tagging procedures; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these individuals from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the sturgeon are returned to the wild. The capture of live sturgeon will not reduce the numbers of Atlantic sturgeon in the action area, the numbers of NYB DPS Atlantic sturgeon in the Delaware River or the species as a whole. Similarly, as the capture of live Atlantic sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of live Atlantic sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of Atlantic sturgeon throughout their range. As any effects to individual live Atlantic sturgeon removed from the intakes or trawl will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that of the 133 dead NYB DPS Atlantic sturgeon we expect to be removed from the Salem intakes, 46 will have died prior to impingement. The operation of Salem will cause the impingement and the “capture” or “collection” of these individuals given the presence of the trash bars and traveling screens, the flow of water through them into the facilities’ service and cooling water systems. The capture and collection of NYB DPS Atlantic sturgeon killed prior to impingement would not affect the numbers, reproduction or distribution of shortnose sturgeon in the action area or throughout their range.

The mortality of 87 juveniles and 32 subadult or adult Atlantic sturgeon from the NYB DPS over an 18 year period represents a very small percentage of the NYB DPS. We expect an average mortality rate of five juveniles per year at Salem.We expect an average mortality rate of two subadults or adults per year at Salem. Hale *et al.* (2016) estimated that 3,656 (95 percent confidence interval from 1,935 to 33,041) juveniles (ages 0–1) used the Delaware River estuary as a nursery in 2014. Mortality of adults due to the continued operation of Salem 1 or 2 is expected to continue to be rare. There are an estimated combined 34,566 NYB DPS subadults and adults (8,642 adults and 25,925 subadults). The total DPS population includes those adults and subadults in marine waters, plus all of the juveniles, young of the year and subadults that are not in the ocean. While the death of these 87 juvenile and 32 subadult or adult Atlantic sturgeon will reduce the number of NYB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the juvenile and subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). This loss represents no more than 0.1% of the juvenile population of the NYB DPS in the Delaware River on an annual basis and approximately 2% of the juvenile population of the NYB DPS in the Delaware River in total over the 18 years. For NYB DPS subadults and adults, this loss represents no more than 0.006% of the DPS on an annual basis and approximately .09% in total over the 18 years.

The reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individuals. We expect the annual loss of an average of seven NYB DPS Atlantic sturgeon each year. The loss of female juveniles or a subadult or adult would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of male juveniles or a subadult or adult may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

The proposed action will also not affect the spawning grounds within the Hudson or Delaware River where NYB DPS fish spawn. The action will also not create a barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds or result in the mortality of any spawning adults.

The proposed action is not likely to reduce distribution because the action will not impede NYB DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Delaware River or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of areas near the thermal plume. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon.

Based on the information provided above, the death of an average of seven NYB DPS Atlantic sturgeon over a 18-year period, for a total of no more than 87 juveniles and 32 subadults or adults, will not reduce appreciably the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these NYB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these NYB DPS Atlantic sturgeon is not likely to have a effect on the levels of genetic heterogeneity in the population; (4) the loss of these sturgeon will not result in the loss of any age class; (5) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effects on the ability of NYB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging NYB DPS Atlantic sturgeon.

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

No Recovery Plan for the NYB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained, would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the NYB DPS likelihood of recovery.

This action will not change the status or trend of the Hudson or Delaware River population of Atlantic sturgeon or the status and trend of the NYB DPS as a whole. The proposed action will result in a small amount of mortality (average of seven individuals per year over a 18-year period consisting primarily of juveniles) and a subsequent small reduction in future reproductive output.

This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant or extremely unlikely. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. Because it will not reduce the likelihood that the Hudson or Delaware River population can recover, it will not reduce the likelihood that the NYB DPS as a whole can recover. Therefore, the proposed action will not reduce appreciably the likelihood that the NYB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered.

Despite the threats faced by individual NYB DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions 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 actions, resulting in the mortality of seven NYB DPS Atlantic sturgeon per year over 18 years, is not likely to reduce appreciably the survival and recovery of this species. Based on the analysis presented herein, the proposed action, is not likely to reduce appreciably the survival and recovery of this species.

8.2.2 Chesapeake Bay DPS

Subadults and adults originating from the CB DPS occur in the action area. The CB DPS is listed as endangered. We expect that 16% of the subadult and adult Atlantic sturgeon in the action area will originate from the CB DPS. Most of these fish are expected to be subadults, with few adults from the CB DPS expected to be present in the Delaware River. While Atlantic sturgeon occur in several rivers in the CB DPS at the time of listing, spawning was only known to occur in the James River. Since the listing, there is evidence of additional spawning populations for the Chesapeake Bay DPS, including the Pamunkey River, a tributary of the York River, and in Marshyhope Creek, a tributary of the Nanticoke River (Hager *et al.* 2014, Kahn *et al.* 2014, Richardson and Secor 2016, Secor *et al.* 2021). 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 (Hilton *et al.* 2016, ASMFC 2017, Kahn *et al.* 2019). However, information for these populations is limited and the research is ongoing.

Chesapeake Bay origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently no census nor enough information to establish a trend, for any life stage, for the James River spawning population, or for the DPS as a whole. However, the NEAMAP data indicates that the estimated ocean population of CB DPS Atlantic sturgeon is 8,811 sub-adult and adult individuals (2,203 adults and 6,608 subadults). The ASMFC (2017) stock assessment determined that abundance of the CB DPS is "depleted" relative to historical levels. The assessment, while noting significant uncertainty in trend data, also determined that there is a relatively low probability (36 percent) that abundance of the CB DPS has increased since the implementation of the 1998 fishing moratorium, and a 30 percent probability that mortality for the CB DPS exceeds the mortality threshold used for the assessment (ASMFC 2017).

In the *Effects of the Action* section above, we determined that of the 117 subadult or adult Atlantic sturgeon likely to be impinged or collected at the Salem 1 and 2 trash racks, 20 could originate from the Chesapeake Bay DPS. These fish could be removed from the water alive or dead and impingement may be a cause or contributor to death or the fish may have died prior to impingement or collection. Due to the very small number of CB DPS adults likely to be present in the action area, if any Chesapeake Bay DPS Atlantic sturgeon are impinged or collected, we expect them to be subadults. We anticipate the non-lethal capture of up to one CB DPS Atlantic sturgeon during the bottom trawl survey and up to one Atlantic sturgeon during the beach seine survey (originating from any of the five DPSs) to be carried out pursuant to the IBMPWP required by the NJPDES permit issued for Salem. We anticipate the non-lethal capture of one Atlantic sturgeon during the REMP gillnet sampling required by NRC over the duration of the operating period for Salem 1, Salem 2 and Hope Creek; this fish could originate from any of the DPSs, including the CB DPS. In addition to the non lethal capture, we anticipate the non lethal, non injurious handling, tissue sampling and tagging of these fish. We determined that all other effects of these actions on this species would be insignificant or extreme`ly unlikely. In total, we anticipate the activities considered here to result in the mortality of no more than 20 subadult Atlantic sturgeon originating from the CB DPS; these 20 mortalities will occur between now and the time the Salem 2 operating license expires in April 2040.

Live sturgeon captured at the intakes or during the bottom trawl or beach seine survey or gillnet REMP sampling may have minor injuries and may experience no more than short-term stresses as a result of handling, tissue sampling, and tagging procedures; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these individuals from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the sturgeon are returned to the wild. The capture of live sturgeon will not reduce the numbers of CB DPS Atlantic sturgeon in the action area, the numbers of CB DPS Atlantic sturgeon in the Delaware River or the species as a whole. Similarly, as the capture of live Atlantic sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of live CB DPS Atlantic sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of CB DPS Atlantic sturgeon throughout their range. As any effects to individual live Atlantic sturgeon removed from the intakes or trawl will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that the 20 dead CB DPS Atlantic sturgeon we expect to be removed from the Salem trash bars may have died prior to impingement. If this is the case, the operation of Salem will cause the impingement and the “capture” or “collection” of these individuals given the presence of the trash bars and the flow of water through them into the facilities’ service and cooling water systems. The capture and collection of sturgeon killed prior to impingement would not affect the numbers, reproduction or distribution of CB DPS Atlantic sturgeon in the action area or throughout their range.

We have determined that impingement may cause or contribute to the mortality of up to 20 subadult CB DPS Atlantic sturgeon. The mortality of 20 subadult Atlantic sturgeon from the CB DPS over a 18 year period represents a very small percentage of the subadult population. There are estimated to be over 6,600 CB DPS subadults in the ocean. Any subadults killed at Salem (no more than 20 over an 18 year period) represent a very small percentage of the total number of subadults (0.3%).

While the death of 20 subadult CB DPS Atlantic sturgeon over the next 18 years will reduce the number of CB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the CB DPS population of subadults and an even smaller percentage of the overall DPS as a whole. Even if there were only 6,608 subadults in the CB DPS, this loss would represent only 0.3% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

The loss of a female subadult would have the effect of reducing the amount of potential reproduction as any dead CB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals apart from the loss of the 20 CB DPS Atlantic sturgeon. The proposed action will also not affect the spawning grounds within the rivers where CB DPS fish spawn.

The proposed action is not likely to reduce distribution because the action will not impede CB DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area of the thermal plume.

Based on the information provided above, the death of no more than 20 subadult CB DPS Atlantic sturgeon over 18-years, will not reduce appreciably the likelihood of survival of the CB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent CB DPS Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of 20 subadult CB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these CB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these subadult CB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effects on the distribution of the species throughout its range; and, (6) the action will have only an insignificant effect on individual foraging or sheltering CB DPS Atlantic sturgeon.

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

No Recovery Plan for the CB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For CB DPS Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the CB DPS likelihood of recovery.

This action will not change the status or trend of the CB DPS as a whole. The proposed action will result in a small amount of mortality (20 subadults from a population estimated to have at least 6,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant or extremely unlikely and the area of the river that sturgeon may avoid is small and any avoidance will be temporary and limited to the period of time when increased temperature is experienced. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for CB DPS Atlantic sturgeon. For these reasons, the action will not reduce the likelihood that the CB DPS Atlantic sturgeon can recover. Therefore, the proposed action will not reduce appreciably the likelihood that the CB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered.

Despite the threats faced by individual CB DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions 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 actions, resulting in the mortality of 20 subadult CB DPS Atlantic sturgeon over 18 years, is not likely to reduce appreciably the survival and recovery of this species. Based on the analysis presented herein, the proposed action, is not likely to reduce appreciably the survival and recovery of this species.

8.2.3 South Atlantic DPS

Subadults and adults originating from the SA DPS occur in the action area. The SA DPS Atlantic sturgeon is listed as endangered and Atlantic sturgeon originate from at least six rivers where spawning potentially still occurs. We expect that 7% of the subadult and adult Atlantic sturgeon in the action area will originate from the SA DPS. Most of these fish are expected to be subadults, with few adults from the SA DPS expected to be present in the Delaware River. Secor (2002) estimates that 8,000 adult females were present in South Carolina prior to 1890. In Georgia, prior to the collapse of the fishery in the late 1800s, the sturgeon fishery was the third largest fishery. Secor (2002) estimated from U.S. Fish Commission landing reports that approximately 11,000 spawning females were likely present in Georgia prior to 1890. At the time of listing, only six spawning subpopulations were thought to have existed in the SA DPS: Combahee River, Edisto River, Savannah River, Ogeechee River, Altamaha River (including the Oconee and Ocmulgee tributaries), and the Satilla River. Three of the spawning subpopulations in the SA DPS are relatively robust and are considered the second (Altamaha River) and third (Combahee/Edisto River) largest spawning subpopulations across all five DPSs. Peterson *et al.* (2008) estimated the number of spawning adults in the Altamaha River was 324 (95 percent CI: 143-667) in 2004 and 386 (95 percent CI: 216-787) in 2005. Bahr and Peterson (2016) estimated the age-1 juvenile abundance in the Savannah River from 2013-2015 at 528 in 2013, 589 in 2014, and 597 in 2015. No census of the number of Atlantic sturgeon in any of the other spawning rivers or for the DPS as a whole is available. However, the NEAMAP data indicates that the estimated ocean population of SA DPS Atlantic sturgeon sub-adults and adults is 14,911 individuals (3,728 adults and 11,183 subadults).

The 2017 ASMFC stock assessment determined that abundance of the SA DPS is “depleted” relative to historical levels (ASMFC 2017). Due to a lack of suitable indices, the assessment was unable to determine the probability that the abundance of the SA DPS has increased since the implementation of the 1998 fishing moratorium. However, it was estimated that there is a 40 percent probability that mortality for the SA DPS exceeds the mortality threshold used for the assessment (ASMFC 2017). We note that the Commission expressed significant uncertainty in relation to the trends data.

In the *Effects of the Action* section above, we determined that up to 117 subadult or adult Atlantic sturgeon are likely to be captured or impinged at the trash bars while Salem 1 and 2 continue to operate (Table 8); we expect 9 of these fish could originate from the South Atlantic DPS. These fish could be removed from the water alive or dead and impingement may be a cause or contributor to death or the fish may have died prior to impingement or collection. We also anticipate the non-lethal capture of one SA DPS Atlantic sturgeon during the bottom trawl survey and up to one Atlantic sturgeon during the beach seine survey (originating from any of the 5 DPSs) to be carried out pursuant to the UBMWP required by the NJPDES permit. We also anticipate the non-lethal capture of up to one Atlantic sturgeon during the REMP gillnet sampling; this fish could originate from any of the five DPSs. In addition to the non lethal capture, we anticipate the non lethal, non injurious handling, tissue sampling and tagging of these fish. We determined that all other effects of these actions on this species would be insignificant or extremely unlikely. In total, we anticipate the activities considered here will result in the mortality of no more than 9 subadult SA DPS Atlantic sturgeon over an 18-year period.

Live sturgeon captured at the intakes or during the bottom trawl or beach seine survey or REMP gillnet sampling may have minor injuries and may experience no more than short-term stresses as a result of handling, tissue sampling, and tagging procedures; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these individuals from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the sturgeon are returned to the wild. The capture of live sturgeon will not reduce the numbers of SA DPS Atlantic sturgeon in the action area, the numbers of SA DPS Atlantic sturgeon in the Delaware River or the species as a whole. Similarly, as the capture of live Atlantic sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of live SA DPS Atlantic sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of SA DPS Atlantic sturgeon throughout their range. As any effects to individual live Atlantic sturgeon removed from the intakes or sampling gear will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that the up to 9 dead SA DPS Atlantic sturgeon we expect to be removed from the Salem trash bars may have died prior to impingement. If this is the case, the operation of Salem will cause the impingement and the "capture" or "collection" of these individuals given the presence of the trash bars and the flow of water through them into the facilities' service and cooling water systems. The capture and collection of sturgeon killed prior to impingement would not affect the numbers, reproduction or distribution of SA DPS Atlantic sturgeon in the action area or throughout their range.

We have determined that impingement may cause or contribute to the mortality of up to 9 subadult SA DPS Atlantic sturgeon. The number of subadult SA DPS Atlantic sturgeon we expect to be killed due to the continued operation of Salem 1 and 2 (up to 9 over an 18-year period) represents an extremely small percentage of the SA DPS. While the death of 9 subadult SA DPS Atlantic sturgeon over the next 18 years will reduce the number of SA DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the SA DPS population of subadults and an even smaller percentage of the DPS as a whole. Even if there were only 11,183 subadults in the SA DPS, this loss would represent less than 0.08% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

The loss of a female subadult would have the effect of reducing the amount of potential reproduction as any dead SA DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of a male subadult may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals, apart from the 9 mortalities. The proposed action will also not affect the spawning grounds within the rivers where SA DPS fish spawn.

The proposed action is not likely to reduce distribution because the action will not impede SA DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area of increased temperature of the thermal plume.

Based on the information provided above, the death of no more than 9 subadult SA DPS Atlantic sturgeon over 18-years, will not reduce appreciably the likelihood of survival of the SA DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect SA DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of up to 9 subadult SA DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these SA DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these SA DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the action will have only a minor and temporary effect on the distribution of SA DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (5) the action will have only an insignificant effect on individual foraging or sheltering SA DPS Atlantic sturgeon.

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

No Recovery Plan for the SA DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the SA DPS likelihood of recovery.

This action will not change the status or trend of the SA DPS as a whole. The proposed action will result in a small amount of mortality (up to 9 subadults from a population estimated to have more than 11,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant or extremely unlikely and the area of the river that sturgeon may avoid is small and limited to the area occupied by the thermal plume. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the SA DPS can recover. Therefore, the proposed action will not reduce appreciably the likelihood that the SA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered.

Despite the threats faced by individual SA DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions 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 actions, resulting in the mortality of nine subadult SA DPS Atlantic sturgeon over 18 years, is not likely to reduce appreciably the survival and recovery of this species. Based on the analysis presented herein, the proposed action, is not likely to reduce appreciably the survival and recovery of this species.

8.2.4 Gulf of Maine DPS

Subadult and adult Atlantic sturgeon originating from the GOM DPS are likely to occur in the action area. The GOM DPS has been listed as threatened, and while Atlantic sturgeon occur in several rivers of the Gulf of Maine region, recent spawning has only been physically documented in the Kennebec River. That said, spawning is suspected to occur in the Androscoggin, Piscataqua, and Merrimack Rivers. Currently we do not have an estimate of the number of Atlantic sturgeon in any river nor is any currently available for the entire DPS; however, NEAMAP data indicates that the estimated ocean population of GOM DPS Atlantic sturgeon subadults and adults is 7,455 individuals (1,864 adults and 5,591 subadults). Gulf of Maine origin Atlantic sturgeon are subject to numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole. The ASMFC stock assessment concluded that the abundance of the Gulf of Maine DPS is "depleted" relative to historical levels. The Commission also noted that the Gulf of Maine is particularly data poor among all five DPSs. The assessment concluded that there is a 51 percent probability that the abundance of the Gulf of Maine DPS has increased since implementation of the 1998 fishing moratorium. The Commission also concluded that there is a relatively high likelihood (74 percent probability) that mortality for the Gulf of Maine DPS exceeds the mortality threshold used for the assessment (ASMFC 2017). However, the Commission noted that there was considerable uncertainty related to these numbers, particularly concerning trends data for the Gulf of Maine DPS. For example, the stock assessment notes that it was not clear if: (1) the percent probability for the trend in abundance for the Gulf of Maine DPS is a reflection of the actual trend in abundance or of the underlying data quality for the DPS; and, (2) the percent probability that the Gulf of Maine DPS exceeds the mortality threshold actually reflects lower survival or was due to increased tagging model uncertainty owing to low sample sizes and potential emigration.

In the *Effects of the Action* section above, we determined that up to 117 subadult or adult Atlantic sturgeon are likely to be captured or impinged at the trash bars while Salem 1 and 2 continue to operate. We anticipate that up to two of these fish could originate from the Gulf of Maine DPS and that these fish may be alive or dead and if dead, that impingement may have caused or contributed to their death.   We also anticipate the non-lethal capture of up to one GOM DPS Atlantic sturgeon during the bottom trawl survey and up to one Atlantic sturgeon during the beach seine survey (originating from any of the five DPSs) to be carried out pursuant to the UBMWP required by the NJPDES permit. We also anticipate the non-lethal capture of no more than one Atlantic sturgeon during the REMP gillnet sampling required by NRC for the duration of the operation of Salem 1, Salem 2 and Hope Creek; this Atlantic sturgeon could originate from any of the five DPSs. In addition to the non lethal capture, we anticipate the non lethal, non injurious handling, tissue sampling and tagging of these fish. We determined that all other effects of these actions on this species would be insignificant or extremely unlikely. In total, we anticipate the activities considered here will result in the mortality of up to two subadult GOM DPS Atlantic sturgeon.

Live sturgeon captured at the intakes or during the bottom trawl or beach seine survey or REMP gillnet sampling may have minor injuries and may experience no more than short-term stresses as a result of handling, tissue sampling, and tagging procedures; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these individuals from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the sturgeon are returned to the wild. The capture of live sturgeon will not reduce the numbers of GOM DPS Atlantic sturgeon in the action area, the numbers of GOM DPS Atlantic sturgeon in the Delaware River or the species as a whole. Similarly, as the capture of live Atlantic sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of live sturgeon is also not likely to affect the distribution of GOM DPS Atlantic sturgeon in the action area or affect the distribution of sturgeon throughout their range. As any effects to individual live Atlantic sturgeon removed from the intakes or sampling gear will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that the up to two dead GOM DPS Atlantic sturgeon we expect to be removed from the Salem trash bars may have died prior to impingement. If this is the case, the operation of Salem will cause the impingement and the "capture" or "collection" of these individuals given the presence of the trash bars and the flow of water through them into the facilities' service and cooling water systems. The capture and collection of sturgeon killed prior to impingement would not affect the numbers, reproduction or distribution of GOM DPS sturgeon in the action area or throughout their range.

We have determined that impingement may cause or contribute to the mortality of up to two subadult GOM DPS Atlantic sturgeon over the next 18 years. While this mortality will reduce the number of GOM DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the GOM DPS population of subadults and an even smaller percentage of the overall DPS as a whole. Even if there were only 5,591 subadults in the GOM DPS, this loss would represent only 0.04% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

The loss of a female subadult would have the effect of reducing the amount of potential reproduction as any dead GOM DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals, apart from the up to two mortalities of GOM DPS Atlantic sturgeon. The proposed action will also not affect the spawning grounds within the rivers where GOM DPS fish spawn.

The proposed action is not likely to reduce distribution because the action will not impede GOM DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the thermal plume.

Based on the information provided above, the death of no more than twosubadult GOM DPS Atlantic sturgeon over 18-years, will not reduce appreciably the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of two subadult GOM DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these GOM DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these GOM DPS Atlantic sturgeon is not likely to have a effect on the levels of genetic heterogeneity in the population; (4) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (5) the action will have only an insignificant effect on individual foraging or sheltering GOM DPS Atlantic sturgeon.

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

No Recovery Plan for the GOM DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For GOM DPS Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the GOM DPS likelihood of recovery.

This action will not change the status or trend of the GOM DPS as a whole. The proposed action will result in a small amount of mortality (up to two subadult from a population estimated to have more than 5,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant or extremely unlikely and the area of the river that sturgeon may avoid is small and any avoidance will be temporary and limited to the period of time when increased temperature from the thermal plume is experienced. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the GOM DPS can recover. Therefore, the proposed action will not reduce appreciably the likelihood that the GOM DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened.

Despite the threats faced by individual GOM DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions 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 actions, resulting in the mortality of two subadult GOM DPS Atlantic sturgeon over 18 years, is not likely to reduce appreciably the survival and recovery of this species. Based on the analysis presented herein, the proposed action, is not likely to reduce appreciably the survival and recovery of this species.

8.2.5 Carolina DPS

As explained in section 4.6, very few Carolina DPS fish have been documented in the action area. Considering the genetic sampling of fin clip samples from Atlantic sturgeon incidentally captured at Salem (n=150 individuals), we anticipate that up to 5% of the subadult Atlantic sturgeon take at Salem would be from the Carolina DPS. Of the 150 samples, a small number of individuals were assigned to rivers within the Carolina DPS; the Pee Dee Spring Run (4), Pee Dee Fall Run (2), and Albemarle Complex (1). 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).

Very few data sets are available that cover the full potential life span of an Atlantic sturgeon. The ASMFC concluded for the Stock Assessment that it could not estimate abundance of the Carolina DPS or otherwise quantify the trend in abundance because of the limited available information. However, the Stock Assessment was a comprehensive review of the available information, and used multiple methods and analyses to assess the status of the Carolina DPS and the coast wide stock of Atlantic sturgeon. For example, the Stock Assessment Subcommittee defined a benchmark, the mortality threshold, against which mortality for the coast wide stock of Atlantic sturgeon as well as for each DPS were compared[9] to assess whether the current mortality experienced by the coast wide stock and each DPS is greater than what it can sustain. This information informs the current trend of the Carolina DPS.

In the Stock Assessment, the ASMFC 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).

In the *Effects of the Action* section above, we determined that up to 117 subadult or adult Atlantic sturgeon are likely to be captured or impinged at the trash bars while Salem 1 and 2 continue to operate; up to sevenof those fish may originate from the Carolina DPS. We anticipate these sturgeon will be removed from the water alive or dead and that if dead, impingement may have caused or contributed to the death. We also anticipate the non-lethal capture of no more than one

[9]The analysis considered both a coast wide mortality threshold and a region-specific mortality threshold to evaluate the sensitivity of the model to differences in life history parameters among the different DPSs (e.g., Atlantic sturgeon in the northern region are slower growing, longer lived; Atlantic sturgeon in the southern region are faster growing, shorter lived).

Carolina DPS Atlantic sturgeon during the bottom trawl survey and up to one Atlantic sturgeon during the beach seine survey (originating from any of the five DPSs) to be carried out pursuant to the UBMWP required by the NJPDES permit. We also anticipate the capture of up to one Atlantic sturgeon during the REMP gillnet sampling required by NRC for the duration of the Salem 1, Salem 2 and Hope Creek operations; this fish could originate from any of the five DPSs. In addition to the non lethal capture, we anticipate the non lethal, non injurious handling, tissue sampling and tagging of these fish. We determined that all other effects of these actions on this species would be insignificant or extremely unlikely. In total, we anticipate the activities considered here will result in the mortality of up to seven subadult Carolina DPS Atlantic sturgeon.

Live sturgeon captured at the intakes or during the bottom trawl or beach seine survey or REMP gillnet sampling may have minor injuries and may experience no more than short-term stresses as a result of handling, tissue sampling, and tagging procedures; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these individuals from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the Carolina DPS Atlantic sturgeon are returned to the wild. The capture of live sturgeon will not reduce the numbers of Carolina DPS Atlantic sturgeon in the action area, the numbers of Carolina DPS Atlantic sturgeon in the Delaware River or the species as a whole. Similarly, as the capture of live Atlantic sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of live Carolina DPS Atlantic sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of Carolina DPS Atlantic sturgeon throughout their range. As any effects to individual live Atlantic sturgeon removed from the intakes or trawl will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that the up to seven dead Carolina DPS Atlantic sturgeon we expect to be removed from the Salem trash bars may have died prior to impingement. If this is the case, the operation of Salem will cause the impingement and the "capture" or "collection" of these individuals given the presence of the trash bars, the flow of water through them into the facilities' service and cooling water systems. The capture and collection of sturgeon killed prior to impingement would not affect the numbers, reproduction or distribution of Carolina DPS Atlantic sturgeon in the action area or throughout their range.

We have determined that impingement may cause or contribute to the mortality of up to seven subadult Carolina DPS Atlantic sturgeon. While the death of seven subadult CA DPS Atlantic sturgeon over the next 18 years will reduce the number of CA DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the CA DPS population of subadults and an even smaller percentage of the overall DPS as a whole. Even if there were only 1,017 subadults in the CA DPS, this loss would represent only .69% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

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

The proposed action is not likely to reduce distribution because the action will not impede CA DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the thermal plume.

Based on the information provided above, the death of no more than seven subadult CA DPS Atlantic sturgeon over 18-years, will not reduce appreciably the likelihood of survival of the CA 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 CA DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of seven subadult CA DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these CA DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these CA DPS Atlantic sturgeon is not likely to have a effect on the levels of genetic heterogeneity in the population; (4) the action will have only a minor and temporary effect on the distribution of CA DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (5) the action will have only an insignificant effect on individual foraging or sheltering CA DPS Atlantic sturgeon.

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

No Recovery Plan for the CA DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For CA DPS Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the CA DPS likelihood of recovery.

This action will not change the status or trend of the CA DPS as a whole. The proposed action will result in a small amount of mortality (up to seven subadults from a population estimated to have more than 1,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant or extremely unlikely and the area of the river that sturgeon may avoid is small and any avoidance will be temporary and limited to the period of time when increased temperature from the thermal plume is experienced. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the CA DPS can recover. Therefore, the proposed action will not reduce appreciably the likelihood that the CA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered.

Despite the threats faced by individual CA DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions 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 actions, resulting in the mortality of seven subadult CA DPS Atlantic sturgeon over 18 years, is not likely to reduce appreciably the survival and recovery of this species. Based on the analysis presented herein, the proposed action, is not likely to reduce appreciably the survival and recovery of this species.

8.3 North Atlantic DPS of green sea turtles

The North Atlantic DPS of green sea turtles is the largest of the 11 green turtle DPSs with an estimated abundance of over 167,000 adult females from 73 nesting sites. All major nesting populations demonstrate long-term increases in abundance (Seminoff *et al.* 2015b). While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue for this DPS, they appear to be somewhat resilient to future perturbations. Two green sea turtles have been impinged at the Salem intakes since 1978 (1 in 1991 (alive), and 1 in 1992 (dead)). In the *Effects of the Action* section above, we determined that one green sea turtle is likely to be impinged at the Salem trash bars prior to the expiration of the Salem operating licenses. This turtle could be impinged at either the Salem 1 or Salem 2 intakes. This green sea turtle could be removed from the water dead or alive. If dead, we expect that a necropsy could indicate that the turtle died due to impingement at the trash bars (drowning). However, it is possible that this turtle could have died prior to impingement. We also anticipate the non-lethal capture of one green sea turtle during the UBMWP bottom trawl survey and one green sea turtle during the beach seine survey to be carried out as part of the UBMWP required by the NJPDES permit. We determined that all other effects of these actions on this species would be insignificant or extremely unlikely.

Live turtles captured at the facility may have minor injuries; however, they are expected to make a complete recovery without any impairment to future fitness. Capture at Salem will temporarily prevent these sea turtles from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the turtles are returned to the wild. The capture of a live green sea turtle from the Salem intakes is not likely to reduce the numbers of green sea turtles in the action area, the numbers of greens in any subpopulation or the species as a whole. Similarly, as the capture of a live green sea turtle from the Salem intakes will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of a live green sea turtle from the Salem intakes is also not likely to affect the distribution of green sea turtles in the action area or affect the distribution of sea turtles throughout their range. As any effects to individual live green sea turtles removed from the intakes will be minor and temporary, there are not anticipated to be any population level impacts. The same effects are anticipated for any green sea turtle captured during the trawl and beach seine surveys.

Existing monitoring data indicates that the impinged green sea turtle could have died prior to impingement. The operation of Salem will cause the impingement and the "capture" or "collection" of the turtle given the presence of the trash bars and the flow of water through them into the facilities' service and cooling water systems. The capture and collection of a turtle killed prior to impingement would not affect the numbers, reproduction or distribution of green sea turtles in the action area or throughout their range.

We have also considered that the impinged green sea turtle could die as a result of impingement. The lethal removal of one green sea turtle, whether a male or females, immature or mature animal, would reduce the number of green sea turtles as compared to the number of green that would have been present in the absence of the proposed action assuming all other variables remained the same; the loss of one green sea turtles represents a very small percentage of the species as a whole. Even compared to the number of nesting females (167,000), which represent only a portion of the number of greens worldwide, the mortality of 1 green represents less than

0.006% of the nesting population. The loss of this sea turtle would be expected to reduce the reproduction of green sea turtles as compared to the reproductive output of green sea turtles in the absence of the proposed action. As described in the *Status of the Species* section above, we consider the trend for green sea turtles to be stable. However, as explained below, the death of this green sea turtle will not reduce appreciably the likelihood of survival for the species for the following reasons.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction on the numbers, reproduction and distribution of the species this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of greens because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of greens is likely to be increasing and at worst is stable. These actions are not likely to reduce distribution of greens because the actions will not impede greens from accessing foraging grounds or cause more than a temporary disruption to other migratory behaviors.

Based on the information provided above, the death of 1 green sea turtle between now and when the Salem Unit 2 license expires in April 2040 (a period of 18 years), will not reduce appreciably the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect green sea turtles 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 green sea turtles from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the species' nesting trend is increasing; (2) the death of 1 green sea turtle represents an extremely small percentage of the species as a whole; (3) the loss of 1 green sea turtle will not change the status or trends of the species as a whole; (4) the loss of 1 green sea turtle is not likely to have a effect on the levels of genetic heterogeneity in the population; (5) the loss of 1 green sea turtle is likely to have an undetectable effects on reproductive output of the species as a whole; (6) the action will have no effect on the distribution of greens in the action area or throughout its range; and (7) the action will have no effect on the ability of green sea turtles to shelter and only an insignificant effect on individual foraging green sea turtles.

In rare instances, an action may not reduce appreciably the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not reduce appreciably the likelihood that green sea turtles 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 species can rebuild to a point where listing is no longer appropriate. A Recovery Plan for Green sea turtles was published by NMFS and USFWS in 1991. The plan outlines the steps necessary for recovery and the criteria which, once met, would ensure recovery. In order to be delisted, green sea turtles must experience sustained population growth, as measured in the number of nests laid per year, over time. Additionally, “priority one” recovery tasks must be achieved and nesting habitat must be protected (through public ownership of nesting beaches) and stage class mortality must be reduced. Here, we consider whether this proposed action will affect the population size and/or trend in a way that would affect the likelihood of recovery.

The proposed action will not reduce appreciably the likelihood of survival of green sea turtles. Also, it is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of green sea turtles in any geographic area and since it will not affect the overall distribution of green sea turtles other than to cause minor temporary adjustments in movements in the action area. As explained above, the proposed action is likely to result in the mortality of one green sea turtle; however, the loss of this individual over this time period is not expected to affect the persistence of green sea turtles or the species trend. The actions will not affect nesting habitat. The effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the action will not prevent the species from growing in a way that leads to recovery and the action will not change the rate at which recovery can occur. This is the case because while the action may result in a small reduction in the number of greens and a small reduction in the amount of potential reproduction due to the loss of one individual, these effects will be undetectable over the long-term and the action is not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed action will not reduce appreciably the likelihood that green sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual green sea turtles inside and outside of the action area, the proposed action will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. We have considered the effects 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 1 green sea turtle over 18 years, is not likely to reduce appreciably the survival and recovery of this species.

8.4 Kemp’s ridley sea turtles

Of the sea turtles species in the world, the Kemp's ridley has declined to the lowest population level. Fishery interactions are the main threat to the species. By the mid-1980s, the population had declined to an estimated 300 nesting females from 40,000 females in the 1940s. From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased at 15% annually (Heppell *et al.* 2005). However, due to recent declines in nest counts, decreased survival of immature and adult sea turtles, and updated population modeling, this rate is not expected to continue and the overall trend is unclear (NMFS and U.S. FWS 2015, Caillouett *et al.* 2018). In 2019, there were 11,090 nests, a 37.61% decrease from 2018 and a 54.89% decrease from 2017, which had the highest number (24,587) of nests (Figure 9; unpublished data). The reason for this recent decline is uncertain. The number of mature individuals was recently estimated at 22,341 (Wibbels and Bevan 2019) with an unknown current trend. Over the operational life of Salem, 44 Kemp's ridleys were collected or impiniged and 29 were dead, with 10 of those deaths attributable to operations of the facility.

In the *Effects of the Action* section above, we determined that 32 Kemp's ridley sea turtles are likely to be impinged at the Salem trash bars prior to the expiration of the Salem operating licenses (14 at Salem 1 and 18 at Salem 2). We anticipate that 28 of the 32 Kemp's ridleys will be dead when removed from the water. We expect that a necropsy would indicate that 10 of these turtles died due to impingement at the trash bars (drowning). We also anticipate the non-lethal capture of one Kemp's ridley sea turtle during bottom trawl and beach seine surveys carried out as part of the UBMWP required by the NJPDES permit. We determined that all other effects of these actions on this species would be insignificant or extremely unlikely.

Live turtles captured at the intakes or during bottom trawl and beach seine surveys may have minor injuries; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these sea turtles from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the turtles are returned to the wild. The capture of a live Kemp's ridley sea turtle from the Salem intakes or during bottom trawl and beach seine surveys is not likely to reduce the numbers of Kemp's ridley sea turtles in the action area, the numbers of Kemp's ridleys in any subpopulation or the species as a whole. Similarly, as the capture of a live Kemp's ridley sea turtle will not affect the fitness of any individual and no effects to reproduction are anticipated. The capture of a live Kemp's ridley sea turtle is also not likely to affect the distribution of Kemp's ridley sea turtle in the action area or affect the distribution of sea turtles throughout their range. As any effects to individual live Kemp's ridley sea turtles removed from the intakes or captured during the trawl and beach seine surveys will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that 19 of the Kemp's ridley sea turtle's expected to be impinged are likely to have died prior to impingement. The operation of Salem will cause the impingement and the "capture" or "collection" of the turtles given the presence of the trash bars and the flow of water through them into the facilities' service and cooling water systems. The capture and collection of turtles killed prior to impingement would not affect the numbers, reproduction or distribution of Kemp's ridley sea turtles in the action area or throughout their range.

We anticipate 10 of the impinged Kemp's ridley sea turtles will die as a result of impingement. The mortality of 10 Kemp's ridleys over an 18 year time period represents a very small percentage of the Kemp's ridleys worldwide. Even taking into account just nesting females (7-8,000), the death of 10 Kemp's ridley represents less than 0.13% of the population. While the death of 10 Kemp's ridley will reduce the number of Kemp's ridleys compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the population. Reproductive potential of Kemp's ridleys is not expected to be affected in any other way other than through a reduction in numbers of individuals.

A reduction in the number of Kemp's ridleys would have the effect of reducing the amount of potential reproduction as any dead Kemp's ridleys would have no potential for future reproduction. In 2006, the most recent year for which data is available, there were an estimated 7-8,000 nesting females. While the species is thought to be female biased, there are likely to be several thousand adult males as well. Given the number of nesting adults, it is unlikely that the loss of 10 Kemp's ridley over 18 years would affect the success of nesting in any year. Additionally, this small reduction in potential nesters is expected to result in a small reduction in the number of eggs laid or hatchlings produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future nesters that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be very small and would not change the trend of this species. Additionally, the proposed action will not affect nesting beaches in any way or disrupt migratory movements in a way that hinders access to nesting beaches or otherwise delays nesting.

The proposed action is not likely to reduce distribution because the action will not impede Kemp's ridleys from accessing foraging grounds or cause more than a temporary disruption to other migratory behaviors. Additionally, given the small percentage of the species that will be killed as a result of the proposed action, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction on the numbers, reproduction and distribution of the species this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of Kemp's ridleys because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population.

Based on the information provided above, the death of 10 Kemp's ridley sea turtles over the next 18 years will not reduce appreciably the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect Kemp's ridleys in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent Kemp's ridleys from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of 10 Kemp's ridleys represents an extremely small percentage of the species as a whole; (2) the death of 10 Kemp's ridleys will not change the status or trends of the species as a whole; (3) the loss of these Kemp's ridleys is not likely to have a effect on the levels of genetic heterogeneity in the population; (4) the action will have only a minor and temporary effect on the distribution of Kemp's ridleys in the action area and no effect on the distribution of the species throughout its range; and, (5) the action will have no effect on the ability of Kemp's ridleys to shelter and only an insignificant effect on individual foraging Kemp's ridleys.

In rare instances, an action may not reduce appreciably the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not reduce appreciably the likelihood that Kemp's ridley sea turtles 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 Kemp's ridleys can rebuild to a point where listing is no longer appropriate. In 2011, NMFS and the USFWS issued a recovery plan for Kemp's ridleys (NMFS *et al.* 2011). The plan includes a list of criteria necessary for recovery. These include:

1. An increase in the population size, specifically in relation to nesting females[10];
2. An increase in the recruitment of hatchlings[11];
3. An increase in the number of nests at the nesting beaches;
4. Preservation and maintenance of nesting beaches (i.e. Rancho Nuevo, Tepehuajes, and Playa Dos); and,
5. Maintenance of sufficient foraging, migratory, and inter-nesting habitat.

As explained above, the loss of 10 Kemp's ridley between now and April 2040 will not affect the population trend. The number of Kemp's ridleys likely to die as a result of the proposed action is an extremely small percentage of the species. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed action will not affect the likelihood that criteria one, two or three will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; therefore, the proposed action will have no effect on the likelihood that recovery criteria four will be met. All effects to habitat will be insignificant or extremely unlikely; therefore, the proposed action will have no effect on the likelihood that criteria five will be met.

The effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction. Further, the action will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the action may result in a small reduction in the number of Kemp's ridleys and a small reduction in the amount of potential reproduction due to the loss of one individual between now and when the operating licenses expire, these effects will be undetectable over the long-term and the action is not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed action will not reduce appreciably the likelihood that Kemp's ridley sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

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[10]A population of at least 10,000 nesting females in a season (as measured by clutch frequency per female per season) distributed at the primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos) is attained in order for downlisting to occur; an average of 40,000 nesting females per season over a 6-year period by 2024 for delisting to occur

[11] Recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos).

Despite the threats faced by individual Kemp's ridley sea turtles inside and outside of the action area, the proposed action will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. We have considered the effects 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 10 Kemp's ridleys, is not likely to reduce appreciably the survival and recovery of this species.

8.5 Northwest Atlantic DPS of Loggerhead sea turtles

The Northwest Atlantic DPS of loggerhead sea turtles is listed as threatened. Based on nesting data and population abundance and trends at the time, NMFS and USFWS determined in 2011 that the Northwest Atlantic DPS should be listed as threatened and not endangered based on: (1) the large size of the nesting population, (2) the overall nesting population remains widespread, (3) the trend for the nesting population appears to be stabilizing, and (4) substantial conservation efforts are underway to address threats (76 FR 58868, September 22, 2011).

It takes decades for loggerhead sea turtles to reach maturity. Once they have reached maturity, females typically lay multiple clutches of eggs within a season, but do not typically lay eggs every season (NMFS and USFWS 2008). There are many natural and anthropogenic factors affecting the survival of loggerheads prior to their reaching maturity as well as for those adults who have reached maturity. As described in the *Status of the Species*, *Environmental Baseline* and *Cumulative Effects* sections above, loggerhead sea turtles in the action area continue to be affected by multiple anthropogenic impacts including bycatch in commercial and recreational fisheries, habitat alteration, dredging, power plant intakes and other factors that result in mortality of individuals at all life stages. Negative impacts causing death of various age classes occur both on land and in the water. Many actions have been taken to address known negative impacts to loggerhead sea turtles. However, many remain unaddressed, have not been sufficiently addressed, or have been addressed in some manner but whose success cannot be quantified.

There are five subpopulations of loggerhead sea turtles in the western North Atlantic (recognized as recovery units in the 2008 recovery plan for the species). These subpopulations show limited evidence of interbreeding. As described in the *Status of the Species*, recent assessments have evaluated the nesting trends for each recovery unit. Nesting trends are based on nest counts or nesting females; they do not include non-nesting adult females, adult males, or juvenile males or females in the population.

NMFS SEFSC (2009) estimated the number of adult females in the NWA DPS at 30,000, and if a 1:1 adult sex ratio is assumed, the result is 60,000 adults in this DPS. Based on the reviews of nesting data, as well as information on population abundance and trends, NMFS and USFWS determined in the September 2011 listing rule that the NWA DPS should be listed as threatened. They found that an endangered status for the NWA DPS was not warranted given the large size of the nesting population, the overall nesting population remains widespread, the trend for the nesting population appears to be stabilizing, and substantial conservation efforts are underway to address threats. We expect this stable trend to continue over the period considered in this Opinion.

Nesting trends for each of the loggerhead sea turtle recovery units in the Northwest Atlantic Ocean DPS are variable. A preliminary regional abundance survey of loggerheads within the northwestern Atlantic continental shelf, corrected for unidentified turtles in proportion to the ratio of identified turtles, estimates about 801,000 loggerheads (NMFS-NEFSC 2011). More recent nesting data indicate that nesting in Georgia, South Carolina, and North Carolina is now on an upward trend. Recent data from Florida index nesting beaches, which comprise most of the nesting in the DPS, indicate a 19% increase in nesting from 1989 to 2018. Ceriani and Meylan (2017) report a positive trend for this DPS. The primary threat to sea turtles in the Northwest Atlantic is fishery bycatch. Fisheries bycatch is the highest threat to the loggerhead sea turtles globally (Conant *et al.* 2009). Over the operational period of Salem, 68 loggerheads have been impinged at the facility. Of these turtles, 25 were dead with 19 determined to have died prior to impingement. The remaining six, had the cause of death identified as drowning (due to impingement at the trash bars) or were fresh dead with no signs of decomposition and considered likely to have drowned at the trash bars.

In the *Effects of the Action* section above, we determined that four loggerheads are likely to be captured or impinged while Salem 1 and 2 continue to operate (two at Salem 1 and two at Salem 2). We anticipate that one of the loggerheads will be removed from the water alive and three will be dead. Of the three dead loggerheads, we expect that a necropsy would indicate that one of these turtles died due to impingement at the trash bars (drowning). The remaining two dead loggerheads are likely to have died prior to impingement. We also anticipate the non-lethal capture of two loggerheads during the bottom trawl survey and up to one loggerhead during the beach seine survey to be carried out pursuant to the UBMWP required by the NJPDES permit. We determined that all other effects of these actions on this species would be insignificant or extremely unlikely.

Live turtles captured at the facility or during the bottom trawl and beach seine surveys may have minor injuries; however, they are expected to make a complete recovery without any impairment to future fitness. Capture will temporarily prevent these sea turtles from carrying out essential behaviors such as foraging and migrating. However, these behaviors are expected to resume as soon as the turtles are returned to the wild. The capture of live loggerhead sea turtles is not likely to reduce the numbers of loggerhead sea turtles in the action area, in any subpopulation or the species as a whole over the course of the action. Similarly, as the capture of live loggerhead sea turtles will not affect the fitness of any individual, no effects to reproduction are anticipated over the course of the action. The capture of live loggerhead sea turtles is also not likely to affect the distribution of loggerhead sea turtles in the action area or affect the distribution of sea turtles throughout their range over the course of the action. As any effects to individual live loggerhead sea turtles will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that of the three dead loggerheads we expect to be removed from the Salem intakes, two will have died prior to impingement. The operation of Salem will cause the impingement and the “capture” or “collection” of these turtles given the presence of the trash bars and the flow of water through them into the facilities' service and cooling water systems. The capture and collection of turtles killed prior to impingement would not affect the numbers, reproduction or distribution of NWA DPS loggerhead sea turtles in the action area or throughout their range.

As stated above, we expect that one NWA DPS loggerhead will die as a result of impingement at the Salem trash bars. The lethal removal of one loggerhead sea turtle from the action area over 18 years would be expected to reduce the number of loggerhead sea turtles from the recovery unit of which it originated as compared to the number of loggerheads that would have been present in the absence of the proposed action (assuming all other variables remained the same). We expect that the majority of loggerehads in the action area originated from the Northern Recovery Unit (NRU) or the Peninsular Florida Recovery Unit (PFRU) and assume for purposes of this analysis that this one loggerhead came from one of these two recovery units.

Annual nest totals for the PFRU averaged 64,513 nests from 1989-2007, representing approximately 15,735 females per year (NMFS and USFWS 2008). Nest counts taken at index beaches in Peninsular Florida showed a significant decline in loggerhead nesting from 1989 to 2007, most likely attributed to mortality of oceanic-stage loggerheads caused by fisheries bycatch (Witherington *et al.* 2009). In the trend analysis by Ceriani and Meylan (2017), a 2% decrease for this Recovery Unit was reported.

The Northern Recovery Unit, from the Florida-Georgia border through southern Virginia, is the second largest nesting aggregation in the DPS, with an average of 5,215 nests from 1989-2008, and approximately 1,272 nesting females (NMFS and U.S. FWS 2008). For the Northern recovery unit, nest counts at loggerhead nesting beaches in North Carolina, South Carolina, and Georgia declined at 1.9% annually from 1983 to 2005 (NMFS and U.S. FWS 2007a). In the trend analysis by Ceriani and Meylan (2017), a 35% increase for this Recovery Unit was reported. In 2019, record numbers of loggerhead nests have been reported in Georgia and the Carolinas (https://www.cbsnews.com/news/rare-sea-turtles-smash-nesting-records-in-parts-of-southeast-georgia-south-carolina-north-carolina/; July 14, 2019).

The loss of one loggerhead over an 18-year period represents an extremely small percentage of the number of sea turtles in the PFRU. Even if the total population was limited to 15,735 loggerheads, the loss of one individual would represent approximately 0.006% of the population. If the total NRU population was limited to 1,272 sea turtles (the number of nesting females), the loss of one individual would represent less than 0.08% of the population. Even just considering the number of adult nesting females, this loss is extremely small and would be even smaller when considered for the total recovery unit and represents an even smaller percentage of the DPS as a whole.

The loss of one individual is such a small percentage from any of these recovery units represents an even smaller percentage of the species as a whole. Considering the extremely small percentage of any population that will be killed, it is unlikely that this death will have a detectable effect on the numbers and population trends of loggerheads in these recovery units or the number of loggerheads in the Northwest Atlantic DPS over the course of the action.

The loggerhead that is expected to be killed will be a juvenile. Thus, any effects on reproduction are limited to the loss of this individual on their year class and the loss of its future reproductive potential. Given the number of nesting adults in each of these populations, it is unlikely that the expected loss of one loggerhead over a 18 year period would affect the success of nesting in any year. Additionally, this small reduction in potential nesters is expected to result in a small reduction in the number of eggs laid or hatchlings produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future nesters that would be produced by the individual that would be killed as a result of this action, any effects to future year classes is anticipated to be very small and would not change the stable trend of this species over the course of the action. The proposed action will not affect nesting beaches in any way or disrupt migratory movements in a way that hinders access to nesting beaches or otherwise delays nesting. Additionally, given the small percentage of the species that will be lost, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

The proposed action is not likely to reduce distribution because the action will not impede loggerheads from accessing foraging grounds or cause more than a temporary disruption to other migratory behaviors. There is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction on the numbers, reproduction and distribution of the species, this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of loggerheads because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of loggerheads is likely to be stable or increasing over the time period considered here.

Based on the information provided above, the death of one loggerhead between now and April 2040 is not expected to reduce appreciably the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect loggerheads in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent loggerheads from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of one loggerhead represents an extremely small percentage of the species as a whole; (2) the death of one loggerhead will not change the status or trends of the species as a whole; (3) the loss of this loggerhead is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of one loggerhead is likely to have an extremely small effect on reproductive output that will be insignificant at the recovery unit or DPS level; (5) the action will have only a minor and temporary effect on the distribution of loggerheads in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of loggerheads to shelter and only an insignificant effect on individual foraging loggerheads.

In rare instances, an action may not reduce appreciably the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not reduce appreciably the likelihood that loggerhead sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed action will affect the likelihood that the NWA DPS of loggerheads can rebuild to a point where listing is no longer appropriate. In 2008, NMFS and the USFWS issued a recovery plan for the Northwest Atlantic population of loggerheads (NMFS and USFWS 2008). The plan includes demographic recovery criteria as well as a list of tasks that must be accomplished. Demographic recovery criteria are included for each of the five recovery units. These criteria focus on sustained increases in the number of nests laid and the number of nesting females in each recovery unit, an increase in abundance on foraging grounds, and ensuring that trends in neritic strandings are not increasing at a rate greater than trends in in-water abundance. The recovery tasks focus on protecting habitats, minimizing and managing predation and disease, and minimizing anthropogenic mortalities.

Loggerheads have a stable trend; as explained above, the loss of one loggerhead over 18-years as a result of the proposed action will not affect the population trend. The individual loggerhead likely to die as a result of the proposed action is an extremely small percentage of any recovery unit or the DPS as a whole. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed action will not affect the likelihood that the demographic criteria will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; all effects to habitat will be insignificant or extremely unlikely; therefore, the proposed action will have no effect on the likelihood that habitat based recovery criteria will be achieved. The proposed action will also not affect the ability of any of the recovery tasks to be accomplished.

In summary, the effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the action will not prevent the species from growing in a way that leads to recovery and the action will not change the rate at which recovery can occur. This is the case because while the action may result in a small reduction in the number of loggerheads and a small reduction in the amount of potential reproduction due to the loss of this individual, these effects will be undetectable over the long-term and the action is not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed action will not reduce appreciably the likelihood that the NWA DPS of loggerhead sea turtles can be brought to the point at which they are no longer listed as threatened.

Based on the analysis presented herein, the proposed action is not likely to reduce appreciably the survival and recovery of the NWA DPS of loggerhead sea turtles.

9.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species and designated critical habitat under NMFS jurisdiction, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is NMFS' biological opinion 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.

10.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. 1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. 1538(g). A "person" is defined in part as any entity subject to the jurisdiction of the United States, including an individual, corporation, officer, employee, department or instrument of the Federal government (see 16 U.S.C. 1532(13)). Under the terms of 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 Incidental Take Statement (ITS). In issuing ITSs, NMFS takes no position on whether an action is an "otherwise lawful activity."

Salem 1, Salem 2 and Hope Creek operate pursuant to operating licenses issued by the NRC. The Salem 1 and Salem 2 nuclear reactors use a once-through cooling system requiring water to be withdrawn from the Delaware River. This results in the impingement of Atlantic and shortnose sturgeon and green, Kemp's ridley and loggerhead sea turtles at the trash racks which are part of the intake system. Water withdrawal also results in the impingement or collection of juvenile NYB DPS Atlantic sturgeon on the traveling screens, which are also part of the intake system. No take of shortnose or Atlantic sturgeon or any species of sea turtle is anticipated due to the continued withdrawal of water for the Hope Creek nuclear reactor.

Take, in the form of capture of Atlantic and shortnose sturgeon, will also result from gillnet surveys carried out by PSEG to fulfill the requirements of the REMP. The REMP is required by the NRC over the duration of the continued operations of Salem 1, Salem 2, and Hope Creek. No take of sea turtles is anticipated to occur during REMP sampling for Salem 1, Salem 2 or Hope Creek.

Take, in the form of capture and injury, will also result from PSEG carrying out the beach seine survey and baywide trawl survey. This survey is a required component of the UBMWP; the UBMWP is a mandatory special condition of the SPDES permit issued to PSEG by NJDEP for Salem 1 and Salem 2. As explained in Section 6.0, we have determined that the UBMWP, including the baywide trawl survey, is an effect of the proposed action.

Because all of the anticipated take results from, but is not the purpose of, operation of the Salem 1, Salem 2, and Hope Creek nuclear facilities, it is all considered "incidental take" for purposes of this Opinion (see 50 CFR §402.02). When we exempt incidental take, we must issue Reasonable and Prudent Measures (RPMs) and Terms and Conditions. These RPMs and Terms and Conditions minimize (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 NRC has indicated that they have authority to ensure compliance with RPMs and Terms and Conditions related to the operation of the trash racks and traveling screens. Because the REMP is also required by NRC, NRC can also ensure compliance with RPMs and Terms and Conditions related to surveys necessary to complete the REMP. The NJDEP requires PSEG to implement the UBMWP as condition of the NJPDES permit issued for the operation of Salem 1 and 2. NRC has determined that they do not have the authority to enforce RPMs or Terms and Conditions related to the implementation of the UBMWP because the NRC does not have authority under the Clean Water Act or its implementing regulations under which the UBMWP was established. In the State of New Jersey, that authority lies with the NJDEP, as delegated by the U.S. Environmental Protection Agency. As such, the RPMs and Terms and Conditions necessary and appropriate to minimize and monitor incidental take resulting from the UBMWP are the responsibility of PSEG, not the NRC.

If NRC and PSEG fail to assume and implement the applicable Terms and Conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, NRC and PSEG must report the progress of the action and its impact on the species to us as specified in the ITS [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

10.1 Amount or Extent of Take

This ITS serves two important functions: (1) it provides an exemption from the Section 9 prohibitions for any taking incidental to the proposed action that is in compliance with the Terms and Conditions; and (2) it provides the means to insure the action as it is carried out is not jeopardizing the continued existence of affected species by monitoring and reporting the progress of the action and its impact on the species such that consultation can be reinitiated if any of the criteria in 50 CFR 402.16 are met. This ITS applies to the remaining term of the renewed operating licenses that were issued in 2011. These current renewed operating licenses expire on August 13, 2036 (Salem 1), April 18, 2040 (Salem 2), and April 11, 2046 (Hope Creek).

As explained in the *Effects of the Action* section, effects of the facilities on shortnose and Atlantic sturgeon, green, Kemp's ridley and loggerhead sea turtles also include effects of the thermal plume on distribution and prey. However, based on the available information on the thermal plume and the assumptions regarding sturgeon and sea turtles behavior and thermal tolerances outlined in the Opinion, we do not anticipate or exempt any take of shortnose or Atlantic sturgeon or any species of sea turtle due to effects to prey items or due to exposure to the thermal plume.

We expect shortnose sturgeon and Atlantic sturgeon from the New York Bight (NYB), Gulf of Maine (GOM), Chesapeake Bay (CB), South Atlantic (SA) and Carolina DPSs with body widths greater than 3" to be impinged at the trash bars. However, as explained in the *Effects of the Action* section, we expect some of the sturgeon impinged on the trash bars will be dead or stressed prior to the impingement and the cause of death/stressor is currently unknown. Dead or injured sea turtles may also become impinged on the trash bars. This impingement is expected to result from the operation of Salem 1 and Salem 2 and the presence of the trash bars. These interactions at the trash bars constitute "capture" or "collect" in the definition of "take."

We expect live sea turtles, shortnose sturgeon and subadult Atlantic sturgeon from the NYB, GOM, CB, SA and Carolina DPSs to be captured by the trash rake during trash bar cleaning. These interactions at the trash bars constitute "capture" or "collect" in the definition of "take." These interactions may also result in injuries.

Some live sea turtles, shortnose sturgeon and subadult and adult Atlantic sturgeon from the New York Bight, Gulf of Maine, Chesapeake Bay, South Atlantic and Carolina DPSs may become impinged on the trash bars and die as a result of impingement or have the impingement as a contributing factor in their death. These interactions at the trash bars constitute "kill" in the definition of "take."

The continued operation of Salem 1 and Salem 2 will result in the impingement of juvenile New York Bight DPS origin Atlantic sturgeon at the traveling screens. We expect that some of the sturgeon impinged at the screens will be dead or suffering from injury or illness. Some sturgeon caught in the buckets of the Ristroph screens are likely to have been healthy and free swimming; some of those fish are likely to experience injury or mortality while being transported to the sluice. Other sturgeon that become impinged on the screens are likely to suffer injury or mortality due to their impingement. We also expect that some sturgeon will become tired, disoriented and stressed such that their normal behaviors are impaired or they become injured while in the intake embayment between the trash bars and screens; we expect that these fish will become impinged on the Ristroph screens. Based on the available information and the small number of Atlantic sturgeon documented during impingement monitoring at the traveling screens (seven live and two dead from 1976-2022), we have estimated that Atlantic sturgeon impinged or captured at the Ristroph screens will have a mortality rate of approximately 8.25%. Sturgeon that are impinged at the Ristroph screens but safely returned (i.e., with no injury) alive to the Delaware River are "captured" or "collected."

Salem 1 and Salem 2 operate under separate licenses and will operate for different periods of time. As a result, "take" at the Salem 1 and 2 intakes will be apportioned to each of the two separate actions.

This ITS exempts the following take (injure, kill, capture or collect, as described below) resulting from the operation of the cooling water system:

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 dead due to impingement)	18 (13 dead, 6 dead due to impingement)	32 (23 dead, 11 due to impingement)

Impingement or Collection of Atlantic Sturgeon at the Trash Bars

	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 dead due to impingement)	66 (39 dead, 25 dead due to impingement)	117 (70 dead, 45 dead due to impingement)
Sub adult or adult NYB DPS	37 (22 dead, 15 dead due to impingement)	47 (28 dead, 18 dead due to impingement)	84 (50 dead, 32 dead 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 Carolina DPS	3 dead or alive	4 dead or alive	7 dead or alive
Subadult or adult GOM DPS	1 dead or alive	1 dead or alive	2 dead or alive

Impingement/Collection of Juvenile Atlantic Sturgeon at the Traveling Screens

	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)

Impingement/Collection of Sea Turtles at the Trash Bars

Loggerhead sea turtles: Total collected - 4 (2 at Unit 1 and 2 at Unit 2); Mortality – no more than 3 (subset of total); Mortality due to plant operations – no more than 1 (subset of mortality)

Kemp's ridley sea turtles: Total collected - 32 (14 at Unit 1 and 18 at Unit 2); Mortality – no more than 28 (subset of total); Mortality due to plant operations – no more than 10 (subset of mortality)

<u>Green sea turtles:</u> Total collected – 1 at either Unit 1 or Unit 2; Mortality – no more than 1 (subset of total); Mortality due to plant operations – no more than 1 (subset of mortality)

REMP Gillnet Sampling
We also 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 and Atlantic sturgeon.

UBMWP - Bottom Trawl and Beach Seine
As explained above, we have determined that the UBMWP, including the baywide trawl survey and beach seine sampling, is a effect of the proposed action. In the *Effects of the Action* section, we considered the effects of the UBMWP as required by the NJPDES permit issued to PSEG for the operation of Salem 1 and Salem 2. We have estimated that the continuation of the bottom trawl survey will result in the non-lethal capture of 13 shortnose sturgeon, 17 Atlantic sturgeon (13 NYB, 3 CB, and 1 of either SA, GOM, or Carolina DPS) and three sea turtles (two loggerheads and one Kemp's ridley or green). We also expect the beach seine survey to result in the non-lethal capture of one Atlantic sturgeon (likely NYB DPS origin) or one shortnose sturgeon and one sea turtle. This ITS exempts this amount of take ("capture" or "collect") of live shortnose sturgeon, Atlantic sturgeon, and sea turtles captured during these surveys.

10.2 Reasonable and Prudent Measures
In order to effectively monitor the effects of this action, it is necessary to monitor the intakes to document the amount of incidental take (i.e., the number of each species captured, collected, injured or killed) and to examine these individuals. Monitoring provides information on the characteristics of the individuals encountered and may provide data which will help develop more effective measures to avoid future interactions with listed species. We do not anticipate any additional injury or mortality to be caused by removing the fish or turtles from the water and examining them as required in the RPMs. The transfer of live sea turtles to an appropriate STSSN facility is likely to improve the individual's chance of survival following impingement; particularly as many of the sea turtles impinged may be suffering from previously inflicted injury or illness. No such facilities are available for shortnose or Atlantic sturgeon; as such, any live sturgeon are to be released back into the river, away from the intakes. Any STSSN facility that live sea turtles may be transferred to is required to be authorized to care for, rehabilitate and release sea turtles pursuant to a Stranding Network Agreement and a permit issued by the USFWS pursuant to Section 10 of the ESA. As outlined below, NMFS is requiring NRC to ensure that PSEG prepares arrangements with an appropriate STSSN approved and permitted facility. Reasonable and prudent measures and implementing terms and conditions requiring this monitoring and transport are outlined below. The following reasonable and prudent measures are necessary or appropriate for NRC and/or the licensee, PSEG, to minimize and monitor impacts of incidental take of listed species.

RPMs Applicable to NRC and PSEG at the Intakes:

1. PSEG must continue to implement a NMFS approved program to prevent, monitor and

minimize the incidental take of sea turtles and sturgeon at the Salem intakes as described in the terms and conditions.

2. All observations of sea turtle and sturgeon at the intakes must be reported to NMFS and NRC; this includes live and dead individuals removed from the racks, the trash rake or traveling screens and any incidental sightings of sturgeon or sea turtles during monitoring of the trash racks.

3. All live sea turtles must be transported to an appropriate facility for necessary rehabilitation and release into the wild.

4. A necropsy of any dead sea turtles must be undertaken promptly to attempt to identify the cause of death, particularly whether the sea turtle died as a result of interactions with the intakes.

5. All live sturgeon must be released back into the Delaware River at an appropriate location away from the intakes and thermal plume that minimizes the additional risk of death or injury.

6. Any dead sturgeon must be retained in cold storage until disposal procedures are discussed with NMFS. Disposal may involve transfer to NMFS or an appropriately permitted research facility. Necropsy may be required when the dead body is in sufficient condition (i.e., "fresh dead") and it is necessary to determine the cause of death, particularly whether the fish died as a result of interactions with the intakes.

7. PSEG must continue to use flow-through river water in all fish sampling areas and holding tanks to ensure adequate depth, temperature, and dissolved oxygen.

RPMs Applicable to NRC and PSEG during REMP gillnet sampling:

8. Any listed species caught during the survey must be handled and resuscitated according to established procedures.

9. Any listed species caught and retrieved in the sampling gear must be properly documented.

10. NMFS GARFO and NRC must be notified regarding all interactions with or observations of listed species, including the capture of live and dead sea turtles and sturgeon and incidental observations of live or dead sea turtles or sturgeon observed during REMP sampling.

RPMs to be Implemented by PSEG during UBMWP sampling (beach seine and trawl):

11. PSEG must handle and resuscitate any listed species caught during the survey according to established procedures.

12. PSEG must identify and properly document any listed species caught and retrieved in the

sampling gear.

13. PSEG must notify NMFS GARFO and NRC regarding all interactions with or observations of listed species, including the capture of live and dead sea turtles and sturgeon and incidental observations of live or dead sea turtles or sturgeon observed during UBMWP sampling.

10.3 Terms and Conditions

Terms and Conditions to be Implemented by NRC and PSEG at the Intakes:

1. To implement RPM #1, the intake trash bars upstream of operating circulating water pumps must be cleaned at least once a week year round. During the period of peak sturgeon abundance, December 1 – April 30, trash bars upstream of operating circulators must be cleaned at least twice a week regardless of operational needs.

   a. Cleaning must include the full length of the trash rack, i.e., down to the bottom of each intake bay. Measures to remove trash bar blockage or repair rakes must be promptly pursued (e.g., within two weeks) to ensure that all bar racks can be cleaned as necessary. Operators must wait a minimum of three minutes to close the gripper after lowering it to debris level. To lessen the possibility of injury to a turtle or sturgeon, the raking process must be closely monitored so that it can be stopped immediately if a turtle or sturgeon is sighted.

   b. PSEG personnel must be instructed to look at surface debris beneath the rake, if possible, before the rake is used to lessen the possibility of injury to a turtle or sturgeon.

   c. PSEG personnel cleaning the racks must inspect all debris that is dumped to ensure that no sea turtles or sturgeon are present within the debris.

   d. If any sea turtles or sturgeon are present within the debris, PSEG must report and handle this as described in RPM #2, 4, and 6.

2. To implement RPM #1, inspection of cooling water intake trash bars (and immediate area upstream) must continue to be conducted at least once per 12-hour shift. Times of inspections, including those when no turtles or sturgeon were sighted, must be recorded.

3. To implement RPM#1, an annual inspection of the trash bars with hydroacoustic imaging technology must be carried out to assess the condition of the racks. If any deterioration or damage is detected, a plan to repair or restore the trash bars to design conditions must be developed and implemented in accordance with a repair plan to be submitted to the NMFS. A copy of the annual report and any associated repair/maintenance plans shall be submitted to NMFS and NRC within 30 days of the inspection each year.

4. To implement RPM #1, lighting must be maintained at the intake structure / trash racks to enable inspection personnel to see the river surface and to facilitate safe handling of turtles or sturgeon which are discovered at night. Portable spotlights must be available at the intakes for times when extra lighting is needed.

5. To implement RPM #1, dip nets, baskets, and other equipment must be available at the intakes and must be used to remove sea turtles or sturgeon from the intake structures if possible, to reduce trauma caused by the existing cleaning mechanism. Equipment suitable for rescuing large turtles (e.g., rescue sling or other provision) must be available at Salem and readily accessible from the intakes.

6. To implement RPM #1, PSEG must deploy the ice barriers for the minimum amount of time annually that allows for safe operations. PSEG must conduct analyses of long term river water temperature and any available futurecasts of river temperature and ice conditions to develop an annual installation and removal schedule. This schedule shall consider long-term forecasting and monitoring data from the National Weather Service to predict ice packs in the vicinity of the Salem 1 and Salem 2 intake. In the spring, the ice barrier should be removed as soon as the threat of surface and frazil ice is reduced enough that removal is safe and practicable. The trash rack must be fully cleaned and maintained in a clean condition prior to installation of the ice barrier. Prior to November 1 of each year, PSEG shall submit to NMFS and NRC their plan for deployment and removal of the ice barriers for the coming winter including a summary of the information that was used to determine the schedule.

7. To implement RPM #1, an attempt to resuscitate comatose sea turtles must be made according to the procedures described in Appendix A. These procedures must be posted in appropriate areas such as the intake bay areas, any other area where turtles would be moved for resuscitation, and the operator's office(s).

8. To implement RPM #2, PSEG personnel must report any sea turtles or sturgeon sighted near Salem 1 and Salem 2 to NMFS (nmfs.gar.incidental-take@noaa.gov or by phone 978-281-9328 and NRC (endangeredspecies@nrc.gov) within 24 hours of the observation.

9. To implement RPM #2, PSEG must take fin clips (according to the procedure outlined in Appendix B) of any shortnose and Atlantic sturgeon (live or dead) captured at the intakes. In the case of dead animals, fin clips must be taken prior to preservation of other fish parts or whole bodies. All fin clips must be preserved (see Appendix B) and transported to a NMFS-approved lab. NRC and/orPSEG must coordinate with the qualified lab to process the sample in order to determine DPS (for Atlantic sturgeon) or river (for shortnose sturgeon) of origin. The DPS or river of origin must be reported to NMFS once the sample has been processed. Within 30 days of receiving this Opinion, NRC and/orPSEG must contact NMFS to obtain a list of individuals/facilities with the appropriate ESA authority and technical ability to carry out the genetic identification. Arrangements must be made with an appropriate individual/facility within

60 days of receiving this Opinion. The arrangement should be memorialized via letter to NMFS from NRC and/or PSEG that includes information on arrangements for the frequency of transfer of samples to the facility, timelines for processing of samples, and the mutually agreed upon expectations for costs associated with transport and necropsy services between NRC and/or PSEG and the facility. The DPS or river of origin must be reported to NMFS once the sample has been processed.

10. To implement RPM #2, if any live or dead sea turtles or sturgeon are taken at Salem trash bars or traveling screens, PSEG plant personnel must notify NMFS (nmfs.gar.incidental-take@noaa.gov or by phone 978-281-9328 and the NRC (endangeredspecies@nrc.gov) within 24 hours of the take. An incident report for sea turtle or sturgeon take (Appendix C) must also be completed by PSEG plant personnel and sent to the NMFS Section 7 Coordinator via FAX (978-281-9394) or e-mail (nmfs.gar.incidental-take@noaa.gov) within 24 hours, or on the next business day following the take. Copies of these reports should also be submitted to the NRC electronically (endangeredspecies@nrc.gov) or by mail to the NRC Document Control Desk. PSEG must ensure that every sea turtle and sturgeon is photographed. Information in Appendix D will assist in identification of species impinged.

11. To implement RPM #2, an annual report of incidental takes at the trash bars and traveling screens must be submitted to NMFS by March 15 of the following year. This report will be used to identify trends and further conservation measures necessary to minimize incidental takes of sea turtles and sturgeon. The report must include, as detailed above, all necropsy reports, incidental take reports, photographs (if not previously submitted), a record of all sightings in the vicinity of Salem, and a record of when inspections of the intake trash bars were conducted for the 7 days prior to the take. The report must include a table indicating the number of shortnose and Atlantic sturgeon and sea turtles removed from the trash bars as well as any sturgeon observed during sampling of the traveling screens. The report should include an estimate of the total number of sturgeon likely collected on the traveling screens based on the number observed and the percentage of time sampling occurred. The annual report must also include any potential measures to reduce sea turtle and sturgeon impingement or mortality at the intake structures. This annual report must also include information on arrangements made with a STSSN facility to handle sea turtles taken in the coming year. The report must also include all necropsy reports and results from genetic testing of fin clips. A copy of the annual report should also be submitted to the NRC electronically (endangeredspecies@nrc.gov) or by mail to the NRC Document Control Desk. At the time the report is submitted, NMFS will supply NRC and PSEG with any information on changes to reporting requirements (i.e., staff changes, phone or fax numbers, e-mail addresses) for the coming year.

12. To implement RPM #3, within 30 days of receiving this Opinion, NRC and/or PSEG must contact NMFS to either: (1) obtain a list of stranding/rehabilitation facilities with the appropriate ESA authority to respond to live sea turtles and/or to conduct necropsies of dead sea turtles; or (2) confirm arrangements with one of these facilities to respond to live and dead sea turtles collected from the Salem intakes. If arrangements are not

already in place with one of these facilities, they must be made within 60 days of receiving this Opinion. The appropriate facility must be contacted immediately following any live sea turtle take. Appropriate transport methods must be employed following the stranding facilities protocols, to transport the animal to the care of the stranding/rehabilitation personnel for evaluation, necessary veterinary care, tagging, and release in an appropriate location and habitat. NMFS must be informed of the arrangements made with the facility to respond to live and dead sea turtles.

13. To implement RPM #4, all dead sea turtles must be necropsied at a facility that has the appropriate ESA authorizations (see T&C #9). NRC and/or PSEG must coordinate with a qualified facility or individual to perform the necropsies on sea turtles impinged at Salem, prior to the incidental turtle take, so that there is no delay in performing the necropsy or obtaining the results. The necropsy results must identify, when possible, the sex of the turtle, stomach contents, and the estimated cause of death. Necropsy reports must be submitted to the NMFS Northeast Region with the annual review of incident reports or, if not yet available, within 60 days of the incidental take. Copies of these reports should also be submitted to the NRC electronically (endangeredspecies@nrc.gov) or by mail to the NRC Document Control Desk. The only exception to this requirement is if the approved facility determines, and NMFS agrees, that the condition of the carcass precludes any reasonable likelihood of identifying the cause of death.

14. To implement RPM #5, any live sturgeon must be returned to the river away from the intakes and the thermal plume, following complete documentation of the event.

15. To implement RPM #6, in the event of any lethal takes of sturgeon, PSEG must ensure that any dead specimens or body parts are photographed, measured, and preserved (refrigerate) until disposal procedures are discussed with NMFS. NMFS may request that the specimen be transferred to NMFS or to an appropriately permitted researcher so that a necropsy may be conducted. The form included as Appendix C must be completed and submitted to NMFS as noted above. The requirement for necropsy will be made on a case by case basis and will be based on (1) the condition of the fish and (2) a determination by NMFS that necropsy is necessary to determine whether impingement or collection at the intakes was a cause or factor in the death.

16. To implement RPM #7, PSEG must ensure that no shortnose or Atlantic sturgeon are held for longer than 4 hours, that water depth is sufficient to cover the body of all fish, and that water temperature and dissolved oxygen levels reflect ambient river conditions.

RPMs Applicable to NRC and PSEG during REMP gillnet sampling:

17. To implement RPM#8, PSEG personnel must give priority to handling and processing any listed species that are captured in the sampling gear. Handling times must be minimized for these species.

18. To implement RPM#8 attempts must be made to resuscitate any Atlantic sturgeon that

may appear to be dead by providing a running source of water over the gills.

19. To comply with RPM #9, all survey crews must have at least one crew member who is experienced in the identification of sturgeon on the vessel(s) used for survey where interactions with sturgeon are anticipated at all times that the on-water survey work is conducted. Information provided as Appendix D can aid in species identification.

20. To comply with RPM #9 PSEG must take fin clips (according to the procedure outlined in Appendix B) of any shortnose and Atlantic sturgeon (live or dead) captured at the intakes. In the case of dead animals, fin clips must be taken prior to preservation of other fish parts or whole bodies. All fin clips must be preserved (see Appendix B) and transported to a NMFS-approved lab. PSEG must coordinate with the qualified lab to process the sample in order to determine DPS (for Atlantic sturgeon) or river (for shortnose sturgeon) of origin. The DPS or river of origin must be reported to NMFS once the sample has been processed.

21. To comply with RPM #9, PSEG must ensure that on all vessels where appropriate Passive Integrated Transponder (PIT) tag readers are available, captured sturgeon are scanned for existing PIT tags. Any recorded sturgeon PIT tags must be reported to the USFWS tagging database (Current POC: Mike Mangold at mike_mangold@fws.gov). During surveys where the appropriate PIT tags are available, any untagged sturgeon must be tagged with PIT tags according to the procedure included as Appendix E and the tag numbers recorded and reported to the USFWS tagging database (Current POC: Mike Mangold at mike_mangold@fws.gov).

22. To comply with RPM #9, all interactions with listed species must be documented. Photographs should be taken whenever possible. The condition of each animal must be recorded and any injuries documented on forms provided as Appendix C or on similar forms that contain all of the information fields provided in Appendix C. Individuals should be measured (length) if possible and weighed if adequate scales are available on the sampling vessel.

23. To comply with RPM #10, any dead Atlantic or shortnose sturgeon or sea turtle must be retained and held in cold storage until disposal can be discussed with NMFS. Severely decomposed and partial sturgeon or sea turtle carcasses may be discarded after processing and collection of data for the incident report form and following notification by email or phone to NMFS. A sturgeon incident report form (Appendix C) must be filled out for any dead sturgeon and provided to NMFS.

24. To comply with RPM #10, NMFS PRD must be notified within 24 hours of any interaction with a listed species. If reporting within 24 hours is not possible, the report must be made as soon as possible, preferably on the next business day. These reports should be sent by e-mail (nmfs.gar.incidental-take@noaa.gov). If e-mail notification within 24 hours is not possible, this information can be faxed (978-281-9394 Attn: Section 7 Coordinator) or phoned in (NMFS Protected Resources Division 978-281-9328). For purposes of monitoring the incidental take of sea turtles and sturgeon during

the surveys, reports must be made for any sea turtle or sturgeon: (a) found alive, dead, or injured within the sampling gear; (b) found alive, dead, or injured and retained on any portion of the sampling gear outside of the net bag; or (c) interacting with the vessel and gear in any other way. The report must include: a clear photograph of the animal (multiple views if possible, including at least one photograph of the head scutes); identification of the animal to the species level; GPS or Loran coordinates describing the location of the interaction; time of interaction; date of interaction; condition of the animal upon retrieval (alive uninjured, alive injured, fresh dead, decomposed, comatose or unresponsive); the condition of the animal upon return to the water; GPS or Loran coordinates of the location at which it was released; a description of the care or handling provided; information related to any tags detected and/or inserted; and notification that a genetic sample was taken (if required). Copies of these reports should also be submitted to the NRC electronically (endangeredspecies@nrc.gov) or by mail to the NRC Document Control Desk.

25. To comply with RPM #10, written reports must be provided to NMFS GARFO annually (by March 15 of each year) indicating either that no interactions with ESA-listed species occurred or providing the total number of interactions that occurred with ESA-listed species, as well as copies of all required reporting forms and photographs. Any reports required by Term and Condition 9 that have not been provided to NMFS GARFO must be included in this report. This report must be submitted by e-mail (nmfs.gar.incidental-take@noaa.gov) or mailed to the NMFS Greater Atlantic Regional Fisheries Office, Attn: Section 7 Coordinator, 55 Great Republic Drive, Gloucester, MA 01930. Copies of these reports should also be submitted to the NRC electronically (endangeredspecies@nrc.gov) or by mail to the NRC Document Control Desk.

Terms and Conditions to be Implemented by PSEG during UBMWP sampling (beach seine and trawl):

26. To implement RPM #11, PSEG personnel must give priority to handling and processing any listed species that are captured in the sampling gear. Handling times must be minimized for these species.

27. To implement RPM #11 all personnel carrying out surveys have copies of the sea turtle handling and resuscitation requirements found at 50 CFR 223.206(d)(1) and as reproduced in Appendix A prior to the commencement of any on-water activity where sea turtles may be encountered. PSEG must ensure that all operators carry out these handling and resuscitation procedures as appropriate.

28. To implement RPM #11 attempts must be made to resuscitate any Atlantic sturgeon that may appear to be dead by providing a running source of water over the gills.

29. To comply with RPM #12, all survey crews must have at least one crew member who is experienced in the identification of sturgeon and/or sea turtles on the vessel(s) used for survey where interactions with these species are anticipated at all times that the on-water survey work is conducted. Information provided as Appendix D can aid in species

identification.

30. To comply with RPM #12, PSEG must take fin clips (according to the procedure outlined in Appendix B) of any shortnose and Atlantic sturgeon (live or dead) captured at the intakes. In the case of dead animals, fin clips must be taken prior to preservation of other fish parts or whole bodies. All fin clips must be preserved (see Appendix B) and transported to a NMFS-approved lab. PSEG must coordinate with the qualified lab to process the sample in order to determine DPS (for Atlantic sturgeon) or river (for shortnose sturgeon) of origin. The DPS or river of origin must be reported to NMFS once the sample has been processed.

31. To comply with RPM #12, PSEG must ensure that on all vessels where appropriate Passive Integrated Transponder (PIT) tag readers are available, captured sturgeon and sea turtles are scanned for existing PIT tags. Any recorded sturgeon PIT tags must be reported to the USFWS tagging database (Current POC: Mike Mangold at mike_mangold@fws.gov). PIT tag numbers must be included with any reports submitted to NMFS. During surveys where the appropriate PIT tags are available, any untagged sturgeon must be tagged with PIT tags according to the procedure included as Appendix E and the tag numbers recorded and reported to the USFWS tagging database (Current POC: Mike Mangold at mike_mangold@fws.gov).

32. To implement RPM #12, PSEG must ensure that all sea turtles are inspected for external tags (typically found on the flipper). All tag numbers must be recorded and reported to NMFS on the incident reporting form included as Appendix C.

33. To comply with RPM #12, all interactions with listed species must be documented. Photographs should be taken whenever possible. The condition of each animal must be recorded and any injuries documented on forms provided as Appendix C or on similar forms that contain all of the information fields provided in Appendix C. Individuals should be measured (length) if possible and weighed if adequate scales are available on the sampling vessel.

34. To comply with RPM #12, any dead Atlantic or shortnose sturgeon or sea turtle must be retained and held in cold storage until disposal can be discussed with NMFS. An incident report form (Appendix C) must be filled out for any dead sturgeon and sea turtle and provided to NMFS.

35. To comply with RPM #13, NMFS PRD must be notified within 24 hours of any interaction with a listed species. If reporting within 24 hours is not possible, the report must be made as soon as possible, preferably on the next business day. These reports should be sent by e-mail (nmfs.gar.incidental-take@noaa.gov). If e-mail notification within 24 hours is not possible, this information can be faxed (978-281-9394 Attn: Section 7 Coordinator) or phoned in (NMFS Protected Resources Division 978-281-9328). For purposes of monitoring the incidental take of sea turtles and sturgeon during the surveys, reports must be made for any sea turtle or sturgeon: (a) found alive, dead, or

injured within the sampling gear; (b) found alive, dead, or injured and retained on any portion of the sampling gear outside of the net bag; or (c) interacting with the vessel and gear in any other way. The report must include: a clear photograph of the animal (multiple views if possible, including at least one photograph of the head scutes); identification of the animal to the species level; GPS or Loran coordinates describing the location of the interaction; time of interaction; date of interaction; condition of the animal upon retrieval (alive uninjured, alive injured, fresh dead, decomposed, comatose or unresponsive); the condition of the animal upon return to the water; GPS or Loran coordinates of the location at which it was released; a description of the care or handling provided; information any tags detected and/or inserted; and notification that a genetic sample was taken (if required). Copies of these reports should also be submitted to the NRC electronically (endangeredspecies@nrc.gov) or by mail to the NRC Document Control Desk.

36. To comply with RPM #13, written reports must be provided to NMFS GARFO annually (by March 15 of each year) indicating either that no interactions with ESA-listed species occurred or providing the total number of interactions that occurred with ESA-listed species, as well as copies of all required reporting forms and photographs. Any reports required by Term and Condition #21 that have not been provided to NMFS GARFO must be included in this report. This report must be submitted by e-mail (nmfs.gar.incidental-take@noaa.gov) or mailed to the NMFS Greater Atlantic Regional Fisheries Office, Attn: Section 7 Coordinator, 55 Great Republic Drive, Gloucester, MA 01930.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that might otherwise result from the proposed action. Specifically, these RPMs and Terms and Conditions will ensure that: PSEG continues to implement measures to reduce the potential of mortality for any sea turtles or sturgeon impinged at Salem 1 and Salem 2; to monitor the take of sturgeon during REMP sampling required by NRC for Salem 1, Salem 2, and Hope Creek and to reduce the potential for lethal take during that sampling; require that PSEG report all interactions to NMFS and to provide information on the likely cause of death of any sea turtles, Atlantic or shortnose sturgeon impinged at the facility; the RPMs and Terms and Conditions also serve to monitor the take of sea turtles and sturgeon in surveys required by the UBMWP and to minimize the potential for lethal interactions during those surveys. The discussion below explains why each of these RPMs and Terms and Conditions are necessary and appropriate to minimize or monitor the level of incidental take associated with the proposed action and how they represent only a minor change to the proposed action.

RPM #1 and Term and Conditions #1-6 are necessary and appropriate because they are specifically designed to ensure that all appropriate measures are carried out to prevent, monitor and minimize the incidental take of sea turtles at Salem. These conditions ensure that the potential for detection of sea turtles at the intakes is maximized and that any sea turtles removed from the water are done so in a manner that minimizes the potential for further injury. The procedures and requirements outlined in RPM #1 and Term and Conditions #1-6 are only a minor change because they are not expected to result in any modifications to plant operations and any increase in cost is small. Additionally, these conditions are consistent with conditions in previous ITSs for Salem and are part of the normal procedures at the facility.

RPM#2 and Term and Conditions #7-11 are necessary and appropriate as ensure the proper handling and documentation of any interactions with listed species as well as the prompt reporting of these interactions to NMFS. This represents only a minor change as the implementation of these conditions is not anticipated to result in any increased cost, delay of the project or change in the operation of the facility. Additionally, these conditions are consistent with conditions in previous ITSs for Salem and are part of the normal procedures at the facility.

RPM#3 and Term and Condition #12 are necessary and appropriate as the continued transfer of turtles removed from the water alive to an approved stranding/rehabilitation center minimizes the effects of the proposed action and maximizes the likelihood that these turtles when returned to the wild will be healthy. Additionally, this ensures that any injured turtles can be cared for, reducing the potential impact of any injuries and reducing the potential for delayed mortality. This represents only a minor change as PSEG has maintained a relationship with MMSC to carry out these activities in the past and this condition is consistent with conditions in previous ITSs for Salem and is part of the normal procedures at the facility.

RPM#4 and Term and Condition #13 is necessary and appropriate to determine and document the likely cause of death for any sea turtle removed from the Salem intakes and whether the cause of death is attributable to the action under consideration in this Opinion. This represents only a minor change as PSEG has maintained a relationship with MMSC to carry out these activities in the past and this condition is consistent with conditions in previous ITSs for Salem and is part of the normal procedures at the facility.

RPM #5 and Term and Condition #14 are necessary and appropriate to minimize the effects of the action and ensure that all live sturgeon are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality through inappropriate handling or release near the intakes. This represents only a minor change as following these procedures will not result in any delays to the proposed action or in an increase in cost and is consistent with conditions in previous ITSs for Salem and is part of the normal procedures at the facility.

RPM #6 and Terms and Conditions #14-16 are necessary and appropriate to ensure the proper handling and documentation of any listed species removed from the intakes that are dead or die while in PSEG custody. This is essential for monitoring the level of incidental take associated with the proposed action and in determining whether the death was related to the operation of the facility. These RPMs and Terms and Conditions represent only a minor change as compliance will not result in any delays to the proposed project or in an increase in cost and is consistent with conditions in previous ITSs for Salem and is part of the normal procedures at the facility .

RPM #8-10 and Terms and Conditions #17-25 are necessary and appropriate to ensure the proper identification, handling and documentation of any listed species encountered during REMP sampling for Salem 1, Salem 2 or Hope Creek. This is essential for monitoring the level of incidental take associated with the proposed action. Compliance will also minimize the potential for captures in the gillnet gear to be lethal. These RPMs and Terms and Conditions represent only a minor change as compliance will not result in an increase in cost and will not affect the efficacy or efficiency of the REMP sampling program.

RPM #11-13 and Terms and Conditions #26-36 are necessary and appropriate to ensure the proper identification, handling and documentation of any listed species encountered during trawling and beach seining required by the NJPDES permit issued for Salem. This is essential for monitoring the level of incidental take associated with the proposed action. Compliance will also minimize the potential for captures of sturgeon and sea turtles in the beach seine and trawl gear to be lethal. These RPMs and Terms and Conditions represent only a minor change as compliance will not result in an increase in cost and will not affect the efficacy or efficiency of the UBMWP sampling program.

11.0 CONSERVATION RECOMMENDATIONS

In addition to Section 7(a)(2), which requires agencies to ensure that all projects will not jeopardize the continued existence of listed species, Section 7(a)(1) of the ESA places a responsibility on all federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species." Conservation Recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information in furtherance of these identified purposes. As such, NMFS recommends that the NRC consider the following Conservation Recommendations:

1. The NRC should use its authorities to ensure tissue analysis of dead shortnose and Atlantic sturgeon removed from the Salem intakes is performed to determine contaminant loads, including radionuclides.

2. The NRC should use its authorities to ensure studies are performed that document impacts of impingement, entrainment and heat shock to benthic resources that may serve as forage for shortnose and Atlantic sturgeon and sea turtles.

3. The NRC should use its authorities to require that the REMP sample species that may serve as forage for shortnose and Atlantic sturgeon and sea turtles.

4. The NRC should use its authorities to ensure a scientific study on the mortality of sturgeon impinged on Ristroph Screens is performed.

5. The NRC should use its authorities to support investigations of the use of the action area by Atlantic sturgeon.

6. The NRC should use its authorities to ensure studies are performed that document the presence, if any, of shortnose and Atlantic sturgeon in the broadest area affected by the thermal plume in order to validate the assumption in this Opinion that shortnose and Atlantic sturgeon are likely to move away from the thermal plume.

7. The NRC should use its authorities to ensure studies are performed that continue to evaluate technologies and operational measures (TOMs) that may have potential for reducing incidental takes of Atlantic and shortnose sturgeon at Salem 1 and Salem 2

during raking of the circulating water intake trash racks. This may include investigation of deterrent devices and enhanced monitoring (e.g., hydroacoustics) of the intake area. If such studies are pursued, NRC should ensure coordination with NMFS to determine if any additional authorizations or permits are required.

12.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the continued operation of the Salem and Hope Creek Nuclear Generating Stations. 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 a effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is *exceeded*, Section 7 consultation must be reinitiated immediately.

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APPENDIX A

Handling and Resuscitation Procedures for Sea Turtles

Handling:

Do not assume that an inactive turtle is dead. The onset of rigor mortis and/or rotting flesh are often the only definite indications that a turtle is dead. Releasing a comatose turtle into any amount of water will drown it, and a turtle may recover once its lungs have had a chance to drain. There are three methods that may elicit a reflex response from an inactive animal:

- Nose reflex. Press the soft tissue around the nose which may cause a retraction of the head or neck region or an eye reflex response.
- Cloaca or tail reflex. Stimulate the tail with a light touch. This may cause a retraction or side movement of the tail.
- Eye reflex. Lightly touch the upper eyelid. This may cause an inward pulling of the eyes, flinching or blinking response.

General handling guidelines:

- Keep clear of the head.
- Adult male sea turtles of all species other than leatherbacks have claws on their foreflippers. Keep clear of slashing foreflippers.
- Pick up sea turtles by the front and back of the top shell (carapace). Do not pick up sea turtles by flippers, the head or the tail.
- If the sea turtle is actively moving, it should be retained at Salem until transported by stranding/rehabilitation personnel to the nearest designated stranding/rehabilitation facility. The rehabilitation facility should eventually release the animal in the appropriate location and habitat for the species and size class of the turtle. Turtles should not be released where there is a risk of re-impingement at Salem.

Sea Turtle Resuscitation Regulations: (50 CFR 223.206(d)(1))

If a turtle appears to be comatose (unconscious), contact the designated stranding/rehabilitation personnel immediately. Once the rehabilitation personnel has been informed of the incident, attempts should be made to revive the turtle at once. Sea turtles have been known to revive up to 24 hours after resuscitation procedures have been followed.

- Place the animal on its bottom shell (plastron) so that the turtle is right side up and elevate the hindquarters at least 6 inches for a period of 4 up to 24 hours. The degree of elevation depends on the size of the turtle; greater elevations are required for larger turtles.
- Periodically, rock the turtle gently left to right and right to left by holding the outer edge of the shell (carapace) and lifting one side about 3 inches then alternate to the other side.
- Periodically, gently conduct one of the above reflex tests to see if there is a response.
- Keep the turtle in a safe, contained place, shaded, and moist (e.g., with a water-soaked towel over the eyes, carapace, and flippers) and observe it for up to 24 hours.
- If the turtle begins actively moving, retain the turtle until the appropriate rehabilitation personnel can evaluate the animal. The rehabilitation facility should eventually release

the animal in a manner that minimizes the chances of re-impingement and potential harm to the animal (i.e., from cold stunning).

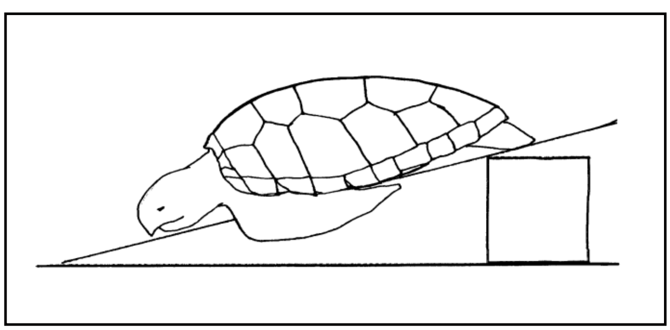
- Turtles that fail to move within several hours (up to 24) should be transported to a suitable facility for necropsy (if the condition of the sea turtle allows).

<u>Stranding/rehabilitation contact in New Jersey</u>:
Bob Schoelkopf, Marine Mammal Stranding Center
P.O. Box 773
Brigantine, NJ
(609-266-0538)

<u>Special Instructions for Cold-Stunned Turtles</u>:

Comatose turtles found in the fall or winter (in waters less than 10°C) may be "cold-stunned". If a turtle appears to be cold-stunned, the following procedures should be conducted:

- Contact the designated stranding/rehabilitation personnel immediately and arrange for them to pick up the animal.
- Until the rehabilitation facility can respond, keep the turtle in a sheltered place, where the ambient temperature is cool and will not cause a rapid increase in core body temperature.



APPENDIX B

Procedure for obtaining fin clips from sturgeon for genetic analysis

Obtaining Sample

1. Wash hands and use disposable gloves. Ensure that any knife, scalpel or scissors used for sampling has been thoroughly cleaned and wiped with alcohol to minimize the risk of contamination.

2. For any sturgeon, after the specimen has been measured and photographed, take a one-cm square clip from the pelvic fin.

3. Each fin clip should be placed into a vial of 95% non-denatured ethanol and the vial should be labeled with the species name, date, name of project and the fork length and total length of the fish along with a note identifying the fish to the appropriate observer report. All vials should be sealed with a lid and further secured with tape Please use permanent marker and cover any markings with tape to minimize the chance of smearing or erasure.

Storage of Sample

1. If possible, place the vial on ice for the first 24 hours. If ice is not available, please refrigerate the vial. Send to the NMFS-approved lab for processing to determine DPS or river of origin per the agreement you have with that facility.

APPENDIX C

Part 1 (Sea Turtle) - **Incident Report Sea Turtle**

Photographs should be taken and the following information should be collected from all turtles and sturgeon (alive and dead) found in association with Salem. Please submit all turtle necropsy results (including sex and stomach contents) to NMFS upon receipt.

Observer's full name:____
Reporter's full name:____

Species Identification (Key attached):____________________________________

Site of Impingement (Unit 1 or 2, CWS or DWS, Bay #, etc.):____________________________

Date animal observed:______________ Time animal observed: _____________________
Date animal collected:______________ Time animal collected:_____________________
Date rehab facility contacted: ______________ Time rehab facility contacted: ____________
Date animal picked up: __________________ Time animal picked up: ________________

Environmental conditions at time of observation (i.e., tidal stage, weather):
____
____

Date and time of last inspection of screen:________________________________
Water temperature (°C) at site and time of observation:______________________
Number of pumps operating at time of observation:_______________________________
Average percent of power generating capacity achieved per unit at time of observation:_______
Average percent of power generating capacity achieved per unit over the 48 hours previous to observation:____

Sea Turtle Information: *(please designate cm/m or inches)*

Fate of animal (circle one): dead alive
Condition of animal (*include comments on injuries, whether the turtle is healthy or emaciated, general behavior while at Salem*):____
____
____
____*(please complete attached diagram)*

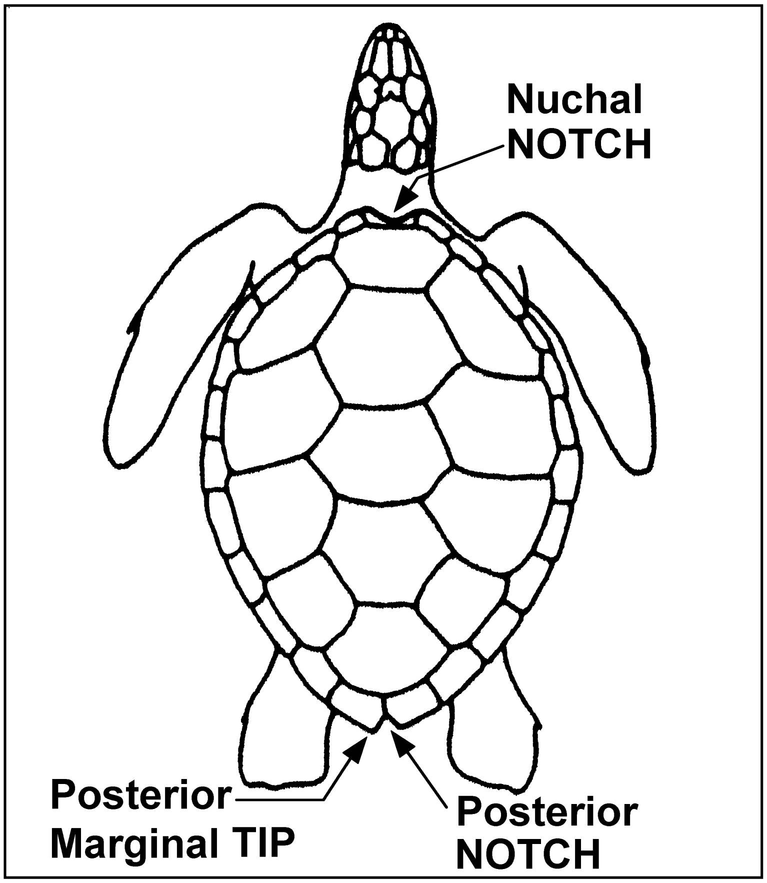
Carapace length - Curved:______________Straight:______________
Carapace width - Curved:______________Straight:______________

Existing tags?: YES / NO *Please record all tag numbers.* Tag # ____________________
Photograph attached: YES / NO

(please label *species, date, location of impingement* on back of photograph)

APPENDIX C, continued **(Incident Report of Sea Turtle Take)**

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



Description of animal:

All information should be sent to the following address:

National Marine Fisheries Service, Northeast Region
Protected Resources Division
Attention: Section 7 Coordinator
55 Great Republic Drive
Gloucester, MA 01930
Phone: (978) 281-9328
FAX: (978) 281-9394
Email: Nmfs.gar.incidental-take@noaa.gov

Appendix C, Part 2A (Sturgeon)

Photographs should be taken and the following information should be collected from all sturgeon (alive and dead). Please submit all necropsy results (including sex and stomach contents) to NMFS upon receipt. You must also complete and submit the "Sturgeon Data Collection Form"

Observer's full name:____
Reporter's full name:____

Species Identification :____

Site of Collection:_________________________________

Date animal observed:________________ Time animal observed: ________________________
Date animal collected:________________ Time animal collected:_________________________

Environmental conditions at time of observation (i.e., tidal stage, weather):
____
____

If removed from intakes (trash racks or traveling screens):
Date and time of last inspection of screen:_____________________________________
Water temperature (°C) at site and time of observation:_________________________
Number of pumps operating at time of observation:____________________________________
Average percent of power generating capacity achieved per unit at time of observation:________
Average percent of power generating capacity achieved per unit over the 48 hours previous to observation:____

STURGEON DATA COLLECTION FORM

REPORTER'S CONTACT INFORMATION
Name: First ________________ Last ________________________
Agency Affiliation ________________ Email________________________
Address ____
____
Area code/Phone number ______________________________________

UNIQUE IDENTIFIER (Assigned by NMFS)

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

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

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

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

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

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

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

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

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

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

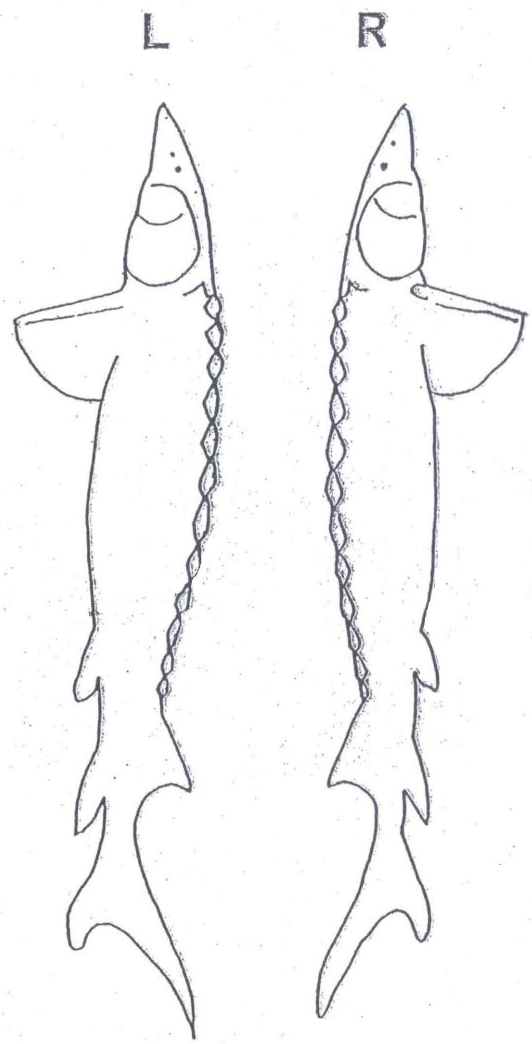
PHOTODOCUMENTATION:
Photos/vide taken? ☐ Yes ☐ No
Disposition of Photos/Video:__________
____
____

SAMPLES COLLECTED? ☐ **Yes** ☐ **No**

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

Comments:

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



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

____

____

____

____

____

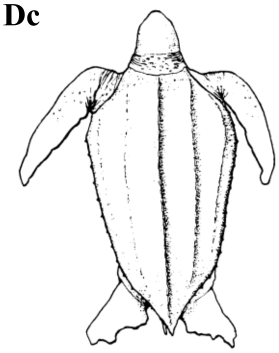
Submit completed forms (within 7 days of observation of fish): by email to Incidental.Take@noaa.gov or by fax (978-281-9394). Questions can be directed to NMFS Protected Resources Division at 978-281-9328.

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

Identification Key for Sea Turtles and Sturgeon Found in Northeast U.S. Waters

SEA TURTLES

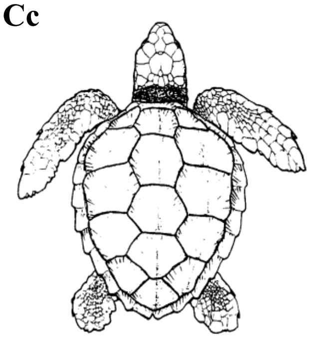
Dc



Leatherback (*Dermocheyls coriacea*)

Found in open water throughout the Northeast from spring through fall. Leathery shell with 5-7 ridges along the back. Largest sea turtle (4-6 feet). Dark green to black; may have white spots on flippers and underside.

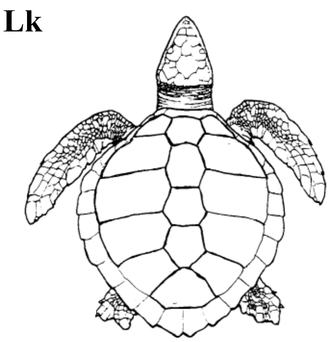
Cc



Loggerhead (*Caretta caretta*)

Bony shell, reddish-brown in color. Mid-sized sea turtle (2-4 feet). Commonly seen from Cape Cod to Hatteras from spring through fall, especially in southern portion of range. Head large in relation to body.

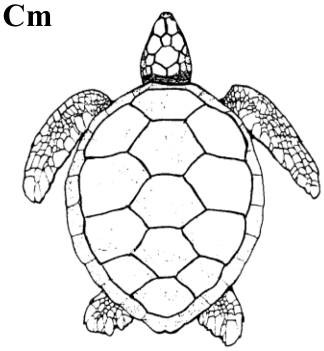
Lk



Kemp's ridley (*Lepidochelys kempii*)

Most often found in Bays and coastal waters from Cape Cod to Hatteras from summer through fall. Offshore occurrence undetermined. Bony shell, olive green to grey in color. Smallest sea turtle in Northeast (9-24 inches). Width equal to or greater than length.

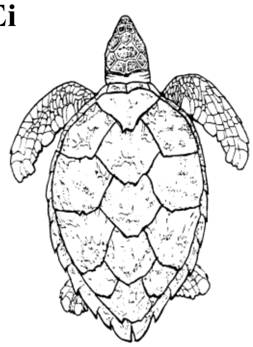
Cm



Green turtle (*Chelonia mydas*)

Uncommon in the Northeast. Occur in Bays and coastal waters from Cape Cod to Hatteras in summer. Bony shell, variably colored; usually dark brown with lighter stripes and spots. Small to mid-sized sea turtle (1-3 feet). Head small in comparison to body size.

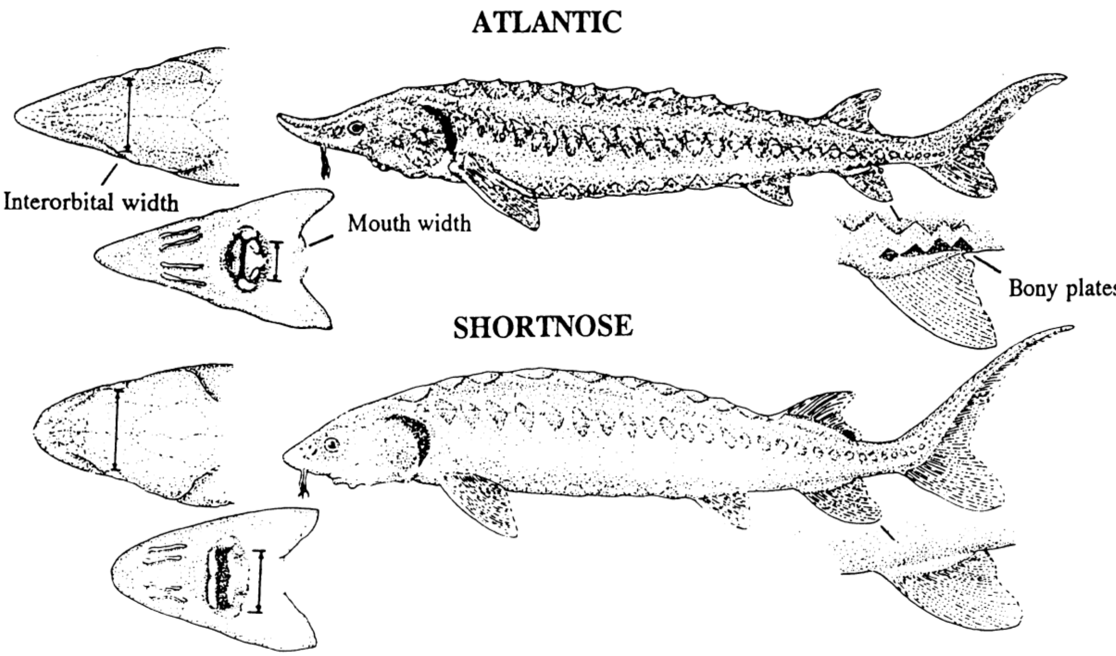
Ei



Hawksbill (*Eretmochelys imbricata*)

Rarely seen in Northeast. Elongate bony shell with overlapping scales. Color variable, usually dark brown with yellow streaks and spots (tortoise-shell). Small to mid-sized sea turtle (1-3 feet). Head relatively small, neck long.

Appendix D continued
Sturgeon Identification



Distinguishing Characteristics of Atlantic and Shortnose Sturgeon

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

* From Vecsei and Peterson, 2004

APPENDIX E

PIT Tagging Procedures for Shortnose and Atlantic sturgeon

(adapted from Damon-Randall *et al*. 2010)

Passive integrated transponder (PIT) tags provide long term marks. These tags are injected into the musculature below the base of the dorsal fin and above the row of lateral scutes on the left side of the Atlantic sturgeon (Eyler *et al*. 2009), where sturgeon are believed to experience the least new muscle growth. Sturgeon should not be tagged in the cranial location. Until safe dorsal PIT tagging techniques are developed for sturgeon smaller than 300 mm, only sturgeon larger than 300 mm should receive PIT tags.

It is recommended that the needles and PIT tags be disinfected in isopropyl alcohol or equivalent rapid acting disinfectant. After any alcohol sterilization, we recommend that the instruments be air dried or rinsed in a sterile saline solution, as alcohol can irritate and dehydrate tissue (Joel Van Eenennam, University of California, pers. comm.). Tags should be inserted antennae first in the injection needle after being checked for operation with a PIT tag reader.

Sturgeon should be examined on the dorsal surface posterior to the desired PIT tag site to identify a location free of dermal scutes at the injection site. The needle should be pushed through the skin and into the dorsal musculature at approximately a 60 degree angle (Figure 5). After insertion into the musculature, the needle angle should be adjusted to close to parallel and pushed through to the target PIT tag site while injecting the tag. After withdrawing the needle, the tag should be scanned to check operation again and tag number recorded.

Some researchers check tags in advance and place them in individual 1.5 ml microcentrifuge tubes with the PIT number labeled to save time in the field.

Because of the previous lack of standardization in placement of PIT tags, we recommend that the entire dorsal surface of each fish be scanned with a PIT tag reader to ensure detection of fish tagged in other studies. Because of the long life span and large size attained, Atlantic sturgeon may grow around the PIT tag, making it difficult to get close enough to read the tag in later years. For this reason, full length (highest power) PIT tags should be used.

Fuller *et al.* (2008) provide guidance on the quality of currently available PIT tags and readers and offer recommendations on the most flexible systems that can be integrated into existing research efforts while providing a platform for standardizing PIT tagging programs for Atlantic sturgeon on the east coast. The results of this study were consulted to assess which PIT tags/readers should be recommended for distribution. To increase compatibility across the range of these species, the authors currently recommend the Destron TX1411 SST 134.2 kHz PIT tag and the AVID PT VIII, Destron FS 2001, and Destron PR EX tag readers. These readers can read multiple tags, but software must be used to convert the tag ID number read by the Destron PR EX. The USFWS/Maryland Fishery Resources Office (MFRO) will collect data in the coastal tagging database and provide approved tags for distribution to researchers.

Figure 5. (from Damon-Randall *et al*. 2010). Illustration of PIT tag location (indicated by white arrow; top), and photo of a juvenile Atlantic sturgeon being injected with a PIT tag (bottom). *Photos courtesy of James Henne, US USFWS.*