ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Agency: Nuclear Regulatory Commission

Activity: **Continued Operation of Salem and Hope Creek Nuclear Generating Stations**
NER-2010-6581
GARFO-2010-00010

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

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1.0 INTRODUCTION

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued 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 Nuclear Generating Station, Unit 1s 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 based on information provided in a Biological Assessment dated December 2010, the *Final Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 45 Regarding Hope Creek Generating Station and Salem Nuclear Generating Station Units 1 and 2* dated March 2011, permits issued by the State of New Jersey, previous Opinions completed for these facilities and other sources of information as cited herein. We will keep a complete administrative record of this consultation at the NMFS Greater Atlantic Regional Fisheries Office (GARFO)in Gloucester, Massachusetts.

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). All three units are operated by PSEG Nuclear, LLC (PSEG).

Consultation pursuant to section 7 of the ESA between NRC and NMFS on the effects of the operation of these facilities has been ongoing since 1979. A Biological Opinion was issued by NMFS in April 1980; in this Opinion, we concluded that the ongoing operation of the Salem facility was not likely to jeopardize the continued existence of shortnose sturgeon. Consultation was reinitiated in 1988 due to the impingement of sea turtles at the Salem facility. An Opinion was issued on January 2, 1991 in which we concluded that the ongoing operation was not likely to jeopardize shortnose sturgeon, Kemp's ridley, green or loggerhead sea turtles. Consultation was reinitiated in 1992 due to the number of sea turtle impingements at the Salem intake exceeding the number exempted in the 1991 Incidental Take Statement (ITS). A new Opinion was issued on August 4, 1992. Consultation was reinitiated in January 1993 when the number of sea turtle impingements exceeded the 1992 ITS; a new Opinion was issued on May 14, 1993. The 1993 Biological Opinion (NMFS 1993) required that PSEG tag and acoustically track all loggerhead sea turtles taken alive at the cooling water intake structure (CWIS) and released. Also in 1993, PSEG implemented a policy of removing the ice barriers from the trash racks on the intake structure during the period between May 1 and October 24, which resulted in substantially lower turtle impingement rates at Salem.

In 1998, NRC requested that NMFS modify the Reasonable and Prudent Measures and Terms and Conditions of the ITS, and, specifically, remove a requirement to conduct studies of released turtles. NRC made this request based on the reduction in the number of turtles impinged after the 1993 change in procedure regarding the removal of ice barriers. We responded to this request in a letter dated January 21, 1999. In this letter, we stated that PSEG could discontinue these studies because it appeared that the reason for the relatively high impingement numbers previously was the ice barriers that had been left on the intake structure during the warmer months (NMFS, 1999). Accompanying this letter was a revised ITS which served to amend the May 14, 1993 Opinion. The 1999 ITS exempts the annual take (capture or impingement at intake with injury or mortality) of 5 shortnose sturgeon, 30 loggerhead sea turtles, 5 green sea turtles, and 5 Kemp's ridleys. The RPMs included as part of the ITS require ice barrier removal by May 1 and replacement after October 24. The ITS also requires that in the warmer months the trash racks must be cleaned weekly and inspected every other hour; in the winter they must be cleaned every other week. The RPMs also require that in any year that a dead sea turtle is removed from the racks, the racks must be inspected every hour for the rest of the warm season. Dead shortnose sturgeon are required to be inspected for tags (NMFS, 1999). This Opinion is a reinitiation of the 1993 consultation and will replace the Opinion issued in May 1993 and the amended ITS issued in January 1999.

In advance of relicensing, NRC began coordination with us in 2009. In a letter dated December 23, 2009, NRC requested information on the occurrence of threatened, endangered, or other protected species at the site and the potential for impacts on those species from license renewal. On February 11, 2010, we provided information to NRC on the listed species likely to occur in the action area. On December 29, 2010, we received a Biological Assessment from NRC. Conference calls between NRC staff and NMFS staff were held on February 7, 2011 and March 4, 2011 to clarify the scope of NRC's proposed action. Additional coordination between NRC staff and NMFS staff was ongoing through the spring and summer of 2011 to clarify NRC's authorities regarding the proposed action. A draft Opinion was transmitted to NRC in December 2011 with comments received in January 2012. On April 6, 2012, we listed five Distinct Population Segments (DPS) of Atlantic sturgeon. This triggered the need to consider these species in the consultation. In a letter dated March 13, 2012, NRC requested consultation on the effects of the continued operation of Hope Creek and Salem 1 and 2 on Atlantic sturgeon. During 2012 and 2013, NMFS staff met with NRC and PSEG to discuss effects of project operations on listed species and to discuss comments on several draft Opinions. Also, during 2013 we discussed the need to consider effects of studies required by the New Jersey Pollutant Discharge Elimination System (NJPDES) permit as well as effects to sturgeon and sea turtles of sampling carried out as part of the annual Radiological Environmental Monitoring Program (REMP).

3.0 DESCRIPTION OF THE PROPOSED ACTIONS

The proposed actions 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 4, 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. New Jersey's NPDES program is administered by the Department of Environmental Protection (NJDEP). 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 a direct effect of 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 continued operation of Salem Unit 1, Salem Unit 2 and Hope Creek pursuant to the renewed operating licenses, 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 SPDES permits issued by NJDEP in 2001 and 2011 that are currently in effect. A complete history of NJDEP permits is included in NRC's FSEIS (NRC 2011)at Section 4.5.2 (Regulatory Background).

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 for condenser cooling that withdraws brackish water from the Delaware Estuary through one intake structure located at the shoreline on the south end of the site.

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 an 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 nominal enriched to 5.0 percent (percent uranium-235 by weight) and 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 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 establisheda 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 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):

- Ice Barriers. 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.
- Trash Racks. 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.
- Traveling Screens. After the coarse-grid trash racks, the intake water passes through finer vertical travelling screens. These are modified Ristroph screens 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). The velocity through the Salem intake screens is approximately 1 foot per second (fps) (0.3 meters per second [m/s]) at mean low tide.
- Fish Return System. 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 extends 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). 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 m3/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 1 fps (0.3 m/s) at the design flow rate. 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 612,000 gpm (2,300 m^3/min) of water to the CWS via four pumps. The CWS provides water to the main condenser to condense steam from the turbine and the heated water is returned back to the Estuary via the cooling tower blowdown.

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, 2001b). 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 are both once-through circulating water systems that 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, 2001a). 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 m3/min) for each pump, or a total of

66,000 gpm (250 m3/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 m3) of water, and circulates water through the CWS at a rate of 612,000 gpm (2,300 m3/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 m3/day), of which 6.7 MGD (25,000 m3/day) are returned as screen backwash, and 13 MGD (49,000 m3/day) is evaporated. The remainder (approximately 46 MGD [174,000 m3/day]) is discharged back to the river (PSEG, 2009b). The HCGS DRBC contract allows withdrawals up to 16.998 billion gallons (64 million m3) per year, including up to 4.086 billion gallons (15 million m3) 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 which 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 is situated at mean tide level. The discharge from HCGS is regulated under the terms of NJPDES Permit No. NJ0025411 (NJDEP, 2011).

3.4.4 NPDES/SPDES Permits

Section 316(b) of the CWA requires that the location, design, construction, and capacity of cooling water intake structures reflect the BTA for minimizing adverse environmental impacts (33 USC 1326). In July 2004, the EPA published the Phase II Rule implementing Section 316(b) of the CWA for Existing Facilities (69 FR 41576), which applied to large power producers that withdraw large amounts of surface water for cooling (50 MGD or more) (189,000 m^3/day or more). The rule became effective on September 7, 2004 and included numeric performance standards for reductions in impingement mortality and entrainment that would demonstrate that the cooling water intake system constitutes BTA for minimizing impingement and entrainment impacts. Existing facilities subject to the rule were required to demonstrate compliance with the rule's performance standards during the renewal process for their NPDES permit through development of a Comprehensive Demonstration Study (CDS). As a result of a Federal court decision, EPA officially suspended the Phase II rule on July 9, 2007 (72 FR 37107) pending further rulemaking. EPA instructed permitting authorities to utilize best professional judgment in establishing permit requirements on a case by-case basis for cooling water intake structures at Phase II facilities until it has resolved the issues raised by the court's ruling. EPA signed the final rule on May 19, 2014. To date, the rule has not been published in the Federal Register.

3.4.4.1 Salem

In 1990, NJDEP issued a draft NJPDES permit that proposed closed-cycle cooling as BTA for Salem. In 1993, NJDEP concluded that the cost of retrofitting Salem to closed-cycle cooling would be wholly disproportionate to the environmental benefits realized, and a new permit was issued in 1994 (PSEG, 1999a). The 1994 final NJPDES permit stated that the existing cooling water intake system was BTA for Salem, with certain conditions (NJDEP, 1994).

Conditions of the 1994 permit included improvements to the screens and Ristroph buckets, a monthly average limitation on cooling water flow of 3,024 MGD (11.4 million m3/day), and a pilot study for the use of a sound deterrent system. In addition to technology and operational measures, the 1994 permit required restoration measures that included a wetlands restoration and enhancement program designed to increase primary production in the Delaware Estuary and fish ladders at dams along the Delaware River to restore access to traditional spawning runs for anadromous species such as blueback herring and alewife. A Biological Monitoring Work Plan (BMWP) was also required to monitor the efficacy of the technology and operational measures employed at the site and the restoration programs funded by PSEG (NJDEP, 1994). In addition to the entrainment and impingement abundance monitoring, the BMWP included monitoring plans for fish utilization of restored wetlands, elimination of impediments to fish migration, bay-wide trawl survey, and a beach seine survey (PSEG, 1994). The main purpose of these studies was to monitor the success of the wetland restoration activities and screen modifications undertaken by PSEG.

As required by the Salem NJPDES Permit and as described in the BMWP, PSEG began implementation of the baywide bottom trawl monitoring program in 1995. As described in the BWMP, the regulatory requirement is as follows:

> 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 intensive years (2002, 2003, and 2004) of the NJPDES permit period, an additional 30 samples will be 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. Fish and blue crabs collected will be identified to the lowest practicable taxonomic level, sorted by species, and counted. The length distribution of target species will be determined in a representative subsample of each target species. Lengths will be measured to the nearest millimeter. In addition, sampling information as well as water temperature, dissolved oxygen, salinity, and water clarity will be recorded for each sample.

A new NJPDES permit was issued in 2001. This permit required continuation of the restoration programs implemented in response to the 1994 permit, an Improved Biological Monitoring Work Plan (IBMWP), and a more detailed analysis of impingement mortality and entrainment losses at the facility (NJDEP, 2001). PSEG submitted a renewal application in 2006. In that application, PSEG responded to the requirement for a detailed analysis by including a CDS as required by the Phase II rule and an assessment of alternative intake technologies (AIT). The AIT assessment includes a detailed analysis of the costs and benefits associated with the existing intake configuration and alternatives along with an analysis of the costs and benefits of the wetlands restoration program that PSEG implemented in response to the requirements of the 1994 NJPDES permit (PSEG, 2006c).

The IBMWP was submitted to NJDEP in April 2002 and approved in July 2003. A reduction in the frequency of monitoring at fish ladder sites that successfully pass river herring was submitted in December 2003 and approved was in May 2004. In 2006 PSEG submitted a revised IBMWP that proposed a reduction in sampling at the restored wetland sites. Sampling would be conducted at representative locations instead of at every restoration site (PSEG, 2006c). The NJDEP-approved IBMWP requires continuation of the bottom trawl monitoring program originally defined in 1995. PSEG anticipates that this program will continue to be required by all future NJPDES Permits.

Salem's 2006 NJPDES permit renewal application included a CDS because the Phase II rule was still in effect at that time. The CDS for Salem was completed in 2006 and included an analysis of impingement mortality and entrainment at the facility's cooling water intake system. According to PSEG (2006c), this analysis shows that the changes in technology and operation of the Salem cooling water intake system satisfied the performance standards of the Phase II rule and that the current configuration constitutes BTA. In 2006, NJDEP administratively continued Salem's 2001 NJPDES permit (NJ0005622), and no timeframe has been determined for issuance of the new NJPDES permit.

3.4.4.2 Hope Creek

The current NJPDES Permit No. NJ0025411 for the HCGS facility was effective on July 1, 2011 and will expire on July 1, 2016. This replaced a previous permit issued on March 1, 2003.

The HCGS NJPDES permit regulates water withdrawals and discharges associated with both stormwater and industrial wastewater, including discharges of cooling tower blowdown (NJDEP, 2003). 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.

Industrial wastewater is regulated at five locations, designated DSNs 461A, 461C, and 462B. Discharge DSN 461A is the discharge for the cooling water blowdown, and the permit established reporting and compliance limits for intake and discharge volume (in MGD), pH, chlorine-produced oxidants, intake and discharge temperature, total organic carbon, and heat content in millions of BTUs per hour, in both summer and winter (NJDEP, 2003). Discharge DSN 461C is a discharge for the oil/water separator system and has established reporting and compliance limits for discharge volume, total suspended solids, total recoverable petroleum hydrocarbons, and total organic carbon (NJDEP, 2003).

In this consultation, we have considered effects of the operation of Salem and Hope Creek through the extended operating period with the 2001 and 2011 NJPDES permits in effect. This scenario is the one defined by NRC as its proposed action in its Final SEIS and the Biological Assessment provided to NMFS in which NRC considered effects of the operation of the facility during the extended operating period on listed species. Therefore, it is the subject of this consultation. However, if a new NJPDES permit is issued for either facility, NRC and NMFS would have to determine if reinitiation of this consultation is necessary to consider any effects of the operation of the facility on listed species that were not considered in this Opinion.

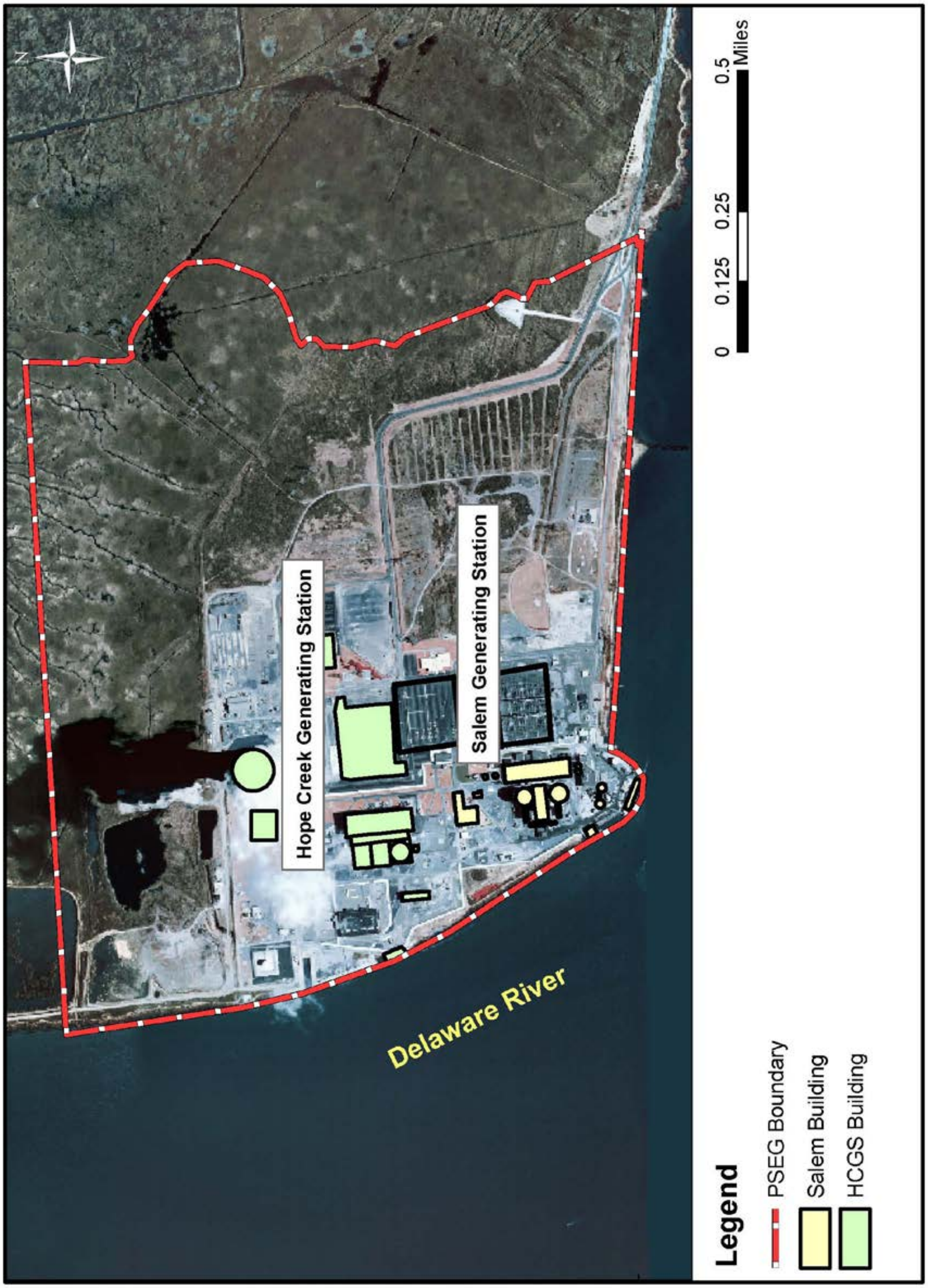
3.5 Action Area

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 Hope Creek (HCGS) facilities are located at River Mile (RM) 50 (River Kilometer 80 [RK 80]) and RM 51 (RK 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 direct and indirect effects of Salem 1, Salem 2 and Hope Creek are 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 IBMWP is carried out. The proposed actions have the potential to affect NMFS listed species in several ways: impingement of individuals at the intakes; altering the abundance or availability of potential prey items; and, altering the riverine environment through the discharge of heated effluent and other pollutants. The combined action areas for this consultation includes 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).

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 IBMWP is carried out.

Figure 1. Location of Salem and Hope Creek Generating Stations

Figure 2. Aerial photo of facilities



4.0 LISTED SPECIES IN THE ACTION AREA

NMFS has determined that the following endangered or threatened species may be affected by the proposed action:

Sea turtles	
Northwest Atlantic DPS of Loggerheads (*Caretta caretta*)	Threatened
Kemp's ridley (*Lepidochelys kempii*)	Endangered
Green (*Chelonia mydas*)	Endangered
Fish	
Shortnose sturgeon (*Acipenser brevirostrum*)	Endangered
New York Bight DPS of Atlantic sturgeon	Endangered
Gulf of Maine DPS of Atlantic sturgeon	Threatened
Chesapeake Bay DPS of Atlantic sturgeon	Endangered
South Atlantic DPS of Atlantic sturgeon	Endangered
Carolina DPS of Atlantic sturgeon	Endangered

No critical habitat has been designated for species under NMFS jurisdiction in the action area. Thus, effects to critical habitat will not be considered in this Opinion.

This section will focus on the status of the various species within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action.

4.1 Overview of Status of Sea Turtles

With the exception of loggerheads, sea turtles are listed under the ESA at the species level rather than as subspecies or DPS. Therefore, information on the range-wide status of Kemp's ridley and green sea turtles is included to provide the status of each species overall. Information on the status of loggerheads will only be presented for the DPS affected by this action. Additional background information on the range-wide status of these species can be found in a number of published documents, including sea turtle status reviews and biological reports (NMFS and USFWS 1995; Hirth 1997; Marine Turtle Expert Working Group [TEWG] 1998, 2000, 2007, 2009; NMFS and USFWS 2007a, 2007b, 2007c; Conant *et al.* 2009), and recovery plans for the loggerhead sea turtle (NMFS and USFWS 2008), Kemp's ridley sea turtle (NMFS *et al.* 2011) and green sea turtle (NMFS and USFWS 1991, 1998b).

2010 BP Deepwater Horizon Oil Spill

The April 20, 2010, explosion of the Deepwater Horizon oil rig affected sea turtles in the Gulf of Mexico. There is an on-going assessment of the long-term effects of the spill on Gulf of Mexico marine life, including sea turtle populations. Following the spill, juvenile Kemp's ridley, green, and loggerhead sea turtles were found in *Sargassum* algae mats in the convergence zones, where currents meet and oil collected. Sea turtles found in these areas were often coated in oil and/or had ingested oil. Approximately 536 live adult and juvenile sea turtles were recovered from the Gulf and brought into rehabilitation centers; of these, 456 were visibly oiled (these and the following numbers were obtained from http://www.nmfs.noaa.gov/pr/pdfs/oilspill/species_data.pdf; last accessed on July 1, 2014). As of April 12, 2011, 469 of the live recovered sea turtles have been successfully returned to the wild, 25 died during rehabilitation, and 42 are still in care but will hopefully be returned to the wild eventually. During the clean-up period, 613 dead sea turtles were recovered in coastal waters or on beaches in Mississippi, Alabama, Louisiana, and the Florida Panhandle. As of February 2011, 478 of these dead turtles had been examined. Many of the examined sea turtles showed indications that they had died as a result of interactions with trawl gear, most likely used in the shrimp fishery, and not as a result of exposure to or ingestion of oil.

During the spring and summer of 2010, nearly 300 sea turtle nests were relocated from the northern Gulf to the east coast of Florida with the goal of preventing hatchlings from entering the oiled waters of the northern Gulf. From these relocated nests, 14,676 sea turtles, including 14,235 loggerheads, 125 Kemp's ridleys, and 316 greens, were ultimately released from Florida beaches.

A thorough assessment of the long-term effects of the spill on sea turtles has not yet been completed. However, the spill resulted in the direct mortality of many sea turtles and may have had sublethal effects or caused environmental damage that will impact other sea turtles into the future. The population level effects of the spill and associated response activity are likely to remain unknown for some period into the future.

4.2 Northwest Atlantic DPS of loggerhead sea turtle

The loggerhead is the most abundant species of sea turtle in U.S. waters. Loggerhead sea turtles are found in temperate and subtropical waters and occupy a range of habitats including offshore waters, continental shelves, bays, estuaries, and lagoons. They are also exposed to a variety of natural and anthropogenic threats in the terrestrial and marine environment.

Listing History

Loggerhead sea turtles were listed as threatened throughout their global range on July 28, 1978. Since that time, several status reviews have been conducted to review the status of the species and make recommendations regarding its ESA listing status. Based on a 2007 5-year status review of the species, which discussed a variety of threats to loggerheads including climate change, NMFS and USFWS determined that loggerhead sea turtles should not be delisted or reclassified as endangered. However, it was also determined that an analysis and review of the species should be conducted in the future to determine whether DPSs should be identified for the loggerhead (NMFS and USFWS 2007a). Genetic differences exist between loggerhead sea turtles that nest and forage in the different ocean basins (Bowen 2003; Bowen and Karl 2007). Differences in the maternally inherited mitochondrial DNA also exist between loggerhead nesting groups that occur within the same ocean basin (TEWG 2000; Pearce 2001; Bowen 2003; Bowen *et al.* 2005; Shamblin 2007; TEWG 2009; NMFS and USFWS 2008). Site fidelity of females to one or more nesting beaches in an area is believed to account for these genetic differences (TEWG 2000; Bowen 2003).

In part to evaluate those genetic differences, in 2008, NMFS and USFWS established a Loggerhead Biological Review Team (BRT) to assess the global loggerhead population structure to determine whether DPSs exist and, if so, the status of each DPS. The BRT evaluated genetic data, tagging and telemetry data, demographic information, oceanographic features, and geographic barriers to determine whether population segments exist. The BRT report was completed in August 2009 (Conant *et al.* 2009). In this report, the BRT identified the following nine DPSs as being discrete from other conspecific population segments and significant to the species: (1) North Pacific Ocean, (2) South Pacific Ocean, (3) North Indian Ocean, (4) Southeast Indo-Pacific Ocean, (5) Southwest Indian Ocean, (6) Northwest Atlantic Ocean, (7) Northeast Atlantic Ocean, (8) Mediterranean Sea, and (9) South Atlantic Ocean.

The BRT concluded that although some DPSs are indicating increasing trends at nesting beaches (Southwest Indian Ocean and South Atlantic Ocean), available information about anthropogenic threats to juveniles and adults in neritic and oceanic environments indicate possible unsustainable additional mortalities. According to an analysis using expert opinion in a matrix model framework, the BRT report stated that all loggerhead DPSs have the potential to decline in the foreseeable future. Based on the threat matrix analysis, the potential for future decline was reported as greatest for the North Indian Ocean, Northwest Atlantic Ocean, Northeast Atlantic Ocean, Mediterranean Sea, and South Atlantic Ocean DPSs (Conant *et al.* 2009). The BRT concluded that the North Pacific Ocean, South Pacific Ocean, North Indian Ocean, Southeast Indo-Pacific Ocean, Northwest Atlantic Ocean, Northeast Atlantic Ocean, and Mediterranean Sea DPSs were at risk of extinction. The BRT concluded that although the Southwest Indian Ocean and South Atlantic Ocean DPSs were likely not currently at immediate risk of extinction, the extinction risk was likely to increase in the foreseeable future.

On March 16, 2010, NMFS and USFWS published a proposed rule (75 FR 12598) to divide the worldwide population of loggerhead sea turtles into nine DPSs, as described in the 2009 Status Review. Two of the DPSs were proposed to be listed as threatened and seven of the DPSs, including the Northwest Atlantic Ocean DPS, were proposed to be listed as endangered. NMFS and the USFWS accepted comments on the proposed rule through September 13, 2010 (75 FR 30769, June 2, 2010). On March 22, 2011 (76 FR 15932), NMFS and USFWS extended the date by which a final determination on the listing action will be made to no later than September 16, 2011. This action was taken to address the interpretation of the existing data on status and trends and its relevance to the assessment of risk of extinction for the Northwest Atlantic Ocean DPS, as well as the magnitude and immediacy of the fisheries bycatch threat and measures to reduce this threat. New information or analyses to help clarify these issues were requested by April 11, 2011.

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

The September 2011 final rule also noted that critical habitat for the two DPSs occurring within the U.S. (NWA DPS and North Pacific DPS) will be designated in a future rulemaking. Information from the public related to the identification of critical habitat, essential physical or biological features for this species, and other relevant impacts of a critical habitat designation was solicited. Currently, no critical habitat is designated for any DPS of loggerhead sea turtles, and therefore, no critical habitat for any DPS occurs in the action area.

Presence of Loggerhead Sea Turtles in the Action Area
The effects of this proposed action are only experienced within the Delaware River and Delaware Bay. NMFS has considered the available information on the distribution of the 9 DPSs to determine the origin of any loggerhead sea turtles that may occur in the action area. As noted in Conant *et al.* (2009), the range of the four DPSs occurring in the action area (considered for these purposes as part of the Atlantic Ocean) are as follows: NWA DPS – north of the equator, south of 60° N latitude, and west of 40° W longitude; Northeast Atlantic Ocean (NEA) DPS – north of the equator, south of 60° N latitude, east of 40° W longitude, and west of 5° 36’ W longitude; South Atlantic DPS – south of the equator, north of 60° S latitude, west of 20° E longitude, and east of 60° W longitude; Mediterranean DPS – the Mediterranean Sea east of 5° 36’ W longitude. These boundaries were determined based on oceanographic features, loggerhead sightings, thermal tolerance, fishery bycatch data, and information on loggerhead distribution from satellite telemetry and flipper tagging studies. While adults are highly structured with no overlap, there may be some degree of overlap by juveniles of the NWA, NEA, and Mediterranean DPSs on oceanic foraging grounds (Laurent *et al.* 1993, 1998; Bolten *et al.* 1998; LaCasella *et al.* 2005; Carreras *et al.* 2006, Monzón-Argüello *et al.* 2006; Revelles *et al.* 2007). Previous literature (Bowen *et al.* 2004) has suggested that there is the potential, albeit small, for some juveniles from the Mediterranean DPS to be present in U.S. Atlantic coastal foraging grounds. These conclusions must be interpreted with caution however, as they may be representing a shared common haplotype and lack of representative sampling at Eastern Atlantic rookeries rather than an actual presence of Mediterranean DPS turtles in US Atlantic coastal waters. A re-analysis of the data by the Atlantic loggerhead Turtle Expert Working Group has found that that it is unlikely that U.S. fishing fleets are interacting with either the Northeast Atlantic loggerhead DPS or the Mediterranean loggerhead DPS (LaCasella et al. 2013). Given that the action area is a subset of the area fished by US fleets, it is reasonable to assume that based on this new analysis, no individuals from the Mediterranean DPS or Northeast Atlantic DPS would be present in the action area. Sea turtles of the South Atlantic DPS do not inhabit the action area of this consultation (Conant *et al.* 2009). As such, the remainder of this consultation will only focus on the NWA DPS, listed as threatened.

Distribution and Life History
Ehrhart *et al.* (2003) provided a summary of the literature identifying known nesting habitats and foraging areas for loggerheads within the Atlantic Ocean. Detailed information is also provided in the 5-year status review for loggerheads (NMFS and USFWS 2007a), the TEWG report (2009), and the final revised recovery plan for loggerheads in the Northwest Atlantic Ocean (NMFS and USFWS 2008), which is a second revision to the original recovery plan that was approved in 1984 and subsequently revised in 1991.

In the western Atlantic, waters as far north as 41° N to 42° N latitude are used for foraging by juveniles, as well as adults (Shoop 1987; Shoop and Kenney 1992; Ehrhart *et al.* 2003; Mitchell *et al.* 2003). In U.S. Atlantic waters, loggerheads commonly occur throughout the inner continental shelf from Florida to Cape Cod, Massachusetts and in the Gulf of Mexico from Florida to Texas, although their presence varies with the seasons due to changes in water temperature (Shoop and Kenney 1992; Epperly *et al.* 1995a, 1995b; Braun and Epperly 1996; Braun-McNeill *et al.* 2008; Mitchell *et al.* 2003). Loggerheads have been observed in waters with surface temperatures of 7°C to 30°C, but water temperatures ≥11°C are most favorable (Shoop and Kenney 1992; Epperly *et al.* 1995b). The presence of loggerhead sea turtles in U.S. Atlantic waters is also influenced by water depth. Aerial surveys of continental shelf waters north of Cape Hatteras, North Carolina indicated that loggerhead sea turtles were most commonly sighted in waters with bottom depths ranging from 22 m to 49 m deep (Shoop and Kenney 1992). However, more recent survey and satellite tracking data support that they occur in waters from the beach to beyond the continental shelf (Mitchell *et al.* 2003; Braun-McNeill and Epperly 2004; Mansfield 2006; Blumenthal *et al.* 2006; Hawkes *et al.* 2006; McClellan and Read 2007; Mansfield *et al.* 2009).

Loggerhead sea turtles occur year round in ocean waters off North Carolina, South Carolina, Georgia, and Florida. In these areas of the South Atlantic Bight, water temperature is influenced by the proximity of the Gulf Stream. As coastal water temperatures warm in the spring, loggerheads begin to migrate to inshore waters of the Southeast United States (*e.g.,* Pamlico and Core Sounds) and also move up the U.S. Atlantic coast (Epperly *et al.* 1995a, 1995b, 1995c; Braun-McNeill and Epperly 2004), occurring in Virginia foraging areas as early as April/May and on the most northern foraging grounds in the Gulf of Maine in June (Shoop and Kenney 1992). The trend is reversed in the fall as water temperatures cool. The large majority leave the Gulf of Maine by mid-September but some turtles may remain in Mid-Atlantic and Northeast areas until late fall. By December, loggerheads have migrated from inshore and more northern coastal waters to waters offshore of North Carolina, particularly off of Cape Hatteras, and waters further south where the influence of the Gulf Stream provides temperatures favorable to sea turtles (Shoop and Kenney 1992; Epperly *et al.* 1995b).

Recent studies have established that the loggerhead's life history is more complex than previously believed. Rather than making discrete developmental shifts from oceanic to neritic environments, research is showing that both adults and (presumed) neritic stage juveniles continue to use the oceanic environment and will move back and forth between the two habitats (Witzell 2002; Blumenthal *et al.* 2006; Hawkes *et al.* 2006; McClellan and Read 2007; Mansfield *et al.* 2009). One of the studies tracked the movements of adult post-nesting females and found that differences in habitat use were related to body size with larger adults staying in coastal waters and smaller adults traveling to oceanic waters (Hawkes *et al.* 2006). A tracking study of large juveniles found that the habitat preferences of this life stage were also diverse with some remaining in neritic waters and others moving off into oceanic waters (McClellan and Read 2007). However, unlike the Hawkes *et al.* (2006) study, there was no significant difference in the body size of turtles that remained in neritic waters versus oceanic waters (McClellan and Read 2007).

Pelagic and benthic juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988; NMFS and USFWS 2008). Sub-adult and adult loggerheads are primarily coastal dwelling and typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hard bottom habitats (NMFS and USFWS 2008).

As presented below, Table 3 from the 2008 loggerhead recovery plan (Table 1 in this Opinion) highlights the key life history parameters for loggerheads nesting in the United States.

Table 1. Life History Characteristics of Loggerhead Sea Turtles (Reprinted from NMFS and USFWS 2008)

Life History Parameter	**Data**
Clutch size	100-126 eggs[1]
Egg incubation duration (varies depending on time of year and latitude)	42-75 days[2,3]
Pivotal temperature (incubation temperature that produces an equal number of males and females)	29.0°C[5]
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	45-70%[2,6]
Clutch frequency (number of nests/female/season)	3-5.5 nests[7]
Internesting interval (number of days between successive nests within a season)	12-15 days[8]
Juvenile (<87 cm CCL) sex ratio	65-70% female[4]
Remigration interval (number of years between successive nesting migrations)	2.5-3.7 years[9]
Nesting season	late April-early September
Hatching season	late June-early November
Age at sexual maturity	32-35 years[10]
Life span	>57 years[11]

1 Dodd 1988.
2 Dodd and Mackinnon (1999, 2000, 2001, 2002, 2003, 2004).
3 Blair Witherington, FFWCC, personal communication, 2006 (information based on nests monitored throughout Florida beaches in 2005, n=865).
4 National Marine Fisheries Service (2001); Allen Foley, FFWCC, personal communication, 2005.
5 Mrosovsky (1988).
6 Blair Witherington, FFWCC, personal communication, 2006 (information based on nests monitored throughout Florida beaches in 2005, n=1,680).
7 Murphy and Hopkins (1984); Frazer and Richardson (1985); Ehrhart, unpublished data; Hawkes *et al*. 2005; Scott 2006; Tony Tucker, Mote Marine Laboratory, personal communication, 2008.
8 Caldwell (1962), Dodd (1988).
9 Richardson *et al*. (1978); Bjorndal *et al*. (1983); Ehrhart, unpublished data.
10 Melissa Snover, NMFS, personal communication, 2005; see Table A1-6.
11 Dahlen *et al*. (2000).

Population Dynamics and Status
By far, the majority of Atlantic nesting occurs on beaches of the southeastern United States (NMFS and USFWS 2007a). For the past decade or so, the scientific literature has recognized five distinct nesting groups, or subpopulations, of loggerhead sea turtles in the Northwest Atlantic, divided geographically as follows: (1) a northern group of nesting females that nest from North Carolina to northeast Florida at about 29° N latitude; (2) a south Florida group of nesting females that nest from 29° N latitude on the east coast to Sarasota on the west coast; (3) a Florida Panhandle group of nesting females that nest around Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán group of nesting females that nest on beaches of the eastern Yucatán Peninsula, Mexico; and (5) a Dry Tortugas group that nests on beaches of the islands of the Dry Tortugas, near Key West, Florida and on Cal Sal Bank (TEWG 2009). Genetic analyses of mitochondrial DNA, which a sea turtle inherits from its mother, indicate that there are genetic differences between loggerheads that nest at and originate from the beaches used by each of the five identified nesting groups of females (TEWG 2009). However, analyses of microsatellite loci from nuclear DNA, which represents the genetic contribution from both parents, indicates little to no genetic differences between loggerheads originating from nesting beaches of the five Northwest Atlantic nesting groups (Pearce and Bowen 2001; Bowen 2003; Bowen *et al.* 2005; Shamblin 2007). These results suggest that female loggerheads have site fidelity to nesting beaches within a particular area, while males provide an avenue of gene flow between nesting groups by mating with females that originate from different nesting groups (Bowen 2003; Bowen *et al.* 2005). The extent of such gene flow, however, is unclear (Shamblin 2007).

The lack of genetic structure makes it difficult to designate specific boundaries for the nesting subpopulations based on genetic differences alone. Therefore, the Loggerhead Recovery Team recently used a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries, in addition to genetic differences, to reassess the designation of these subpopulations to identify recovery units in the 2008 recovery plan.

In the 2008 recovery plan, the Loggerhead Recovery Team designated five recovery units for the Northwest Atlantic population of loggerhead sea turtles based on the aforementioned nesting groups and inclusive of a few other nesting areas not mentioned above. The first four of these recovery units represent nesting assemblages located in the Southeast United States. The fifth recovery unit is composed of all other nesting assemblages of loggerheads within the Greater Caribbean, outside the United States, but which occur within U.S. waters during some portion of their lives. The five recovery units representing nesting assemblages are: (1) the Northern Recovery Unit (NRU: Florida/Georgia border through southern Virginia), (2) the Peninsular Florida Recovery Unit (PFRU: Florida/Georgia border through Pinellas County, Florida), (3) the Dry Tortugas Recovery Unit (DTRU: islands located west of Key West, Florida), (4) the Northern Gulf of Mexico Recovery Unit (NGMRU: Franklin County, Florida through Texas), and (5) the Greater Caribbean Recovery Unit (GCRU: Mexico through French Guiana, Bahamas, Lesser Antilles, and Greater Antilles).

The Recovery Team evaluated the status and trends of the Northwest Atlantic loggerhead population for each of the five recovery units, using nesting data available as of October 2008 (NMFS and USFWS 2008). The level and consistency of nesting coverage varies among recovery units, with coverage in Florida generally being the most consistent and thorough over time. Since 1989, nest count surveys in Florida have occurred in the form of statewide surveys (a near complete census of entire Florida nesting) and index beach surveys (Witherington *et al.* 2009). Index beaches were established to standardize data collection methods and maintain a constant level of effort on key nesting beaches over time.

Note that NMFS and USFWS (2008), Witherington *et al.* (2009), and TEWG (2009) analyzed the status of the nesting assemblages within the NWA DPS using standardized data collected over periods ranging from 10-23 years. These analyses used different analytical approaches, but found the same finding that there had been a significant, overall nesting decline within the NWA DPS. However, with the addition of nesting data from 2008-2010, the trend line changes showing a very slight negative trend, but the rate of decline is not statistically different from zero (76 FR 58868, September 22, 2011). The nesting data presented in the Recovery Plan (through 2008) is described below, with updated trend information through 2010 for two recovery units.

From the beginning of standardized index surveys in 1989 until 1998, the PFRU, the largest nesting assemblage in the Northwest Atlantic by an order of magnitude, had a significant increase in the number of nests. However, from 1998 through 2008, there was a 41% decrease in annual nest counts from index beaches, which represent an average of 70% of the statewide nesting activity (NMFS and USFWS 2008). From 1989-2008, the PFRU had an overall declining nesting trend of 26% (95% CI: -42% to -5%; NMFS and USFWS 2008). With the addition of nesting data through 2010, the nesting trend for the PFRU does not show a nesting decline statistically different from zero (76 FR 58868, September 22, 2011). The NRU, the second largest nesting assemblage of loggerheads in the United States, has been declining at a rate of 1.3% annually since 1983 (NMFS and USFWS 2008). The NRU dataset included 11 beaches with an uninterrupted time series of coverage of at least 20 years; these beaches represent approximately 27% of NRU nesting (in 2008). Through 2008, there was strong statistical data to suggest the NRU has experienced a long-term decline, but with the inclusion of nesting data through 2010, nesting for the NRU is showing possible signs of stabilizing (76 FR 58868, September 22, 2011). Evaluation of long-term nesting trends for the NGMRU is difficult because of changed and expanded beach coverage. However, the NGMRU has shown a significant declining trend of 4.7% annually since index nesting beach surveys were initiated in 1997 (NMFS and USFWS 2008). No statistical trends in nesting abundance can be determined for the DTRU because of the lack of long-term data. Similarly, statistically valid analyses of long-term nesting trends for the entire GCRU are not available because there are few long-term standardized nesting surveys representative of the region. Additionally, changing survey effort at monitored beaches and scattered and low-level nesting by loggerheads at many locations currently precludes comprehensive analyses (NMFS and USFWS 2008).

Sea turtle census nesting surveys are important in that they provide information on the relative abundance of nesting each year, and the contribution of each nesting group to total nesting of the species. Nest counts can also be used to estimate the number of reproductively mature females nesting annually. The 2008 recovery plan compiled information on mean number of loggerhead nests and the approximated counts of nesting females per year for four of the five identified recovery units (*i.e.*, nesting groups). They are: (1) for the NRU, a mean of 5,215 loggerhead nests per year (from 1989-2008) with approximately 1,272 females nesting per year; (2) for the PFRU, a mean of 64,513 nests per year (from 1989-2007) with approximately 15,735 females nesting per year; (3) for the DTRU, a mean of 246 nests per year (from 1995-2004, excluding

2002) with approximately 60 females nesting per year; and (4) for the NGMRU, a mean of 906 nests per year (from 1995-2007) with approximately 221 females nesting per year. For the GCRU, the only estimate available for the number of loggerhead nests per year is from Quintana Roo, Yucatán, Mexico, where a range of 903-2,331 nests per year was estimated from 1987-2001 (NMFS and USFWS 2007a). There are no annual nest estimates available for the Yucatán since 2001 or for any other regions in the GCRU, nor are there any estimates of the number of nesting females per year for any nesting assemblage in this recovery unit. Note that the above values for average nesting females per year were based upon 4.1 nests per female per Murphy and Hopkins (1984).

Genetic studies of juvenile and a few adult loggerhead sea turtles collected from Northwest Atlantic foraging areas (beach strandings, a power plant in Florida, and North Carolina fisheries) show that the loggerheads that occupy East Coast U.S. waters originate from these Northwest Atlantic nesting groups; primarily from the nearby nesting beaches of southern Florida, as well as the northern Florida to North Carolina beaches, and finally from the beaches of the Yucatán Peninsula, Mexico (Rankin-Baransky *et al.* 2001; Witzell *et al.* 2002; Bass *et al.* 2004; Bowen *et al.* 2004). The contribution of these three nesting assemblages varies somewhat among the foraging habitats and age classes surveyed along the east coast. The distribution is not random and bears a significant relationship to the proximity and size of adjacent nesting colonies (Bowen *et al.* 2004). Bass *et al.* (2004) attribute the variety in the proportions of sea turtles from loggerhead turtle nesting assemblages documented in different east coast foraging habitats to a complex interplay of currents and the relative size and proximity of nesting beaches.

Unlike nesting surveys, in-water studies of sea turtles typically sample both sexes and multiple age classes. In-water studies have been conducted in some areas of the Northwest Atlantic and provide data by which to assess the relative abundance of loggerhead sea turtles and changes in abundance over time (Maier *et al.* 2004; Morreale *et al.* 2005; Mansfield 2006; Ehrhart *et al.* 2007; Epperly *et al.* 2007). The TEWG (2009) used raw data from six in-water study sites to conduct trend analyses. They identified an increasing trend in the abundance of loggerheads from three of the four sites located in the Southeast United States, one site showed no discernible trend, and the two sites located in the northeast United States showed a decreasing trend in abundance of loggerheads. The 2008 loggerhead recovery plan also includes a full discussion of in-water population studies for which trend data have been reported, and a brief summary will be provided here.

Maier *et al.* (2004) used fishery-independent trawl data to establish a regional index of loggerhead abundance for the southeast coast of the United States (Winyah Bay, South Carolina to St. Augustine, Florida) during the period 2000-2003. A comparison of loggerhead catch data from this study with historical values suggested that in-water populations of loggerhead sea turtles along the southeast U.S. coast appear to be larger, possibly an order of magnitude higher than they were 25 years ago, but the authors caution a direct comparison between the two studies given differences in sampling methodology (Maier *et al.* 2004). A comparison of catch rates for sea turtles in pound net gear fished in the Pamlico-Albemarle Estuarine Complex of North Carolina between the years 1995-1997 and 2001-2003 found a significant increase in catch rates for loggerhead sea turtles for the latter period (Epperly *et al.* 2007). A long-term, on-going study of loggerhead abundance in the Indian River Lagoon System of Florida found a significant increase in the relative abundance of loggerheads over the last 4 years of the study (Ehrhart *et al.*

2007). However, there was no discernible trend in loggerhead abundance during the 24-year time period of the study (1982-2006) (Ehrhart *et al.* 2007). At St. Lucie Power Plant, data collected from 1977-2004 show an increasing trend of loggerheads at the power plant intake structures (FPL and Quantum Resources 2005).

In contrast to these studies, Morreale *et al.* (2005) observed a decline in the percentage and relative numbers of loggerhead sea turtles incidentally captured in pound net gear fished around Long Island, New York during the period 2002-2004 in comparison to the period 1987-1992, with only two loggerheads (of a total 54 turtles) observed captured in pound net gear during the period 2002-2004. This is in contrast to the previous decade's study where numbers of individual loggerheads ranged from 11 to 28 per year (Morreale *et al.* 2005). No additional loggerheads were reported captured in pound net gear in New York through 2007, although two were found cold-stunned on Long Island bay beaches in the fall of 2007 (Memo to the File, L. Lankshear, December 2007). Potential explanations for this decline include major shifts in loggerhead foraging areas and/or increased mortality in pelagic or early benthic stage/age classes (Morreale *et al.* 2005). Using aerial surveys, Mansfield (2006) also found a decline in the densities of loggerhead sea turtles in Chesapeake Bay over the period 2001-2004 compared to aerial survey data collected in the 1980s. Significantly fewer loggerheads ($p<0.05$) were observed in both the spring (May-June) and the summer (July-August) of 2001-2004 compared to those observed during aerial surveys in the 1980s (Mansfield 2006). A comparison of median densities from the 1980s to the 2000s suggested that there had been a 63.2% 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).

As with other turtle species, population estimates for loggerhead sea turtles are difficult to determine, largely given their life history characteristics. However, a recent loggerhead assessment using a demographic matrix model estimated that the loggerhead adult female population in the western North Atlantic ranges from 16,847 to 89,649, with a median size of 30,050 (NMFS SEFSC 2009). The model results for population trajectory suggest that the population is most likely declining, but this result was very sensitive to the choice of the position of the parameters within their range and hypothesized distributions. The pelagic stage survival parameter had the largest effect on the model results. As a result of the large uncertainty in our knowledge of loggerhead life history, at this point predicting the future populations or population trajectories of loggerhead sea turtles with precision is very uncertain. It should also be noted that additional analyses are underway which will incorporate any newly available information.

As part of the Atlantic Marine Assessment Program for Protected Species (AMAPPS), line transect aerial abundance surveys and turtle telemetry studies were conducted along the Atlantic coast in the summer of 2010. AMAPPS is a multi-agency initiative to assess marine mammal, sea turtle, and seabird abundance and distribution in the Atlantic. Aerial surveys were conducted from Cape Canaveral, Florida to the Gulf of St. Lawrence, Canada. Satellite tags on juvenile loggerheads were deployed in two locations – off the coasts of northern Florida to South Carolina (n=30) and off the New Jersey and Delaware coasts (n=14). As presented in NMFS NEFSC (2011), the 2010 survey found a preliminary total surface abundance estimate within the entire study area of about 60,000 loggerheads (CV=0.13) or 85,000 if a portion of unidentified hard-shelled sea turtles were included (CV=0.10). Surfacing times were generated from the satellite tag data collected during the aerial survey period, resulting in a 7% (5%-11% inter-quartile range) median surface time in the South Atlantic area and a 67% (57%-77% inter-quartile range) median surface time to the north. The calculated preliminary regional abundance estimate is about 588,000 loggerheads along the U.S. Atlantic coast, with an inter-quartile range of 382,000-817,000 (NMFS NEFSC 2011). The estimate increases to approximately 801,000 (inter-quartile range of 521,000-1,111,000) when based on known loggerheads and a portion of unidentified turtle sightings. The density of loggerheads was generally lower in the north than the south; based on number of turtle groups detected, 64% were seen south of Cape Hatteras, North Carolina, 30% in the southern Mid-Atlantic Bight, and 6% in the northern Mid-Atlantic Bight. Although they have been seen farther north in previous studies (*e.g.*, Shoop and Kenney 1992), no loggerheads were observed during the aerial surveys conducted in the summer of 2010 in the more northern zone encompassing Georges Bank, Cape Cod Bay, and the Gulf of Maine. These estimates of loggerhead abundance over the U.S. Atlantic continental shelf are considered very preliminary. A more thorough analysis will be completed pending the results of further studies related to improving estimates of regional and seasonal variation in loggerhead surface time (by increasing the sample size and geographical area of tagging) and other information needed to improve the biases inherent in aerial surveys of sea turtles (*e.g.*, research on depth of detection and species misidentification rate). This survey effort represents the most comprehensive assessment of sea turtle abundance and distribution in many years. Additional aerial surveys and research to improve the abundance estimates are anticipated in 2011-2014, depending on available funds.

Threats

The diversity of a sea turtle's life history leaves them susceptible to many natural and human impacts, including impacts while they are on land, in the neritic environment, and in the oceanic environment. The 5-year status review and 2008 recovery plan provide a summary of natural as well as anthropogenic threats to loggerhead sea turtles (NMFS and USFWS 2007a, 2008). Amongst those of natural origin, hurricanes are known to be destructive to sea turtle nests. Sand accretion, rainfall, and wave action that result from these storms can appreciably reduce hatchling success. Other sources of natural mortality include cold-stunning, biotoxin exposure, and native species predation.

Anthropogenic factors that impact hatchlings and adult females on land, or the success of nesting and hatching include: beach erosion, beach armoring, and nourishment; artificial lighting; beach cleaning; beach pollution; increased human presence; recreational beach equipment; vehicular and pedestrian traffic; coastal development/construction; exotic dune and beach vegetation; removal of native vegetation; and poaching. An increased human presence at some nesting beaches or close to nesting beaches has led to secondary threats such as the introduction of exotic fire ants, feral hogs, dogs, and an increased presence of native species (*e.g.*, raccoons, armadillos, and opossums), which raid nests and feed on turtle eggs (NMFS and USFWS 2007a, 2008). Although sea turtle nesting beaches are protected along large expanses of the Northwest Atlantic coast (in areas like Merritt Island, Archie Carr, and Hobe Sound National Wildlife Refuges), other areas along these coasts have limited or no protection. Sea turtle nesting and hatching success on unprotected high density East Florida nesting beaches from Indian River to Broward County are affected by all of the above threats.

Loggerheads are affected by a completely different set of anthropogenic threats in the marine environment. These include oil and gas exploration, coastal development, and transportation; marine pollution; underwater explosions; hopper dredging; offshore artificial lighting; power plant entrainment and/or impingement; entanglement in debris; ingestion of marine debris; marina and dock construction and operation; boat collisions; poaching; and fishery interactions.

A 1990 National Research Council report concluded that for juveniles, subadults, and breeding adults in coastal waters, the most important source of human caused mortality in U.S. Atlantic waters was fishery interactions. The sizes and reproductive values of sea turtles taken by fisheries vary significantly, depending on the location and season of the fishery, and size-selectivity resulting from gear characteristics. Therefore, it is possible for fisheries that interact with fewer, more reproductively valuable turtles to have a greater detrimental effect on the population than one that takes greater numbers of less reproductively valuable turtles (Wallace *et al.* 2008). The Loggerhead Biological Review Team determined that the greatest threats to the NWA DPS of loggerheads result from cumulative fishery bycatch in neritic and oceanic habitats (Conant *et al.* 2009). Attaining a more thorough understanding of the characteristics, as well as the quantity of sea turtle bycatch across all fisheries is of great importance.

Finkbeiner *et al.* (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. Information was obtained from peer reviewed publications and NMFS documents (e.g., Biological Opinions and bycatch reports). In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). The Southeast/Gulf of Mexico shrimp trawl fishery was responsible for the vast majority of U.S. interactions (up to 98%) and mortalities (more than 80%). While this provides an initial cumulative bycatch assessment, there are a number of caveats that should be considered when interpreting this information, such as sampling inconsistencies and limitations.

Of the many fisheries known to adversely affect loggerheads, the U.S. South Atlantic and Gulf of Mexico shrimp fisheries were considered to pose the greatest threat of mortality to neritic juvenile and adult age classes of loggerheads (National Research Council 1990, Finkbeiner *et al.* 2011). Significant changes to the South Atlantic and Gulf of Mexico shrimp fisheries have occurred since 1990, and the effects of these shrimp fisheries on ESA-listed species, including loggerhead sea turtles, have been assessed several times through section 7 consultations carried out by NMFS. There is also a lengthy regulatory history with regard to the use of Turtle Excluder Devices (TEDs) in the U.S. South Atlantic and Gulf of Mexico shrimp fisheries (Epperly and Teas 2002; NMFS 2002a; Lewison *et al.* 2003). A 2002 Biological Opinion on the U.S. South Atlantic and Gulf of Mexico shrimp fisheries estimated the total annual level of take for loggerhead sea turtles to be 163,160 interactions (the total number of turtles that enter a shrimp trawl, which may then escape through the TED or fail to escape and be captured) with 3,948 of those takes being lethal (NMFS 2002a).

In addition to improvements in TED designs and TED enforcement, interactions between loggerheads and the shrimp fishery have also been declining because of reductions in fishing effort unrelated to fisheries management actions. The 2002 Opinion take estimates are based in part on fishery effort levels. In recent years, low shrimp prices, rising fuel costs, competition with imported products, and the impacts of recent hurricanes in the Gulf of Mexico have all impacted the shrimp fleets; in some cases reducing fishing effort by as much as 50% for offshore waters of the Gulf of Mexico (GMFMC 2007). As a result, loggerhead interactions and mortalities in the Gulf of Mexico have been substantially less than projected in the 2002 Opinion. Currently, the estimated annual number of interactions between loggerheads and shrimp trawls in the Gulf of Mexico shrimp fishery is 23,336, with 647 (2.8%) of those interactions resulting in mortality (Memo from Dr. B. Ponwith, Southeast Fisheries Science Center to Dr. R. Crabtree, Southeast Region, PRD, December 2008). In August 2010, NMFS reinitiated section 7 consultation on southeastern state and federal shrimp fisheries based on a high level of strandings, elevated nearshore sea turtle abundance as measured by trawl catch per unit of effort, and lack of compliance with TED requirements. The 2012 section 7 consultation on the shrimp fishery was unable to estimate the current total annual level of take for loggerheads. Instead, it qualitatively estimated that the shrimp fishery, as currently operating, would result in at least thousands and possibly tens of thousands of interactions annually, of which at least hundreds and possibly thousands are expected to be lethal (NMFS 2012a).

Loggerhead sea turtles are also known to interact with non-shrimp trawl, gillnet, longline, dredge, pound net, pot/trap, and hook and line fisheries. The National Research Council (1990) report stated that other U.S. Atlantic fisheries collectively accounted for 500 to 5,000 loggerhead deaths each year, but recognized that there was considerable uncertainty in the estimate. The reduction of sea turtle captures in fishing operations is identified in recovery plans and 5-year status reviews as a priority for the recovery of all sea turtle species. In the threats analysis of the loggerhead recovery plan, trawl bycatch is identified as the greatest source of mortality. While loggerhead bycatch in U.S. Mid-Atlantic bottom otter trawl gear was previously estimated for the period 1996-2004 (Murray 2006, 2008), a recent bycatch analysis estimated the number of loggerhead sea turtle interactions with U.S. Mid-Atlantic bottom trawl gear from 2005-2008 (Warden 2011a). Northeast Fisheries Observer Program data from 1994-2008 were used to develop a model of interaction rates and those predicted rates were applied to 2005-2008 commercial fishing data to estimate the number of interactions for the trawl fleet. The number of predicted average annual loggerhead interactions for 2005-2008 was 292 (CV=0.13, 95% CI=221-369), with an additional 61 loggerheads (CV=0.17, 95% CI=41-83) interacting with trawls but being released through a TED. Of the 292 average annual observable loggerhead interactions, approximately 44 of those were adult equivalents. Warden (2011b) found that latitude, depth and SST were associated with the interaction rate, with the rates being highest south of 37°N latitude in waters < 50 m deep and SST > 15°C. This estimate is a decrease from the average annual loggerhead bycatch in bottom otter trawls during 1996-2004, estimated to be 616 sea turtles (CV=0.23, 95% CI over the 9-year period: 367-890) (Murray 2006, 2008).

There have been several published estimates of the number of loggerheads taken annually as a result of the dredge fishery for Atlantic sea scallops, ranging from a low of zero in 2005 (Murray 2007) to a high of 749 in 2003 (Murray 2004). Murray (2011) recently re-evaluated loggerhead sea turtle interactions in scallop dredge gear from 2001-2008. In that paper, the average number of annual observable interactions of hard-shelled sea turtles in the Mid-Atlantic scallop dredge fishery prior to the implementation of chain mats (January 1, 2001 through September 25, 2006) was estimated to be 288 turtles (CV = 0.14, 95% CI: 209-363) [equivalent to 49 adults], 218 of which were loggerheads [equivalent to 37 adults]. After the implementation of chain mats, the average annual number of observable interactions was estimated to be 20 hard-shelled sea turtles (CV = 0.48, 95% CI: 3-42), 19 of which were loggerheads. If the rate of observable interactions from dredges without chain mats had been applied to trips with chain mats, the estimated number of observable and inferred interactions of hard-shelled sea turtles after chain mats were implemented would have been 125 turtles per year (CV = 0.15, 95% CI: 88-163) [equivalent to 22 adults], 95 of which were loggerheads [equivalent to 16 adults]. Interaction rates of hard-shelled turtles were correlated with sea surface temperature, depth, and use of a chain mat. Results from this recent analysis suggest that chain mats and fishing effort reductions have contributed to the decline in estimated loggerhead sea turtle interactions with scallop dredge gear after 2006 (Murray 2011).

An estimate of the number of loggerheads taken annually in U.S. Mid-Atlantic gillnet fisheries has also recently been published (Murray 2009a, b). From 1995-2006, the annual bycatch of loggerheads in U.S. Mid-Atlantic gillnet gear was estimated to average 350 turtles (CV=0.20, 95% CI over the 12-year period: 234 to 504). Bycatch rates were correlated with latitude, sea surface temperature, and mesh size. The highest predicted bycatch rates occurred in warm waters of the southern Mid-Atlantic in large-mesh gillnets (Murray 2009a).

The U.S. tuna and swordfish longline fisheries that are managed under the Highly Migratory Species (HMS) FMP are estimated to capture 1,905 loggerheads (no more than 339 mortalities) for each 3-year period starting in 2007 (NMFS 2004a). NMFS has mandated gear changes for the HMS fishery to reduce sea turtle bycatch and the likelihood of death from those incidental takes that would still occur (Garrison and Stokes 2012). In 2010, there were 40 observed interactions between loggerhead sea turtles and longline gear used in the HMS fishery (Garrison and Stokes 2012). All of the loggerheads were released alive, with 29 out of 40 (72.5%) released with all gear removed. A total of 344.4 (95% CI: 236.6-501.3) loggerhead sea turtles were estimated to have interacted with the longline fisheries managed under the HMS FMP in 2010 based on the observed bycatch events (Garrison and Stokes 2012). The 2010 estimate is considerably lower than those in 2006 and 2007 and is well below the historical highs that occurred in the mid-1990s (Garrison and Stokes 2012). This fishery represents just one of several longline fisheries operating in the Atlantic Ocean. Lewison *et al.* (2004) estimated that 150,000-200,000 loggerheads were taken in all Atlantic longline fisheries in 2000 (including the U.S. Atlantic tuna and swordfish longline fisheries as well as others).

Documented takes also occur in other fishery gear types and by non-fishery mortality sources (*e.g.*, hopper dredges, power plants, vessel collisions), but quantitative estimates are unavailable. Past and future impacts of global climate change are considered in Section 6.0 below.

Summary of Status for Loggerhead Sea Turtles

Loggerheads are a long-lived species and reach sexual maturity relatively late at around 32-35 years in the Northwest Atlantic (NMFS and USFWS 2008). The species continues to be affected by many factors occurring on nesting beaches and in the water. These include poaching, habitat loss, and nesting predation that affects eggs, hatchlings, and nesting females on land, as well as fishery interactions, vessel interactions, marine pollution, and non-fishery (*e.g.*, dredging) operations affecting all sexes and age classes in the water (National Research Council 1990; NMFS and USFWS 2007a, 2008). As a result, loggerheads still face many of the original threats that were the cause of their listing under the ESA.

As mentioned previously, a final revised recovery plan for loggerhead sea turtles in the Northwest Atlantic was recently published by NMFS and USFWS in December 2008. The revised recovery plan is significant in that it identifies five unique recovery units, which comprise the population of loggerheads in the Northwest Atlantic, and describes specific recovery criteria for each recovery unit. The recovery plan noted a decline in annual nest counts for three of the five recovery units for loggerheads in the Northwest Atlantic, including the PFRU, which is the largest (in terms of number of nests laid) in the Atlantic Ocean. The nesting trends for the other two recovery units could not be determined due to an absence of long term data.

NMFS convened a new Loggerhead Turtle Expert Working Group (TEWG) to review all available information on Atlantic loggerheads in order to evaluate the status of this species in the Atlantic. A final report from the Loggerhead TEWG was published in July 2009. In this report, the TEWG indicated that it could not determine whether the decreasing annual numbers of nests among the Northwest Atlantic loggerhead subpopulations were due to stochastic processes resulting in fewer nests, a decreasing average reproductive output of adult females, decreasing numbers of adult females, or a combination of these factors. Many factors are responsible for past or present loggerhead mortality that could impact current nest numbers; however, no single mortality factor stands out as a likely primary factor. It is likely that several factors compound to create the current decline, including incidental capture (in fisheries, power plant intakes, and dredging operations), lower adult female survival rates, increases in the proportion of first-time nesters, continued directed harvest, and increases in mortality due to disease. Regardless, the TEWG stated that "it is clear that the current levels of hatchling output will result in depressed recruitment to subsequent life stages over the coming decades" (TEWG 2009). However, the report does not provide information on the rate or amount of expected decrease in recruitment but goes on to state that the ability to assess the current status of loggerhead subpopulations is limited due to a lack of fundamental life history information and specific census and mortality data.

While several documents reported the decline in nesting numbers in the NWA DPS (NMFS and USFWS 2008, TEWG 2009), when nest counts through 2010 are analyzed, the nesting trends from 1989-2010 are not significantly different than zero for all recovery units within the NWA DPS for which there are enough data to analyze (76 FR 58868, September 22, 2011). 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.

4.3 Status of Kemp's Ridley Sea Turtles

Distribution and Life History

The Kemp's ridley is one of the least abundant of the world's sea turtle species. In contrast to loggerhead, leatherback, and green sea turtles, which are found in multiple oceans of the world, Kemp's ridleys typically occur only in the Gulf of Mexico and the northwestern Atlantic Ocean (NMFS *et al.* 2011).

Kemp's ridleys mature at 10-17 years (Caillouet *et al.* 1995; Schmid and Witzell 1997; Snover *et al.* 2007; NMFS and USFWS 2007b). Nesting occurs from April through July each year with hatchlings emerging after 45-58 days (NMFS *et al.* 2011). Females lay an average of 2.5 clutches within a season (TEWG 1998, 2000) and the mean remigration interval for adult females is 2 years (Marquez *et al.* 1982; TEWG 1998, 2000).

Once they leave the nesting beach, hatchlings presumably enter the Gulf of Mexico where they feed on available S*argassum* and associated infauna or other epipelagic species (NMFS *et al.* 2011). The presence of juvenile turtles along both the U.S. Atlantic and Gulf of Mexico coasts, where they are recruited to the coastal benthic environment, indicates that post-hatchlings are distributed in both the Gulf of Mexico and Atlantic Ocean (TEWG 2000).

The location and size classes of dead turtles recovered by the Sea Turtle Stranding and Salvage Network (STSSN) suggests that benthic immature developmental areas occur along the U.S. coast and that these areas may change given resource quality and quantity (TEWG 2000). Developmental habitats are defined by several characteristics, including coastal areas sheltered from high winds and waves such as embayments and estuaries, and nearshore temperate waters shallower than 50 m (NMFS and USFWS 2007b). The suitability of these habitats depends on resource availability, with optimal environments providing rich sources of crabs and other invertebrates. Kemp's ridleys consume a variety of crab species, including *Callinectes*, *Ovalipes*, *Libinia*, and *Cancer* species. Mollusks, shrimp, and fish are consumed less frequently (Bjorndal 1997). A wide variety of substrates have been documented to provide good foraging habitat, including seagrass beds, oyster reefs, sandy and mud bottoms, and rock outcroppings (NMFS and USFWS 2007b).

Foraging areas documented along the U.S. Atlantic coast include Charleston Harbor, Pamlico Sound (Epperly *et al.* 1995c), Chesapeake Bay (Musick and Limpus 1997), Delaware Bay (Stetzar 2002), and Long Island Sound (Morreale and Standora 1993; Morreale *et al.* 2005). For instance, in the Chesapeake Bay, Kemp's ridleys frequently forage in submerged aquatic grass beds for crabs (Musick and Limpus 1997). Upon leaving Chesapeake Bay in autumn, juvenile Kemp's ridleys migrate down the coast, passing Cape Hatteras in December and January (Musick and Limpus 1997). These larger juveniles are joined by juveniles of the same size from North Carolina sounds and smaller juveniles from New York and New England to form one of the densest concentrations of Kemp's ridleys outside of the Gulf of Mexico (Epperly *et al.* 1995a, 1995b; Musick and Limpus 1997).

Adult Kemp's ridleys are found in the coastal regions of the Gulf of Mexico and southeastern United States, but are typically rare in the northeastern U.S. waters of the Atlantic (TEWG

2000). Adults are primarily found in nearshore waters of 37 m or less that are rich in crabs and have a sandy or muddy bottom (NMFS and USFWS 2007b).

Population Dynamics and Status

The majority of Kemp's ridleys nest along a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; NMFS and USFWS 2007b; NMFS *et al.* 2011). There is a limited amount of scattered nesting to the north and south of the primary nesting beach (NMFS and USFWS 2007b. Nesting often occurs in synchronized emergences termed *arribadas*. The number of recorded nests reached an estimated low of 702 nests in 1985, corresponding to fewer than 300 adult females nesting in that season (TEWG 2000; NMFS and USFWS 2007b; NMFS *et al.* 2011). Conservation efforts by Mexican and U.S. agencies have aided this species by eliminating egg harvest, protecting eggs and hatchlings, and reducing at-sea mortality through fishing regulations (TEWG 2000). Since the mid-1980s, the number of nests observed at Rancho Nuevo and nearby beaches has increased 14-16% per year (Heppell *et al.* 2005), allowing cautious optimism that the population is on its way to recovery. An estimated 5,500 females nested in the State of Tamaulipas over a 3-day period in May 2007 and over 4,000 of those nested at Rancho Nuevo (NMFS and USFWS 2007b). In 2008, 17,882 nests were documented on Mexican nesting beaches (NMFS et al. 2011). There is limited nesting in the United States, most of which is located in South Texas. While six nests were documented in 1996, a record 195 nests were found in 2008 (NMFS et al. 2011).

Threats

Kemp's ridleys face many of the same natural threats as loggerheads, including destruction of nesting habitat from storm events, predators, and oceanographic-related events such as cold-stunning. Although cold-stunning can occur throughout the range of the species, it may be a greater risk for sea turtles that utilize the more northern habitats of Cape Cod Bay and Long Island Sound. In the last five years (2006-2010), the number of cold-stunned turtles on Cape Cod beaches averaged 115 Kemp's ridleys, 7 loggerheads, and 7 greens (NMFS unpublished data). The numbers ranged from a low in 2007 of 27 Kemp's ridleys, 5 loggerheads, and 5 greens to a high in 2010 of 213 Kemp's ridleys, 4 loggerheads, and 14 greens. Annual cold stun events vary in magnitude; the extent of episodic major cold stun events may be associated with numbers of turtles utilizing Northeast U.S. waters in a given year, oceanographic conditions, and/or the occurrence of storm events in the late fall. Although many cold-stunned turtles can survive if they are found early enough, these events represent a significant source of natural mortality for Kemp's ridleys.

Like other sea turtle species, the severe decline in the Kemp's ridley population appears to have been heavily influenced by a combination of exploitation of eggs and impacts from fishery interactions. From the 1940s through the early 1960s, nests from Ranch Nuevo were heavily exploited, but beach protection in 1967 helped to curtail this activity (NMFS *et al.* 2011). Following World War II, there was a substantial increase in the number of trawl vessels, particularly shrimp trawlers, in the Gulf of Mexico where adult Kemp's ridley sea turtles occur. Information from fisheries observers helped to demonstrate the high number of turtles taken in these shrimp trawls (USFWS and NMFS 1992). Subsequently, NMFS has worked with the industry to reduce sea turtle takes in shrimp trawls and other trawl fisheries, including the development and use of turtle excluder devices (TEDs). As described above, there is lengthy regulatory history with regard to the use of TEDs in the U.S. South Atlantic and Gulf of Mexico shrimp fisheries (NMFS 2002a; Epperly 2003; Lewison *et al.* 2003). The 2002 Biological Opinion on shrimp trawling in the southeastern United States concluded that 155,503 Kemp's ridley sea turtles would be taken annually in the fishery with 4,208 of the takes resulting in mortality (NMFS 2002a).

Although modifications to shrimp trawls have helped to reduce mortality of Kemp's ridleys, a recent assessment found that the Southeast/Gulf of Mexico shrimp trawl fishery remained responsible for the vast majority of U.S. fishery interactions (up to 98%) and mortalities (more than 80%). Finkbeiner *et al.* (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. Information was obtained from peer reviewed publications and NMFS documents (e.g., Biological Opinions and bycatch reports). In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). While this provides an initial cumulative bycatch assessment, there are a number of caveats that should be considered when interpreting this information, such as sampling inconsistencies and limitations.

This species is also affected by other sources of anthropogenic impact (fishery and non-fishery related), similar to those discussed above. Three Kemp's ridley captures in Mid-Atlantic trawl fisheries were documented by NMFS observers between 1994 and 2008 (Warden and Bisack 2010), and eight Kemp's ridleys were documented by NMFS observers in mid-Atlantic sink gillnet fisheries between 1995 and 2006 (Murray 2009a). Additionally, in the spring of 2000, a total of five Kemp's ridley carcasses were recovered from the same North Carolina beaches where 275 loggerhead carcasses were found. The cause of death for most of the turtles recovered was unknown, but the mass mortality event was suspected by NMFS to have been from a large-mesh gillnet fishery for monkfish and dogfish operating offshore in the preceding weeks (67 FR 71895, December 3, 2002). The five Kemp's ridley carcasses that were found are likely to have been only a minimum count of the number of Kemp's ridleys that were killed or seriously injured as a result of the fishery interaction, since it is unlikely that all of the carcasses washed ashore. The NMFS Northeast Fisheries Science Center also documented 14 Kemp's ridleys entangled in or impinged on Virginia pound net leaders from 2002-2005. Note that bycatch estimates for Kemp's ridleys in various fishing gear types (*e.g.*, trawl, gillnet, dredge) are not available at this time, largely due to the low number of observed interactions precluding a robust estimate. Kemp's ridley interactions in non-fisheries have also been observed; for example, the Oyster Creek Nuclear Generating Station in Barnegat Bay, New Jersey, recorded a total of 27 Kemp's ridleys (15 of which were found alive) impinged or captured on their intake screens from 1992-2006 (NMFS 2006).

Summary of Status for Kemp's Ridley Sea Turtles

The majority of Kemp's ridleys nest along a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; NMFS and USFWS 2007b; NMFS *et al.* 2011). The number of nesting females in the Kemp's ridley population declined dramatically from the late 1940s through the mid-1980s, with an estimated 40,000 nesting females in a single *arribada* in 1947 and fewer than 300 nesting females in the entire 1985 nesting season (TEWG 2000; NMFS *et al.* 2011). However, the total annual number of nests at Rancho Nuevo gradually began to increase in the 1990s (NMFS and USFWS 2007b). Based on the number of nests laid in 2006 and the remigration interval for Kemp's ridley sea turtles (1.8-2 years), there were an estimated 7,000-8,000 adult female Kemp's ridley sea turtles in 2006 (NMFS and USFWS 2007b). The number of adult males in the population is unknown, but sex ratios of hatchlings and immature Kemp's ridleys suggest that the population is female-biased, suggesting that the number of adult males is less than the number of adult females (NMFS and USFWS 2007b). While there is cautious optimism for recovery, events such as the Deepwater Horizon oil release, and stranding events associated increased skimmer trawl use and poor TED compliance in the northern Gulf of Mexico may dampen recent population growth.

As with the other sea turtle species, fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches, while other activities like dredging, pollution, and habitat destruction account for an unknown level of other mortality. Based on their 5-year status review of the species, NMFS and USFWS (2007b) determined that Kemp's ridley sea turtles should not be reclassified as threatened under the ESA. A revised bi-national recovery plan was published for public comment in 2010, and in September 2011, NMFS, USFWS, and the Services and the Secretary of Environment and Natural Resources, Mexico (SEMARNAT) released the second revision to the Kemp's ridley recovery plan.

4.4 Status of Green Sea Turtles

Green sea turtles are distributed circumglobally, and can be found in the Pacific, Indian, and Atlantic Oceans as well as the Mediterranean Sea (NMFS and USFWS 1991, 2007c; Seminoff 2004). In 1978, the Atlantic population of the green sea turtle was listed as threatened under the ESA, except for the breeding populations in Florida and on the Pacific coast of Mexico, which were listed as endangered. As it is difficult to differentiate between breeding populations away from the nesting beaches, all green sea turtles in the water are considered endangered.

Pacific Ocean

Green sea turtles occur in the western, central, and eastern Pacific. Foraging areas are also found throughout the Pacific and along the southwestern U.S. coast (NMFS and USFWS 1998b). In the western Pacific, major nesting rookeries at four sites including Heron Island (Australia), Raine Island (Australia), Guam, and Japan were evaluated and determined to be increasing in abundance, with the exception of Guam which appears stable (NMFS and USFWS 2007c). In the central Pacific, nesting occurs on French Frigate Shoals, Hawaii, which has also been reported as increasing with a mean of 400 nesting females annually from 2002-2006 (NMFS and USFWS 2007c). The main nesting sites for the green sea turtle in the eastern Pacific are located in Michoacan, Mexico and in the Galapagos Islands, Ecuador (NMFS and USFWS 2007c). The number of nesting females per year exceeds 1,000 females at each site (NMFS and USFWS 2007c). However, historically, greater than 20,000 females per year are believed to have nested in Michoacan alone (Cliffton *et al.* 1982; NMFS and USFWS 2007c). The Pacific Mexico green turtle nesting population (also called the black turtle) is considered endangered.

Historically, green sea turtles were used in many areas of the Pacific for food. They were also commercially exploited, which, coupled with habitat degradation, led to their decline in the Pacific (NMFS and USFWS 1998b). Green sea turtles in the Pacific continue to be affected by poaching, habitat loss or degradation, fishing gear interactions, and fibropapillomatosis, which is a viral disease that causes tumors in affected turtles (NMFS and USFWS 1998b; NMFS 2004b).

Indian Ocean

There are numerous nesting sites for green sea turtles in the Indian Ocean. One of the largest nesting sites for green sea turtles worldwide occurs on the beaches of Oman where an estimated 20,000 green sea turtles nest annually (Hirth 1997; Ferreira *et al.* 2003). Based on a review of the 32 Index Sites used to monitor green sea turtle nesting worldwide, Seminoff (2004) concluded that declines in green sea turtle nesting were evident for many of the Indian Ocean Index Sites. While several of these had not demonstrated further declines in the more recent past, only the Comoros Island Index Site in the western Indian Ocean showed evidence of increased nesting (Seminoff 2004).

Mediterranean Sea

There are four nesting concentrations of green sea turtles in the Mediterranean from which data are available – Turkey, Cyprus, Israel, and Syria. Currently, approximately 300-400 females nest each year, about two-thirds of which nest in Turkey and one-third in Cyprus. Although green sea turtles are depleted from historic levels in the Mediterranean Sea (Kasparek *et al.* 2001), nesting data gathered since the early 1990s in Turkey, Cyprus, and Israel show no apparent trend in any direction. However, a declining trend is apparent along the coast of Palestine/Israel, where 300-350 nests were deposited each year in the 1950s (Sella 1982) compared to a mean of 6 nests per year from 1993-2004 (Kuller 1999; Y. Levy, Israeli Sea Turtle Rescue Center, unpublished data). A recent discovery of green sea turtle nesting in Syria adds roughly 100 nests per year to green sea turtle nesting activity in the Mediterranean (Rees *et al.* 2005). That such a major nesting concentration could have gone unnoticed until recently (the Syria coast was surveyed in 1991, but nesting activity was attributed to loggerheads) bodes well for the ongoing speculation that the unsurveyed coast of Libya may also host substantial nesting.

Atlantic Ocean

Distribution and Life History

As has occurred in other oceans of its range, green sea turtles were once the target of directed fisheries in the United States and throughout the Caribbean. In 1890, over one million pounds of green sea turtles were taken in a directed fishery in the Gulf of Mexico (Doughty 1984). However, declines in the turtle fishery throughout the Gulf of Mexico were evident by 1902 (Doughty 1984).

In the western Atlantic, large juvenile and adult green sea turtles are largely herbivorous, occurring in habitats containing benthic algae and seagrasses from Massachusetts to Argentina, including the Gulf of Mexico and Caribbean (Wynne and Schwartz 1999). Green sea turtles occur seasonally in Mid-Atlantic and Northeast waters such as Chesapeake Bay and Long Island Sound (Musick and Limpus 1997; Morreale and Standora 1998; Morreale *et al.* 2005), which serve as foraging and developmental habitats.

Some of the principal feeding areas in the western Atlantic Ocean include the upper west coast of Florida, the Florida Keys, and the northwestern coast of the Yucatán Peninsula. Additional important foraging areas in the western Atlantic include the Mosquito and Indian River Lagoon systems and nearshore wormrock reefs between Sebastian and Ft. Pierce Inlets in Florida, Florida Bay, the Culebra archipelago and other Puerto Rico coastal waters, the south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean coast of Panama, and scattered areas along Colombia and Brazil (Hirth 1971). The waters surrounding the island of Culebra, Puerto Rico, and its outlying keys are designated critical habitat for the green sea turtle.

Age at maturity for green sea turtles is estimated to be 20-50 years (Balazs 1982; Frazer and Ehrhart 1985; Seminoff 2004). As is the case with the other sea turtle species described above, adult females may nest multiple times in a season (average 3 nests/season with approximately 100 eggs/nest) and typically do not nest in successive years (NMFS and USFWS 1991; Hirth 1997).

Population Dynamics and Status

Like other sea turtle species, nest count information for green sea turtles provides information on the relative abundance of nesting, and the contribution of each nesting group to total nesting of the species. Nest counts can also be used to estimate the number of reproductively mature females nesting annually. The 5-year status review for the species identified eight geographic areas considered to be primary sites for threatened green sea turtle nesting in the Atlantic/Caribbean, and reviewed the trend in nest count data for each (NMFS and USFWS 2007c). These include: (1) Yucatán Peninsula, Mexico, (2) Tortuguero, Costa Rica, (3) Aves Island, Venezuela, (4) Galibi Reserve, Suriname, (5) Isla Trindade, Brazil, (6) Ascension Island, United Kingdom, (7) Bioko Island, Equatorial Guinea, and (8) Bijagos Achipelago, Guinea-Bissau (NMFS and USFWS 2007c). Nesting at all of these sites is considered to be stable or increasing with the exception of Bioko Island, which may be declining. However, the lack of sufficient data precludes a meaningful trend assessment for this site (NMFS and USFWS 2007c).

Seminoff (2004) reviewed green sea turtle nesting data for eight sites in the western, eastern, and central Atlantic, including all of the above threatened nesting sites with the exception that nesting in Florida was reviewed in place of Isla Trindade, Brazil. He concluded that all sites in the central and western Atlantic showed increased nesting with the exception of nesting at Aves Island, Venezuela, while both sites in the eastern Atlantic demonstrated decreased nesting. These sites are not inclusive of all green sea turtle nesting in the Atlantic Ocean. However, other sites are not believed to support nesting levels high enough that would change the overall status of the species in the Atlantic (NMFS and USFWS 2007c).

By far, the most important nesting concentration for green sea turtles in the western Atlantic is in Tortuguero, Costa Rica (NMFS and USFWS 2007c). Nesting in the area has increased considerably since the 1970s and nest count data from 1999-2003 suggest nesting by 17,402-37,290 females per year (NMFS and USFWS 2007c). The number of females nesting per year on beaches in the Yucatán, at Aves Island, Galibi Reserve, and Isla Trindade number in the hundreds to low thousands, depending on the site (NMFS and USFWS 2007c).

The status of the endangered Florida breeding population was also evaluated in the 5-year review (NMFS and USFWS 2007c). The pattern of green sea turtle nesting shows biennial peaks in abundance, with a generally positive trend since establishment of the Florida index beach surveys in 1989. This trend is perhaps due to increased protective legislation throughout the Caribbean (Meylan *et al.* 1995), as well as protections in Florida and throughout the United States (NMFS and USFWS 2007c).

The statewide Florida surveys (2000-2006) have shown that a mean of approximately 5,600 nests are laid annually in Florida, with a low of 581 in 2001 to a high of 9,644 in 2005 (NMFS and USFWS 2007c). Most nesting occurs along the east coast of Florida, but occasional nesting has been documented along the Gulf coast of Florida, at Southwest Florida beaches, as well as the beaches in the Florida Panhandle (Meylan *et al.* 1995). More recently, green sea turtle nesting occurred on Bald Head Island, North Carolina (just east of the mouth of the Cape Fear River), Onslow Island, and Cape Hatteras National Seashore. One green sea turtle nested on a beach in Delaware in 2011, although its occurrence was considered very rare.

Threats

Green sea turtles face many of the same natural threats as loggerhead and Kemp's ridley sea turtles. In addition, green sea turtles appear to be particularly susceptible to fibropapillomatosis, an epizootic disease producing lobe-shaped tumors on the soft portion of a turtle's body. Juveniles appear to be most affected in that they have the highest incidence of disease and the most extensive lesions, whereas lesions in nesting adults are rare. Also, green sea turtles frequenting nearshore waters, areas adjacent to large human populations, and areas with low water turnover, such as lagoons, have a higher incidence of the disease than individuals in deeper, more remote waters. The occurrence of fibropapilloma tumors may result in impaired foraging, breathing, or swimming ability, leading potentially to death (George 1997).

As with the other sea turtle species, incidental fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches. Witherington *et al.* (2009) observes that because green sea turtles spend a shorter time in oceanic waters and as older juveniles occur on shallow seagrass pastures (where benthic trawling is unlikely), they avoid high mortalities in pelagic longline and benthic trawl fisheries. Although the relatively low number of observed green sea turtle captures makes it difficult to estimate bycatch rates and annual take levels, green sea turtles have been observed captured in the pelagic driftnet, pelagic longline, southeast shrimp trawl, and mid-Atlantic trawl and gillnet fisheries. Murray (2009a) also lists five observed captures of green turtle in Mid-Atlantic sink gillnet gear between 1995 and 2006.

Finkbeiner *et al.* (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. Information was obtained from peer reviewed publications and NMFS documents (e.g., Biological Opinions and bycatch reports). In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). The Southeast/Gulf of Mexico shrimp trawl fishery was responsible for the vast majority of U.S. interactions (up to 98%) and mortalities (more than 80%). While this provides an initial cumulative bycatch assessment, there are a number of caveats that should be considered when interpreting this information, such as sampling inconsistencies and limitations.

Other activities like channel dredging, marine debris, pollution, vessel strikes, power plant impingement, and habitat destruction account for an unquantifiable level of other mortality. Stranding reports indicate that between 200-400 green sea turtles strand annually along the eastern U.S. coast from a variety of causes most of which are unknown (STSSN database).

Summary of Status of Green Sea Turtles
A review of 32 Index Sites[1] distributed globally revealed a 48-67% decline in the number of mature females nesting annually over the last three generations[2] (Seminoff 2004). An evaluation of green sea turtle nesting sites was also conducted as part of the 5-year status review of the species (NMFS and USFWS 2007c). Of the 23 threatened nesting groups assessed in that report for which nesting abundance trends could be determined, ten were considered to be increasing, nine were considered stable, and four were considered to be decreasing (NMFS and USFWS 2007c). Nesting groups were considered to be doing relatively well (the number of sites with increasing nesting were greater than the number of sites with decreasing nesting) in the Pacific, western Atlantic, and central Atlantic (NMFS and USFWS 2007c). However, nesting populations were determined to be doing relatively poorly in Southeast Asia, eastern Indian Ocean, and perhaps the Mediterranean. Overall, based on mean annual reproductive effort, the report estimated that 108,761 to 150,521 females nest each year among the 46 threatened and endangered nesting sites included in the evaluation (NMFS and USFWS 2007c). However, given the late age to maturity for green sea turtles, caution is urged regarding the status for any of the nesting groups since no area has a dataset spanning a full green sea turtle generation (NMFS and USFWS 2007c).

Seminoff (2004) and NMFS and USFWS (2007d) made comparable conclusions with regard to nesting for four nesting sites in the western Atlantic that indicate sea turtle abundance is increasing in the Atlantic Ocean. Each also concluded that nesting at Tortuguero, Costa Rica represented the most important nesting area for green sea turtles in the western Atlantic and that nesting had increased markedly since the 1970s (Seminoff 2004; NMFS and USFWS 2007c).

However, the 5-year review also noted that the Tortuguero nesting stock continued to be affected by ongoing directed take at their primary foraging area in Nicaragua (NMFS and USFWS 2007c). The endangered breeding population in Florida appears to be increasing based upon index nesting data from 1989-2010 (NMFS 2011).

As with the other sea turtle species, fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches, while other activities like hopper dredging, pollution, and habitat destruction account for an unknown level of other mortality. Based on its 5-year status review of the species, NMFS and USFWS (2007d) determined that the listing classification for green sea turtles should not be changed. However, it was also determined that an analysis and review of the species should be conducted in the future to determine whether DPSs should be identified (NMFS and USFWS 2007c).

4.5 Shortnose Sturgeon

Shortnose sturgeon life history
Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans

[1] The 32 Index Sites include all of the major known nesting areas as well as many of the lesser nesting areas for which quantitative data are available.

[2] Generation times ranged from 35.5 years to 49.5 years for the assessment depending on the Index Beach site

(amphipods, chironomids, isopods), and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell et al. 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)[3] when the freshwater temperatures increase to 8-9ºC. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse et al. 1987; Crowder et al. 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980b), and Pee Dee-Winyah River (0.08-0.12; Dadswell et al. 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell et al. 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female and a mean of 11,568 eggs/kg body weight (Dadswell et al. 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked 7-12 days after hatching in comparison to Savannah River larve that had longer dispersal rates with multiple, prolonged peaks, and a low level of downstream movement that continued throughout the entire larval and early juvenile period (Parker 2007). Synder (1988) and Parker (2007) considered individuals to be juvenile when they reached 57mm TL. Laboratory studies demonstrated that larvae from the Connecticut River made this transformation on day 40 while Savannah River fish made this transition on day 41 and 42 (Parker 2007).

The juvenile phase can be subdivided in to young of the year (YOY) and immature/ sub-adults. YOY and sub-adult habitat use differs and is believed to be a function of differences in salinity tolerances. Little is known about YOY behavior and habitat use, though it is believed that they

[3] For purposes of this consultation, Northern rivers are considered to include tributaries of the Chesapeake Bay northward to the St. John River in Canada. Southern rivers are those south of the Chesapeake Bay.

are typically found in channel areas within freshwater habitats upstream of the saltwedge for about one year (Dadswell et al. 1984, Kynard 1997). One study on the stomach contents of YOY revealed that the prey items found corresponded to organisms that would be found in the channel environment (amphipods) (Carlson and Simpson 1987). Sub-adults are typically described as age one or older and occupy similar spatio-temporal patterns and habitat-use as adults (Kynard 1997). Though there is evidence from the Delaware River that sub-adults may overwinter in different areas than adults and no not form dense aggregations like adults (ERC Inc. 2007). Sub-adults feed indiscriminately, typical prey items found in stomach contents include aquatic insects, isopods, and amphipods along with large amounts of mud, stones, and plant material (Dadswell 1979, Carlson and Simpson 1987, Bain 1997).

In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures reach between 7-9.7ºC, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996). In the Merrimack River, males returned to only one reach during a four year telemetry study (Kieffer and Kynard 1996). Squires (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam and Kieffer and Kynard (1996) found that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell et al. 1984; NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 15º, and bottom water velocities of 0.4 to 0.8 m/sec (Dadswell et al. 1984; Hall et al. 1991, Kieffer and Kynard 1996, NMFS 1998). For northern shortnose sturgeon, the temperature range for spawning is 6.5-18.0ºC (Kynard et al. 2012). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell et al. 1984). Between 8° and 12°C, eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles or sub-adults tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes and move upstream in spring and feed mostly in freshwater reaches during summer.

Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell et al. 1984; Hall et al. 1991). Non-spawning movements include wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Adult sturgeon occurring in freshwater or freshwater/tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total length (Buckley and Kynard 1985). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adult and juvenile shortnose sturgeon congregate (Flournoy et al. 1992; Rogers et al. 1994; Rogers and Weber 1995; Weber 1996).

While shortnose sturgeon do not undertake the significant marine migrations seen in Atlantic sturgeon, telemetry data indicates that shortnose sturgeon do make localized coastal migrations. This is particularly true within certain areas such as the Gulf of Maine (GOM) and among rivers in the Southeast. Interbasin movements have been documented among rivers within the GOM and between the GOM and the Merrimack, between the Connecticut and Hudson rivers, the Delaware River and Chesapeake Bay, and among the rivers in the Southeast.

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 (Dadswell et al. 1984) and as high as 34ºC (Heidt and Gilbert 1978). However, temperatures above 28ºC are thought to adversely affect shortnose sturgeon. In the Altamaha River, temperatures of 28-30ºC during summer months create unsuitable conditions and shortnose sturgeon are found in deep cool water refuges. 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).

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6m is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30m but are generally found in waters less than 20m (Dadswell et al. 1984; Dadswell 1979). Shortnose sturgeon have also demonstrated tolerance to a wide range of salinities. Shortnose sturgeon have been documented in freshwater (Taubert 1980; Taubert and Dadswell 1980) and in waters with salinity of 30 parts-per-thousand (ppt) (Holland and Yelverton 1973; Squiers and Smith 1978). McCleave et al. (1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10ppt within a two hour period. The tolerance of shortnose sturgeon to increasing salinity is thought to increase with age (Kynard 1996). Shortnose sturgeon typically occur in the deepest parts of rivers or estuaries where suitable oxygen and salinity values are present (Gilbert 1989).

Status and Trends of Shortnose Sturgeon Rangewide

Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication, issued by the US Department of the Interior, stated that shortnose sturgeon were "in peril…gone in most of the rivers of its former range [but] probably not as yet extinct" (USDOI 1973). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon commonly were taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon (*Acipenser oxyrinchus*). More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (e.g., southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (see NMFS 1998). Shortnose sturgeon are listed as "vulnerable" on the IUCN Red List.

Although shortnose sturgeon are listed as endangered range-wide, in the final recovery plan NMFS recognized 19 separate populations occurring throughout the range of the species. These populations are in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). NMFS has not formally recognized distinct population segments (DPS)[4] of shortnose sturgeon under the ESA. Although genetic information within and among shortnose sturgeon occurring in different river systems is largely unknown, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1997) and, therefore, should be considered discrete. The 1998 Recovery Plan indicates that while genetic information may reveal that interbreeding does not occur between rivers that drain into a common estuary, at this time, such river systems are considered a single population compromised of breeding subpopulations (NMFS 1998).

Studies conducted since the issuance of the Recovery Plan have provided evidence that suggests that years of isolation between populations of shortnose sturgeon have led to morphological and genetic variation. Walsh et al. (2001) examined morphological and genetic variation of shortnose sturgeon in three rivers (Kennebec, Androscoggin, and Hudson). The study found that the Hudson River shortnose sturgeon population differed markedly from the other two rivers for most morphological features (total length, fork length, head and snout length, mouth width, interorbital width and dorsal scute count, left lateral scute count, right ventral scute count). Significant differences were found between fish from Androscoggin and Kennebec rivers for interorbital width and lateral scute counts which suggests that even though the Androscoggin and Kennebec rivers drain into a common estuary, these rivers support largely discrete populations of shortnose sturgeon. The study also found significant genetic differences among all three populations indicating substantial reproductive isolation among them and that the observed

4 The definition of species under the ESA includes any subspecies of fish, wildlife, or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. To be considered a DPS, a population segment must meet two criteria under NMFS policy. First, it must be discrete, or separated, from other populations of its species or subspecies. Second, it must be significant, or essential, to the long-term conservation status of its species or subspecies. This formal legal procedure to designate DPSs for shortnose sturgeon has not been undertaken.

morphological differences may be partly or wholly genetic.

Grunwald et al. (2002) examined mitochondrial DNA (mtDNA) from shortnose sturgeon in eleven river populations. The analysis demonstrated that all shortnose sturgeon populations examined showed moderate to high levels of genetic diversity as measured by haplotypic diversity indices. The limited sharing of haplotypes and the high number of private haplotypes are indicative of high homing fidelity and low gene flow. The researchers determined that glaciation in the Pleistocene Era was likely the most significant factor in shaping the phylogeographic pattern of mtDNA diversity and population structure of shortnose sturgeon. The Northern glaciated region extended south to the Hudson River while the southern non-glaciated region begins with the Delaware River. There is a high prevalence of haplotypes restricted to either of these two regions and relatively few are shared; this represents a historical subdivision that is tied to an important geological phenomenon that reflects historical isolation. Analyses of haplotype frequencies at the level of individual rivers showed significant differences among all systems in which reproduction is known to occur. This implies that although higher level genetic stock relationships exist (i.e., southern vs. northern and other regional subdivisions), shortnose sturgeon appear to be discrete stocks, and low gene flow exists between the majority of populations.

Waldman et al. (2002) also conducted mtDNA analysis on shortnose sturgeon from 11 river systems and identified 29 haplotypes. Of these haplotypes, 11 were unique to northern, glaciated systems and 13 were unique to the southern non-glaciated systems. Only 5 were shared between them. This analysis suggests that shortnose sturgeon show high structuring and discreteness and that low gene flow rates indicated strong homing fidelity.

Wirgin et al. (2005), also conducted mtDNA analysis on shortnose sturgeon from 12 rivers (St. John, Kennebec, Androscoggin, Upper Connecticut, Lower Connecticut, Hudson, Delaware, Chesapeake Bay, Cooper, Peedee, Savannah, Ogeechee and Altamaha). This analysis suggested that most population segments are independent and that genetic variation among groups was high.

The best available information demonstrates differences in life history and habitat preferences between northern and southern river systems and given the species' anadromous breeding habits, the rare occurrence of migration between river systems, and the documented genetic differences between river populations, it is unlikely that populations in adjacent river systems interbreed with any regularity. This likely accounts for the failure of shortnose sturgeon to repopulate river systems from which they have been extirpated, despite the geographic closeness of persisting populations. This characteristic of shortnose sturgeon also complicates recovery and persistence of this species in the future because, if a river population is extirpated in the future, it is unlikely that this river will be recolonized. Consequently, this Opinion will treat the nineteen separate populations of shortnose sturgeon as subpopulations (one of which occurs in the action area) for the purposes of this analysis.

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. Shortnose sturgeon are large, long lived fish species. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) in the south and Merrimack and Penobscot rivers in the north (~ several hundred to several thousand adults depending on population estimates used; SSSRT 2010; Dionne 2010), while the largest populations are found in the Saint John (~18, 000; Dadswell 1979) and Hudson Rivers (~61,000; Bain et al. 1998). As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. Kynard 1996 indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the St John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species or the shortnose sturgeon population in the Northeastern United States exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed.

Threats to shortnose sturgeon recovery
The Shortnose Sturgeon Recovery Plan (NMFS 1998) identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival.

Several natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon. Shortnose sturgeon continue to be taken incidentally in fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979; Dovel et al. 1992; Collins et al. 1996). Bridge construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb sturgeon concentration areas. Unless appropriate precautions are made, internal damage and/or death may result from blasting projects with powerful explosives. Hydroelectric dams may affect shortnose sturgeon by restricting habitat, altering river flows or temperatures necessary for successful spawning and/or migration and causing mortalities to fish that become entrained in turbines. Maintenance dredging of Federal navigation channels and other areas can adversely affect or jeopardize shortnose sturgeon populations. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. Mechanical dredges have also been documented to lethally take shortnose sturgeon. In addition to direct effects, dredging operations may also impact shortnose sturgeon by destroying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. Shortnose sturgeon are susceptible to impingement on cooling water intake screens at power plants. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. The operation of power plants can have unforeseen and extremely detrimental impacts to water quality which can affect shortnose sturgeon. For example, the St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June 1991 when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates. Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low dissolved oxygen water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that twenty shortnose sturgeon were killed during this low dissolved oxygen event.

Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sinderman 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long term effects are not yet known (Ruelle and Henry 1992; Ruelle and Kennlyne 1993). Available data suggests that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Although there is scant information available on the levels of contaminants in shortnose sturgeon tissues, some research on other related species indicates that concern about the effects of contaminants on the health of sturgeon populations is warranted. Detectible levels of chlordane, DDE (1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene), DDT (dichlorodiphenyl-trichloroethane), and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (Ruelle and Henry 1994). These compounds were found in high enough levels to suggest they may be causing reproductive failure and/or increased physiological stress (Ruelle and Henry 1994). In addition to compiling data on contaminant levels, Ruelle and Henry also determined that heavy metals and organochlorine compounds (i.e. PCBs) accumulate in fat tissues. Although the long term effects of the accumulation of contaminants in fat tissues is not yet known, some speculate that lipophilic toxins could be transferred to eggs and potentially inhibit egg viability. In other fish species, reproductive impairment, reduced egg viability, and reduced survival of larval fish are associated with elevated levels of environmental contaminants including chlorinated hydrocarbons. A strong correlation that has been made between fish weight, fish fork length, and DDE concentration in pallid sturgeon livers indicates that DDE increases proportionally with fish size (NMFS 1998).

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002). Sixteen metals, two semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs, DDE (an organochlorine pesticide) were detected in the "adverse affect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. Contaminant analysis conducted in 2003 on tissues from a shortnose sturgeon from the Kennebec River revealed the presence of fourteen metals, one semivolatile compound, one PCB Aroclor, Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fish in the literature (ERC 2003). While no directed studies of chemical contamination in shortnose sturgeon have been undertaken, it is evident that the heavy industrialization of the rivers where shortnose sturgeon are found is likely adversely affecting this species.

During summer months, especially in southern areas, shortnose sturgeon must cope with the physiological stress of water temperatures that may exceed 28ºC. Flournoy et al.(1992) suspected that, during these periods, shortnose sturgeon congregate in river regions which support conditions that relieve physiological stress (i.e., in cool deep thermal refuges). In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flournoy et al.1992; Rogers and Weber 1994; Weber 1996). The loss and/or manipulation of these discrete refuge habitats may limit or be limiting population survival, especially in southern river systems.

Pulp mill, silvicultural, agricultural, and sewer discharges, as well as a combination of non-point source discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. Shortnose sturgeon are known to be adversely affected by dissolved oxygen levels below 5 mg/L. Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28ºC (Flournoy et al. 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

Status and Distribution of Shortnose Sturgeon in the Delaware River

Shortnose sturgeon occur in the Delaware River from the lower bay upstream to at least Lambertville, New Jersey (river mile 148). Tagging studies by O'Herron et al. (1993) found that the most heavily used portion of the river appears to be between river mile 118 below Burlington Island and river mile 137 at the Trenton Rapids. Hastings et al. (1987) used Floy T-anchor tags in a tag-and-recapture experiment from 1981 to 1984 to estimate the size of the Delaware River population in the Trenton to Florence reach. Population sizes by three estimation procedures ranged from 6,408 to 14,080 adult sturgeon. These estimates compare favorably with those based upon similar methods in similar river systems. This is the best available information on population size, but because the recruitment and migration rates between the population segment studied and the total population in the river are unknown, model assumptions may have been violated.

In the Delaware River, movement to the spawning grounds occurs in early spring, typically in late March[5], with spawning occurring through the end of April. Movement to the spawning areas is triggered in part by water temperature and fish typically arrive at the spawning locations when water temperatures are between 8-9ºC with most spawning occurring when water

[5] Based on US Geological Survey (USGS) water temperature data for the Delaware River at the Trenton gage (USGS gage 01463500; the site closest to the Scudders Falls area), for the period 2003-2009, water temperature reached 8°C sometime between March 26 (2006) and April 21 (2007), with temperatures typically reaching 8°C in the last few days of March. During this period, mean water temperatures at Trenton reached 10°C between March 28 (2004) and April 22 (2007) and 15ºC between April 15 (2006) and April 21 (2003). There is typically a three to four week period with mean daily temperatures between 8 and 15°C.

temperatures are between 10 and 15ºC. Until recently, actual spawning (i.e., fertilized eggs or larvae) had not been documented in this area; however, the concentrated use of the Scudders Falls region in the spring by large numbers of mature male and female shortnose sturgeon indicated that this is the major spawning area (O'Herron et al. 1993). The same area was identified as a likely spawning area based on the collection of two ripe females in the spring of 1965 (Hoff 1965). The capture of early life stages (eggs and larvae) in this region in the spring of 2008 confirms that this area of the river is used for spawning and as a nursery area (ERC 2009). During the spawning period, males remain on the spawning grounds for approximately a week while females only stay for a few days (O'Herron and Hastings 1985). After spawning, which typically ceases by the time water temperatures reach 15ºC (although sturgeon have been reported on the spawning grounds at water temperatures as high as 18ºC), shortnose sturgeon move rapidly downstream to the Philadelphia area.

Shortnose sturgeon eggs generally hatch after approximately 9-12 days (Buckley and Kynard 1981). The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment. Larvae are expected to begin swimming downstream at 9-14 days old (Richmond and Kynard 1995). Larvae are expected to be less than 20mm TL at this time (Richmond and Kynard 1995). This initial downstream migration generally lasts two to three days (Richmond and Kynard 1995). Studies (Kynard and Horgan 2002) suggest that larvae move approximately 7.5km/day during this initial 2 to 3 day migration. Laboratory studies indicate that young sturgeon move downstream in a 2-step migration: the initial 2-3 day migration followed by a residency period of the YOY, then a resumption of migration by yearlings in the second summer of life (Buckley and Kynard 1981).

In other river systems, older juveniles (3-10 years old) occur in the saltwater/freshwater interface (NMFS 1998). In these systems, juveniles moved back and forth in the low salinity portion of the salt wedge during summer. In the Delaware River the oligohaline/fresh interface can range from as far south as Wilmington, Delaware, north to Philadelphia, Pennsylvania, depending upon meteorological conditions such as excessive rainfall or drought. As a result, it is possible that in the Delaware River, juveniles could range from Artificial Island (river mile 54) to the Schuylkill River (river mile 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 that juveniles are typically found over silt and sand/mud substrates in deep water of 10-20m. Juvenile sturgeon primarily feed in 10 to 20 meter deep river channels, over sand-mud or gravel-mud bottoms (Pottle and Dadswell 1979). However, little is known about the specific feeding habits of juvenile shortnose sturgeon in the Delaware River.

As noted above, after spawning, adult shortnose sturgeon migrate rapidly downstream to the Philadelphia area (RM 100). After adult sturgeon migrate to the area around Philadelphia, many adults return upriver to between river mile 127 and 134 within a few weeks, while others gradually move to the same area over the course of the summer (O'Herron et al. 1993). By the time water temperatures have reached 10°C, typically by mid-November[6], adult sturgeon have returned to the overwintering grounds around Duck Island and Newbold Island. These patterns are generally supported by the movement of radio-tagged fish in the region between river mile 125 and river mile 148 as presented by Brundage (1986). Based on water temperature data collected at the USGS gage at Philadelphia, in general, shortnose sturgeon are expected to be at the overwintering grounds between early November and mid-April. Adult sturgeon overwinter in dense sedentary aggregations in the upper tidal reaches of the Delaware between river mile 118 and 131. The areas around Duck Island and Newbold Island seem to be regions of intense overwintering concentrations. However, unlike sturgeon in other river systems, shortnose sturgeon in the Delaware do not appear to remain as stationary during overwintering periods. Overwintering fish have been found to be generally active, appearing at the surface and even breaching through the skim ice (O'Herron et al. 1993). Due to the relatively active nature of these fish, the use of the river during the winter is difficult to predict. However, O'Herron et al. (1993) found that the typical overwintering movements are fairly localized and sturgeon appear to remain within 1.24 river miles of the aggregation site (O'Herron and Able 1986). Investigations with video equipment by the USACE in March 2005 (Versar 2006) documented two sturgeon of unknown species at Marcus Hook and 1 sturgeon of unknown species at Tinicum. Gillnetting in these same areas caught only one Atlantic sturgeon and no shortnose sturgeon. Video surveys of the known overwintering area near Newbold documented 61 shortnose sturgeon in approximately 1/3 of the survey effort. This study supports the conclusion that the vast majority of adult shortnose sturgeon overwinter near Duck and Newbold Island but that a limited number of shortnose sturgeon occur in other downstream areas, including Marcus Hook, during the winter months. Overwintering juveniles are expected to occur on the freshwater side of the oligohaline/fresh water interface (O'Herron 1990). In the Delaware River, the oligohaline/freshwater interface occurs in the area between Wilmington, Delaware and Marcus Hook, Pennsylvania (O'Herron 1990).

Shortnose sturgeon appear to be strictly benthic feeders (Dadswell et al. 1984). Adults eat mollusks, insects, crustaceans and small fish. Juveniles eat crustaceans and insects. While shortnose sturgeon forage on a variety of organisms, in the Delaware River, sturgeon primarily feed on the Asiatic river clam (*Corbicula manilensis*). *Corbicula* is widely distributed at all depths in the upper tidal Delaware River, but it is considerably more numerous in the shallows on both sides of the river than in the navigation channels. Foraging is heaviest immediately after spawning in the spring and during the summer and fall, and lighter in the winter.

Historically, sturgeon were relatively rare below Philadelphia due to poor water quality. Since the 1990s, the water quality in the Philadelphia area has improved leading to an increased use of

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

the lower river by shortnose sturgeon. Few studies have been conducted to document the use of the river below Philadelphia by sturgeon. Brundage and Meadows (1982) have reported incidental captures in commercial gillnets in the lower Delaware. During a study focusing on Atlantic sturgeon, Shirey et al. (1999) captured 9 shortnose sturgeon in 1998. During the June through September study period, Atlantic and shortnose sturgeon were found to use the area on the west side of the shipping channel between Deep Water Point, New Jersey and the Delaware-Pennsylvania line. The most frequently utilized areas within this section were off the northern and southern ends of Cherry Island Flats in the vicinity of the Marcus Hook Bar. A total of 25 shortnose sturgeon have been captured by Shirey in this region of the river from 1992 - 2004, with capture rates ranging from 0-10 fish per year (Shirey 2006). Shortnose sturgeon have also been documented at the trash racks of the Salem nuclear power plant in Salem, New Jersey at Artificial Island.

In May 2005, a one-year survey for juvenile sturgeon in the Delaware River in the vicinity of the proposed Crown Landing LNG project was initiated. The objective of the survey was to obtain information on the occurrence and distribution of juvenile shortnose and Atlantic sturgeon near the proposed project site to be located near RM 78, approximately 20 miles south of Philadelphia. Sampling for juvenile sturgeon was performed using trammel nets and small mesh gill nets. The nets were set at three stations, one located adjacent to the project site, one at the upstream end of the Marcus Hook anchorage (approximately 2.7 miles upstream of the project site, at RM 81), and one near the upstream end of the Cherry Island Flats (at RM 74; approximately 3.8 miles downstream of the site). Nets were set within three depth ranges at each station: shallow (<10 feet at MLW), intermediate (10-20 feet at MLW) and deep (20-30+ feet at MLW). Each station/depth zone was sampled once per month. Nets were fished for at least 4 hours when water temperatures were less than 27°C and limited to 2 hours when water temperature was greater than 27°C. The sampling from April through August 2005 yielded 3,014 specimens of 22 species, including 3 juvenile shortnose sturgeon. Juvenile shortnose sturgeon were collected one each during the June, July and August sampling events. Two of the shortnose sturgeon were collected at RM 78 and one was taken at the downstream sampling station at RM 74. Total length ranged from 311-367mm. During the September – December sampling, one juvenile shortnose sturgeon was caught in September at RM 78 and one in November at the same location. One adult shortnose sturgeon was captured in October at RM 74. All of the shortnose sturgeon were collected in deep water sets (greater than 20 feet). These depths are consistent with the preferred depths for foraging shortnose sturgeon juveniles reported in the literature (NMFS 1998). The capture of an adult in the Cherry Island Flats area (RM 74) is consistent with the capture location of several adult sturgeon reported by Shirey et al. 1999 and Shirey 2006.

Brundage compiled a report presenting an analysis of telemetry data from receivers located at Torresdale RM 93, Tinicum RM 86, Bellevue RM 73 and New Castle RM 58 during April through December 2003. The objective of the study was to provide information on the occurrence and movements of shortnose sturgeon in the general vicinity of the proposed Crown Landing LNG facility. A total of 60 shortnose sturgeon had been tagged with ultrasonic transmitters: 30 in fall 2002, 13 in early summer 2003 and 13 in fall 2003. All tagged fish were adults tagged after collection in gill nets in the upper tidal Delaware River, between RM 126-132. Of the 60 tagged sturgeon, 39 (65%) were recorded at Torresdale, 22 (36.7%) were recorded at Tinicum, 16 (26.7%) at Bellevue and 18 (30%) at New Castle. The number of tagged sturgeon recorded at each location varied with date of tagging. Of the 30 sturgeon tagged in fall 2002, 26 were recorded at Torresdale, 17 at Tinicum, 11 at Bellevue and 13 at New Castle. Only two of the 13 tagged in fall 2003 were recorded, both at Torresdale only. Brundage concludes that seasonal movement patterns and time available for dispersion likely account for this variation, particularly for the fish tagged in fall 2003. Eleven of the 30 shortnose sturgeon tagged in fall 2002 and 5 of the 17 fish tagged in summer 2003 were recorded at all four locations. Some of the fish evidenced rapid movements from one location sequentially to the next in upstream and/or downstream direction. These periods of rapid sequential movement tended to occur in the spring and fall, and were probably associated with movement to summer foraging and overwintering grounds, respectively. As a group, the shortnose sturgeon tagged in summer 2003 occurred a high percentage of time within the range of the Torresdale receiver. The report concludes that the metrics indicate that the Torresdale Range of the Delaware River is utilized by adult shortnose sturgeon more frequently and for greater durations than the other three locations. Of the other locations, the New Castle Range appears to be the most utilized region. At all ranges, shortnose were detected throughout the study period, with most shortnose sturgeon detected in the project area between April and October. The report indicates that most adult shortnose sturgeon used the Torresdale to New Castle area as a short-term migratory route rather than a long-term concentration or foraging area. Adult sturgeon in this region of the river are highly mobile, and as noted above, likely using the area as a migration route.

As evidenced by the Crown Landing study, juvenile shortnose sturgeon have been documented between RM 81-74 from June – November. Due to the limited geographic scope of this study, it is difficult to use these results to predict the occurrence of juvenile shortnose sturgeon throughout the action area. However, the April – August time frame is when flows in the Delaware River are highest and the time when the action area is likely to experience the low salinity levels preferred by juveniles (FERC 2006). Beginning in August, flows decrease and the salt wedge begins to move upstream, which may preclude juveniles from occurring in the action area. Based on this information, it is likely that juvenile shortnose sturgeon are present in the action area at least during the April – August time frame. The capture of juvenile shortnose sturgeon in the RM 81-74 range in November of 2005 suggests that if water conditions are appropriate, juveniles may also be present in this area through the fall. While it is possible, based on habitat characteristics, that this area of the river is used as an overwintering site for juveniles, there is currently no evidence to support this assumption.

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

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

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

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

Water clarity in the Trenton survey area was much greater (about 6 feet ahead of the camera) and large numbers of shortnose sturgeon were seen in the video recordings. In a total of 7.9 survey miles completed in two separate days of bottom imaging, 61 shortnose sturgeons were observed.

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

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

4.6 Status of Atlantic sturgeon

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

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott, 1988; ASSRT, 2007; T. Savoy, CT DEP, pers. comm.). NMFS has delineated U.S. populations of Atlantic sturgeon into five DPSs (77 FR 5880 and 77 FR 5914). These are: the Gulf of Maine (GOM), New York Bight (NYB), Chesapeake Bay (CB), Carolina, and South Atlantic (SA) DPSs (see Figure 3). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

On February 6, 2012, we published notice in the *Federal Register* that we were listing the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs as endangered, and the Gulf of Maine DPS as threatened (77 FR 5880 and 77 FR 5914). The effective date of the listings was April 6, 2012. The DPSs do not include Atlantic sturgeon that are spawned in Canadian rivers. Therefore, Canadian spawned fish are not included in the listings.

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

Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[7] fish (Bigelow and Schroeder, 1953; Vladykov and Greeley 1963; Mangin, 1964; Pikitch *et al.*, 2005; Dadswell, 2006; ASSRT, 2007).

The life history of Atlantic sturgeon can be divided up into five general categories as described in the table below (adapted from ASSRT 2007).

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

[7] Anadromous refers to a fish that is born in freshwater, spends most of its life in the sea, and returns to freshwater to spawn (NEFSC FAQ's, available at http://www.nefsc.noaa.gov/faq/fishfaq1a.html, modified June 16, 2011)

Age Class	Size	Description
Subadults	**>76cm and <150cm TL**	Fish that are not sexually mature but make coastal migrations
Adults	**>150 cm TL**	Sexually mature fish

Table 2. Descriptions of Atlantic sturgeon life history stages.

Atlantic sturgeon are a relatively large fish, even amongst sturgeon species (Pikitch *et al.*, 2005). Atlantic sturgeons are bottom feeders that suck food into a ventrally-located protruding mouth (Bigelow and Schroeder, 1953). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder, 1953). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007; Savoy, 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007).

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m) (Smith *et al.*, 1982; Smith *et al.*, 1984; Smith, 1985; Scott and Scott, 1988; Young *et al.*, 1998; Collins *et al.*, 2000; Caron *et al.*, 2002; Dadswell, 2006; ASSRT, 2007; Kahnle *et al.*, 2007; DFO, 2011). The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greeley, 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). However, while females are prolific with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of 2-5 years (Vladykov and Greeley, 1963; Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Stevenson and Secor, 1999; Dadswell, 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman, 1997). Males exhibit spawning periodicity of 1-5 years (Smith, 1985; Collins *et al.*, 2000; Caron *et al.*, 2002). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (ASMFC, 2009). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco, 1977; Smith, 1985; Bain, 1997; Smith and Clugston, 1997; Caron *et al.*, 2002). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (Smith *et al.*, 1982; Dovel and Berggren, 1983; Smith, 1985; ASMFC, 2009), 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; Collins *et al.*, 2000), make rapid spawning migrations upstream, and quickly depart following spawning (Bain, 1997).

The spawning areas in most U.S. rivers have not been well defined. However, the habitat characteristics of spawning areas have been identified based on historical accounts of where fisheries occurred, tracking and tagging studies of spawning sturgeon, and physiological needs of early life stages. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46-76 cm/s and depths are 3-27 m (Borodin, 1925; Dees, 1961; Leland, 1968; Scott and Crossman, 1973; Crance, 1987; Shirey *et al.* 1999; Bain *et al.*, 2000; Collins *et al.*, 2000; Caron *et al.* 2002; Hatin *et al.* 2002; ASMFC, 2009). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Dees, 1961; Scott and Crossman, 1973; Gilbert, 1989; Smith and Clugston, 1997; Bain *et al.* 2000; Collins *et al.*, 2000; Caron *et al.*, 2002; Hatin *et al.*, 2002; Mohler, 2003; ASMFC, 2009), and become adhesive shortly after fertilization (Murawski and Pacheco, 1977; Van den Avyle, 1983; Mohler, 2003). Incubation time for the eggs increases as water temperature decreases (Mohler, 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT, 2007).

Larval Atlantic sturgeon (i.e. less than 4 weeks old, with total lengths (TL) less than 30 mm; Van Eenennaam *et al.* 1996) are assumed to undertake a demersal existence and inhabit the same riverine or estuarine areas where they were spawned (Smith *et al.*, 1980; Bain *et al.*, 2000; Kynard and Horgan, 2002; ASMFC, 2009). 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 (Haley, 1999; Hatin *et al.*, 2007; McCord *et al.*, 2007; Munro *et al.*, 2007) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Collins *et al.*, 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton, 1973; Dovel and Berggen, 1983; Waldman *et al.*, 1996; Dadswell, 2006; ASSRT, 2007).

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 50 m in depth, using coastal bays, sounds, and ocean waters (Vladykov and Greeley, 1963; Murawski and Pacheco, 1977; Dovel and Berggren, 1983; Smith, 1985; Collins and Smith, 1997; Welsh *et al.*, 2002; Savoy and Pacileo, 2003; Stein *et al.*, 2004; USFWS, 2004; Laney *et al.*, 2007; Dunton *et al.*, 2010; Erickson *et al.*, 2011; Wirgin and King, 2011). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast. Satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight at depths greater than 20 m during winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 m in summer and fall (Erickson *et al.*, 2011). Shirey (Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009) found a similar movement pattern for juvenile Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, juvenile Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, North

Carolina from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow near shore fisheries with few fish reported from waters in excess of 25 m (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (e.g., Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, New York Bight, Delaware Bay, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 m (Dovel and Berggren, 1983; Dadswell *et al.*, 1984; Johnson *et al.*, 1997; Rochard *et al.*, 1997; Kynard *et al.*, 2000; Eyler *et al.*, 2004; Stein *et al.*, 2004; Wehrell, 2005; Dadswell, 2006; ASSRT, 2007; Laney *et al.*, 2007). These sites may be used as foraging sites and/or thermal refuge.

Distribution and Abundance

Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing in the mid to late 19th century when a caviar market was established (Scott and Crossman 1973; Taub 1990; Kennebec River Resource Management Plan 1993; Smith and Clugston 1997; Dadswell 2006; ASSRT 2007). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware River, and at least 10,000 females for other spawning stocks (Secor and Waldman 1999; Secor 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 17 U.S. rivers are known to support spawning (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years) (ASSRT 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only five rivers (Kennebec, Androscoggin, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia, where historical records show that there used to be 15 spawning rivers (ASSRT 2007). Thus, there are substantial gaps between Atlantic sturgeon spawning rivers among northern and Mid-Atlantic states which could make recolonization of extirpated populations more difficult.

At the time of the listing, there were no current, published population abundance estimates for any of the currently known spawning stocks or for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985 to 1995 (Kahnle *et al.*, 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson 2006). Using the data collected from the Hudson and Altamaha Rivers to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Vladykov and Greeley 1963; Smith 1985; Van Eenennaam *et al.* 1996; Stevenson and Secor 1999; Collins *et al.* 2000; Caron *et al.* 2002), the age structure of these populations is not well understood, and stage-to-stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (*e.g.*, yearlings, subadults, and adults) in a population is lacking. The ASSRT presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations and concluded that the other U.S. spawning populations were likely less than 300 spawning adults per year (ASSRT 2007).

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NEFSC developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (see Kocik et al. 2013). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance. The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment (Table 3). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the United States Fish and Wildlife Service (USFWS) sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The USFWS sturgeon tagging database is a repository for sturgeon tagging information on the Atlantic coast. The database contains tag, release, and recapture information from state and federal researchers. The database records recaptures by the fishing fleet, researchers, and researchers on fishery vessels.

In additional to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) (Table 4). NEAMAP trawl surveys are conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall since 2007 and spring since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations. The Atlantic States Marine Fisheries Commission (ASMFC) has initiated a new stock assessment with the goal of completing it by the end of 2014. NOAA Fisheries will be partnering with them to conduct the stock assessment, and the ocean population abundance estimates produced by the NEFSC will be shared with the stock assessment committee for consideration in the stock assessment.

Table 3. Description of the ASPI model and NEAMAP survey based area estimate method.

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

Table 4. Modeled Results

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

The information from the NEAMAP survey can be used to calculate minimum swept area population estimates within the strata swept by the survey. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 5). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e. net efficiency) 100% of the sturgeon in the water column along the tow path and that all sturgeon are with the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the fraction of the population within the sampling domain. Catchabilities less than 100% will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100% are common for most species. The ratio of total sturgeon habitat to area sampled by the NEAMAP survey is unknown, but is certainly greater than one (i.e. the NEAMAP survey does not survey 100% of the Atlantic sturgeon habitat).

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

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

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

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

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

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

Table 6. Summary of calculated population estimates based upon the NEAMAP Survey swept area assuming 50% efficiency (based on net efficiency and area sampled) derived from applying the Mixed Stock Analysis to the total estimate of Atlantic sturgeon in the Ocean and the 1:3 ratio of adults to subadults)

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

Threats Faced by Atlantic Sturgeon Throughout Their Range

Atlantic sturgeon are susceptible to over-exploitation given their life history characteristics (e.g., late maturity and dependence on a wide variety of habitats). Similar to other sturgeon species (Vladykov and Greeley 1963; Pikitch *et al.* 2005), Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (Taub 1990; Smith and Clugston 1997; Secor and Waldman 1999).

Because a DPS is a group of populations, the stability, viability, and persistence of individual populations that make up the DPS affects the persistence and viability of the larger DPS. The loss of any population within a DPS could result in: (1) a long-term gap in the range of the DPS that is unlikely to be recolonized; (2) loss of reproducing individuals; (3) loss of genetic biodiversity; (4) loss of unique haplotypes; (5) loss of adaptive traits; and (6) reduction in total number. The loss of a population will negatively impact the persistence and viability of the DPS as a whole, as fewer than two individuals per generation spawn outside their natal rivers (Secor and Waldman 1999). The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, emigration to marine habitats to grow, and return of adults to natal rivers to spawn.

Based on the best available information, NMFS has concluded that unintended catch in fisheries, vessel strikes, poor water quality, fresh water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from Labrador, Canada to Cape Canaveral, FL, as well as estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, because Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

Atlantic sturgeon are particularly sensitive to bycatch mortality because they are a long-lived species, have an older age at maturity, have lower maximum fecundity values, and a large percentage of egg production occurs later in life. Based on these life history traits, Boreman (1997) calculated that Atlantic sturgeon can only withstand the annual loss of up to 5% of their population to bycatch mortality without suffering population declines. Mortality rates of Atlantic sturgeon taken as bycatch in various types of fishing gear range between 0 and 51%, with the greatest mortality occurring in sturgeon caught by sink gillnets. Atlantic sturgeon are particularly vulnerable to being caught in sink gillnets; therefore, fisheries using this type of gear account for a high percentage of Atlantic sturgeon bycatch. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or may result in post-capture mortality.

As a wide-ranging anadromous species, Atlantic sturgeon are subject to numerous federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency activities. While these mechanisms, including the prohibition on possession, have addressed impacts to Atlantic sturgeon through directed fisheries, the listing determination concluded that the mechanisms in place to address the risk posed to Atlantic sturgeon from commercial bycatch were insufficient.

An ASMFC interstate fishery management plan for sturgeon (Sturgeon FMP) was developed and implemented in 1990 (Taub 1990). In 1998, the remaining Atlantic sturgeon fisheries in U.S. state waters were closed per Amendment 1 to the Sturgeon FMP. Complementary regulations were implemented by NMFS in 1999 that prohibit fishing for, harvesting, possessing, or retaining Atlantic sturgeon or their parts in or from the EEZ in the course of a commercial fishing activity.

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO, 2011; Wirgin and King 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian-directed Atlantic sturgeon fisheries and of Canadian fish incidentally captured in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

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

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

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NMFS NEFSC 2011b). The analysis estimates that from 2006 through 2010, there were averages of 1,548 and 1,569 encounters per year in observed gillnet and trawl fisheries, respectively, with an average of 3,118 encounters combined annually. Mortality rates in gillnet gear were approximately 20%. Mortality rates in otter trawl gear are generally lower, at approximately 5%.

Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. The proposed action takes place in the Delaware River and estuary. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Delaware River, and thereby, in the action area, will have originated from the Delaware River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Delaware River and estuary would not be limited to just individuals originating from the NYB DPS. Based on mixed-stock analysis, we have determined that subadult and adult Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%. These percentages are largely based on genetic sampling of individuals (n=105) sampled in directed research targeting Atlantic sturgeon along the Delaware Coast, just south of Delaware Bay. This is the closest sampling effort (geographically) to the action area for which mixed stock analysis results are available. Because the genetic composition of the mixed stock changes with distance from the rivers of origin, it is appropriate to use mixed stock analysis results from the nearest sampling location. Therefore, this represents the best available information on the likely genetic makeup of individuals occurring in the action area. We also considered information on the genetic makeup of individuals captured within the Delaware River. However, we only have information on the assignment of these individuals to the river of origin and do not have a mixed stock analysis for these samples. The river assignments are very similar to the mixed stock analysis results for the Delaware Coastal sampling, with the Hudson/Delaware accounting for 55-61% of the fish, James River accounting for 17-18%, South Atlantic 17-18%, and Gulf of Maine 9-11%. The range in assignments considers the slightly different percentages calculated by treating each sample individually versus treating each fish individually (some fish were captured in more than one of the years during the three year study). Carolina DPS origin fish have rarely been detected in samples taken in the Northeast and are not detected in either the Delaware Coast or in-river samples noted above. However, mixed stock analysis from one sampling effort (i.e., Long Island Sound, n=275), indicates that approximately 0.5% of the fish sampled were Carolina DPS origin. Additionally, 4% of Atlantic sturgeon captured incidentally in commercial fisheries along the U.S. Atlantic coast north of Cape Hatteras and genetically analyzed belong to the Carolina DPS. No Carolina DPS fish have been documented in sampling carried out in the Delaware River or along the Delaware Coast. However, because any Carolina origin sturgeon that were sampled in Long Island Sound could have swam through the action area on their way between Long Island Sound and their rivers of origin, it is reasonable to expect that 0.5% of the Atlantic sturgeon captured in the action area could originate from the Carolina DPS. The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al.* (2012).

4.6.1 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning still occurs in the Kennebec River, and it is possible that it still occurs in the Penobscot River as well. Recent evidence indicates that spawning may also be occurring in the Androscoggin River. During the 2011 spawning season, the Maine Department of Marine Resources captured a larval Atlantic sturgeon below the Brunswick Dam. There is no evidence of recent spawning in the remaining rivers. In the 1800s, construction of the Essex Dam on the Merrimack River at river kilometer (rkm) 49 blocked access to 58 percent of Atlantic sturgeon habitat in the river (Oakley, 2003; ASSRT, 2007). However, the accessible portions of the Merrimack seem to be suitable habitat for Atlantic sturgeon spawning and rearing (i.e., nursery habitat) (Keiffer and Kynard, 1993). Therefore, the availability of spawning habitat does not appear to be the reason for the lack of observed spawning in the Merrimack River. Studies are on-going to determine whether Atlantic sturgeon are spawning in these rivers. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT, 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS as well as likely throughout the entire range (ASSRT, 2007; Fernandes, *et al.*, 2010).

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (Squiers *et al.*, 1981; ASMFC, 1998; NMFS and USFWS, 1998). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (i.e., expressing milt) in July 1994 below the (former) Edwards Dam; (2) capture of 31 adult Atlantic sturgeon from June 15,1980, through July 26,1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least 4 ripe males and 1 ripe female captured on July 26,1980; and, (3) capture of nine adults during a gillnet survey conducted from 1977-1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, ME (NMFS and USFWS, 1998; ASMFC 2007). The low salinity values for waters above Merrymeeting Bay are consistent with values found in other rivers where successful Atlantic sturgeon spawning is known to occur.

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

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

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon are known to occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. While not expected to be killed or injured during passage at a dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The extent that Atlantic sturgeon are affected by operations of dams in the Gulf of Maine region is currently unknown; however, the documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests 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, sturgeon can now travel as far upstream as the Great Works Dam. The Great Works Dam prevents Atlantic sturgeon from accessing the presumed historical spawning habitat located downstream of Milford Falls, the site of the Milford Dam. While removal of the Great Works Dams is anticipated to occur in the near future, the presence of this dam is currently preventing access to significant habitats within the Penobscot River. While Atlantic sturgeon are known to occur in the Penobscot River, it is unknown if spawning is currently occurring or whether the presence of the Great Works Dam affects the likelihood of spawning occurring in this river. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

Gulf of Maine DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (Lichter *et al.* 2006; EPA, 2008). 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.

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

Summary of the Gulf of Maine DPS

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

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

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

4.6.2 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, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (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).

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800's is unknown but, has been conservatively estimated at 10,000 adult females (Secor, 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (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. All available data on abundance of juvenile Atlantic sturgeon in the Hudson River Estuary indicate a substantial drop in production of young since the mid 1970s (Kahnle *et al.*, 1998). A decline 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). Catch-per-unit-effort data suggests that recruitment has remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980's (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 and 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. In addition to bycatch mortality in Federal waters, bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (shad), has now been closed and there is no indication that it will reopen soon. In the Hudson River sources of potential mortality include vessel strikes and entrainment in dredges. Individuals are also exposed to effects of bridge construction (including the ongoing replacement of the Tappan Zee bridge). Impingement at water intakes, including the Danskammer, Roseton and Indian Point power plants also occurs. There is currently not enough information regarding any life stage to establish a trend for the 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 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.

Several threats play a role in shaping the current status and trends observed in the Delaware River and Estuary. In-river threats include habitat disturbance from dredging, and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron, 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River; however, at this time we do not have information to quantify this threat or its impact to the population or the New York Bight DPS. Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

Summary of the New York Bight DPS

Atlantic sturgeon originating from the New York Bight DPS spawn in the Hudson and Delaware rivers. While genetic testing can differentiate between individuals originating from the Hudson or Delaware river the available information suggests that the straying rate is high between these rivers. There are no indications of increasing abundance for the New York Bight DPS (ASSRT, 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 and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Both the Hudson and Delaware rivers have navigation channels that are maintained by dredging. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities many do not. We have reports of one Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects 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. The extent that Atlantic sturgeon are affected by operations of dams in the New York Bight region is currently unknown.

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. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Given the time of year in which the fish were observed (predominantly May through July, with two in August), it is likely that many of the adults were migrating through the river to the spawning grounds. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the New York Bight DPS.

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. NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.6.3 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT, 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT, 2007). Spawning still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (Musick *et al.*, 1994; ASSRT, 2007; Greene et al. 2009). However, conclusive evidence of current spawning is only available for the James River. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (Vladykov and Greeley, 1963; ASSRT, 2007; Wirgin *et al.*, 2007; Grunwald *et al.*, 2008).

Age to maturity for Chesapeake Bay DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is 5 to 19 years for Atlantic sturgeon originating from South Carolina rivers (Smith *et al.*, 1982) and 11 to 21 years for Atlantic sturgeon originating from the Hudson River (Young *et al.*, 1998). Therefore, age at maturity for Atlantic sturgeon of the Chesapeake Bay DPS likely falls within these values.

Several threats play a role in shaping the current status of Chesapeake Bay DPS Atlantic sturgeon. Historical records provide evidence of the large-scale commercial exploitation of Atlantic sturgeon from the James River and Chesapeake Bay in the 19th century (Hildebrand and Schroeder, 1928; Vladykov and Greeley, 1963; ASMFC, 1998; 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 is thought to have reduced available spawning habitat in the James River (Holton and Walsh, 1995; Bushnoe *et al.*, 2005; ASSRT, 2007). At this time, we do not have information to quantify this loss of spawning habitat.

Decreased water quality also threatens Atlantic sturgeon of the Chesapeake Bay DPS, especially since the Chesapeake Bay system is vulnerable to the effects of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface to volume ratio, and strong stratification during the spring and summer months (Pyzik *et al.*, 2004; ASMFC, 1998; ASSRT, 2007; 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). At this time we do not have sufficient information to quantify the extent that degraded water quality effects habitat or individuals in the James River or throughout the Chesapeake Bay.

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

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

Summary of the Chesapeake Bay DPS

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

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

4.6.4 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.

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 7). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. There may also be spawning populations in the Neuse, Santee and Cooper Rivers, though it is uncertain. Historically, both the Sampit and Ashley Rivers were documented to have spawning populations at one time. However, the spawning population in the Sampit River is believed to be extirpated and the current status of the spawning population in the Ashley River is unknown. Both rivers may be used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. This represents our current knowledge of the river systems utilized by the Carolina DPS for specific life functions, such as spawning, nursery habitat, and foraging. However, fish from the Carolina DPS likely use other river systems than those listed here for their specific life functions.

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

Table 7. 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.

The riverine spawning habitat of the Carolina DPS occurs within the Mid-Atlantic Coastal Plain ecoregion. The Nature Conservancy (TNC) describes the South Atlantic Coastal Plain eco-region as fall-line sandhills to rolling longleafpine uplands to wet pine flatwoods; from small streams to large river systems to rich estuaries; from isolated depression wetlands to Carolina bays to the Okefenokee Swamp. Other ecological systems in the eco-region include maritime forests on barrier islands, pitcher plant seepage bogs and Altamaha grit (sandstone) outcrops. The primary threats to biological diversity in the Mid-Atlantic Coastal Plain, as listed by TNC are: global climate change and rising sea level; altered surface hydrology and landform alteration (e.g., flood-control and hydroelectric dams, inter-basin transfers of water, drainage ditches, breached levees, artificial levees, dredged inlets and river channels, beach renourishment, and spoil deposition banks and piles); a regionally receding water table, probably resulting from both over-use and inadequate recharge; fire suppression; land fragmentation, mainly by highway development; land-use conversion (e.g., from forests to timber plantations, farms, golf courses, housing developments, and resorts); the invasion of exotic plants and animals; air and water pollution, mainly from agricultural activities including concentrated animal feed operations; and over-harvesting and poaching of species. Many of the Carolina DPS' spawning rivers, located in the Mid-Coastal Plain, originate in areas of marl. Waters draining calcareous, impervious surface materials such as marl are: (1) likely to be alkaline; (2) dominated by surface run-off; (3) have little groundwater connection; and, (4) are seasonally ephemeral.

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

Threats

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

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

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

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

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

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

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

Summary of the Status of the Carolina DPS of Atlantic Sturgeon

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

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

4.6.5 South Atlantic DPS of Atlantic sturgeon

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

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, and Satilla Rivers. We determined spawning was occurring if YOY were observed, or mature adults were present, in freshwater portions of a system (Table 8). 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. However, the spawning population in the St. Marys River, as well as any historical spawning population present in the St. Johns, is believed to be extirpated, and the status of the spawning population in the Broad-Coosawatchie is unknown. Both the St. Marys and St. Johns Rivers are used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. The use of the Broad-Coosawatchie by sturgeon from other spawning populations is unknown at this time. The presence of historical and current spawning populations in the Ashepoo River has not been documented; however, this river may currently be used for nursery habitat by young Atlantic sturgeon originating from other spawning populations. This represents our current knowledge of the river systems utilized by the South Atlantic DPS for specific life functions, such as spawning, nursery habitat, and foraging. However, fish from the South Atlantic DPS likely use other river systems than those listed here for their specific life functions.

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	Extirpated	
St. Johns River, FL	Extirpated	

Table 8. Major rivers, tributaries, and sounds within the range of the South Atlantic DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

The riverine spawning habitat of the South Atlantic DPS occurs within the South Atlantic Coastal Plain ecoregion (TNC 2002b), which includes fall-line sandhills, rolling longleaf pine uplands, wet pine flatwoods, isolated depression wetlands, small streams, large river systems, and estuaries. Other ecological systems in the ecoregion include maritime forests on barrier islands, pitcher plant seepage bogs and Altamaha grit (sandstone) outcrops. Other ecological systems in the ecoregion include maritime forests on barrier islands, pitcher plant seepage bogs and Altamaha grit (sandstone) outcrops. The primary threats to biological diversity in the South Atlantic Coastal Plain listed by TNC are intensive silvicultural practices, including conversion of natural forests to highly managed pine monocultures and the clear-cutting of bottomland hardwood forests. Changes in water quality and quantity, caused by hydrologic alterations (impoundments, groundwater withdrawal, and ditching), and point and nonpoint pollution, are threatening the aquatic systems. Development is a growing threat, especially in coastal areas. Agricultural conversion, fire regime alteration, and the introduction of nonnative species are additional threats to the ecoregion's diversity. The South Atlantic DPS' spawning rivers, located in the South Atlantic Coastal Plain, are primarily of two types: brownwater (with headwaters north of the Fall Line, silt-laden) and blackwater (with headwaters in the coastal plain, stained by tannic acids).

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

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

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

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

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

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

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

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

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

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

4.7 Summary of Available Information on Use of Action Area by Listed Species

4.7.1 Sea turtles

One of the main factors influencing sea turtle presence in northern waters is seasonal temperature patterns (Ruben and Morreale 1999). Temperature is correlated with the time of year, with the warmer waters in the late spring, summer, and early fall being the most suitable for cold-blooded sea turtles. Sea turtles are most likely to occur in the action area between June and October when water temperatures are above 11°C and depending on seasonal weather patterns, could be present in May and early November. In the Delaware River, sea turtles occur as far upstream as Artificial Island, where the Salem and Hope Creek facilities are located.

4.7.2 Shortnose Sturgeon

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. Distribution of adult and juvenile shortnose sturgeon in the action area is influenced by seasonal water temperature, the distribution of forage items, and salinity.

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. The estuary can be divided into four longitudinal salinity zones. Starting at the downstream end, the mouth of the Bay to RM 34 is considered polyhaline (18-30ppt), RM 34-44 is mesohaline (5-18ppt), RM 44-79 is oligohaline (0.5-5ppt), and Marcus Hook (RM 79) to Trenton is considered Fresh (0.0-0.5ppt). Based on this information and the known tolerances and preferences of shortnose sturgeon to salinity, shortnose sturgeon are most likely to occur upstream of RM 44 (rkm 70) where salinity is typically less than 5ppt. The action area is located at RM 50, in the lower reaches of the oligohaline zone.

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[8]. All but two shortnose sturgeon documented at the Salem intakes have occurred between April and November. 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 further 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.

4.7.3 Atlantic sturgeon in the Action Area

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

5.0 ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of the listed species in the action area.

[8] 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).

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

NMFS has undertaken several ESA section 7 consultations to address the effects of actions authorized, funded or carried out by Federal agencies. Each of those consultations sought to develop ways of reducing the probability of adverse impacts of the action on listed species. Consultations that considered activities that occur in the action area are detailed below.

5.1.1 Delaware River – Philadelphia to the Sea Federal Navigation Project

The Army Corps of Engineers(ACOE) maintains the 40-foot Philadelphia to the Sea Federal navigation project (FNP) with hopper and cutterhead dredges annually. We issued a Biological Opinion to the ACOE in 1996 that considered the effects of the maintenance of this project on shortnose sturgeon and sea turtles. In the Opinion we concluded that ongoing maintenance of the channel was likely to adversely affect but not likely to jeopardize the continued existence of shortnose sturgeon, or loggerhead, Kemp's ridley, green or leatherback sea turtles. We amended this Opinion with a revised ITS in 1999.

The Philadelphia District Endangered Species Monitoring Program began in August 1992. Since that time, all hopper dredge operations conducted downstream of the Delaware Memorial Bridge between May and November have used endangered species observers to monitor for interactions with sea turtles. No shortnose or Atlantic sturgeon have been observed during any hopper dredging event. Several sea turtles have been entrained during hopper dredging operations including two loggerheads in August 1993 and one loggerhead on June 22, 1994. Relocation trawling was conducted in 1994, and eight loggerheads were captured and relocated away from the channel. On November 13, 1995 one loggerhead was entrained by a hopper dredge working in the channel. On July 27, 2005, fresh loggerhead parts were observed in the hopper basket during two different loads. Outside of the disposal site inspectors working at upland disposal areas, no endangered species observers have been used during any cutterhead dredging operations for this project or at any hopper dredge operation upstream of the Delaware Memorial Bridge.

5.1.2 Deepening of the Delaware River Philadelphia to the Sea FNP

In 2009, we consulted with the ACOE on the effects of the proposed deepening of the Philadelphia to the Sea FNP. In an Opinion dated July 17, 2009, we concluded that the deepening was likely to adversely affect but not likely to jeopardize the continued existence of shortnose sturgeon or loggerhead, Kemp's ridley or green sea turtles. The deepening project began in March 2010. Between March and August, 2010, approximately 3 million cy of material was removed via cutterhead dredge from reach C. The disposal site was inspected daily for evidence of entrained sturgeon. No shortnose sturgeon or their parts were observed during the dredging operations. Dredging to execute contract 2, Reach B began in November 2011 and was completed in December 2012 with approximately 1 million cy of material removed. No sturgeon or their parts have been observed at the disposal site. Consultation with the ACOE has been reinitiated to consider effects to Atlantic sturgeon. A new Opinion is expected to be issued during the summer of 2012.

5.1.3 Scientific Studies

There are currently four scientific research permits issued pursuant to Section 10(a)(1)(A) of the ESA, that authorize research on sturgeon in the Delaware River. The activities authorized under these permits are presented below.

Hal Brundage of Environmental Research and Consulting, Inc. holds a scientific research permit (#14604, which replaces his previously held permit #1486) authorizing research on relative abundance, reproduction, juvenile recruitment, temporal and spatial distributions, and reproductive health of shortnose sturgeon. Methods would include capturing up to 1,000 adult and juvenile shortnose sturgeon annually via gill net, trammel net, and trawl net; measure; weigh; scan (for tags); PIT and Floy T-bar tag; and sample tissue for genetic analysis. A subset of 30 adults and 30 juveniles annually will be tagged with acoustic transmitters. Another subset of 24 adults annually will be examined internally using laparoscopic techniques, blood drawn for analysis, and a biopsy of the gonads taken. Up to 500 eggs and larvae will be collected by artificial substrate, D-frame ichthyoplankton net, and/or epibenthic sled. The unintentional mortality of one adult or juvenile shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on April 19, 2015.

Mr. Brundage also holds a scientific research permit (#16438) authorizing research on Atlantic sturgeon. Mr. Brundage is authorized to capture and tag 384 juvenile, subadult and adult Atlantic sturgeon as well as 500 Atlantic sturgeon eggs or larvae. The unintentional mortality of one adult or juvenile shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on April 5, 2017.

Dr. Dewayne Fox of Delaware State University holds a scientific research permit (#16507) authorizing research on Atlantic and shortnose sturgeon. Dr. Fox is authorized to capture and tag 510 Atlantic sturgeon and 100 shortnose sturgeon as well as 300 Atlantic sturgeon eggs. This permit expires on April 5, 2017. No mortality is authorized by this permit.

The Delaware Department of Natural Resources and Environmental Control (DNREC) holds a scientific research permit (#14396) authorizing research on shortnose sturgeon. DNREC is authorized to capture, handle and tag 215 shortnose sturgeon. The unintentional mortality of one adult or juvenile shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on December 13, 2014.

5.1.4 Other Federally Authorized Actions

We have completed several informal consultations on effects of in-water construction activities in the Delaware River permitted by the ACOE. This includes several dock, pier, and bank stabilization projects. No interactions with shortnose or Atlantic sturgeon or sea turtles have been reported in association with any of these projects.

We have also completed several informal consultations on effects of private dredging projects permitted by the ACOE. All of the dredging was with a mechanical or cutterhead dredge. No interactions with shortnose or Atlantic sturgeon or sea turtles have been reported in association with any of these projects.

5.2 State or Private Activities in the Action Area

5.2.1 State Authorized Fisheries

Atlantic and shortnose sturgeon, and sea turtles may be vulnerable to capture, injury and mortality in fisheries occurring in state waters. The action area includes Delaware and New

Jersey state waters in the Delaware River as defined in Section 3.4 above. Information on the number of sturgeon captured or killed in state fisheries is extremely limited and as such, efforts are currently underway to obtain more information on the numbers of sturgeon captured and killed in state water fisheries. We are currently working with the ASMFC and the coastal states to assess the impacts of state authorized fisheries on sturgeon. We anticipate that some states are likely to apply for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no applications have been submitted. Below, we discuss the different fisheries authorized by the states and any available information on interactions between these fisheries and sturgeon and sea turtles.

American Eel
American eel (*Anguilla rostrata*) is exploited in fresh, brackish and coastal waters from the southern tip of Greenland to northeastern South America. American eel fisheries are conducted primarily in tidal and inland waters. Eels are typically caught with hook and line or with eel traps and may also be caught with fyke nets. Sturgeon and sea turtles are not known to interact with the eel fishery.

Shad and River herring
Shad and river herring (blueback herring (*Alosa aestivalis*) and alewives (*Alosa pseudoharengus*)) are managed under an ASMFC Interstate Fishery Management Plan. In the action area, fishing for river herring is prohibited. Limited fishing effort for shad continues to occur. Recreational shad fishing is currently allowed within the Delaware River with hook and line only; commercial fishing for shad occurs with gill nets, but only in Delaware Bay, outside of the action area. In the past, it was estimated that over 100 shortnose sturgeon were captured annually in shad fisheries in the Delaware River, with an unknown mortality rate (O'Herron and Able 1985). Nearly all captures occurred in the upper Delaware River, upstream of the action area. No recent estimates of captures or mortality of shortnose or Atlantic sturgeon are available. In 2012, only one commercial fishing license was granted for shad in New Jersey. Shortnose and Atlantic sturgeon continue be exposed to the risk of interactions with this fishery; however, because increased controls have been placed on the shad fishery, impacts to shortnose and Atlantic sturgeon are likely less than they were in the past. We have no reports of sea turtles captured in shad fisheries in the Delaware River.

Striped bass
Striped bass(*Morone saxatilis*) are managed by ASMFC through Amendment 6 to the Interstate FMP, which requires minimum sizes for the commercial and recreational fisheries, possession limits for the recreational fishery, and state quotas for the commercial fishery (ASMFC 2003). Under Addendum 2, the coastwide striped bass quota remains the same, at 70% of historical levels. Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the striped bass fishery accounted for 43% of Atlantic sturgeon recaptures; however, no information on the total number of Atlantic sturgeon caught by fishermen targeting striped bass or the mortality rate is available. No interactions with sea turtles or shortnose sturgeon have been reported to us in the action area; however, given the gear type used, interactions are possible.

5.3 Other Impacts of Human Activities in the Action Area

5.3.1 Contaminants and Water Quality

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

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

Sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from coastal development, groundwater discharges, and industrial development. Chemical contaminants may also have an effect on sea turtle reproduction and survival. While the effects of contaminants on turtles is relatively unclear, pollution may be linked to the fibropapilloma virus that kills many turtles each year (NMFS 1997). If pollution is not the causal agent, it may make sea turtles more susceptible to disease by weakening their immune systems.

Contaminants have been detected in Delaware River fish. PCBs have been detected in elevated levels in several species of fish. Large portions of the Delaware River is bordered by highly industrialized waterfront development. Sewage treatment facilities, refineries, manufacturing plants and power generating facilities all intake and discharge water directly from the Delaware River. This results in large temperature variations, heavy metals, dioxin, dissolved solids, phenols and hydrocarbons which may alter the pH of the water eventually leading to fish mortality. Industrialized development, especially the presence of refineries, has also resulted in storage and leakage of hazardous material into the Delaware River. Presently 13 Superfund sites have been identified in Marcus Hook and one dumpsite has yet to be labeled as a Superfund site, but does contain hazardous waste. It is possible that the presence of contaminants throughout the Delaware River generally as well as in the action area may have affected shortnose and Atlantic sturgeon.

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

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

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002). Sixteen metals, two semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs and DDE (an organochlorine pesticide) were detected in the "adverse effect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. While no directed studies of chemical contamination in shortnose sturgeon in the Delaware River have been undertaken, it is evident that the heavy industrialization of the Delaware River is likely adversely affecting this population.

Excessive turbidity due to coastal development and/or construction sites could influence sea turtle foraging ability. Turtles are not very easily affected by changes in water quality or increased suspended sediments, but if these alterations make habitat less suitable for turtles and hinder their capability to forage, eventually they would tend to leave or avoid these less desirable areas (Ruben and Morreale 1999).

Marine debris (*e.g.*, discarded fishing line or lines from boats) can entangle turtles in the water and drown them. Turtles commonly ingest plastic or mistake debris for food. Chemical contaminants may also have an effect on sea turtle reproduction and survival. Excessive turbidity due to coastal development and/or construction sites could influence sea turtle foraging ability. As mentioned previously, turtles are not very easily affected by changes in water quality or increased suspended sediments, but if these alterations make habitat less suitable for turtles and hinder their capability to forage, eventually they would tend to leave or avoid these less desirable areas (Ruben and Morreale 1999).

5.3.2 Private and Commercial Vessel Operations

Private and commercial vessels, including fishing vessels, operating in the action area of this consultation also have the potential to interact with 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. Sea turtles are known to be vulnerable to vessel strikes; however, no estimate of the number of vessel strikes in the action area is available.

There is limited information on the effects of vessel operations on shortnose sturgeon. It is generally assumed that as shortnose sturgeon are benthic species, that their movements are limited to the bottom of the water column and that vessels operating with sufficient navigational clearance would not pose a risk of ship strike. Shortnose sturgeon may not be as susceptible due to their smaller size in comparison to Atlantic sturgeon that are larger and for which ship strikes have been documented more frequently. However, anecdotal evidence suggests that shortnose sturgeon at least occasionally interact with vessels, as evidence by wounds that appear to be caused by propellers. There has been only one confirmed incidence of a ship strike on a shortnose sturgeon and 2 suspected ship strike mortalities. On November 5, 2008, in the Kennebec River, Maine, Maine Department of Marine Resources (MEDMR) staff observed a small (<20) ft boat transiting a known shortnose sturgeon overwintering area at high speeds. When MEDMR approached the area after the vessel had passed, a fresh dead shortnose sturgeon was discovered. The fish was collected for necropsy, which later confirmed that the mortality was the result of a propeller wound to the right side of the mouth and gills. The other two suspected ship strike mortalities occurred in the Delaware River. On June 8, 2008, a shortnose was collected near Philadelphia. The fish was necropsied and found to have suffered from blunt force trauma; though there was no ability to confirm whether the source of the trauma resulted from a vessel interaction. Lastly, on November 28, 2007, a shortnose sturgeon was collected on the trash racks of the Salem Nuclear Generating Facility. The fish was not necropsied, however, a pattern of lacerations on the carcass suggested a possible vessel interaction. Aside from these incidents, no information on the characteristics of vessels that are most likely to interact with shortnose sturgeon is available and there is no information on the rate of interactions, however it is assumed to be low.

As noted in the 2007 Status Review and the final listing rules, vessel strikes have been identified as a threat to Atlantic sturgeon. While the exact number of Atlantic sturgeon killed as a result of being struck by boat hulls or propellers is unknown, it is an area of concern. Brown and Murphy (2010) examined twenty-eight dead Atlantic sturgeon observed in the Delaware River from 2005-2008. Fifty-percent of the mortalities resulted from apparent vessel strikes and 71% of these (10 of 14) had injuries consistent with being struck by a large vessel (Brown and Murphy 2010). Eight of the fourteen vessel-struck sturgeon were adult-sized fish (Brown and Murphy 2010). Given the time of year in which the fish were observed (predominantly May through July; Brown and Murphy 2010), it is likely that many of the adults were migrating through the river to or from the spawning grounds.

The factors relevant to determining the risk to Atlantic sturgeon from vessel strikes are currently unknown, but they may be related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of Atlantic sturgeon in the area (e.g., foraging, migrating, etc.). It is unknown to what extent the mortalities documented by Brown and Murphy (2010) accurately characterize the extent of vessel strikes in the Delaware River, but it is unlikely that all Atlantic sturgeon that died in the time period of the study were observed by the authors. Vessel interactions are thought to cause the death of several Atlantic sturgeon in the Delaware River each year.

6.0 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Additionally, we present the available information on predicted effects of climate change in the action area (i.e., the Delaware River and estuary) and how listed sea turtles and sturgeon may be affected by those predicted environmental changes over the life of the proposed action (i.e., between now and 2046). Climate change is relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion. Effects of the proposed action that are relevant to climate change are included in the Effects of the Action section below (section 7.0 below).

6.1 Background Information on Global climate change

The global mean temperature has risen 0.76ºC (1.36°F) over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a) and precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and other pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b); these trends are most apparent over the past few decades.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3^{o}-5^{o}C (5^{o}-9^{o}F) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2^{o}C (0.4°F) per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008).

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene *et al.* 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (Greene *et al.* 2008, IPCC 2006). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the earth's atmosphere caused by anthropogenic forces (IPCC 2006). The NAO impacts climate variability throughout the northern hemisphere (IPCC 2006). Data from the 1960s through the present show that the NAO index has increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2006). This warming extends over 1000m (0.62 miles) deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (Greene *et al.* 2008, IPCC 2006). There is evidence that the NADW has already freshened significantly (IPCC 2006). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the whole earth system (Greene *et al.* 2008).

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the next few decades on coastal and marine resources on smaller geographic scales, such as the Delaware River, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHGs, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that the rate of change will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007).

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Expected consequences could be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch *et al.* 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants other than heat currently degrade water quality (Murdoch *et al.* 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer *et al.* 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development may experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2°C (0.4°F) per decade; and 3) a rise in sea level (NAST 2000). A warmer and drier climate will reduce stream flows and increase water temperature resulting in a decrease of DO and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing. Sea level is expected to continue rising: during the 20th century global sea level has increased 15 to 20 cm (6-8 inches).

6.2 Species Specific Information on Climate Change Effects

6.2.1 Loggerhead Sea Turtles

The most recent Recovery Plan for loggerhead sea turtles as well as the 2009 Status Review Report identifies global climate change as a threat to loggerhead sea turtles. However, trying to assess the likely effects of climate change on loggerhead sea turtles is extremely difficult given the uncertainty in all climate change models and the difficulty in determining the likely rate of temperature increases and the scope and scale of any accompanying habitat effects. Additionally, no significant climate change-related impacts to loggerhead sea turtle populations have been observed to date. Over the long-term, climate change related impacts are expected to influence biological trajectories on a century scale (Parmesan and Yohe 2003). As noted in the 2009 Status Review (Conant *et al.* 2009), impacts from global climate change induced by human activities are likely to become more apparent in future years (Intergovernmental Panel on Climate Change (IPCC) 2007). Climate change related increasing temperatures, sea level rise, changes in ocean productivity, and increased frequency of storm events may affect loggerhead sea turtles.

Increasing temperatures are expected to result in rising sea levels (Titus and Narayanan 1995 in Conant *et al.* 2009), which could result in increased erosion rates along nesting beaches. Sea level rise could result in the inundation of nesting sites and decrease available nesting habitat (Daniels *et al.* 1993; Fish *et al.* 2005; Baker *et al.* 2006). The BRT noted that the loss of habitat as a result 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; both in Conant *et al.* 2009). Along developed coastlines, and especially in areas where erosion control structures have been constructed to limit shoreline movement, rising sea levels may cause severe effects on nesting females and their eggs as nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation. However, if global temperatures increase and there is a range shift northwards, beaches not currently used for nesting may become available for loggerhead sea turtles, which may offset some loss of accessibility to beaches in the southern portions of the range.

Climate change has the potential to result in changes at nesting beaches that may affect loggerhead sex ratios. Loggerhead sea turtles exhibit temperature-dependent sex determination. Rapidly increasing global temperatures may result in warmer incubation temperatures and highly female-biased sex ratios (*e.g.*, Glen and Mrosovsky 2004; Hawkes *et al.* 2009); however, to the extent that nesting can occur at beaches further north where sand temperatures are not as warm, these effects may be partially offset. The BRT specifically identified climate change as a threat to loggerhead sea turtles in the neritic/oceanic zone where climate change may result in future trophic changes, thus impacting loggerhead prey abundance and/or distribution. In the threats matrix analysis, climate change was considered for oceanic juveniles and adults and eggs/hatchlings. The report states that for oceanic juveniles and adults, "although the effect of trophic level change from…climate change…is unknown it is believed to be very low." For eggs/hatchlings the report states that total mortality from anthropogenic causes, including sea level rise resulting from climate change, is believed to be low relative to the entire life stage. However, only limited data are available on past trends related to climate effects on loggerhead sea turtles; current scientific methods are not able to reliably predict the future magnitude of climate change, associated impacts, whether and to what extent some impacts will offset others, or the adaptive capacity of this species.

However, Van Houtan and Halley (2011) recently developed climate based models to investigate loggerhead nesting (considering juvenile recruitment and breeding remigration) in the North Pacific and Northwest Atlantic. These models found that climate conditions/oceanographic influences explain loggerhead nesting variability, with climate models alone explaining an average 60% (range 18%-88%) of the observed nesting changes over the past several decades. In terms of future nesting projections, modeled climate data show a future positive trend for Florida nesting, with increases through 2040 as a result of the Atlantic Multidecadal Oscillation signal.

6.2.2 Kemp's Ridley Sea Turtles

The recovery plan for Kemp's ridley sea turtles (NMFS *et al.* 2011) identifies climate change as a threat; however, as with the other species discussed above, no significant climate change-related impacts to Kemp's ridley sea turtles have been observed to date. Atmospheric warming could cause habitat alteration which may change food resources such as crabs and other invertebrates. It may increase hurricane activity, leading to an increase in debris in nearshore and offshore waters, which may result in an increase in entanglement, ingestion, or drowning. In addition, increased hurricane activity may cause damage to nesting beaches or inundate nests with sea water. Atmospheric warming may change convergence zones, currents and other oceanographic features that are relevant to Kemp's ridleys, as well as change rain regimes and levels of nearshore runoff.

Considering that the Kemp's ridley has temperature-dependent sex determination (Wibbels 2003) and the vast majority of the nesting range is restricted to the State of Tamaulipas, Mexico, global warming could potentially shift population sex ratios towards females and thus change the reproductive ecology of this species. A female bias is presumed to increase egg production (assuming that the availability of males does not become a limiting factor) (Coyne and Landry 2007) and increase the rate of recovery; however, it is unknown at what point the percentage of males may become insufficient to facilitate maximum fertilization rates in a population. If males become a limiting factor in the reproductive ecology of the Kemp's ridley, then reproductive output in the population could decrease (Coyne 2000). Low numbers of males could also result in the loss of genetic diversity within a population; however, there is currently no evidence that this is a problem in the Kemp's ridley population (NMFS *et al.* 2011). Models (Davenport 1997, Hulin and Guillon 2007, Hawkes *et al.* 2007, all referenced in NMFS *et al.* 2011) predict very long-term reductions in fertility in sea turtles due to climate change, but due to the relatively long life cycle of sea turtles, reductions may not be seen until 30 to 50 years in the future.

Another potential impact from global climate change is sea level rise, which may result in increased beach erosion at nesting sites. Beach erosion may be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents. In the case of the Kemp's ridley where most of the critical nesting beaches are undeveloped, beaches may shift landward and still be available for nesting. The Padre Island National Seashore (PAIS) shoreline is accreting, unlike much of the Texas coast, and with nesting increasing and the sand temperatures slightly cooler than at Rancho Nuevo, PAIS could become an increasingly important source of males for the population.

6.2.3 Green Sea Turtles

The five year status review for green sea turtles (NMFS and USFWS 2007c) notes that global climate change is affecting green sea turtles and is likely to continue to be a threat. There is an increasing female bias in the sex ratio of green turtle hatchlings. While this is partly attributable to imperfect egg hatchery practices, global climate change is also implicated as a likely cause. This is because warmer sand temperatures at nesting beaches are likely to result in the production of more female embryos. At least one nesting site, Ascension Island, has had an increase in mean sand temperature in recent years (Hays *et al.* 2003 in NMFS and USFWS 2007c). Climate change may also affect nesting beaches through sea level rise, which may reduce the availability of nesting habitat and increase the risk of nest inundation. Loss of appropriate nesting habitat may also be accelerated by a combination of other environmental and oceanographic changes, such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion. Oceanic changes related to rising water temperatures could result in changes in the abundance and distribution of the primary food sources of green sea turtles, which in turn could result in changes in behavior and distribution of this species. Seagrass habitats may suffer from decreased productivity and/or increased stress due to sea level rise, as well as salinity and temperature changes (Short and Neckles 1999; Duarte 2002).

As noted above, the increasing female bias in green sea turtle hatchlings is thought to be at least partially linked to increases in temperatures at nesting beaches. However, at this time, we do not know how much of this bias is due to hatchery practice and how much is due to increased sand temperature. Because we do not have information to predict the extent and rate to which sand temperatures at the nesting beaches used by green sea turtles may increase in the short-term future, we cannot predict the extent of any future bias. Also, we do not know to what extent to which green sea turtles may be able to cope with this change by selecting cooler areas of the beach or shifting their nesting distribution to other beaches at which increases in sand temperature may not be experienced.

6.2.4 Shortnose sturgeon

Global climate change may affect shortnose sturgeon in the future. Rising sea level may result in the salt wedge moving upstream in affected rivers. Shortnose sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile shortnose sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, shortnose sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, for most spawning rivers there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Shortnose sturgeon are tolerant to 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, sturgeon may be excluded from some habitats.

Increased droughts (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 spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all shortnose sturgeon life stages, including adults, may become susceptible to strandings. Low flow and drought conditions are also expected to cause additional water quality issues. 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. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing shortnose sturgeon in rearing habitat; however, this would be mitigated if prey species also had a shift in distribution or if developing sturgeon were able to shift their diets to other species.

6.2.5 Atlantic sturgeon

Global climate change may affect all DPSs of Atlantic sturgeon in the future; however, effects of increased water temperature and decreased water availability are most likely to effect the South

Atlantic and Carolina DPSs. Rising sea level may result in the salt wedge moving upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile Atlantic sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, shortnose sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

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Increased droughts (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 spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all Atlantic sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. 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. Additionally, 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.

6.3 Effects of Climate Change in the Action Area

Available information on climate change related effects for the Delaware River largely focuses on effects that rising water levels may have on the human environment (Barnett et al. 2008) and the availability of water for human use (e.g., Ayers et al. 1994). Documents prepared by ACOE for the Philadelphia to the Sea deepening project have considered climate change (ACOE 2009, 2011), with a focus on sea level rise and a change in the location of the salt line.

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

The report notes that the Mid-Atlantic States are anticipated to experience sealevel rise greater than the global average (GCRP, 2009). While the global sea level rise is largely attributed to melting ice sheets and expanding water as it warms, there is regional variation because of gravitational forces, wind, and water circulation patterns. In the Mid-Atlantic region, changing water circulation patterns are expected to increase sea-level by approximately 10 cm over this century (Yin et al., 2009 in Kreeger et al. 2010). Subsidence and sediment accretion also influence sea level rise in the Mid-Atlantic, including in the Delaware estuary. As described by Kreeger, postglacial settling of the land masses has occurred in the Delaware system since the last Ice Age. This settling causes a steady loss of elevation, which is called subsidence. Through the next century, subsidence is estimated to hold at an average 1-2 mm of land elevation loss per year (Engelhart et al., 2009 in 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 sediments to compensate for elevation loss plus absolute sea-level rise. The net increase in sea-level compared to the change in land elevation is referred to as the rate of relative sea-level rise (RSRL). Kreeger states that the best estimate for RSLR by the end of the century is 0.8 to 1.7 m in the Delaware Estuary.

Sea level rise combined with more frequent droughts and increased human demand for water are 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 river mile 71. Collier predicts that without mitigation (e.g., increased release of flows into downstream areas of the river), at high tide in the peak of the summer during extreme drought conditions, the salt line could be as far upstream as river mile 114 (rkm 183) in 2050 and 117 (rkm 188) in 2100. The farthest north the salt line has historically been documented was approximately river mile 103 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 11 miles further upstream by 2050 and 14 miles further upstream by 2100.

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.

Sea surface temperatures have fluctuated around a mean for much of the past century, as measured by continuous 100+ year records at Woods Hole (Mass.), and Boothbay Harbor (Maine) and shorter records from Boston Harbor and other bays. Periods of higher than average temperatures (in the 1950s) and cooler periods (1960s) have been associated with changes in the North Atlantic Oscillation (NAO), which affects current patterns. Over the past 30 years however, records indicate that ocean temperatures in the Northeast have been increasing; for example, Boothbay Harbor's temperature has increased by about 1°C since 1970. Water temperature in the Delaware River, including the action area, varies seasonally. A 2007 examination of long-term trends in Delaware River water temperature shows no indication of any long-term trends in these seasonal changes (BBL Sciences 2007). Monthly mean temperature in 2001 compares almost identically to long-term monthly mean temperatures for the period from 1964 to 2000, with lowest temperatures recorded in April (10–11°C) and peak temperatures observed in August (approximately 26–27°C). While water temperature rises have been observed in other mid-Atlantic rivers (e.g., a 2°C increase in the Hudson River from the 1960s to 2000s (Pisces 2008)), a similar trend does not currently appear in the Delaware River.

While we are not able to find predictive models for water temperature in Delaware Bay or the Delaware River, given the geographic proximity of these waters to the Northeast, we assume that predictions would be similar. For marine waters, the model projections are for an increase of somewhere between 3-4°C by 2100 and a pH drop of 0.3-0.4 units by 2100 (Frumhoff et al. 2007). Assuming that these predictions also apply to the action area, one could anticipate similar conditions in the action area over that same time period.

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

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on sea turtles, shortnose and Atlantic sturgeon; however, we have considered the available information to consider likely impacts to sturgeon and sea turtles 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.

Over time, the most likely effect to shortnose and Atlantic sturgeon would be if sea level rise was great enough to consistently shift the salt wedge far enough north which would restrict the range of juvenile sturgeon and may affect the development of these life stages. Upstream shifts in spawning or rearing habitat in the Delaware River are not limited by any impassable falls or manmade barriers. Habitat that is suitable for spawning is known to be present upstream of the areas that are thought to be used by shortnose and Atlantic sturgeon suggesting that there may be some capacity for spawning to shift further upstream to remain ahead of the saltwedge. Based on predicted upriver shifts in the saltwedge, areas where Atlantic sturgeon currently spawn could, over time, become too saline to support spawning and rearing. Modeling conducted by the ACOE indicates that this is unlikely to occur before 2040 but modeling conducted by Collier (2011) suggests that by 2100 areas where spawning is thought to occur (rkm 120-150 and 170-190), may be too salty and spawning would need to shift further north. Given the availability of spawning habitat in the river, it is unlikely that the saltwedge would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. The available habitat for juvenile sturgeon could decrease over time; however, even if the saltwedge shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon because there would still be sufficient freshwater habitat available.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations through the area as sturgeon move throughout the river. There could be shifts in the timing of spawning; presumably, if water temperatures warm earlier in the spring, and water temperature is a primary spawning cue, spawning migrations and spawning events could occur earlier in the year. However, because spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of sturgeon through the action area. However, it seems most likely that spawning would shift earlier in the year.

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 seems 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 (Ziegweid *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. Shortnose sturgeon, have been documented in the lab to experience mortality at temperatures of 33.7°C (92.66°F) or greater and are thought to experience stress at temperatures above 28°C. For purposes of considering thermal tolerances, we consider Atlantic sturgeon to be a reasonable surrogate for shortnose sturgeon given similar geographic distribution and known biological similarities.

Mean monthly ambient temperatures in the Delaware estuary range from 11-27°C from April – November, with temperatures lower than 11°C from December-March. No estimates for any predicted rise in water temperatures for the Delaware River is available. As explained above, based upon predictions for nearby areas, we assume an increase in water temperature in the action area of 3-4°C by 2100. Assuming that this increase is gradual over time, we would expect an increase of approximately 1°C between now and 2046. This could result in temperatures approaching 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.

6.5 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). It is important to consider that in order for nesting to be successful in the mid-Atlantic, fall and winter temperatures need to be warm enough to support the successful rearing of eggs and sea temperatures must be warm enough for hatchlings not to die when they enter the water. 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. Therefore, it is unlikely that over the time period considered here, that there would be an increase in nesting activity in the action area or that hatchlings would be present in the action area.

7.0 EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR 402.02). Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). This Opinion examines the likely effects (direct and indirect) of the proposed action 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 and Hope Creek facilities as authorized by NRC pursuant to three licenses issued under the authority of the Atomic Energy Act. The NJPDES permit issued for Salem requires the completion of the annual IBMWP. This involves bottom trawl surveys, a beach seine survey, monitoring at fish ladder sites, and sampling at restored wetland sites. We consider the annual IBMWP, trawl surveys, beach seine surveys, and other activities required by the NJPDES permits to be interdependent activities as they are required only because of the continued operations of Salem and therefore have no independent utility apart from the continued operations of this facility. The IBMWP is a required component of the NJPDES permit issued for the operations of Salem, which has no independent utility from the NRC operating licenses. 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 proposed actions 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; and, incidental capture during the gillnet sampling required by the REMP and activities required by the Salem NJPDES permit.

7.1 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. 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.

7.1.1 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 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. 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. 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 shortnose sturgeon in the future at Salem 1, Salem 2 or HCGS. This conclusion is supported by the lack of any sturgeon eggs or larvae documented during entrainment monitoring at any of the intakes.

7.1.2 Entrainment of Atlantic sturgeon

The southern extent of the Atlantic sturgeon spawning area in the Delaware River is approximately RM 75 (RKM 120*)*, more than 25 RM 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. 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. This conclusion is supported by the lack of any sturgeon eggs or larvae documented during entrainment monitoring at any of the intakes.

7.1.3 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 either facility.

7. 2 Impingement of Atlantic sturgeon, Shortnose sturgeon and sea turtles – Hope Creek
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 ever 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.

7.3 Impingement of Atlantic sturgeon, shortnose sturgeon and sea turtles – Salem
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 or injury.

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. 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. 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.

PSEG carries out monitoring of impingement at the trash racks and the traveling screens. Trash racks are visually inspected every two hours 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 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 occurs 10 times per day, three days per week.

Impingement monitoring of the traveling screens has been carried out since May 1977. Impingement abundance samples were collected at the CWS and SWS intakes from May 1977 through December 1982. CWS samples were collected at least four times per day at six-hour intervals three days a week from May 1977 through September 1978. In September 1978, sampling frequency was increased to a minimum of 10 samples per day six days a week. In the spring of 1980, sampling frequency was reduced to four times a day, but remained at six days a week (PSEG, 1984).

Special impingement-related studies in addition to impingement monitoring studies also were performed. Studies were conducted from 1979 through February 1982 to quantify impingement collection efficiency. Studies of blueback herring, bay anchovy, white perch, weakfish, spot, and Atlantic croaker were conducted to determine the percentage of different size classes of fish that would not be collected by the screen washing and fish collection procedures (PSEG, 1984).

Studies of impingement mortality rates also were conducted from May 1977 through December 1982. Studies were conducted to estimate the percentage of impinged individuals that do not survive being impinged and washed from the intake screens (initial mortality) and the percentage that exhibit delayed mortality and do not survive for a longer period of at least two days (extended or latent mortality). Studies of initial mortality were conducted at a rate of three times per week until October 1978, after which samples were collected six times per week if impingement levels for target species exceeded predetermined levels. Initial mortality studies were conducted using the same counting pools as the abundance samples. Screen-wash water was diverted into the counting pool, samples were held for five min, the water was drained from the pool, and organisms were sorted as live, damaged, or dead. Each subset was identified to species and the total number and weight, maximum and minimum lengths, and length frequency distribution were recorded. Studies of latent mortality were conducted using the organisms classified as live or damaged in the studies of initial mortality. At the beginning of the latent mortality studies, only organisms classified as live were used, but damaged fish also were evaluated after November 1978. Two-day latent mortality studies were conducted at least weekly and entailed holding impinged organisms in aerated tanks for 48 hrs. Organisms were monitored continuously for the first 30 min, at hour intervals for the next four hours, and then at approximately 24-hr intervals. Control specimens also were collected with a seine and subjected to the same survival study (PSEG, 1984).

Impingement mortality was found to be seasonally variable and dependent on several environmental factors, including temperature and salinity. Initial and latent mortality rates were estimated on a monthly basis and summed to provide a total mortality rate (PSEG, 1984). Following the installation of modified Ristroph screens in 1995, updated impingement mortality studies were conducted (1995 and 1997-1999) to compare mortality rates at the new and old screens. Impingement mortality was demonstrated to be lower at the new screens.

PSEG submitted a 316(b) demonstration in 1999 as part of the application for NJPDES permit renewal (PSEG, 1999a). This demonstration assessed the effects of Salem's cooling water intake structure on the biological community of the Delaware Estuary (PSEG, 1999a). It focused on the same RS fish species as the earlier studies and added the blue crab. Impingement losses at Salem were estimated using impingement density (the number of impinged individuals collected divided by the total volume sampled, expressed as number/m3) and adjusting for impingement survival, collection efficiency, and recirculation factor. This result was then scaled by month using the water withdrawal rates and summed for the year to provide annual impingement losses for the facility.

Impingement monitoring was conducted annually in accordance with the BMWP from 1995 through 2002. In 2002, the IBMWP was developed to include improvements to the BMWP. These monitoring plans include provisions to quantify impingement and entrainment losses at Salem, as well as fish populations in the Delaware Estuary and the positive effects of the restoration program (PSEG, 2006c). The IBMWP has been in place since 2002. This requires a minimum of 10 impingement samples per day on at least three days per week.

The 1994 NJPDES permit required modifications to reduce impingement mortality. Improved Ristroph screens were installed at that time. Improved intake screen panels have a smooth mesh surface to allow impinged fish to more easily slide across the panels. The Ristroph buckets and screen-wash system were modified to increase survival of impinged organisms. The new buckets are constructed from smooth, nonmetallic materials and have several design elements that minimize turbulence inside the bucket, including a reshaped lower lip, mounting hardware located behind the screen mesh, a flow spoiler inside the bucket, and flap seals to prevent fish and debris from bypassing their respective troughs (PSEG, 1999a). The screen wash system was redesigned to provide an optimal spray pattern using low-pressure nozzles to more gently remove organisms from the screens prior to use of high pressure nozzles that remove debris. In addition, the maximum screen rotation speed was increased from 17.5 feet per minute (fpm) (5.3 m/min) to 35 fpm (11 m/min) to reduce the differential pressure across the screens during times of high debris loading. The screens are continuously rotated, and the rotation speed automatically adjusts as the pressure differential increases. The fish return trough was redesigned from the original rectangular trough to incorporate a custom formed fiberglass trough with radius rounded corners. The fish return system has a bi-directional flow that is coordinated with the tidal cycle to minimize re-impingement. The flow from the trough discharges to the downstream side of the cooling water intake system on the ebb tide and to the upstream side on the flood tide (PSEG, 1999a).

PSEG (PSEG, 1999a) reports estimates of impingement mortality with the modified screens were compared to estimates of mortality with the original screens to assess the reduction in impingement mortality due to the screen modifications. The assessment relied on data from impingement studies conducted in 1995, 1997, and 1998 and compared to data collected in 1978 through 1982 when impingement survival studies were conducted for the original screen configuration. A side-by-side comparison also was conducted in 1995 when only one of the units had the modified intake system. PSEG (PSEG, 1999a) concluded that results from the comparison of 1997 and 1998 data for the modified screens to data from 1978 to 1982 for the original screens indicate that the modified intake system generally provides reductions in impingement mortality.

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 only four Atlantic sturgeon have been observed during sampling at the traveling screens.

7.3.1 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 1976-2013, a total of 96 sea turtles have been removed from the Salem intakes, with 38 dead upon removal from the water or dying shortly after. Of these 96 sea turtles, there have been 68 loggerheads, 2 green and 26 Kemp’s ridleys (see Table 9). 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 - 2013, 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); only three Kemp’s ridleys have been impinged from 1993-2013.

Table 9. **Total number of sea turtles captured or impinged at Salem from 1976 – October 2013.** 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	0	**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**
TOTAL	**14**	**12**	**43**	**25**	**1**	**1**	**58**	**38**	**96**
% dead	**46%**		**37%**		**50%**		**40%**		

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 is thought 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 1993-2013, nine sea turtles (6 loggerheads, 3 Kemp's) have been removed from the Salem trash bars. Only two sea turtles were impinged at Salem between January 2002 and December 2013.

Given the low velocity at the intakes (less than 1 foot per second), it is thought that live sea turtles removed from the intakes were not likely stuck on the racks, but rather were 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).

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.

Of the 38 dead sea turtles, 26 were determined to have died prior to impingement (8 boat strikes, 6 illness or internal injury and 12 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. Five turtles (including the second Kemp's ridley impinged in 2013) had no apparent signs of trauma and necropsy did not reveal a cause of death.

Of the 25 dead loggerheads removed from the intakes, 19 were determined to have died prior to impingement. The remaining 6 (approximately 24%), 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 12 dead Kemp's ridleys, 7 (approximately 58%) 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 Kemps) 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). 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 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 recent 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 (0.9fps) 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 five turtles (3 loggerheads, 2 Kemp's) recovered from the intakes from 2000-2013, two loggerheads were severely decomposed, indicating that death occurred prior to impingement (the trash racks are inspected every 2 hours and cleaned at least three times a week). One Kemp's ridley was suffering from a serious head injury that occurred prior to impingement. 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. The most recent 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).

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; this change is thought to be largely facilitated by the seasonal removal of ice barriers which is thought to allow sea turtles to more readily escape from the intake area. From 1976-2013, an annual average of less than 2 loggerheads (average 1.8/year), less than 1 green (average 0.05/year) and less than 1 Kemp's ridley (0.68) 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, three 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. However, as the reduction in the number of sea turtles impinged at this facility has been sustained over the last 21 years, it is reasonable to anticipate that it is likely to continue through the extended operating period.

When predicting the number of 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. As the seasonal use of the ice barriers will continue in the future, we consider the impingement rate from 1993-2013 to be the best predictor of the likely impingement rate in the extended operating period. The mean number of sea turtles of each species captured or impinged at Salem from January 1993- December 1993 is: 0.14 Kemp's ridley/year, 0.29 loggerheads/year, and 0 greens/year.

The impingement rate calculated above is based on the operation of both Salem 1 and Salem 2. Records have not been maintained to determine which intakes the impinged turtles have been removed from. However, assuming that it is equally probable that a turtle 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 (0.15 loggerheads/year per Unit * 23 years) it is likely that no more than four 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, it is likely that no more than five loggerheads (0.15 loggerheads per unit per year * 27 years) would be impinged at the Salem Unit 2 intakes between now and the expiration of the extended operating license.

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 these species may be impinged in the future. However, given the low rate of impingement in the past (2 individuals, 1976-2013), 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 duration of the operating licenses.

Given the low rate of impingement of Kemp's ridleys from 1993-2013 (0.14 Kemp's ridley/year), we expect that the rate of impingement in the future would be very low. As such, we expect that no more than two Kemp's ridley sea turtle will be impinged or captured at Salem 1 (0.07 Kemp's per unit per year * 23 years) and no more than 2 Kemp's ridleys (0.07 Kemp's per unit per year * 27 years) will be impinged or captured at Salem 2 over the 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 1993-2013 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 nine 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 six of these turtles will be dead with no more than two (i.e., 21% of 6) of those deaths due to drowning at the trash bars. The other four dead loggerheads removed from the intakes are likely to have been killed prior 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.

Existing monitoring data (1993-2013; 3 Kemp's with 1 alive, 1 with massive pre-impingement head injury that would have been fatal, and 1 with no apparent cause of death and presumed to die due to drowning) indicates that 67% 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 50% of mortalities attributable to drowning at the intakes. We expect the impingement of four Kemp's ridleys between now and when the operating licenses expire. Using the past mortality rates, we expect three of these turtles to be dead with no more than two of those deaths due to impingement at the intakes.

7.3.2 Impingement of Sturgeon – Salem 1 and 2

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. 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.

A few 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.

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).

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 Ucrit 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.

7.3.2.1 Impingement of Shortnose sturgeon

Between 1977 and the end of 2013, 25 shortnose sturgeon have been removed from the Salem intakes (see Table 10). All of these fish have been observed at the trash racks. No shortnose sturgeon have been observed during impingement monitoring at the traveling screens.

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 24 impinged shortnose sturgeon ranged from 65-84cm, with an average length of approximately 72cm.

7.3.2.1.1 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 shortnose sturgeon at the trash racks, 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 or stressed and, therefore, unable to avoid the current caused by the facility’s water intake and swim away from the trash racks.

Table 10. Shortnose sturgeon removed from the Salem trash bars, 1977-2013.

Date	Length (total, mm)	Length (FL, mm)	Condition
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
5/6/61998	~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	
TOTAL	**25**		**Total Dead: 20 (11 determined dead prior to impingement)**	**Total alive: 5**

Of the 25 shortnose sturgeon removed from the Salem trash bars (see Table 10), five 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.

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, 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.

Fifteen sturgeon were dead upon removal from the intakes. Nine 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 five 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, twenty-percent (5 of 25) 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. The remaining 80% (20 of 25) were dead or dying. Of the dead or dying fish, 50% (10 of 20) 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 ten 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 50% of the shortnose sturgeon (10 of 20 fish) removed from the intakes impingement was a factor in their death.

Predicted Future Impingement of Shortnose sturgeon – Trash Racks
From 1976-2013, an average of less than one shortnose sturgeon per year has been removed from the Salem trash racks (average of 0.66/year). We have considered whether the seasonal removal of the ice barriers (beginning in 1993) would have affected the likelihood of impingement of shortnose sturgeon. Prior to 1993, the impingement rate was 0.47 fish/year (8 in 17 years). The rate for 1993-2013 was 0.81 fish/year (17 in 21 years). The ice barriers are present near the water surface. They are thought to affect sea turtles as they may affect their ability to surface for air or may cause them to become disoriented when above water between the ice barrier and the trash rack. Because shortnose sturgeon are benthic fish that remain below the water, the ice barriers are not likely to affect shortnose sturgeon. Therefore, 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 mark-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 1993-2013 is an artifact of the low number of impingements and annual variability. For example, in the 38 years of monitoring, interactions have been recorded in only 14 years with the number of interactions ranging from 1 to 4 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 1991-2013 (22 shortnose sturgeon in 23 years; average 0.96/year) compared to 1976-1990 (3 shortnose sturgeon in 16 years; average 0.19/year). Based on the available information, the impingement rate for 1991-2013 (approximately 1 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 0-4 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 23 years. The impingement rate calculated above (1 shortnose sturgeon/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. (0.5 fish/unit/year) it is likely that no more than 12 shortnose 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 27 years, it is likely that no more than 14 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 (1976-2013) indicate that approximately 80% of the shortnose sturgeon removed from the intakes will be dead or dying and that 50% of these mortalities may be attributable to impingement at the trash racks. As noted above, we expect a total of 12 shortnose sturgeon to be impinged at the Salem 1 trash racks between now and license expiration in 2036. We expect ten 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 14 shortnose sturgeon prior to license expiration in 2040. We expect 12 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.

7.3.2.1.2 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.

7.3.2.2 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, four Atlantic sturgeon have been observed during impingement monitoring at the traveling screens; one in 2006, one in 2007, one in 2011, and one in 2013 (Strait, PSEG, Personal Communication 2014). From February 2011 through December 2013, 23 Atlantic sturgeon were removed from the trash bars (see Table 11).

Table 11. Impingement of Atlantic sturgeon at the Salem trash bars February 2011 – December 2013.

Date Found	Length	Condition
4/20/2011	NA	Live
4/24/2011	NA	Live
9/7/2011	180mm TL	Live
Nov 14, 2012	425mm FL; 485mm TL	Dead; no signs of injury or decomposition
Nov 30, 2012	522mm FL; 593mm TL	Live; abrasions on fins and scutes
Jan 16, 2013	446mm FL; 522mm TL	Live
Feb 11, 2013	542mm FL; 643mm TL	Live; minor injuries near tail that were beginning to heal
Feb 19, 2013	665mm FL; >760mm TL	Live; minor abrasions
Mar 13, 2013	406mm FL; 446mm TL	Live
Mar 15, 2013	473mm FL; 546mm TL	Live
Mar 18, 2013	449mm FL; 518mm TL	Live
Mar 20, 2013	660mm FL; 742mm TL	Live; injured - large abrasion in front of tail
Mar 25, 2013	677mm FL; 784mm TL	Live; injured - large, deep gash in front of tail
April 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
August 7, 2013	910mm FL; 1067mm TL	Dead; DENRC confirmed died prior to impingement
October 28, 2013	611mm FL; 713mm TL	Dead. Extensive decomposition. Determined to have died prior to impingement
October 28, 2013	NA	Dead. Extensive decomposition. Determined to have died prior to impingement.
Dec 13 2013	570mm TL	Live
Dec 20 2013	570mm TL	Live
Dec 26 2013	625mm FL; 732mm TL	Live
Dec 26 2013	548mm FL; 621mm TL	Dead – fresh; no signs of injury or decomposition
Dec 26 2013	1900mm FL; 2100mm TL	Live

Dec 27 2013	595mm FL; 679mm TL	Dead-partly decomposed; DENRC confirmed died prior to impingement	
Total: 23		**Total Alive: 16**	**Total Dead: 7(5 died prior to impingement)**

7.3.2.2.1 Predicted Future Impingement on the Trash Bars

Reporting of Atlantic sturgeon removed from the trash bars has been occurring for approximately three years (February 2011 – December 2013). During this time, 23 Atlantic sturgeon have been removed from the trash bars (three in 2011, two in 2012, and 18 in 2013 (three of these are suspected to be the same fish)). There is likely to be annual variability in the number of impingements, as is seen for shortnose sturgeon. The short time period of available data makes predicting future impingement more difficult. However, assuming that the 2011-2013 period is representative of typical impingement rates, we would predict an average of 8 impingements per year, with a range of 2 – 18 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 23 years. The average impingement rate calculated above (8 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 (4.0 fish/unit/year * 23 years) it is likely that no more than 92 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 27 years, it is likely that no more than 108 Atlantic sturgeon would be impinged at the Salem Unit 2 intakes between now and the expiration of the extended operating license.

Sixteen of the 23 Atlantic sturgeon removed from the Salem intakes were alive (approximately 70%). With the exception of one live fish that had a significant laceration, the other live fish exhibited minor injuries (abrasions), 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 seven dead Atlantic sturgeon, five were determined to have died prior to impingement (due to traumatic injury). The other two fish (29% of the dead Atlantic sturgeon) had no signs of decomposition or injury 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 can not 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 – 2013 information to predict future conditions, we expect 30% of the Atlantic sturgeon removed from the trash racks will be dead, with impingement causing or contributing to the death of 29% of those dead fish.

As calculated above, we expect a total of 92 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 28 of these fish to be dead, with impingement causing or contributing to the death of 8 of these fish. At Unit 2, we expect the impingement of 108 Atlantic sturgeon prior to license expiration in 2040, with 33 of these fish being removed from the water dead and impingement causing or contributing to the death of 10 of those fish.

All but one of the Atlantic sturgeon removed from the trash racks between 2011 and 2013 was in the 442-666 mm 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 has not yet been completed. One adult Atlantic sturgeon was removed from the racks (alive) in December 2013. This occurrence is considered highly unusual as we do not expect adult Atlantic sturgeon to be in the Delaware River during December (see for example, Breece et al. 2013 which indicate that acoustically tagged adults are only present in the river in April, May and June). Using the 23 fish recorded from 2011-2013 to predict future impingement, we would expect 96% of impinged sturgeon to be juveniles (22/23 from 2011-2013) and 4% (1/23 from 2011-2013) to be a 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 mixed-stock analysis we expect subadult and adult Atlantic sturgeon in the action area to originate from all five DPSs at the following frequencies: NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%.

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

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

Table 12. 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.

7.3.2.2.2 Atlantic sturgeon impingement – Traveling Screens

The intensity of monitoring at the traveling screens has varied over time. From 1976-2013, only four Atlantic sturgeon have been observed during impingement sampling. All 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 41cm 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 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). This fish was 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 demonstrated 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%. 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%.

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, three 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 16 years (i.e., 1997-2013) 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. Three Atlantic sturgeon have been collected in 17 years of routine sampling. This equates to 0.18 sturgeon/year for 1.5% sampling which can be extrapolated to a total of 12 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 23 years. The impingement rate calculated above (12 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, (6 fish/year) it is likely that no more than 138 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 27 years, it is likely that no more than 162 Atlantic sturgeon would be impinged at the Salem Unit 2 traveling screens between now and the expiration of the extended operating license.

All four Atlantic sturgeon observed during impingement sampling were alive. 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 all four 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 four 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 12 Atlantic sturgeon impinged on the traveling screens each year, we would anticipate that no more than 1 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 138

Atlantic sturgeon at the traveling screens, we would anticipate no more than 12 of those fish to be injured or killed. For Salem 2, where we anticipate the impingement of 162 Atlantic sturgeon, we would anticipate the injury or mortality of no more than 14 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	138 (12 injury or mortality)	162 (14 injury or mortality)	300 (26 dead or injured)

7.4 Effects on Prey – Impingement and Entrainment

7.4.1 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 were submitted to NJDEP on an annual basis from 1995 through the present (PSEG, 1996; PSEG,1997; PSEG, 1998; PSEG,1999b; 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).

7.4.1.1 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.

7.4.1.2 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 and discountable.

7.4.2 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 and discountable as explained for Salem above.

7.5 Discharge of Heated Effluent

7.5.1 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).

7.5.1.1 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 outside of which the DRBC temperature-increase standards shall not be exceeded. 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 2006, PSEG submitted an NJPDES permit renewal application (PSEG, 2006c in NRC 2011) with a request for renewal of the Section 316(a) variance. The variance renewal request summarizes studies that were conducted at the Salem plant, including the 1999 Section 316(a) Demonstration, and evaluates 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. In 2006, NJDEP administratively continued Salem's NJPDES permit (NJ0005622), including the Section 316(a) variance. No timeframe for issuance of the new NJPDES permit has been determined.

7.5.1.2 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 4 through 7 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 13 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 13. 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 4. Surface ΔT isotherms for Salem's longest plume at the end of flood on May 31, 1998 (Source: NRC 2011).

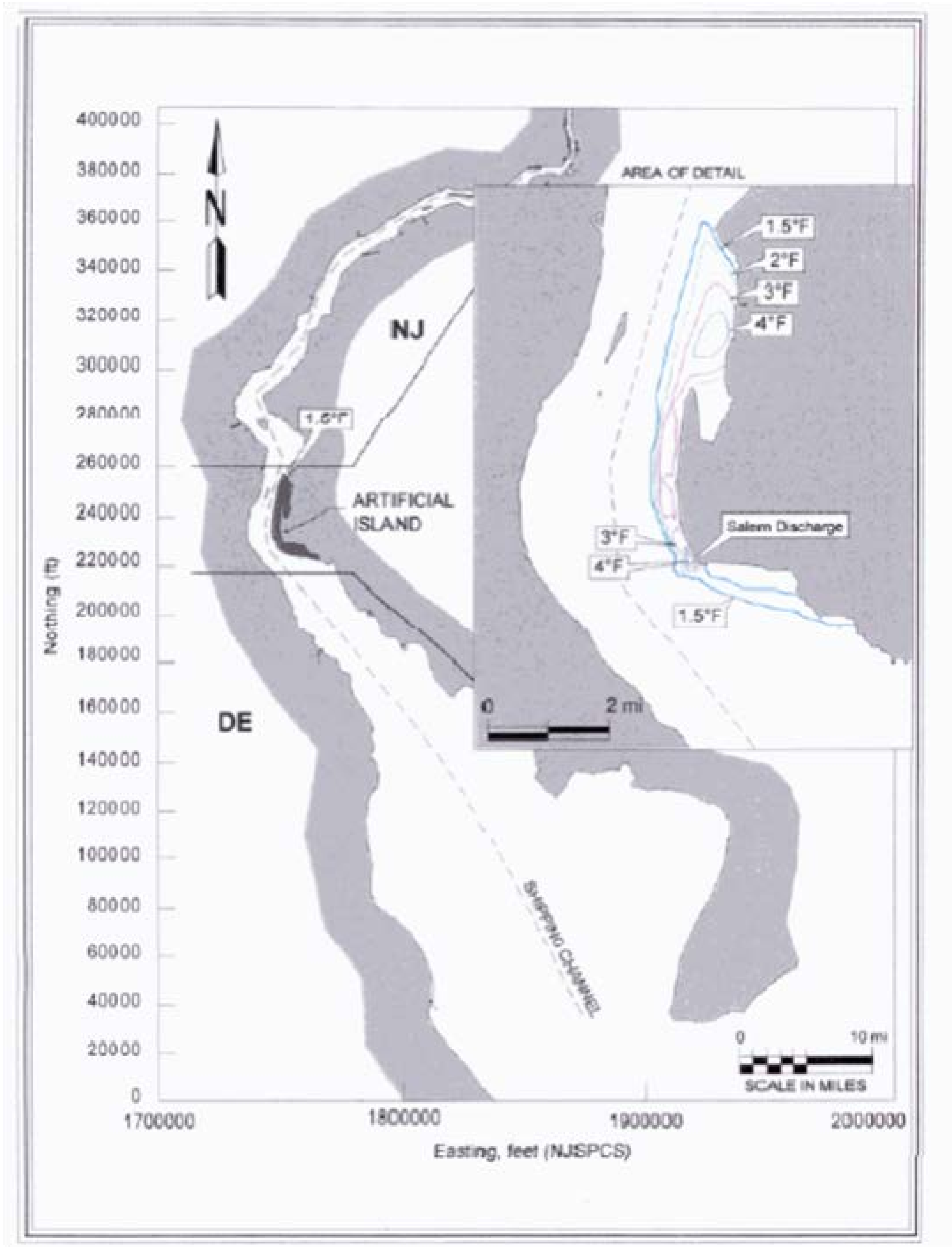


Figure 5. Surface ΔT isotherms for Salem at the end of ebb on June 2, 1998 (Source: NRC 2011).

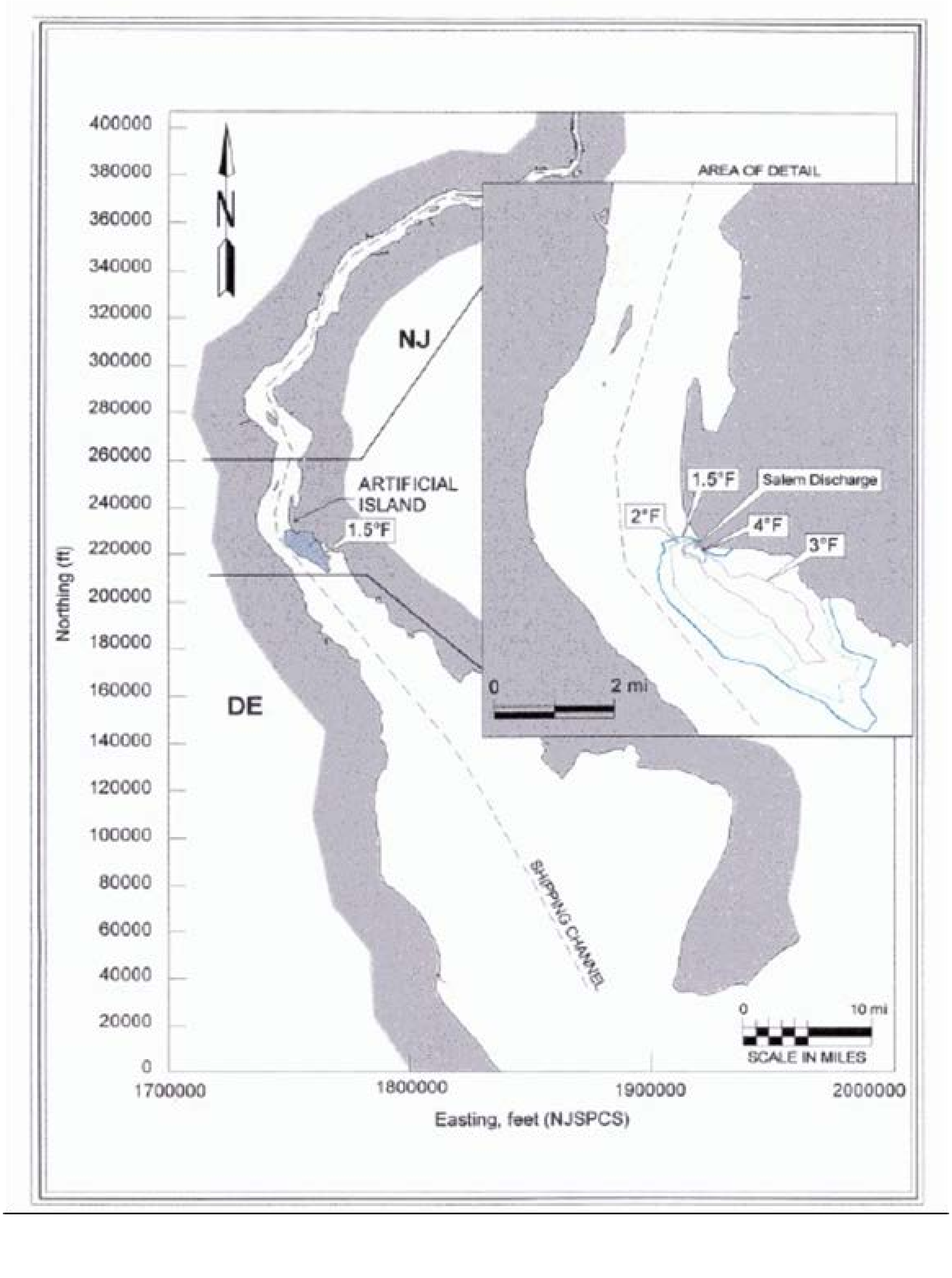


Figure 6. Bottom ΔT isotherms for Salem's longest plume at the end of the flood on May 31, 1998 (Source: NRC 2011).

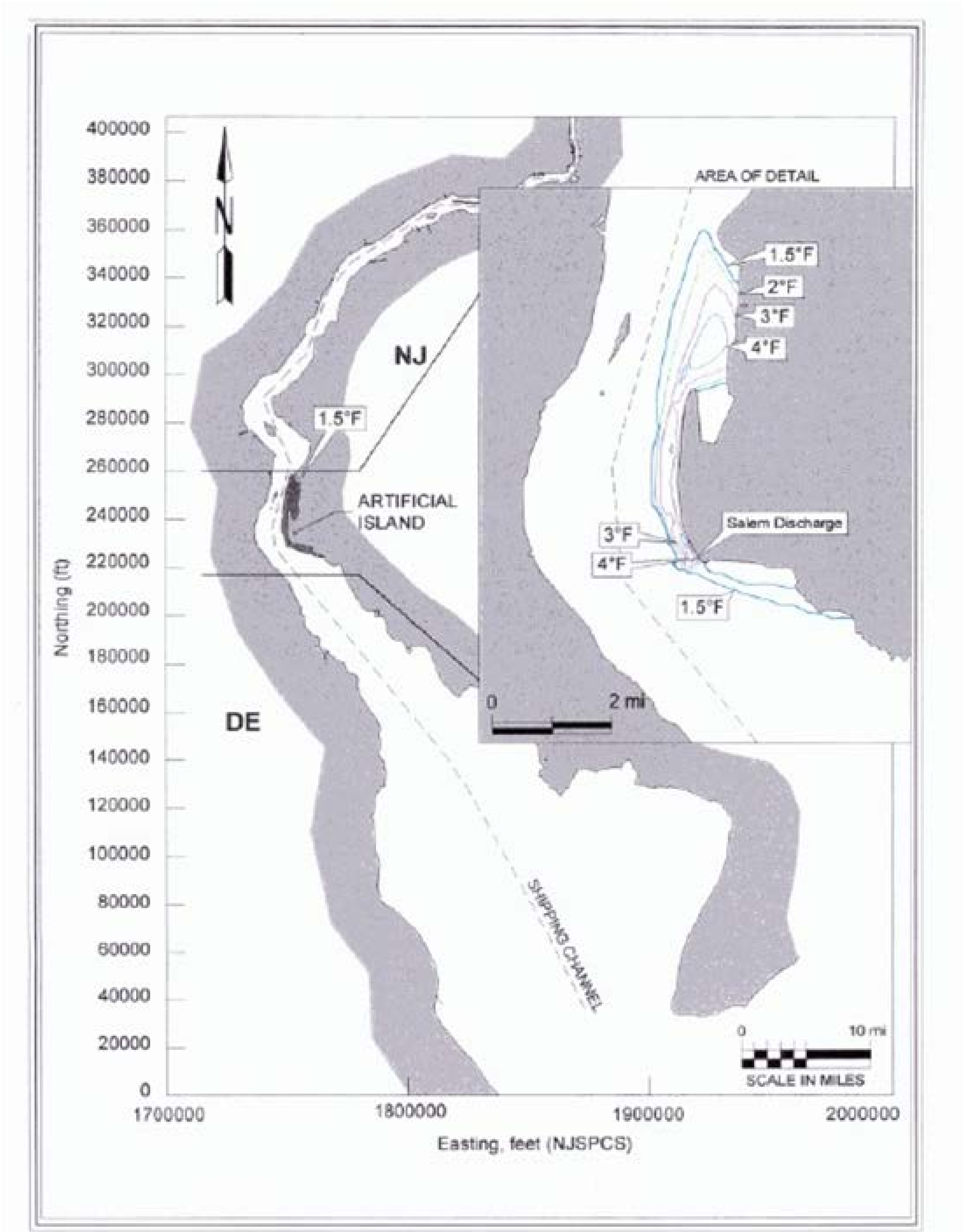
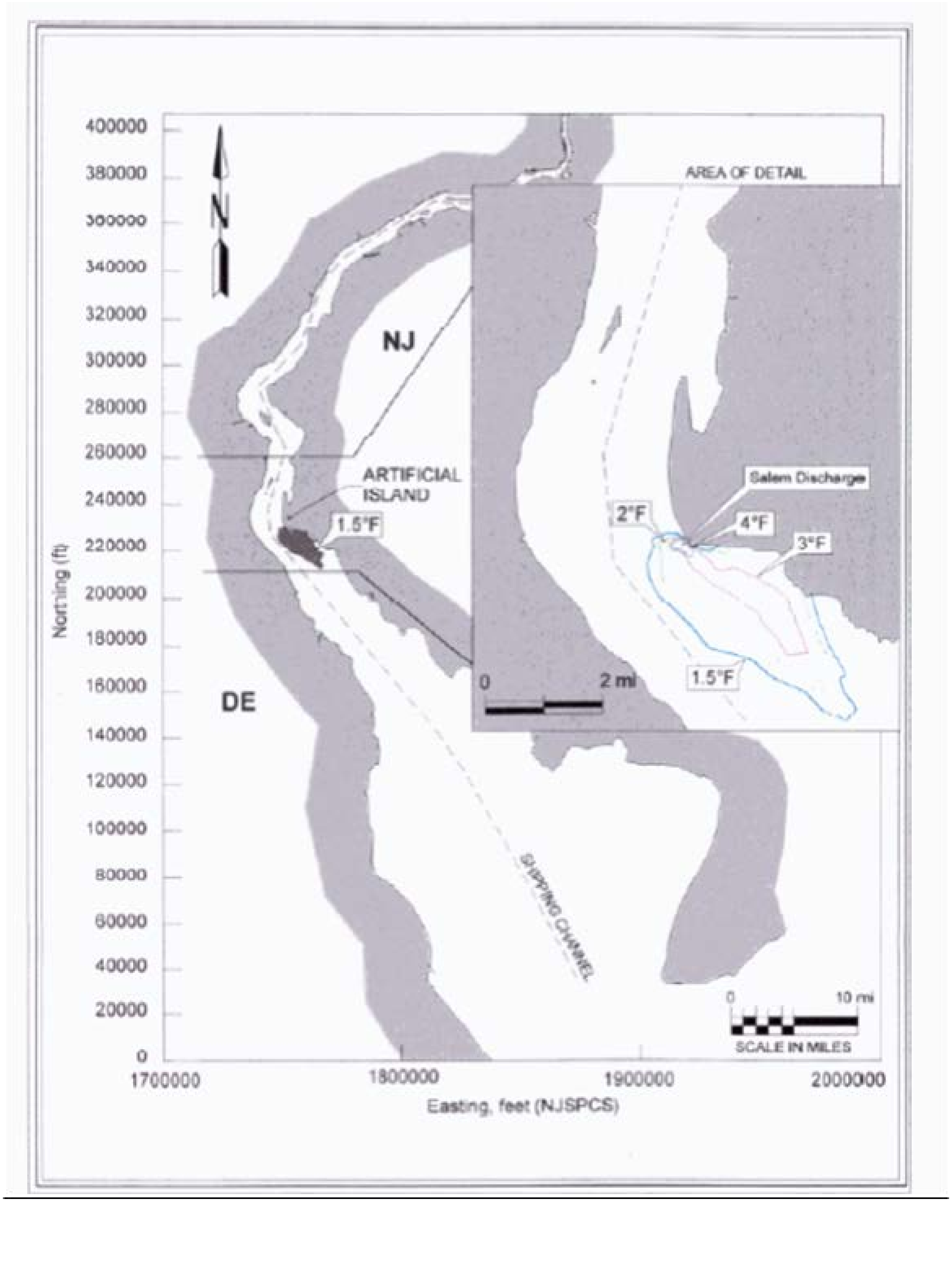


Figure 7. Bottom ΔT isotherms for Salem at the end of the ebb on June 2, 1998 (Source: NRC 2011).



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).

7.5.1.3 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).

7.5.1.4 Thermal Tolerances – Atlantic sturgeon

Limited information on the thermal tolerances of Atlantic 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 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 (Ziegweid *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 7.5.1.3 above.

7.5.1.5 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. 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 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 or higher. However, given that fish are known to avoid areas with unsuitable conditions and that 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 and what is known about fish behavior generally, it is likely that shortnose and Atlantic sturgeon will avoid the area where temperatures are greater than tolerable. As such, it is extremely unlikely that any shortnose or Atlantic sturgeon would remain within the area where surface temperatures are elevated to 33.7°C and be exposed to potentially lethal temperatures. This risk is further reduced by the limited amount of time shortnose sturgeon spend near the surface, the small area where such high temperatures will be experienced and the gradient of warm temperatures extending from the outfall; shortnose sturgeon are likely to begin avoiding areas with temperatures greater than 28°C and are unlikely to remain within the heated surface waters to swim towards the outfall and be exposed to temperatures which could result in mortality. Near the bottom where shortnose and Atlantic sturgeon most often occur, water temperatures will not be elevated more than 4°C, creating no risk of exposure to temperatures likely to be lethal near the bottom of the river.

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). Depending on ambient temperatures, the surface area with temperatures greater than 28°C 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 as benthic oriented fish which results in limited occurrence near the water surface. Any surfacing sturgeon are likely to avoid near surface waters with temperatures greater than 28°C and reactions to this elevated temperature is expected to be limited to swimming away from the plume by traveling deeper in the water column or swimming around the plume. Given the extremely small percentage of the estuary that may have temperatures elevated above 28°C (no more than 0.77%), it is extremely unlikely that these minor changes in behavior 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.

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 extremely small percentage of the estuary that may have temperatures elevated above 28°C (no more than 0.17%), 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, 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.

7.5.1.6 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 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 and discountable.

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 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.

7.5.1.7 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 in areas where their swimming ability would allow them to be exposed. 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 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 the prey of shortnose sturgeon and Atlantic sturgeon, as well as loggerhead, Kemp's ridley, and green sea turtles are impacted insignificantly, if at all, by the thermal discharge from Salem.

7.5.2 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 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). There are no HDAs associated with the Hope Creek discharge; thus, the effluent from Hope Creek must not cause any increases in temperature that cause the river temperature to be greater than 30°C; thus, there is no potential for stress to sea turtles or mortality of shortnose sturgeon. 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 tempearatures 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, all effects are anticipated to be insignificant and discountable as explained for Salem above.

7.6 Other Pollutants Discharged from the Facility

Pollutants discharged from Salem are regulated under the facility's NJPDES permit (MA0003557; NJDEP 2001). Pollutants discharged from Hope Creek are regulated under NJPDES permit NJ, reissued in 2011. 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, 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 listed species. Therefore, the effect of the discharge of these pollutants at levels that are less that 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.

7.7 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 46 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 33 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 33 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 4.7.2), 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 45 years of sampling, we do not expect any future capture of sea turtles during REMP sampling.

7.8 Radiological Impacts

We have reviewed the information presented in the FEIS and the most recent reports of the Radiological Evaluation Monitoring Report ((REMP) PSEG 2008, 2009, 2010, 2011 and 2012) 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 listed species and their prey from radionuclides to be insignificant and discountable.

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 or sea turtles have been exposed to tritium resulting from the Spent Fuel Pool leak.

7.9 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 consequences 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 are discountable. 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.

7.10 Interrelated or Interdependent Activities

7.10.1 Improved Biological Monitoring Work Plan required by the NJPDES permit

The IBMWP, approved by NJDEP in 2006, requires the completion of several tasks, including: abundance monitoring for adult and juvenile passage of river herring as well as stocking in connection with the eight fish ladder sites; improved impingement and entrainment monitoring; review and discussion as to the appropriateness of Atlantic silverside as a representative important species; improved bay-wide abundance monitoring; continued detrital production monitoring; and, continued study of fish utilization of restored wetlands. Here, we consider the effects of the implementation of these activities on NMFS listed species.

7.10.1 Monitoring Restored Wetlands

7.10.1.1 Vegetative Cover and Geomorphology Mapping

Vegetative cover at the wetland restoration sites will be monitored using a combination of aerial photography and field sampling methodologies. Quantitative field sampling of the vascular vegetation will be conducted during the peak growing season, in quadrats located along fixed transects at each study site. The sampling will consist of percent cover, vegetation height, and calculation of above ground biomass for the vascular plants. No effects to Atlantic or shortnose sturgeon or sea turtles are anticipated to result from these survey efforts. This is because aerial photography will not interact with these species. No effects to these species will result from the field sampling because none of these species occur in the wetlands where sampling will take place.

7.10.1.2 Fish Utilization of Restored Wetlands

Studies of habitat utilization by finfish will be conducted in representative wetland restoration sites and the results will be compared to those from reference marshes. Sampling will be conducted in one site representative of each type of restoration (formerly diked or formerly

Phragmites-dominated) plus the comparable reference marsh for that restoration type (Moores Beach West or Mad Horse Creek, respectively) until all sites of that restoration type meet the final vegetative success criteria. The specified representative wetland restoration sites and reference marshes will be sampled monthly from late spring through mid-fall.

Two sampling methods will be employed, trawls and block nets. At each site, two marsh creeks will be sampled at three locations with an otter trawl: upper tidal creek, lower tidal creek and creek mouth. At each of the three stations, three 2-minute tows will be conducted. Block nets will also be deployed at two locations on each site to sample intertidal creeks draining into one of the creeks sampled with the trawl. Block net sampling will occur during daylight ebb tides. All finfish will be identified to the lowest practical taxon and counted. The length of the target species will be measured in a subsample taken from each collection. Data on water temperature, dissolved oxygen, salinity, and turbidity also will be recorded at each sampling location.

No effects to shortnose sturgeon, Atlantic sturgeon or sea turtles will result from the field sampling because none of these species occur in the wetlands where sampling will take place.

7.10.1.3 Adult and Juvenile River Herring Monitoring at Fish Ladder Sites

Use of the eight installed fish ladders by blueback herring and alewife will be monitored to document adult utilization of the fish ladders in all years of the permit period. In addition, two new fish ladders located in New Jersey and two new fish ladders located in Delaware will be installed during the permit period. Monitoring upstream migration at these new sites will begin in the spring immediately following installation.

In impoundments where a target adult density of 5 fish per acre will not be achieved by adult passage alone, adult passage through the fish ladder will be supplemented with the trapping and transfer ("stocking") of adult river herring from other nearby source waters. The availability of adult river herring for stocking, and uncertainty concerning the size and duration of annual spawning runs, may impact the ability to achieve the 5 adult fish per acre target in each impoundment. PSEG will continue to conduct supplemental stocking of individual impoundments each year, when adequate numbers of adult river herring are available from other nearby water sources, until the target of 5 adult fish per acre is achieved in each specific impoundment. Impoundments where the fish ladders have passed at least 5 adult river herring per acre for two consecutive years will not be stocked in subsequent years.

Juvenile river herring production will be monitored by electrofishing once per month from September through November in each year of the permit period for those impoundments in which juvenile production has not yet been documented.

No effects to shortnose sturgeon, Atlantic sturgeon or sea turtles will result from the monitoring associated with the fish ladder installation because none of these species occur in the tributary impoundments where sampling will take place.

7.10.2 River Abundance Monitoring

7.10.2.1 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 1995-2013, 18 Atlantic sturgeon and 13 shortnose sturgeon have been captured during PSEG's NJPDES Permit-required baywide bottom trawl monitoring program (Table 14). 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 14. 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	1	0
2013	1	1
Total	**18**	**13**

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. In a typical year, no more than one Atlantic sturgeon and one shortnose sturgeon are captured during the trawl program. Outside of the 2002-2004 period, captures of Atlantic and shortnose sturgeon averaged 0.38 and 0.31 fish per year, respectively.

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 (0.38 Atlantic sturgeon/year and 0.31/shortnose sturgeon/year), we expect the capture of 11 Atlantic sturgeon and 9 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 4.7.2), we anticipate the 11 Atlantic sturgeon to consist of 6 individuals from the New York Bight DPS, 2 from the Chesapeake Bay DPS, and 3 from the South Atlantic, 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 eight long-term trawl surveys carried out by Northeast States (ME/NH, MA, CT, NJ, DE, VA) that capture sturgeon, including two surveys that occur in the Delaware River. These surveys have collectively operated for thousands of hours with some dating back as far as the 1960s. A total of nearly 900 Atlantic and shortnose sturgeon have been captured during these surveys, with no recorded injuries or mortalities. All of these surveys operate with tow times of thirty minutes or less. Similarly, the NEFSC surveys have recorded the capture of 110 Atlantic sturgeon since 1972; the NEAMAP survey has captured 102 Atlantic sturgeon since 2007. To date, there have been no recorded injuries or mortalities. In the Hudson River, a trawl survey that incidentally captures shortnose and Atlantic sturgeon has been ongoing since the late 1970s. To date, no injuries or mortalities of any sturgeon have been recorded. Based on this information, we do not anticipate the injury or mortality of any shortnose or Atlantic sturgeon captured in the trawl operating for the IBMWP 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 (1979-2013) is an average of 0.18 sea turtles per year (6 captures in 34 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 (27 years), we anticipate the capture of five 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 4 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.

7.10.2.2 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.

No sea turtles or shortnose sturgeon have been encountered during past beach seine surveys. One Atlantic sturgeon has been captured.

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 also 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. 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 sturgeon. This is consistent with the low number of encounters that have occurred in the study to date. 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 shortnose sturgeon are expected to be able to rapidly recover and resume their normal behaviors. 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.

7.10.3 Plant Effects Monitoring

7.10.3.1 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.

7.9.3.2 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 12 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.

7.11 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 6.0 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.

8.0 CUMULATIVE EFFECTS

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

Actions carried out or regulated by the States of New Jersey and Delaware within the action area that may affect 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. 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[9]. 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 6.0 and 7.0 above.

On May 25, 2010, PSEG filed an application with the NRC for construction and operation of a new generating facility, to consist of up to two units with closed cycle cooling, at Artificial Island. A Draft EIS is scheduled for release by NRC in 2014. We provided comments to PSEG on the proposed Early Site Permit in 2010. No section 7 consultation has occurred to date, but we expect that any necessary consultation will occur prior to any NRC approval of the project. Because the construction and operation of a new nuclear reactor 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 this new facility is not dependent on the continued operation of Salem 1, Salem 2 or HCGS, it cannot be considered an interrelated or interdependent action.

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[9] 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."

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

9.0 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, and loggerhead, Kemp's ridley and green sea turtles. We anticipate the mortality of a green, loggerhead and Kemp's ridley sea turtles, shortnose sturgeon, and Atlantic sturgeon. Mortality will occur as a result of impingement at Salem. 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). 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 and discountable. 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 action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of the listed species that will be adversely affected by the action. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of 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 considers whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the federal Endangered Species Act.

9.1 Shortnose sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard 1996, 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 1996). The species as a whole is considered to be stable.

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

While no reliable estimate of the size of either the shortnose sturgeon population in the Northeastern US or of the species throughout its range exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of some populations, such as that in the Chesapeake Bay, 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 and in-water construction activities. It is difficult to quantify the number of shortnose sturgeon that may be killed in the Delaware River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions, we obtain some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Delaware River each year, with little if any mortality. With the exception of five shortnose sturgeon observed during dredging activities in Philadelphia to Trenton reach of the Delaware River (outside of the action area for this consultation) in the 1990s, we have no reports of interactions or mortalities of shortnose sturgeon in the Delaware River resulting from dredging or other in-water construction activities. NMFS also has 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 thought to be less now than they were in the past. Despite these ongoing threats, the Delaware River population of shortnose sturgeon is stable at high numbers. Over the life of the action, shortnose sturgeon in the Delaware River will continue to experience anthropogenic and natural sources of mortality. However, we are not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Delaware River population. If the salt line shifts further upstream as is predicted in climate change modeling, the range of juvenile shortnose sturgeon is likely to be restricted. However, because there is no barrier to upstream movement it is not clear if this will impact the stability of the Delaware River population of shortnose sturgeon; we do not anticipate changes in distribution or abundance of shortnose sturgeon in the river due to climate change in the time period considered in this Opinion. As such, NMFS expects 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 26 shortnose sturgeon are likely to be captured or impinged while Salem 1 and 2 continue to operate (12 at Salem 1 and 14 at Salem 2). We anticipate that four of the shortnose sturgeon will be removed from the water alive and 22 will be dead. Of the 22 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 11 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 9 shortnose sturgeon during the bottom trawl survey and the non-lethal capture of 1 shortnose of Atlantic sturgeon during the beach seine survey to be carried out pursuant to the IBMWP 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.. We determined that all other effects to this species of the actions considered in this Opinion would be insignificant and discountable.

Live sturgeon captured at the facility or during the bottom trawl survey, beach seine or REMP gillnet sampling may have minor injuries; 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 there are not anticipated to be any population level impacts over the course of the action.

Existing monitoring data indicates that of the 22 dead shortnose sturgeon we expect to be removed from the Salem intakes, 11 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 a 27-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 27-year period, will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect shortnose sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent shortnose sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter (i.e., it will not increase the risk of extinction faced by this species). This is the case because: given that: (1) the population trend of shortnose sturgeon in the Delaware River is stable; (2) the 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 appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that 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 and discountable, 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. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

9.2 Atlantic sturgeon

In the "Effects of the Action" section above, we determined that 200 Atlantic sturgeon are likely to be captured or impinged at the trash racks while Salem 1 and 2 continue to operate (92 at Salem 1 and 108 at Salem 2). We anticipate that 139 of these Atlantic sturgeon will be removed from the water alive and 61will be dead. Of the 61 dead Atlantic sturgeon, we expect that a necropsy would indicate that impingement caused or contributed to the death of 18 of these sturgeon. The remaining dead sturgeon (43) are likely to have died prior to impingement. We also anticipate the non-lethal capture of 11 Atlantic sturgeon during the bottom trawl survey and 1 non-lethal capture during the beach seine survey; both surveys are carried out pursuant to the IBMWP 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 300 juvenile Delaware River origin New York Bight DPS Atlantic sturgeon at the traveling screens (138 at Salem 1 and 162 at Salem 2); we conservatively anticipate that up to 26 of these individuals may be injured or killed. All other effects of the continued operation of Salem 1, Salem 2 and Hope Creek will be insignificant and discountable.

9.2.1 New York Bight DPS

The NYB DPS is listed as endangered. 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. We expect that 58% of the subadult and Atlantic sturgeon in the action area will originate from the NYB DPS.

While Atlantic sturgeon occur in several rivers in the NYB DPS, recent spawning has only been documented in the Hudson and Delaware rivers. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 34,566 NYB DPS adults and subadults in the ocean (8,642 adults and 25,925 subadults). This estimate is the best available at this time and represents only a percentage of the total NYB DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. NYB origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

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 11 fish captured in the Delaware River for which genetic assignments are available, six were from the New York Bight DPS, with four originating from the Delaware River and two from the Hudson River. This suggest that within the Delaware River, the composition of New York Bight fish is approximately 2/3 Delaware and 1/3 Hudson. Thus, if a NYB subadult Atlantic sturgeon is killed, it could originate from the Delaware or Hudson River. All juvenile Atlantic sturgeon in the action area originate from the Delaware 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 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.

In the “Effects of the Action” section above, we determined that 192 juvenile NYB DPS Atlantic sturgeon are likely to be captured or impinged at the trash bars while Salem 1 and 2 continue to operate (88 at Salem 1 and 104 at Salem 2). We anticipate that 133 of these sturgeon will be removed from the water alive and 59 will be dead. Of the 59 dead Atlantic sturgeon, we expect that a necropsy would indicate that impingement was a cause or contributor to the death of 16 of these sturgeon. The remaining 43 dead sturgeon are likely to have died prior to impingement. Additionally, we anticipate the capture or impingement of six subadult or adult Atlantic sturgeon from the NYB DPS. We expect two of these subadults of adults would be dead, with impingement or collection causing or contributing to the death. We also anticipate the impingement or capture of 300 juvenile NYB DPS Atlantic sturgeon at the Salem 1 and 2 traveling screens (138 at Salem 1 and 162 at Salem 2). We anticipate that 26 of these sturgeon will be injured or killed. We also anticipate the non-lethal capture of 9 NYB DPS Atlantic sturgeon during the IBMWP bottom trawl survey and one Atlantic sturgeon during the beach seine survey (originating from any of the five DPSs) to be carried out pursuant to the IBMWP required by the NJPDES permit. We also anticipate the 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. We determined that all other effects of these actions on this species would be insignificant and discountable.

In total, we anticipate the continued operation of Salem 1 and 2 will result in the mortality of up to 44 NYB DPS Atlantic sturgeon (42 Delaware River origin juveniles, 2 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; 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 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 shortnose sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of shortnose 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 61 dead NYB DPS Atlantic sturgeon we expect to be removed from the Salem trash bars, 18 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 mortality of 42 juveniles and two subadult or adult Atlantic sturgeon from the NYB DPS over a 27 year period represents a very small percentage of the NYB DPS. We expect an average mortality rate of two juveniles per year at Salem. There is no estimate of the number of Delaware River juveniles. There are an estimated combined 34,566 NYB DPS subadults and adults. The total DPS population includes those individuals, plus all of the juveniles, young of the year and subadults that are not in the ocean. While the death of these 42 juvenile and 2 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 0.006% of the DPS on an annual basis and approximately 0.13% in total over the 27 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 two 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 any 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 two NYB DPS Atlantic sturgeon over a 27-year period, for a total of no more than 42 juveniles and 2 subadults or adulst, will not appreciably reduce 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 an 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 loss of these NYB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (6) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (7) the action will have no effect 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 appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where the NYB 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 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 not 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 2 individuals per year over a 27-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 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 and discountable. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. Because it will not reduce the likelihood that the Hudson or Delaware River population can recover, it will not reduce the likelihood that the NYB DPS as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2.2 Chesapeake Bay DPS

Subadults and adults originating from the CB DPS occur in the action area. The CB DPS is listed as threatened. We expect that 18% of the subadult and 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, recent spawning has only been documented in the James River. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 8,811 CB DPS adults and subadults in the ocean (2,203 adults and 6,608 subadults). This estimate is the best available at this time and represents only a percentage of the total CB DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. CB origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

In the "Effects of the Action" section above, we determined that of the 8 subadult or adult Atlantic sturgeon likely to be impinged or collected at the Salem 1 and 2 trash racks, two could originate from the Chesapeake Bay DPS. These fish could be dead or alive and the cause of death may be attributable to impingement. 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 2 CB DPS Atlantic sturgeon during the bottom trawl survey and 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. We determined that all other effects of these actions on this species would be insignificant and discountable. In total, we anticipate the activities considered here to result in the mortality of no more than 2 subadult Atlantic sturgeon originating from the CB DPS; these two 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; 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 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 shortnose sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of shortnose 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 two 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, 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.

We have determined that impingement will cause or contribute to the mortality of two subadult

CB DPS Atlantic sturgeon. The mortality of two subadult Atlantic sturgeon from the CB DPS over a 27 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 2 over a 27 year period) represent a very small percentage of the total number of subadults (0.03%).

While the death of two subadult CB DPS Atlantic sturgeon over the next 27 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 0.03% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the CB DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of 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 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. 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 increased sediment around the working dredge or in-water disposal site.

Based on the information provided above, the death of no more than two subadult CB DPS Atlantic sturgeon over 27-years, will not appreciably reduce the likelihood of survival of the CB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of two 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 effect on the distribution of the species throughout its range; and, (6) the action will have only an insignificant effect on individual foraging or sheltering CB DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the CB DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose 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 part 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 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 (two 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 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 and discountable 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 suspended sediment 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 CB DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the CB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2.3 South Atlantic DPS

Subadults and adults originating from the SA DPS occur in the action area. The SA DPS is listed as threatened. We expect that 17% of the subadult and adult Atlantic sturgeon in the action area will originate from the SA DPS. Most of these fish are expected to be subadults, with few adults from the SA DPS expected to be present in the Delaware River. No total population estimates are available for any river population or the SA DPS as a whole. As discussed in section 4.7, NMFS has estimated a total of 14,911 SA DPS adults and subadults in the ocean (3,728 adults and 11,183 subadults). This estimate is the best available at this time and represents only a percentage of the total SA DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. SA origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

In the “Effects of the Action” section above, we determined that up to 8 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 12); we expect two 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 1 SA DPS Atlantic sturgeon during the bottom trawl survey and one Atlantic sturgeon during the beach seine survey (originating from any of the 5 DPSs) to be carried out pursuant to the IBMWP required by the NJPDES permit. We also anticipate the capture of one Atlantic sturgeon during the REMP gillnet sampling; this fish could originate from any of the five DPSs. . We determined that all other effects of these actions on this species would be insignificant and discountable. In total, we anticipate the activities considered here will result in the mortality of no more than 2 subadult SA DPS Atlantic sturgeon over a 27-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; 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 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 shortnose sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of shortnose 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 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, 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.

We have determined that impingement will cause or contribute to the mortality of two 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 (two over a 27-year period) represents an extremely small percentage of the SA DPS. While the death of two subadult SA DPS Atlantic sturgeon over the next 27 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 0.01% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the SA DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of 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. 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 sediment around the working dredge or in-water disposal site.

Based on the information provided above, the death of no more than two subadult SA DPS Atlantic sturgeon over 27-years, will not appreciably reduce the likelihood of survival of the SA DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect SA DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of up to 2 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 loss of these subadult SA DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of SA DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have only an insignificant effect on individual foraging or sheltering SA DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose 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 two subadults from a population estimated to have more than11,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and discountable 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 appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

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

In the "Effects of the Action" section above, we determined that up to 8 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 2 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 1 GOM DPS Atlantic sturgeon during the bottom trawl survey and one Atlantic sturgeon during the beach seine survey (originating from any of the five DPSs) to be carried out pursuant to the IBMWP 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. We determined that all other effects of these actions on this species would be insignificant and discountable. 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; 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 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 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, 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.

We have determined that impingement will cause or contribute to the mortality of up to two subadult GOM DPS Atlantic sturgeon over the next 27 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 0.02% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the GOM DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of 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 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. 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 two subadult GOM DPS Atlantic sturgeon over 27-years, will not appreciably reduce the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of 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 an effect on the levels of genetic heterogeneity in the population; (4) the loss of these subadult GOM DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) 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 appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where the GOM 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 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 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 subadults 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 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 and discountable 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 suspended sediment 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 appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2.5 Carolina DPS

As explained in section 4.7, no Carolina DPS fish have been documented in the action area. This is based on genetic sampling of fish in the Delaware River (n=11 individuals) and sampling in Delaware coastal waters (n=105). However, Carolina DPS fish have been documented in Long Island Sound (0.5% of samples). Because Carolina fish would swim past Delaware Bay on their way to Long Island Sound, we considered the possibility that up to 0.5% of the subadult and adult Atlantic sturgeon in the action area would originate from the Carolina DPS.

No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 1,356 Carolina DPS adults and subadults in the ocean (339 adults and 1,017 subadults) between the Gulf of Maine and Cape Hatteras. This estimate is the best available at this time and represents only a percentage of the total Carolina (CA) DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. CA DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

In the “Effects of the Action” section above, we determined that up to 8 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 2 of 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 1 Carolina DPS Atlantic sturgeon during the bottom trawl survey and one Atlantic sturgeon during the beach seine survey (originating from any of the five DPSs) to be carried out pursuant to the IBMWP required by the NJPDES permit. We also anticipate the capture of 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. We determined that all other effects of these actions on this species would be insignificant and discountable. In total, we anticipate the activities considered here will result in the mortality of up to two subadult CA 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; 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 CA 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 shortnose sturgeon is also not likely to affect the distribution of Atlantic sturgeon in the action area or affect the distribution of shortnose 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 two dead CA 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 shortnose sturgeon in the action area or throughout their range.

We have determined that impingement will cause or contribute to the mortality of up to two subadult CA DPS Atlantic sturgeon. While the death of two subadult CA DPS Atlantic sturgeon over the next 27 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 0.09% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the CA DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of 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 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. 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 two subadult CA DPS Atlantic sturgeon over 27-years, will not appreciably reduce 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 two 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 an effect on the levels of genetic heterogeneity in the population; (4) the loss of these subadult CA 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 CA DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have only an insignificant effect on individual foraging or sheltering CA DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the CA DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose 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 part 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 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 two 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 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 and discountable 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 suspended sediment 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 appreciably reduce the likelihood that the CA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.3 Green sea turtles

Green sea turtles are listed as both threatened and endangered under the ESA. Breeding colony populations in Florida and on the Pacific Coast of Mexico are considered endangered while all others are considered threatened. Due to the inability to distinguish between these populations away from the nesting beach, for this Opinion, green sea turtles are considered endangered wherever they occur in U.S. waters. Green sea turtles are distributed circumglobally and can be found in the Pacific, Indian, and Atlantic Oceans as well as the Mediterranean Sea (NMFS and USFWS 1991; Seminoff 2004; NMFS and USFWS 2007c). As is also the case with the other sea turtle species, green sea turtles face numerous threats on land and in the water that affect the survival of all age classes.

A review of 32 Index Sites distributed globally revealed a 48% to 67% decline in the number of mature females nesting annually over the last three generations (Seminoff 2004). For example, in the eastern Pacific, the main nesting sites for the green sea turtle are located in Michoacan, Mexico, and in the Galapagos Islands, Ecuador, where the number of nesting females exceeds 1,000 females per year at each site (NMFS and USFWS 2007c). Historically, however, greater than 20,000 females per year are believed to have nested in Michoacan alone (Cliffton *et al.* 1982; NMFS and USFWS 2007c). However, the decline is not consistent across all green sea turtle nesting areas. Increases in the number of nests counted and, presumably, the numbers of mature females laying nests were recorded for several areas (Seminoff 2004; NMFS and USFWS 2007c). Of the 32 index sites reviewed by Seminoff (2004), the trend in nesting was described as: increasing for 10 sites, decreasing for 19 sites, and stable (no change) for 3 sites. Of the 46 green sea turtle nesting sites reviewed for the 5-year status review, the trend in nesting was described as increasing for 12 sites, decreasing for 4 sites, stable for 10 sites, and unknown for 20 sites (NMFS and USFWS 2007c). The greatest abundance of green sea turtle nesting in the western Atlantic occurs on beaches in Tortuguero, Costa Rica (NMFS and USFWS 2007c). Nesting in the area has increased considerably since the 1970s and nest count data from 1999-2003 suggest nesting by 17,402-37,290 females per year (NMFS and USFWS 2007c). One of the largest nesting sites for green sea turtles worldwide is still believed to be on the beaches of Oman in the Indian Ocean (Hirth 1997; Ferreira *et al.* 2003; NMFS and USFWS 2007c). However, nesting data for this area has not been published since the 1980s and updated nest numbers are needed (NMFS and USFWS 2007c).

The results of genetic analyses show that green sea turtles in the Atlantic do not contribute to green sea turtle nesting elsewhere in the species' range (Bowen and Karl 2007). Therefore, increased nesting by green sea turtles in the Atlantic is not expected to affect green sea turtle abundance in other ocean basins in which the species occurs. However, the ESA-listing of green sea turtles as a species across ocean basins means that the effects of a proposed actions must, ultimately, be considered at the species level for section 7 consultations. NMFS recognizes that the nest count data available for green sea turtles in the Atlantic clearly indicates increased nesting at many sites. However, NMFS also recognizes that the nest count data, including data for green sea turtles in the Atlantic, only provides information on the number of females currently nesting, and is not necessarily a reflection of the number of mature females available to nest or the number of immature females that will reach maturity and nest in the future. Given the late age to maturity for green sea turtles (20 to 50 years) (Balazs 1982; Frazer and Ehrhart 1985; Seminoff 2004), caution is urged regarding the trend for any of the nesting groups since no area has a dataset spanning a full green sea turtle generation (NMFS and USFWS 2007c).

As described in the Status of the Species, Environmental Baseline and Cumulative Effects sections above, green sea turtles in the action area continue to be affected by multiple anthropogenic impacts including bycatch in commercial and recreational fisheries, habitat alteration and other factors that result in mortality of individuals at all life stages.

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 bottom trawl surveys carried out as part of the IBMWP required by the NJPDES permit. We determined that all other effects of these actions on this species would be insignificant and discountable.

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 survey.

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, 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 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 actions 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 (17,000-37,000), 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 appreciably reduce 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 1 license expires in April 2040 (a period of 27 years), will not appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect 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 an effect on the levels of genetic heterogeneity in the population; (5) the loss of 1 green sea turtle is likely to have an undetectable effect 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 appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that green sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the 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 actions will affect the population size and/or trend in a way that would affect the likelihood of recovery.

The proposed actions will not appreciably reduce 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 actions are likely to result in the mortality of one green sea turtle; however, as explained above, the loss of these individuals 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 and will have only an extremely small effect on mortality. The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of 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 actions 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 actions will not appreciably reduce 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 actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions in light of cumulative effects explained above, including climate change, and has 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 1 green sea turtle over 28 years, is not likely to appreciably reduce the survival and recovery of this species.

9.4 Kemp’s ridley sea turtles

Kemp’s Ridley sea turtles are listed as a single species classified as “endangered” under the ESA. Kemp’s ridleys occur in the Atlantic Ocean and Gulf of Mexico. The only major nesting site for Kemp’s ridleys is a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; USFWS and NMFS 1992; NMFS and USFWS 2007b).

Nest count data provides the best available information on the number of adult females nesting each year. As is the case with the other sea turtle species discussed above, nest count data must be interpreted with caution given that these estimates provide a minimum count of the number of nesting Kemp’s ridley sea turtles. In addition, the estimates do not account for adult males or juveniles of either sex. Without information on the proportion of adult males to females, and the age structure of the Kemp’s ridley population, nest counts cannot be used to estimate the total population size (Meylan 1982; Ross 1996; Zurita *et al.* 2003; Hawkes *et al.* 2005; letter to J. Lecky, NMFS Office of Protected Resources, from N. Thompson, NMFS Northeast Fisheries Science Center, December 4, 2007). Nevertheless, the nesting data does provide valuable information on the extent of Kemp’s ridley nesting and the trend in the number of nests laid. Estimates of the adult female nesting population reached a low of approximately 250-300 in 1985 (USFWS and NMFS 1992; TEWG 2000). From 1985 to 1999, the number of nests observed at Rancho Nuevo and nearby beaches increased at a mean rate of 11.3% per year

(TEWG 2000). Current estimates suggest an adult female population of 7,000-8,000 Kemp's ridleys (NMFS and USFWS 2007b).

The most recent review of the Kemp's ridleys suggests that this species is in the early stages of recovery (NMFS and USFWS 2007b). Nest count data indicate increased nesting and increased numbers of nesting females in the population. NMFS also takes into account a number of recent conservation actions including the protection of females, nests, and hatchlings on nesting beaches since the 1960s and the enhancement of survival in marine habitats through the implementation of TEDs in the early 1990s and a decrease in the amount of shrimping off the coast of Tamaulipas and in the Gulf of Mexico in general (NMFS and USFWS 2007b). We expect this increasing trend to continue over the time period considered in this Opinion.

In the "Effects of the Action" section above, we determined that four Kemp's ridley sea turtles are likely to be impinged at the Salem trash bars prior to the expiration of the Salem operating licenses (two at Salem 1 and two at Salem 2). We anticipate that three of these Kemp's ridleys will be dead when removed from the water. We expect that a necropsy would indicate that two 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 surveys carried out as part of the IBMWP required by the NJPDES permit. We determined that all other effects of these actions on this species would be insignificant and discountable.

Live turtles captured at the intakes or during bottom trawl 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 surveysis 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, 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 survey will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that one of the Kemp's ridley sea turtle's expected to be impinged is likely to 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, 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 two of the impinged Kemp's ridley sea turtle will die as a result of impingement. The mortality of two Kemp's ridleys over a 27 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 two Kemp's ridley represents less than 0.028% of the population. While the death of two Kemp's ridley will reduce the number of Kemp's ridleys compared to the number that would have been present absent the proposed actions, it is not likely that this reduction in numbers will change the status of this species or its stable to increasing trend 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 two Kemp's ridley over 27 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 actions, any effect to future year classes is anticipated to be very small and would not change the stable to increasing trend of this species. Additionally, the proposed actions 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 actions are not likely to reduce distribution because the actions 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 actions, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

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

Based on the information provided above, the death of two Kemp's ridley sea turtles over the next 27 years will not appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The actions 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 species' nesting trend is increasing; (2) the death of two Kemp's ridleys represents an extremely small percentage of the species as a whole; (3) the death of two Kemp's ridleys will not change the status or trends of the species as a whole; (4) the loss of these Kemp's ridleys is not likely to have an effect on the levels of genetic heterogeneity in the population; (5) the loss of these Kemp's ridleys is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the actions will have only a minor and temporary effect on the distribution of Kemp's ridleys in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of Kemp's ridleys to shelter and only an insignificant effect on individual foraging Kemp's ridleys.

In rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that Kemp's ridley sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that Kemp's ridleys can rebuild to a point where listing is no longer appropriate. In 2011, 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.

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

The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction. Further, the actions will not prevent the species from growing in a way

[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).

that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of Kemp's ridleys and a small reduction in the amount of potential reproduction due to the average loss of one individual per year, these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that Kemp's ridley sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

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

9.5 Northwest Atlantic DPS of Loggerhead sea turtles

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

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.

In the "Effects of the Action" section above, we determined that nine loggerheads are likely to be captured or impinged while Salem 1 and 2 continue to operate (four at Salem 1 and five at Salem 2). We anticipate that three of the loggerheads will be removed from the water alive and six will be dead. Of the six dead loggerheads, we expect that a necropsy would indicate that two of these turtles died due to impingement at the trash bars (drowning). The remaining four dead loggerheads are likely to have died prior to impingement. We also anticipate the non-lethal capture of 4 loggerheads during the bottom trawl survey to be carried out pursuant to the IBMWP required by the NJPDES permit. We determined that all other effects of these actions on this species would be insignificant and discountable.

Live turtles captured at the facility or during the bottom trawl survey 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 intakes 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 removed from the intakes will be minor and temporary there are not anticipated to be any population level impacts.

Existing monitoring data indicates that of the six dead loggerheads we expect to be removed from the Salem intakes, four 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, 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 two NWA DPS loggerhead will die as a result of impingement at the Salem trash bars. The lethal removal of two loggerhead sea turtles from the action area over 27 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 actions (assuming all other variables remained the same). However, this does not necessarily mean that the recovery unit will experience reductions in reproduction, numbers or distribution in response to these effects to the extent that survival and recovery would be appreciably reduced. The final revised recovery plan for loggerheads compiled the most recent information on mean number of loggerhead nests and the approximated counts of nesting females per year for four of the five identified recovery units (i.e., nesting groups). They are: (1) for the NRU, a mean of 5,215 loggerhead nests per year with approximately 1,272 females nesting per year; (2) for the PFRU, a mean of 64,513 nests per year with approximately 15,735 females nesting per year; (3) for the DTRU, a mean of 246 nests per year with approximately 60 females nesting per year; and (4) for the NGMRU, a mean of 906 nests per year with approximately 221 females nesting per year. For the GCRU, the only estimate available for the number of loggerhead nests per year is from Quintana Roo, Yucatán, Mexico, where a range of 903-2,331 nests per year was estimated from 1987-2001 (NMFS and USFWS 2007a). There are no annual nest estimates available for the Yucatán since 2001 or for any other regions in the GCRU, nor are there any estimates of the number of nesting females per year for any nesting assemblage in this recovery unit.

It is likely that the loggerhead sea turtles in Delaware Bay originate from several of the recovery units. Limited information is available on the genetic makeup of sea turtles in the mid-Atlantic, where the majority of sea turtle interactions are expected to occur. Cohorts from each of the five western Atlantic subpopulations are expected to occur in the action area. Genetic analysis of samples collected from immature loggerhead sea turtles captured in pound nets in the Pamlico-Albemarle Estuarine Complex in North Carolina from September-December of 1995-1997 indicated that cohorts from all five western Atlantic subpopulations were present (Bass *et al.* 2004). In a separate study, genetic analysis of samples collected from loggerhead sea turtles from Massachusetts to Florida found that all five western Atlantic loggerhead subpopulations were represented (Bowen *et al.* 2004). Bass *et al.* (2004) found that 80 percent of the juveniles and sub-adults utilizing the foraging habitat originated from the south Florida nesting population, 12 percent from the northern subpopulation, 6 percent from the Yucatan subpopulation, and 2 percent from other rookeries. The previously defined loggerhead subpopulations do not share the exact delineations of the recovery units identified in the 2008 recovery plan. However, the PFRU encompasses both the south Florida and Florida panhandle subpopulations, the NRU is roughly equivalent to the northern nesting group, the Dry Tortugas subpopulation is equivalent to the DTRU, and the Yucatan subpopulation is included in the GCRU.

Based on the genetic analysis presented in Bass *et al.* (2004) and the small number of loggerheads from the DTRU or the NGMRU likely to occur in the action area it is extremely unlikely that the loggerhead likely to be killed at Salem will originate from either of these recovery units. The majority, at least 80% of the loggerheads in the action area, are likely to have originated from the PFRU, with the remainder from the NRU and GCRU. As such, the two loggerheads likely to be killed due to impingement are most likely to originate from the PFRU but could also originate from either the NRU or the GCRU. Below, we consider the effects of the loss of these individuals from any of these three recovery units and the species as a whole.

As noted above, the most recent population estimates indicate that there are approximately 15,735 females nesting annually in the PFRU and approximately 1,272 females nesting per year in the NRU. For the GCRU, the only estimate available for the number of loggerhead nests per year is from Quintana Roo, Yucatán, Mexico, where a range of 903-2,331 nests per year was estimated from 1987-2001 (NMFS and USFWS 2007a). There are no annual nest estimates available for the Yucatán since 2001 or for any other regions in the GCRU, nor are there any estimates of the number of nesting females per year for any nesting assemblage in this recovery unit; however, the 2008 recovery plan indicates that the Yucatan nesting aggregation has at least 1,000 nesting females annually. As the numbers outlined here are only for nesting females, the total number of loggerhead sea turtles in each recovery unit is likely significantly higher.

The loss of two loggerhead over a 27-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 two individuals would represent approximately 0.013% of the population. Similarly, the loss of two loggerheads from the NRU represents an extremely small percentage of the recovery unit (less than 0.16%). The loss of two loggerheads from the GCRU, which is expected to support at least 1,000 nesting females, represents less than 0.2% of the population. The loss of such a small percentage of the individuals from any of these recovery units represents an even smaller percentage of the species as a whole. Considering the extremely small percentage of any population that will be killed, it is unlikely that these deaths will have a detectable effect on the numbers and population trends of loggerheads in these recovery units or the number of loggerheads in the population as a whole over the course of the action.

The loggerheads that are expected to be killed will be juveniles. 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 two loggerheads over a 27 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 individuals that would be killed as a result of these actions, any effect 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. 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 actions are 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 two loggerheads between now and April 2040 is not expected to appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect loggerheads in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent loggerheads from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the species' nesting trend is stabilizing; (2) the death of two loggerheads represents an extremely small percentage of the species as a whole; (3) the death of two loggerheads will not change the status or trends of the species as a whole; (4) the loss of these loggerheads is not likely to have an effect on the levels of genetic heterogeneity in the population; (5) the loss of these loggerheads is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (6) 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, (7) the action will have no effect on the ability of loggerheads to shelter and only an insignificant effect on individual foraging loggerheads.

In rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that loggerhead sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the NWA DPS of loggerheads can rebuild to a point where listing is no longer appropriate. In 2008, 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 an increasing trend; as explained above, the loss of two loggerheads over 27-years as a result of the proposed actions will not affect the population trend. The number of loggerheads likely to die as a result of the proposed actions is an extremely small percentage of any recovery unit or the DPS as a whole. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that the demographic criteria will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; all effects to habitat will be insignificant and discountable; therefore, the proposed actions will have no effect on the likelihood that habitat based recovery criteria will be achieved. The proposed actions will also not affect the ability of any of the recovery tasks to be accomplished.

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

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

10.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the proposed action, interdependent and interrelated actions 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. No critical habitat is designated in the action area; therefore, none will be affected by either proposed action.

11.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. 1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. 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. 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 Unit 1, Salem Unit 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 (Atlantic sturgeon only) and baywide trawl survey (sea turtles, Atlantic sturgeon and shortnose sturgeon). This survey is a required component of the IBMWP; the IBMWP is a mandatory special condition of the SPDES permit issued to PSEG by NJDEP for Salem Unit 1 and Unit 2. As explained in Section 7.0, we have determined that the IBMWP, including the baywide trawl survey, is an interrelated activity.

Because all of the anticipated take results from, but is not the purpose of, operation of the Salem Unit 1, Salem Unit 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 rack and the 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. PSEG is required to implement the IBMWP by the NJDEP 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 IBMWP because implementation does not involve operations of the nuclear facility. As such, the RPMs and Terms and Conditions necessary and appropriate to minimize and monitor incidental take resulting from the IBMWP 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 Incidental Take Statement [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).

11.1 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.

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, Gulf of Maine, Chesapeake Bay, South Atlantic 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 Units 1 and 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 New York Bight, Gulf of Maine, Chesapeake Bay, South Atlantic 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 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 screen 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 (4 live from 1976-2013), 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**
12 (10 dead, 5 due to impingement)	14 (12 dead, 6 due to impingement)	26 (22 dead, 11 due to impingement)

Impingement or Collection of Atlantic Sturgeon at the Trash Bars

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

Impingement/Collection of Atlantic Sturgeon at the Traveling Screens

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

Impingement/Collection of Sea Turtles at the Trash Bars

<table>
<tr><th></th><th>Salem Unit 1</th><th>Salem Unit 2</th></tr>
<tr><td>Loggerhead</td><td>4 (1 dead)</td><td>5 (1 dead)</td></tr>
<tr><td>Green</td><td colspan="2">One at Unit 1 or Unit 2 (alive or dead)</td></tr>
<tr><td>Kemp's Ridley</td><td>2 (1 dead)</td><td>2 (dead)</td></tr>
</table>

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.

IBMWP - Bottom Trawl and Beach Seine

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

11.2 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 individuals 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 prepare 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. NMFS believes 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 with 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.

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 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 IBMWP 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 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 IBMWP sampling.

11.3 Terms and Conditions

These terms and conditions are non-discretionary.

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

1. To implement RPM #1, the intake trash bars must be cleaned at least once a week year round. Within 30 days of the issuance of this Opinion, PSEG must provide NMFS with an estimated cleaning frequency by season.

    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. 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, 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.

4. 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.

5. 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).

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

7. 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. 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. Within 30 days of receiving this Opinion, PSEG 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 PSEG that includes information on arrangements for the frequency of transfer of samples to the facility and timelines for processing of samples.

8. 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 (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 (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.

9. 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. 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.

10. To implement RPM #3, within 30 days of receiving this Opinion, 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.

11. To implement RPM #4, all dead sea turtles must be necropsied at a facility that has the appropriate ESA authorizations (see T&C #9). 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.

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

13. 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.

14. 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:

15. 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.

16. 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.

17. 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.

18. 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.

19. 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. 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.

20. 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.

21. 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. A sturgeon incident report form (Appendix C) must be filled out for any dead sturgeon and provided to NMFS.

22. 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 (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 must be reported to NMFS. 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).

23. 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 (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.

Terms and Conditions to be Implemented by PSEG during IBMWP sampling (beach seine and trawl):

24. 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.

25. 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.

26. 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.

27. 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.

28. 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.

29. 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. 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.

30. To implement RPM#9, 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.

31. 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.

32. 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.

33. 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 (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 must be reported to NMFS. 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).

34. 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 (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; 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 smapling; require that PSEG report all interactions to NMFS and to provide information on the likely cause of death of any sea turtles 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 IBMWP 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 Condition #6-10 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 #11 are necessary and appropriate as the continued transfer of turtles removed from the water alive to an approved stranding/rehabilitation center 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 #12 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 #12 are necessary and appropriate to 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 an increase in cost and is consistent with conditions in previous ITSs for Salem and is part of the normal procedures at the facility or any delays to the proposed project.

RPM #6 and Terms and Conditions #13-15 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 an increase in cost and is consistent with conditions in previous ITSs for Salem and is part of the normal procedures at the facility or any delays to the proposed project.

RPM #8-10 and Terms and Conditions #15-23 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 #23-34 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 IBMWP sampling program.

12.0 CONSERVATION RECOMMENDATIONS

In addition to Section 7(a)(2), which requires agencies to ensure that all projects will not jeopardize the continued existence of listed species, Section 7(a)(1) of the ESA places a responsibility on all federal agencies to “utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species.” Conservation

Recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. As such, 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.

13.0 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 an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is *exceeded*, Section 7 consultation must be reinitiated immediately.

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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).

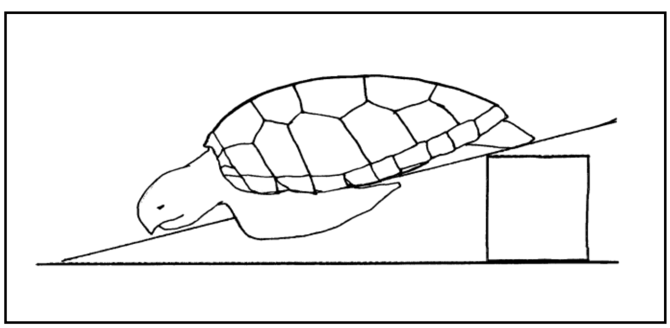
- Turtles that fail to move within several hours (up to 24) should be transported to a suitable facility for necropsy (if the condition of the sea turtle allows).

Stranding/rehabilitation contact in New Jersey:
Bob Schoelkopf, Marine Mammal Stranding Center
P.O. Box 773
Brigantine, NJ
(609-266-0538)

Special Instructions for Cold-Stunned Turtles:

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)*

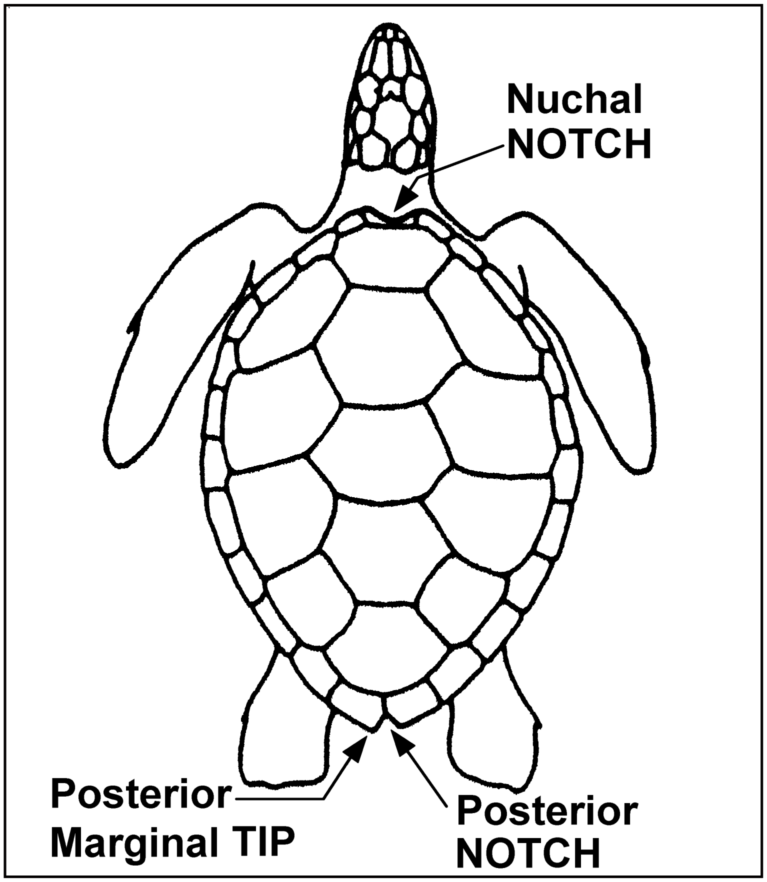
Carapace length - Curved:_______________Straight:________________
Carapace width - Curved:________________Straight:________________

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: 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

For use in documenting sturgeon injury or mortality incidental to a federal action

OBSERVER'S CONTACT INFORMATION

Name: First ________________ Last ________________________

Agency Affiliation ________________ Email ______________________

Address ____

____

Area code/Phone number ____

SEC 7 UNIQUE IDENTIFIER (PCTS No. 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) ☐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)

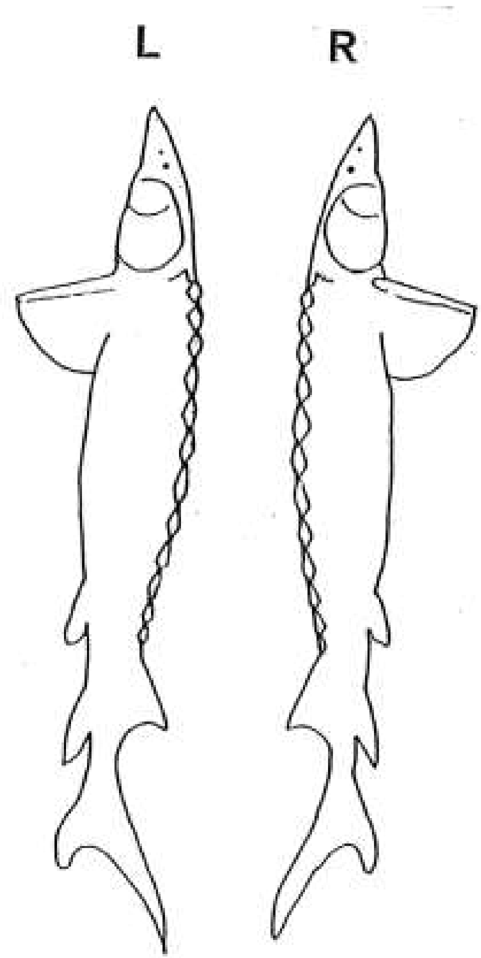
Comments:

____

____

____

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 24 hours 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.

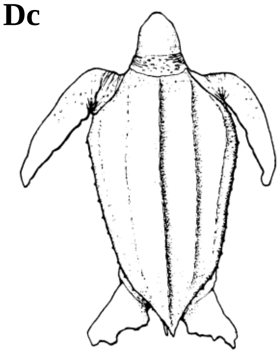
Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service (NOAA Fisheries) on this form will be released to the requestor provided that the requestor credit the collector of the information and NOAA Fisheries. NOAA Fisheries will notify the collector that these data have been requested and the intent of their use.

APPENDIX D

Identification Key for Sea Turtles and Sturgeon Found in Northeast U.S. Waters

SEA TURTLES

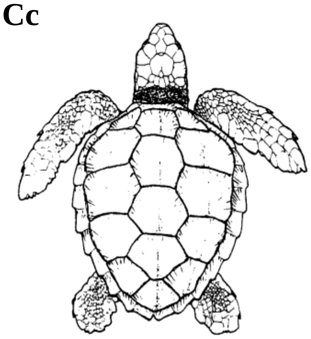
Dc



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.

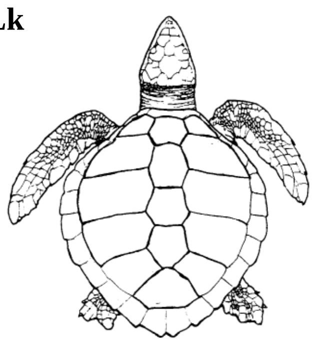
Cc



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.

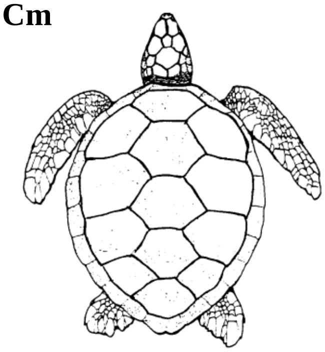
Lk



Kemp's ridley (*Lepidochelys kempi*)

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.

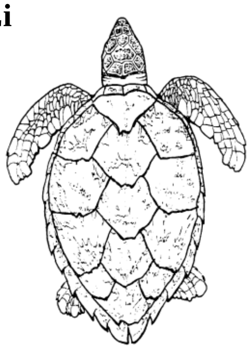
Cm



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.

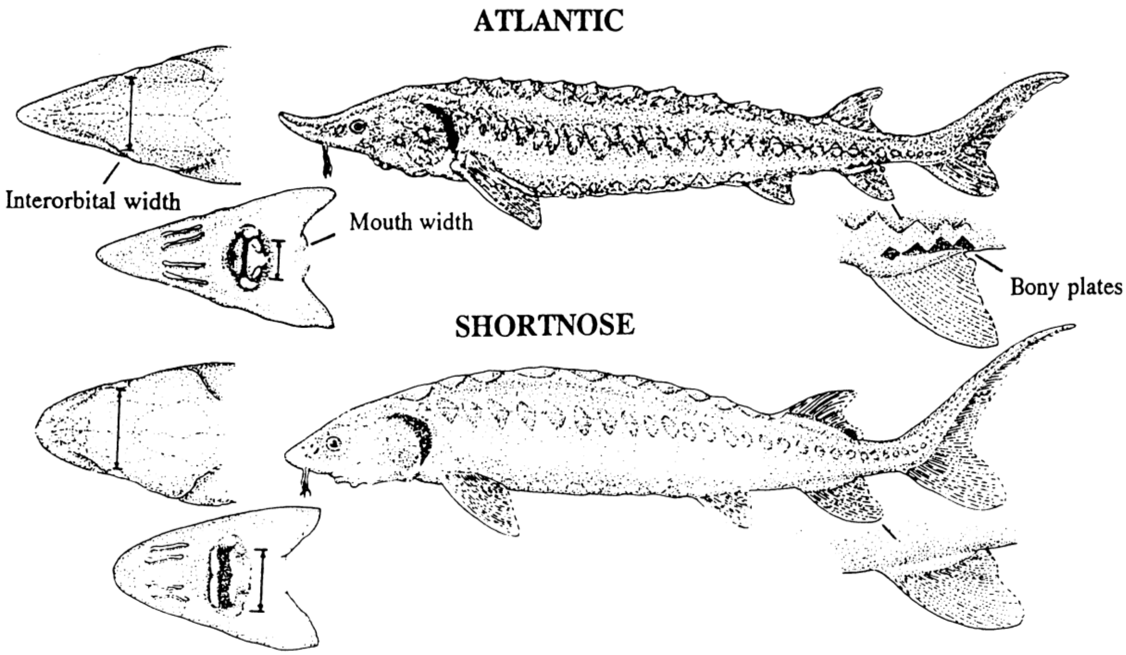
Ei



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.***