Biological Assessment of Impacts to Atlantic Sturgeon and Its Designated Critical Habitat

Salem Nuclear Generating Station, Unit Nos. 1 and 2

Continued Operation Under Renewed Facility Operating License Nos. DPR-70 and DPR-75

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Table of Contents

Tables

Figures

Abbreviations, Acronyms, and Symbols

ADAMS	Agencywide Documents Access and Management System
ASMFC	Atlantic States Marine Fisheries Commission
ASSRT	Atlantic Sturgeon Status Review Team
°C	degrees Celsius
CCC	criteria continuous concentration
CFR	*Code of Federal Regulations*
cm	centimeter(s)
CMC	criteria maximum concentration
CPUE	catch per unit effort
DPS	distinct population segment
EPA	U.S. Environmental Protection Agency
ERC	Environmental Research and Consulting, Inc.
ESA	Endangered Species Act of 1973, as amended
°F	degrees Fahrenheit
FL	fork length
ft	foot (feet)
Hope Creek	Hope Creek Generating Station
IBA	individual-based assignment
IBMWP	Improved Biological Monitoring Work Plan
in.	inch(es)
km	kilometer(s)
m	meter(s)
mg/L	milligrams per liter
mi	mile(s)
MSA	mixed stock analysis
Nc	census population size
Ne	effective population size
NEAMAP	Northeast Area Monitoring and Assessment Program
NJPDES	New Jersey Pollutant Discharge Elimination System
NMFS	National Marine Fisheries Service
NRC	U.S. Nuclear Regulatory Commission
PBF	physical or biological feature
ppt	parts per thousand
PRPA	Philadelphia Regional Port Authority
PSEG	PSEG Nuclear, LLC
REMP	radiological environmental monitoring program
RKM	river kilometer(s)
RM	river mile(s)
RPM	reasonable and prudent measure

Salem	Salem Nuclear Generating Station, Unit Nos. 1 and 2
T&C	term and condition
TL	total length
UBMWP	Updated Biological Monitoring Work Plan
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

1.0 Introduction

The U.S. Nuclear Regulatory Commission (NRC) staff prepared this biological assessment to comply with the provisions of Section 7 of the Endangered Species Act of 1973, as amended (ESA), in support of the NRC's request to reinitiate formal consultation with the National Marine Fisheries Service (NMFS) for continued operation of Salem Nuclear Generating Station, Unit Nos. 1 and 2 (Salem), a two-unit nuclear power plant located in Lower Alloways Creek Township, New Jersey, on the southern end of Artificial Island. This assessment evaluates the impacts of the proposed action—the continued operation of Salem through 2036 (Unit No. 1) and 2040 (Unit No. 2)—on Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and its designated critical habitat.

As explained below, reinitiation of consultation is required because Salem has exceeded the incidental take statement limits for both causal and non-causal mortalities of Atlantic sturgeon from impingement at Salem's cooling water intake structure trash bars. Salem is also approaching the incidental take statement limit for Atlantic sturgeon captures during bottom trawl surveys, which PSEG Nuclear, LLC (PSEG), the licensee for Salem, conducts annually pursuant to its Updated Biological Monitoring Work Plan (UBMWP).[1] The NRC staff addresses these and other impacts in this assessment. The NRC staff also considers the designated critical habitat of the New York Bight distinct population segment (DPS) of Atlantic sturgeon.

Data incorporated into and analyzed in this assessment includes all incidental takes of Atlantic sturgeon at Salem through May 31, 2020. PSEG (2020) reported the incidental take of one additional Atlantic sturgeon on June 9, 2020. The specimen was alive, and PSEG personnel released it back to the Delaware River.

Prior to finalizing this assessment, the NRC staff provided PSEG the opportunity to review the assessment and to affirm the accuracy of the information presented herein. PSEG provided comments on the assessment, which the NRC staff incorporated into the assessment, as appropriate.

2.0 Background/History

The NMFS (2014) issued a biological opinion for the continued operation of Salem on July 17, 2014. The NMFS (2018) subsequently clarified the incidental take statement of its opinion on November 23, 2018.[2] The incidental take statement exempts the take of the following species from the prohibitions of ESA Section 9 subject to compliance with certain reasonable and prudent measures (RPMs) and terms and conditions (T&Cs):

- Atlantic sturgeon,
- shortnose sturgeon (*Acipenser brevirostrum*), and

[1] The New Jersey Pollutant Discharge Elimination System (NJPDES) permit effective on August 1, 2016, prescribes the implementation of the UBMWP. The UBMWP replaced the Improved Biological Monitoring Work Plan (IBMWP) that the NMFS references in its 2014 biological opinion.

[2] For the purposes of this assessment and unless otherwise specified, all references to the "biological opinion" or the "opinion" refer to the July 17, 2014, opinion, as clarified on November 23, 2018.

- sea turtles (*Caretta caretta*, *Chelonia mydas*, and *Lepidochelys kempii*).

The NMFS's biological opinion applies to the continued operation of Salem under the terms of the renewed facility operating licenses issued by the NRC on June 30, 2011. These licenses authorize PSEG to operate Salem through August 13, 2036 (Unit No. 1), and April 18, 2040 (Unit No. 2). The biological opinion applies to both the continued operation of Salem as well as the continued operation of Hope Creek Generating Station (Hope Creek), which is co-located on the same PSEG-owned industrial site. Hope Creek is authorized under its renewed facility operating license issued by the NRC on July 20, 2011, to operate through April 11, 2046.

In an April 2020 teleconference, the NRC (2020a) and the NMFS determined that Salem had exceeded the incidental take statement limit for causal mortalities of Atlantic sturgeon from impingement at Salem's cooling water intake structure trash bars. Since that time, Salem has also exceeded the limit for total impingement mortalities at the trash bars.

The ESA Section 7 regulations at Title 50 of the *Code of Federal Regulations* (50 CFR) Section 402.16 require Federal agencies to reinitiate consultation where discretionary Federal involvement or control over the action has been retained or is authorized by law and the amount or extent of taking specified in the incidental take statement is exceeded. This biological assessment supports the NRC's request to reinitiate consultation.

3.0 Proposed Action

With respect to the current NRC request to reinitiate consultation, the proposed action is the continued operation of Salem under the terms of NRC Renewed Facility Operating License Nos. DPR-70 and DPR-75, which authorize PSEG to operate Salem through August 13, 2036 (Unit No. 1), and April 18, 2040 (Unit No. 2), as described in Section 3.0 of the NMFS's (2014) biological opinion. Section 3.1 of the opinion describes Salem; Section 3.3 describes the radiological environmental monitoring program (REMP); and Section 3.4 describes the cooling and auxiliary water systems.

The NMFS's (2014) biological opinion also addresses the continued operation of Hope Creek as part of the proposed action. Because Hope Creek remains within the incidental take statement limits established in the biological opinion, this assessment does not address the continued operation of Hope Creek.

4.0 Action Area

The implementing regulations for ESA Section 7 define "action area" to mean all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area effectively bounds the analysis of federally listed species and critical habitats because only species and habitats that occur within the action area may be affected by the Federal action.

In Section 3.5 of its biological opinion, the NMFS (2014) describes the action area as including:

> the physical footprint of the Salem 1, Salem 2 and [Hope Creek] facilities as well as the area within the Delaware River occupied by the maximum extent of the thermal plume … and the areas of the Delaware River and Delaware Bay where sampling required by the IBMWP is carried out.

This characterization of the action area remains relevant to the present consultation request. The biological opinion includes a figure showing the location of the Salem and Hope Creek site within a 10-km (6-mi) radius (Figure 1) and an aerial photograph of the site (Figure 2). The NRC staff describes the site in further detail in several documents, including the staff's previous biological assessment (NRC 2010) and the NRC's supplemental environmental impact statement for the license renewal of Salem and Hope Creek (NRC 2011).

5.0 Federally Listed Species

The federally listed species of concern in the action area are Atlantic sturgeon, shortnose sturgeon, loggerhead sea turtle, green sea turtle, and Kemp's ridley sea turtle.

With respect to shortnose sturgeon and sea turtles, Salem remains within the limits set forth in the incidental take statement of the biological opinion; therefore, this assessment does not address these species. The NMFS (2014) describes the life histories, habitat requirements, status and trends, distribution of, and threats to each of these species in Sections 4.1 through 4.5 of the biological opinion. That information continues to accurately describe these species.

The NMFS (2014) describes the Atlantic sturgeon, including each of its DPSs, in Section 4.6 of the biological opinion. The life history and habitat requirements described in the biological opinion continue to accurately describe this species. The remainder of this section focuses on population abundance indices and other information made available since 2014.

Delaware River Effective Population Size Analyses

Population abundances of Atlantic sturgeon are not easily surveyed using traditional fishery methods because of the species' relative scarcity, many age classes, and extensive and differential movements throughout large geographic ranges. As an alternative to traditional population abundance, several research groups have undertaken genetic analyses to estimate effective population size (*Ne*). *Ne* is the size of an ideal population experiencing the same rate of random genetic change over time as the actual population under consideration. *Ne* is typically much smaller than census population size *(Nc)* because of the influences of life history and reproductive biology characteristics (e.g., fluctuating population size, unequal sex ratio, overlapping generations, variance, etc.) in reproductive success among individuals. *Ne* can reveal genetic stress, such as inbreeding, and other population vulnerabilities.

At the time the NMFS prepared the biological opinion, the best available *Ne* estimates were from a 2007 Atlantic Sturgeon Status Review Team (ASSRT) status review. This review presumed that the most robust of the remaining U.S. Atlantic sturgeon spawning populations occupied the Hudson and Altamaha Rivers. The ASSRT (2007) found that spawning populations in other U.S. rivers, including the Delaware River, were likely less than 300 spawning adults per year.

O'Leary et al. (2014) estimated *Ne* for the Hudson, Delaware, and James River spawning populations using tissue samples acquired from Atlantic sturgeon captured at coastal aggregation sites off the coast of Rockaway Peninsula, New York in 2010, 2011, and 2012 trawl surveys. Researchers performed individual-based assignment (IBA) to estimate the most likely river of origin of each sample as well as mixed stock analysis (MSA) to determine DPS and natal river composition of spring aggregations. Of the 460 specimens sampled, 322 were assigned to the Hudson River, 47 to the Delaware River, and 36 to the James River. The MSA results indicated that the New York Bight DPS contributed 83–90% of the individuals in the marine aggregations, and the Chesapeake DPS and Southeast DPS contributed 5.5–11% combined. The two analyses also detected genetic bottlenecks and low levels of inbreeding in all three river populations. O'Leary et al. (2014) estimated *Ne* to be as follows: 172–230 fish in the Hudson River, 75–186 fish in the Delaware River, and 40–100 fish in the James River.

Wirgin et al. (2015a) performed microsatellite DNA and mitochondrial DNA control-region sequence analyses to determine the population and DPS origin of 173 Atlantic sturgeon encountered as by-catch in Atlantic coast fisheries from samples collected between March 2009 and February 2012 from the Gulf of Maine to Cape Hatteras, North Carolina. Hudson River-origin fish accounted for 42.2–46.3% of specimens. Delaware River-origin fish accounted for only 8.7% of specimens. IBA results indicated that the New York Bight DPS (Hudson River and Delaware River populations) accounted for 48.3% of specimens. Wirgin et al. (2015a) postulated that the level of by-catch of Delaware River specimens may be sufficiently high to contribute to the impaired rebuilding of its population given the small estimated size of the Delaware River *Ne* (< 300 adults) and the high immediate mortality rate in sink gillnets.

In another genetic analysis, Wirgin et al. (2015b) analyzed microsatellite DNA and mitochondrial DNA of 261 subadult and adult Atlantic sturgeon collected off the Delaware coast near Bethany Beach during gillnet sampling conducted in March, April, and May of 2009–2012. Using IBA, researchers determined that the Hudson River was the predominant contributor to the coastal collection (38.3%; 100 specimens) followed by the James River (19.9%; 52 specimens) and the Delaware River (13.8%; 36 specimens). MSA yielded similar results: the Hudson River population (44% of specimens) was the predominantly represented population followed by the James River population (20.6%) and the Delaware River population (10.6%). Wirgin et al. (2015b) found these results to be consistent with the Delaware River population's severely depleted status considering the geographic proximity of the coastal collection site to the entrance of the Delaware Bay and the fact that sampling was initially designed to target adults from this system. Wirgin et al. (2015b) determined that its results support the likelihood of persistent successful natural reproduction and recruitment at very low levels over recent decades in the Delaware River population. However, results also indicate that this population's abundance remains extremely low compared with historical levels and that it has not rebounded to the extent of other populations. Wirgin et al. (2015b) postulated that the continued depressed size of the Delaware River population may be attributable to chronically compromised water quality and chemical stressors at the Delaware River nursery grounds and a disproportionate impact from vessel strikes compared with other systems.

In 2017, the Atlantic States Marine Fisheries Commission (ASMFC) released a benchmark stock assessment of the Atlantic sturgeon. The assessment used both fishery-dependent and fishery-independent data, as well as biological and life history information. Fishery-dependent data came from commercial fisheries that formerly targeted Atlantic sturgeon (before the ASMFC instituted a fishing moratorium in 1998), as well as fisheries that catch sturgeon incidentally. Fishery-independent data were collected from scientific research and survey programs. The ASMFC (2017) found that, relative to historic abundance, Atlantic sturgeon populations remained depleted at both the coastwide and DPS levels. Despite the fishing moratorium, Atlantic sturgeon still experience anthropogenic mortality from several sources, including as bycatch in fisheries for other species. However, the ASMFC found that total mortality is currently sustainable and that the coastwide population appears to be recovering slowly since the moratorium was implemented. The 2017 assessment indicates a slight positive trend coastwide for Atlantic sturgeon since the 1998 moratorium with variable signs of recovery by DPS.

The ASMFC (2017) estimated *Ne* from genetic samples of 1,658 Atlantic sturgeon representing 50 collections from 11 rivers and one sound. Based on the analysis of 181 river-resident juveniles (< 50 cm (20.0 in.) total length (TL)) and adults (≥ 150 cm (59.0 in.) TL) from the New York Bight DPS, researchers determined *Ne* within the Delaware River to be 56.7 fish with a 95% confidence interval of 42.5–77.0 fish.

In 2019, the ASSRT (2019) issued its most recent review of the ASMFC's Atlantic sturgeon fishery management plan. The review addresses the status of the stock but does not present information beyond that contained in the ASMFC's 2017 stock assessment. The ASSRT's review supports the ASMFC's assessment that that the coastwide population appears to be recovering slowly since the 1998 moratorium but that the coastwide and DPS populations remain depleted relative to historic levels.

Waldman et al. (2018) analyzed genetic samples from 2,030 Atlantic sturgeon collected from June 1980 to July 2017 across the species' range among 14 spawning populations from the Saint Lawrence River in Canada south to the St. Marys River in Georgia. The Hudson River population was again the most robust with an *Ne* of 156 fish. *Ne* in the Altahama and Savannah Rivers was also estimated to be over 100 fish in each of these systems. For all other rivers, *Ne* was below 100. Waldman et al. (2018) estimated the Delaware River *Ne* to be 40 fish, a mere 7.8% of the estimated historical *Ne* of 509 fish. Waldman et al. (2018) postulated that this *Ne* may reflect a balance between the pervasive genetic signal from an extremely large historical abundance and a contemporary relict population that has experienced a severe bottleneck. Waldman et al. (2018) cited historic overharvesting, low dissolved oxygen concentrations in nursery areas, dredging impacts, and vessel strikes as contributing factors to the Delaware River population's initial decline and low contemporary *Ne*.

Table 1 below summarizes each of the *Ne* estimates discussed above.

Table 1. Delaware River Effective Population Size (*Ne*) Estimates

Estimate Source	Delaware River *Ne*
ASSRT 2007	< 300
O'Leary et al. 2014	75-186
ASMFC 2017	56.7
Waldman et al. 2018	40

Delaware River Subadult and Adult Abundance Estimates

To inform its biological opinion, the NMFS (2014) calculated Atlantic sturgeon subadult and adult population size by DPS using Northeast Area Monitoring and Assessment Program (NEAMAP) data. The NEAMAP data set includes seasonal trawl surveys conducted from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina, in nearshore waters at depths up to 18.3 m (60 ft) 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 NMFS (2014) describes how it used this survey data to calculate population size on pages 60–63 of the biological opinion. Table 2 below summarizes the NMFS's calculations.

Table 2. Calculated Atlantic Sturgeon Population Estimates Based on Northeast Area Monitoring and Assessment Program Trawl Survey Data, 2014

	Estimated Ocean Population Abundance		
Atlantic Sturgeon DPS	**Total**	**Adults**	**Subadults[a]**
Gulf of Maine	7,455	1,864	5,591
New York Bight	34,566	8,642	25,925
Chesapeake Bay	8,811	2,203	6,608
Carolina	1,356	339	1,017
South Atlantic	14,911	3,728	11,183
Canada	678	170	509

[a] This estimate represents only those subadults that are present in the marine environment and of sizes vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment, which is only a fraction of the total number of subadults.

Source: NMFS 2014, Table 6

Delaware River Juvenile Abundance Estimates

In 2016, Hale et al. (2016) estimated the abundance of resident Delaware River estuary juvenile (age 0-1) Atlantic sturgeon using capture and recapture data gathered in 2014 and a Schumacher and Eschmeyer mark–recapture estimator for multiple censuses. These authors estimated the juvenile population of the Delaware River to be 3,656 fish with a 95% confidence interval of 1,935–33,041 fish. Further, using a passive acoustic receiver array, the authors identified significant juvenile habitat areas to include the Marcus Hook area (river kilometer (RKM) 127 (river mile (RM) 79)) as well as some habitat use downriver and upriver of Marcus Hook at Cherry Island and the Chester Range. These results indicate that spawning as well as some level of early juvenile recruitment continues to persist in the estuary despite current depressed population levels.

In 2018, the Delaware Department of Natural Resources and Environmental Control produced another estimate of resident Delaware River estuary juvenile (age 0-1) Atlantic sturgeon using available capture and recapture data gathered in 2018 and a Schumacher and Eschmeyer mark–recapture estimator for multiple censuses (Park 2019). Department staff estimated the 2018 Age 0-1 population to be 13,752 fish with a 95% confidence interval of 5,524–∞ fish. The Department states in its interim report that the upper confidence interval is likely skewed as a result of capturing 52 fish on the last day of sampling. Department staff is determining how to address this problem and will update its abundance estimate in a future progress report.

Sturgeon Monitoring Associated with the Delaware River Main Channel Deepening

In 2010, the U.S. Army Corps of Engineers (USACE) and the Philadelphia Regional Port Authority (PRPA) initiated a project to deepen the Delaware River main navigation channel from approximately 12.2 m (40 ft) to 13.7 m (45 ft). One of the final project phases required blasting and removal of rock outcrops within the Marcus Hook, Chester, Eddystone, and Tinicum ranges of the channel. This region of the river begins roughly 48 RKM (30 RM) upstream of the action area. It is a nursery area for juvenile Atlantic sturgeon and is also used by juvenile and adult shortnose sturgeon.

The USACE conducted five seasons of blasting during the winters of 2015 through 2020. In association with the blasting, Environmental Research and Consulting, Inc. (ERC) conducted sturgeon monitoring, relocation, and other protection activities. For instance, ERC conducted intensive relocation trawling immediately prior to and during each blasting period to capture sturgeon and transport them to upriver release areas. ERC also employed a sound deterrent system at the blast site prior to blasting, monitored the blasting area for the presence of acoustically-tagged sturgeon prior to blasting, and performed surface monitoring for dead or injured sturgeon after blasting.

The results of these efforts are reported in ERC (2016, 2017, 2018, 2019, 2020). Table 3 and Table 4 below summarize the numbers of Atlantic sturgeon collected prior to and during each blasting period. The majority of collected sturgeon were age-0 and age-1 juveniles, although older juveniles and subadults were also present in collections. The results of these efforts provide insight into the robustness of and year-to-year variability in the Delaware River's juvenile population.

Table 3. Atlantic Sturgeon Collection and Relocation Trawling During Delaware River Main Channel Deepening Project Pre-Blasting, 2015–2020

Season	No. Collection Days	No. Hauls	No. Atlantic Sturgeon	Catch Per Unit Effort (CPUE)
Nov 2015	14	105	442	4.2
Nov 2016	14	129	184	1.4
Nov 2017	14	101	1002	9.9
Jan 2019-Feb 2019	14	97	588	5.8
Dec 2019-Jan 2020	15	109	170	1.6
Sources: ERC 2016, 2017, 2018, 2019, 2020				

Table 4. Atlantic Sturgeon Collection and Relocation Trawling During Delaware River Main Channel Deepening Project During Blasting, 2015–2020

Season	No. Collection Days	No. Hauls	No. Atlantic Sturgeon	Catch Per Unit Effort (CPUE)
Dec 2015-Mar 2016	43	212	333	1.6
Dec 2016-Mar 2017	52	502	207	0.4
Dec 2017-Feb 2018	38	275	1504	5.5
Feb 2019-Mar 2019	27	175	771	4.4
Jan 2020-Feb 2020	12	92	58	1.6
Sources: ERC 2016, 2017, 2018, 2019, 2020				

Salem Pilot Sonar Study

In April 2020, S. T. Hudson Engineers, Inc. (Hudson) and ERC, with support from CSA Ocean Sciences, Inc. (CSA), conducted a sonar pilot study (Hudson, ERC, and CSA 2020) of the Salem trash bars and the Delaware River around Artificial Island. PSEG commissioned the study in response to the unprecedented increase in the incidental take of juvenile Atlantic sturgeon at Salem in spring 2020.

The in-plant portion of the study consisted of four days of acoustic imaging using ARIS Explorer 3000 and Humminbird 900c HD sonar to observe real-time subsurface conditions of the immediate environment of the trash bars. The ARIS sonar provided better near-field results, including debris conditions and successfully imaged fish in close proximity to the trash bars, while the Humminbird sonar provided a broader, but lower-resolution view of the immediate area and structural surroundings. Researchers collected imaging on April 15, April 21, April 28, and May 1, 2020. Intake velocity, turbulence, and configuration made the image collection from the circulating water intake structure deck difficult. However, some observations of the trash bars were successful using the ARIS sonar. The imaging revealed significant biofouling and debris build-up on the trash bars. Fish activity was observed in the water column near and adjacent to the trash bars. Identification of fish species and concentrations were beyond the scope of the study. However, PSEG personnel collected two dead Atlantic sturgeon during raking operations on one of the sonar imaging days (April 21) (see Table A1).

The in-river portion of the study consisted of one day of acoustic imaging using Seascan HDS dual frequency side scan sonar adjacent to the entire Artificial Island complex and focusing on the area in front of the Salem circulating water system. Researchers collected this imaging on April 17, 2020. Sonar imaging revealed a total of 41 possible sturgeon targets ranging in length from 0.52 to 1.58 m (20.5 to 62.2 in.) and averaging 0.74 m (29.1 in.) with confidence in target identification as possible sturgeon ranging from low to moderate. Possible sturgeon were scattered throughout the survey area with no clear aggregations. One possible sturgeon was located close to the circulating water system trash bar (within 0.83 m (32.7 in.)) and two were close to the service water system trash bar (within 1.17 and 2.17 m (46.1 and 85.4 in.)).

Full results of the sonar pilot study are reported in Hudson, ERC, and CSA (2020).

Atlantic Sturgeon DPSs and Life Stages Within the Action Area

Atlantic sturgeon are well distributed throughout the Delaware River and Bay and could be present year-round in the action area. Most Atlantic sturgeon in the action area will be subadults or adults, but some younger juveniles could be present during times of the year when salinity in the action area is low (i.e., winter). Subadults from any of the five DPSs could be present in the action area. This life stage is most likely to be in the action area from mid-April to mid-November, although some subadults may overwinter in the river and be present year-round. Adults are only likely to be present in the river for approximately a four-week period from mid-April to mid-June depending on annual water temperatures. Because spawning occurs well upriver, eggs and larvae are not present in the action area.

In Section 4.7.3 of the biological opinion, the NMFS (2014) anticipated that nearly all adults in the river are likely to originate from the New York Bight DPS. Available rangewide tracking information indicates that Atlantic sturgeon adults occasionally appear in non-natal rivers outside their DPS of origin; thus, a small percentage of adults in the action area are likely to originate from non-New York Bight DPSs.

With respect to subadults, the NMFS (2014) determined that within the action area, Atlantic sturgeon of this life stage are likely to originate from the five DPSs at the following frequencies:

- New York Bight DPS: 58%
- Chesapeake Bay DPS: 18%
- South Atlantic DPS: 17%
- Gulf of Maine DPS: 7%
- Carolina DPS: 0.5%

As a T&C of the currently applicable incidental take statement, PSEG must take fin clips of any shortnose and Atlantic sturgeon captured at the intakes and coordinate with a NMFS-approved lab to process the samples to determine the DPS (for Atlantic sturgeon) or river (for shortnose sturgeon) of origin. A U.S. Geological Survey (USGS) lab recently completed a preliminary analysis of the first group of 24 Atlantic sturgeon subadult samples. The NMFS reported the rivers of origin of these samples to the NRC as follows.

- Delaware River: 14 specimens (58%)
- Hudson River: 5 specimens (21%)
- James River: 3 specimens (13%)
- Savannah River: 1 specimen (4%)
- Ogeechee River: 1 specimen (4%)

These results equate to roughly the following percentages by DPS.

- New York Bight DPS (Delaware and Hudson Rivers): 79%
- Chesapeake Bay DPS (James River): 13%
- South Atlantic DPS (Savannah and Ogeechee Rivers): 8%
- Gulf of Maine DPS: 0%
- Carolina DPS: 0%

The USGS lab is currently analyzing additional fin clip samples. Future results will continue to provide a clearer picture of the rivers and DPSs of origin of Atlantic sturgeon in the action area.

6.0 Federally Designated Critical Habitat

Critical habitat represents the habitat that contains the physical or biological features (PBFs) essential to the conservation of the listed species and that may require special management considerations or protection. Critical habitat may also include areas outside the geographical area occupied by the species if the NMFS determines that such areas are essential for the conservation of the species.

In 2017, the NMFS designated critical habitat for all five DPSs of the Atlantic sturgeon (82 FR 39160). In this final rule, the NMFS identified four PBFs that support successful sturgeon reproduction and recruitment (see Table 5). PBFs are those features that are essential to support the life-history needs of the species, including, but not limited to, water characteristics, soil type, geological features, sites, prey, vegetation, symbiotic species, or other features (50 CFR 424.02). A feature may be a single habitat characteristic or a more complex combination of habitat characteristics.

Within the Delaware River, the NMFS designated critical habitat for the New York Bight DPS of Atlantic sturgeon from the crossing of the Trenton-Morrisville Route 1 Toll Bridge (RKM 214 (RM 133)) downstream to where the main stem river discharges into the Delaware Bay (RKM 0 (RM 0)) (82 FR 39160) (see Figure 1). This region is designated as New York Bight DPS Critical Habitat Unit 4. The unit includes all the river from the ordinary high-water mark of one riverbank to the ordinary high-water mark of the opposing riverbank (50 CFR 226.225). Accordingly, the entirety of the Delaware River within the action area is designated critical habitat.

Figure 1. New York Bight DPS Critical Habitat Unit 4 in the Delaware River

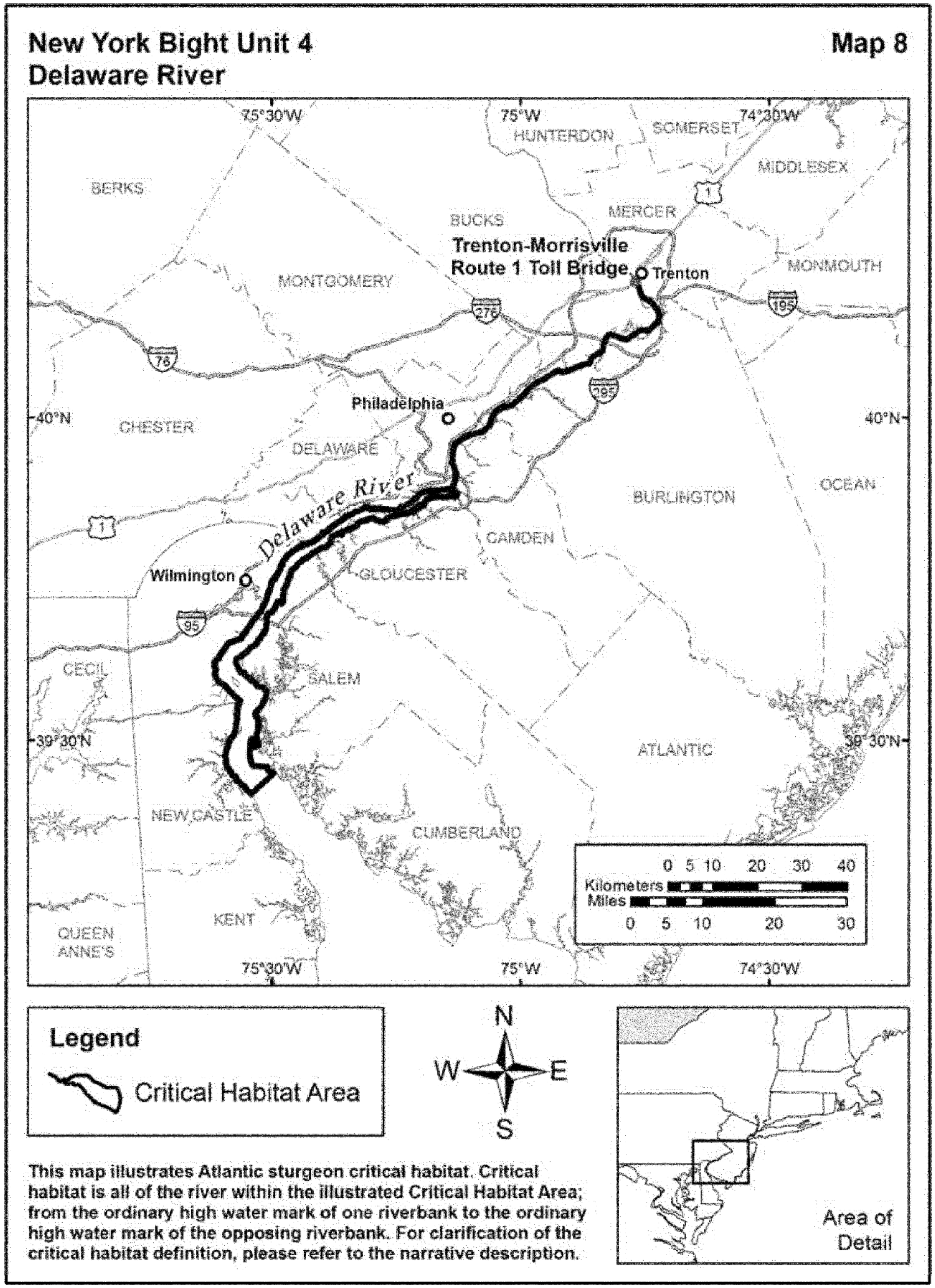


Figure Source: 50 CFR 226.225, Map 8

Table 5. Physical or Biological Features of Atlantic Sturgeon Critical Habitat

PBF[a]	Description
PBF 1	Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0 to 0.5 parts per thousand (ppt) range) for settlement of fertilized eggs, refuge, growth, and development of early life stages.
PBF 2	Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development.
PBF 3	Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (e.g., at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.
PBF 4	Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: (i) Spawning; (ii) Annual and interannual adult, subadult, larval, and juvenile survival; and (iii) Larval, juvenile, and subadult growth, development, and recruitment (e.g., 13 °C to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) dissolved oxygen (DO) or greater for juvenile rearing habitat).

[a] The physical or biological features (PBFs) identified in this table are specific to the Chesapeake Bay, New York Bight, and Gulf of Maine DPSs of Atlantic sturgeon.

Source: 82 FR 39160

7.0 Effects of the Proposed Action

This section describes the potential effects of the proposed action on the Atlantic sturgeon and its critical habitat. The potential stressors that the Atlantic sturgeon could experience from the continued operation of Salem are:

- impingement;
- entrainment;
- thermal effects;
- exposure to radionuclides and nonradiological contaminants;
- reduction in available food resources from effects on prey species; and
- capture during biological sampling.

Sections 7.1 through 7.6 below addresses each of these stressors on the Atlantic sturgeon. Section 7.7 addresses the potential effects of the proposed action on designated critical habitat.

7.1 Impingement

Impingement occurs when the force of incoming water traps organisms against the outer part of a screening device of an intake structure such that they are unable to escape (79 FR 48299). Because Salem's intakes are fitted with Ristroph screens that also have rotating buckets, impingement at Salem includes the collection of organisms in these rotating buckets.

2014 Impingement Predictions

In Section 7.3.2 of the biological opinion, the NMFS (2014) assessed the likelihood of Atlantic sturgeon impingement at Salem's cooling water intake structure using available data on swimming capability of sturgeon at different life stages. The NMFS determined that although most Atlantic sturgeon would have sufficient swimming ability to avoid the draw of Salem's intake, some juveniles and subadults would be impinged during plant operation. The NMFS used past impingement data to estimate the level of take that was likely to occur over the license renewal period.

<u>Trash Bars</u>

For impingement at the trash bars, only three years of data (February 2011–December 2013) were available as PSEG only began collecting Atlantic sturgeon impingement data at this location in February 2011 in response to the NMFS's issuance of the proposed rule to list the species in October 2010. The NMFS (2014) recognized in the biological opinion that the short time period of available data made predicting future impingement at the trash bars difficult, and that there would likely be annual variability in impingement numbers.

The NMFS (2014) predicted that Salem would impinge an average of 8 Atlantic sturgeon per year at the trash bars with an annual range of 2–18 impingements. In total, this would roughly equate to 200 Atlantic sturgeon impingements at both Salem units over the course of their respective renewed facility operating licenses. Of these, 61 would be dead, and impingement would cause or contribute to the death of 18 of those fish. Table 6 below provides the NMFS's predicted impingement at the trash bars by age class, DPS, and Salem unit. The NMFS incorporated these predictions into the incidental take statement of the biological opinion such that these amounts of impingement at the trash bars are exempted from the prohibitions of ESA Section 9, subject to compliance with certain RPMs and T&Cs.

Table 6. 2014 NMFS Predicted Atlantic Sturgeon Impingement at Salem Trash Bars, 2014–2040

<table>
<tr><th>Atlantic Sturgeon Age Class and DPS</th><th>Unit No. 1[(a)(b)]</th><th>Unit No. 2[(a)(b)]</th><th>Total[(a)(b)]</th></tr>
<tr><td>All age classes and DPSs combined</td><td>92 (28, 8)</td><td>108 (33, 10)</td><td>200 (61, 18)</td></tr>
<tr><td>Juveniles: New York Bight DPS</td><td>88 (27, 7)</td><td>104 (32, 9)</td><td>192 (59, 16)</td></tr>
<tr><td>Subadults or adults: All DPSs</td><td>4 (1, 1)</td><td>4 (1, 1)</td><td>8 (2, 2)</td></tr>
<tr><td>Subadults or adults: New York Bight DPS</td><td>3 (1, 1)</td><td>3 (1, 1)</td><td>6 (2, 2)</td></tr>
<tr><td>Subadults or adults: Chesapeake Bay DPS</td><td rowspan="4">1 dead or alive</td><td rowspan="4">1 dead or alive</td><td rowspan="4">2 dead or alive</td></tr>
<tr><td>Subadults or adults: South Atlantic DPS</td></tr>
<tr><td>Subadults or adults: Gulf of Maine DPS</td></tr>
<tr><td>Subadults or adults: Carolina DPS</td></tr>
</table>

(a) Predicted numbers include capture of live sturgeon with the trash rake. Dead due to impingement are a subset of the total dead sturgeon removed from the intakes.

(b) Numbers are presented as: total no. impinged (no. dead, no. dead due to impingement). For example, "92 (28, 8)" means that a total of 92 Atlantic sturgeon are expected to be impinged; of the 92, 28 are expected to be dead; and of the 28, 8 are expected to be dead due to impingement.

Source: NMFS 2014, Table 12

Traveling Screens

For Atlantic sturgeon to be impinged at the traveling screens, individuals must be small enough to pass between the trash bars, which are spaced 7.6 cm (3 in.) apart, where they would then encounter the traveling screens. Such sized individuals would be young of the year (i.e., age-0) or age-1 juveniles. Because Atlantic sturgeon do not leave their natal rivers until they are approximately 76 cm (30 in.) in length, and those individuals that could pass through the trash bar openings and contact the traveling screens would need to be 63 cm (25 in.) in length or less, only Delaware River-origin fish from the New York Bight DPS would be impinged or collected at the traveling screens (NMFS 2014).

PSEG has carried out impingement sampling of varying intensities at the Salem traveling screens since 1976. As of 2014, three Atlantic sturgeon had been collected in 17 years of routine sampling. Based on extrapolations of this data, the NMFS (2014) predicted that Salem would impinge a total of 12 Atlantic sturgeon per year at the traveling screens. In total, this would roughly equate to 300 Atlantic sturgeon impingements at both Salem units over the course of their respective renewed facility operating licenses. Of these, 26 would be dead with impingement causing or contributing to the death of 26 of those fish. Table 7 below provides the NMFS's predicted impingement at the traveling screens. The NMFS incorporated these predictions into the incidental take statement of the biological opinion such that these numbers of impingements at the traveling screens are exempted from the prohibitions of ESA Section 9, subject to compliance with certain RPMs and T&Cs.

Table 7. 2014 NMFS Predicted Atlantic Sturgeon Impingement at Salem Traveling Screens, 2014–2040

Atlantic Sturgeon Age Class and DPS	Unit No. 1[(a)]	Unit No. 2[(a)]	Total[(a)]
Young of the year New York Bight DPS	138 (12)	162 (14)	300 (26)

[(a)] Numbers are presented as: total no. impinged (no. injured or dead). For example, "138 (12)" means that a total of 138 Atlantic sturgeon are expected to be impinged; of the 138, 12 are expected to be injured or dead.

Source: NMFS 2014, Unnumbered Table (p. 125)

Actual Impingement, 2014-Present

Trash Bars

Since the NMFS issued its biological opinion in July 2014, PSEG has collected a total of 102 Atlantic sturgeon at the trash bars. Of these, 39 were alive and 63 were dead. Of the 63, 44 were dead due to impingement,[3] and 19 were dead due to other factors unrelated to Salem operations. Thus, the incidental take statement limits for both total impingement mortality (i.e., 61 sturgeon) and total causal impingement mortality (i.e., 18 sturgeon) at the trash bars has been exceeded. Table 8 below summarizes this information. Appendix A provides detailed listings of each impingement (Table A1) as well as summary tables of impingements by year and location (Table A2) and year, location, and condition (Table A3).

[3] The determination of whether mortality is due to impingement can be subjective and is based on the condition of the sturgeon carcass upon retrieval. PSEG generally considers the mortality of fresh dead specimens to be caused by the trash raking operation. PSEG generally considers the mortality of specimens that exhibit some degree of decomposition to have been caused by factors unrelated to trash raking.

Table 8. Actual Atlantic Sturgeon Impingement at Salem Trash Bars, July 2014–Present

Atlantic Sturgeon Age Class and DPS	Unit No. 1[(a)(b)]	Unit No. 2[(a)(b)]	Total[(a)(b)]
All age classes and DPSs combined	57 (**35**, **24**)	45 (28, **21**)	102 (**63**, **45**)

[(a)] Numbers are presented as: total no. impinged (no. dead, no. dead due to impingement). For example, "57 (35, 24)" means that a total of 57 Atlantic sturgeon were impinged; of the 57, 35 were dead; and of the 35, 24 were dead due to impingement.

[(b)] **Bold red** numbers indicate an exceedance of the incidental take statement limit established in the 2014 biological opinion.

Source: See Appendix A, Table A1

Traveling Screens

With respect to impingements at the traveling screens, PSEG currently samples the traveling screens for about 20 minutes per day, 3 days per week. During such sampling, PSEG has collected four Atlantic sturgeon since the NMFS issued its biological opinion. Of these, two were alive, one was dead due to impingement, and one was dead due to other factors unrelated to Salem operations. Table 9 below summarizes this information. Table A1 in Appendix A provides detailed listings of each of these impingements. When sampling is not being conducted, fish impinged on the traveling screens are returned to the river. As reported in the biological opinion, impingement survival of sturgeon is expected to be high. The NMFS (2014) estimated the annual latent impingement mortality value for Atlantic sturgeon to be 8.25%. Salem remains within the incidental take statement limits for impingement at the traveling screens.

Table 9. Actual Atlantic Sturgeon Impingement at Salem Traveling Screens, July 2014–Present

Atlantic Sturgeon Age Class and DPS	Unit No. 1[(a)(b)]	Unit No. 2[(a)(b)]	Total[(a)(b)]
All age classes and DPSs combined	3 (2, 1)	1 (0, 0)	4 (2, 1)

[(a)] Numbers are presented as: total no. impinged (no. dead, no. dead due to impingement). For example, "3 (2, 1)" means that a total of 3 Atlantic sturgeon were impinged; of the 3, 2 were dead; and of the 2, 1 was dead due to impingement.

Sources: See Appendix A, Table A1

Impingement Analysis

Trash Bars

As explained previously, the NMFS (2014) anticipated that Salem would impinge an average of eight Atlantic sturgeon per year at the trash bars based on data for the period 2011–2013. However, the observed rate of impingement since the NMFS issued the biological opinion (i.e., July 2014–May 2020) has been higher than anticipated, at a rate of 20.2 sturgeon per year (118 sturgeon over 70 months). Considering all available data years (2011–2020), PSEG has collected 141 Atlantic sturgeon at the trash bars since it began reporting collections of the species in February 2011 for an overall average rate of 15.1 Atlantic sturgeon per year (141 sturgeon over 112 months).

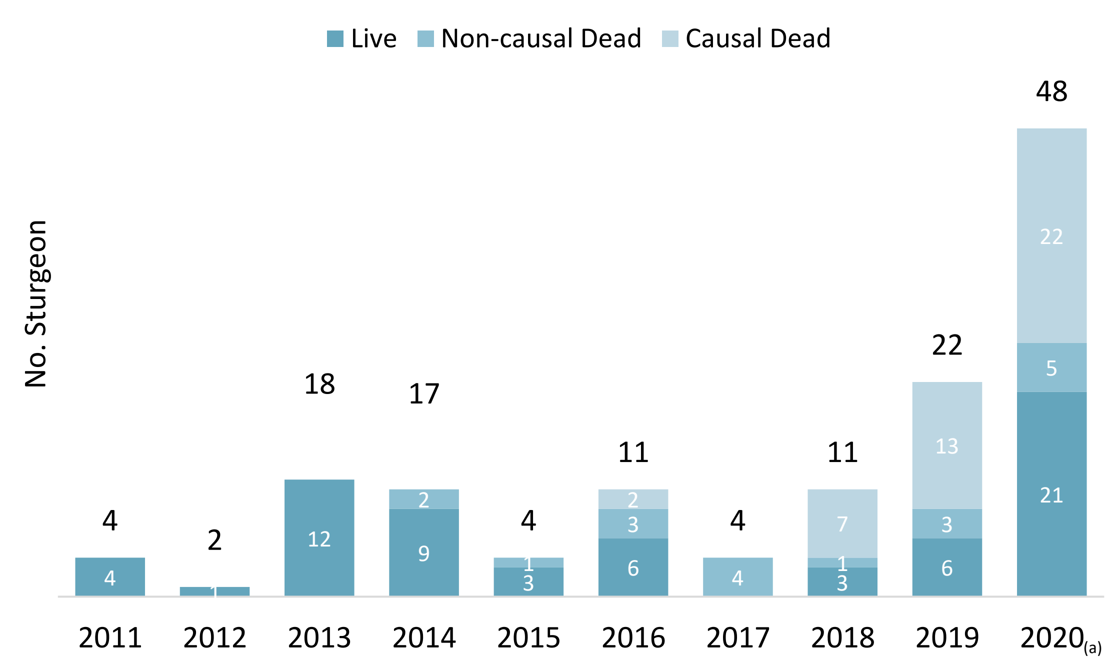
The proportional conditions of the 141 Atlantic sturgeon impinged at the trash bars are:

- 46% alive (65 fish)
- 40% dead due to impingement (57 fish)
- 14% dead due to other factors (19 fish)

Figure 2 below depicts this information graphically by year. As NMFS predicted in its biological opinion, impingement numbers have fluctuated year to year. However, impingements in five of the seven years since the NMFS issued the biological opinion have exceeded predicted average rates.

PSEG has reported a particularly large number of impingements thus far in 2020, and further impingements are likely in late fall and early winter (i.e., November and December). The 2020 impingement spike may be correlated with the 2017 year class size, which was very large according to reports from local researchers (NRC 2020b). PSEG estimates that most of the sturgeon collected in 2020 have been two to three years old, which would make some of these individuals members of the 2017 cohort (NRC 2020b). PSEG also observed that sturgeon lingered in the action area for longer into the spring of 2020 than has been typical in past years (NRC 2020a, 2020b). This behavior also likely contributed to the higher number of impingements in 2020.

Figure 2. Atlantic Sturgeon Impingements at the Salem Trash Bars, February 2011–Present



(a) 2020 numbers include impingements through May 31. Additional Atlantic sturgeon impingements are likely beginning in late fall.

In the biological opinion, the NMFS (2014) predicted that 96% of Atlantic sturgeon impinged at the Salem trash bars would be juveniles and 4% would be subadults or adults.[4] The NMFS based its predictions on length data from 23 Atlantic sturgeon collected at the Salem trash bars from 2011–2013 (NMFS 2014, Table 11). All juveniles were expected to originate from the Delaware River and belong to the New York Bight DPS, while subadults and adults could originate from any of the five DPSs (NMFS 2014).

In examining the additional data gathered by PSEG following the issuance of the biological opinion, the length-frequency distribution of Atlantic sturgeon impinged at the Salem trash bars over the entire time period (2011–2020) indicates that the majority of these sturgeon have been of non-migrant subadults or juveniles. However, subadults have constituted a larger proportion of impingements than the NMFS predicted in 2014. The mean length of Atlantic sturgeon collected at the trash bars falls between the two age classes (i.e., non-migrant subadult or juvenile and subadult) at 77.1 ± 4.6 cm (30.4 ± 1.8 in.) TL, and the median length falls within the non-migrant subadult or juvenile age class at 72.0 cm (28.3 in.) TL. Of the 127 impinged fish for which length data are available, only 1 young of the year and 3 adults were collected. This equates to the following proportions by age class:

- 0.8% young of the year (1 fish)
- 62.2% non-migrant subadult or juvenile (79 fish)
- 34.6% subadult (44 fish)
- 2.4% adult (3 fish)

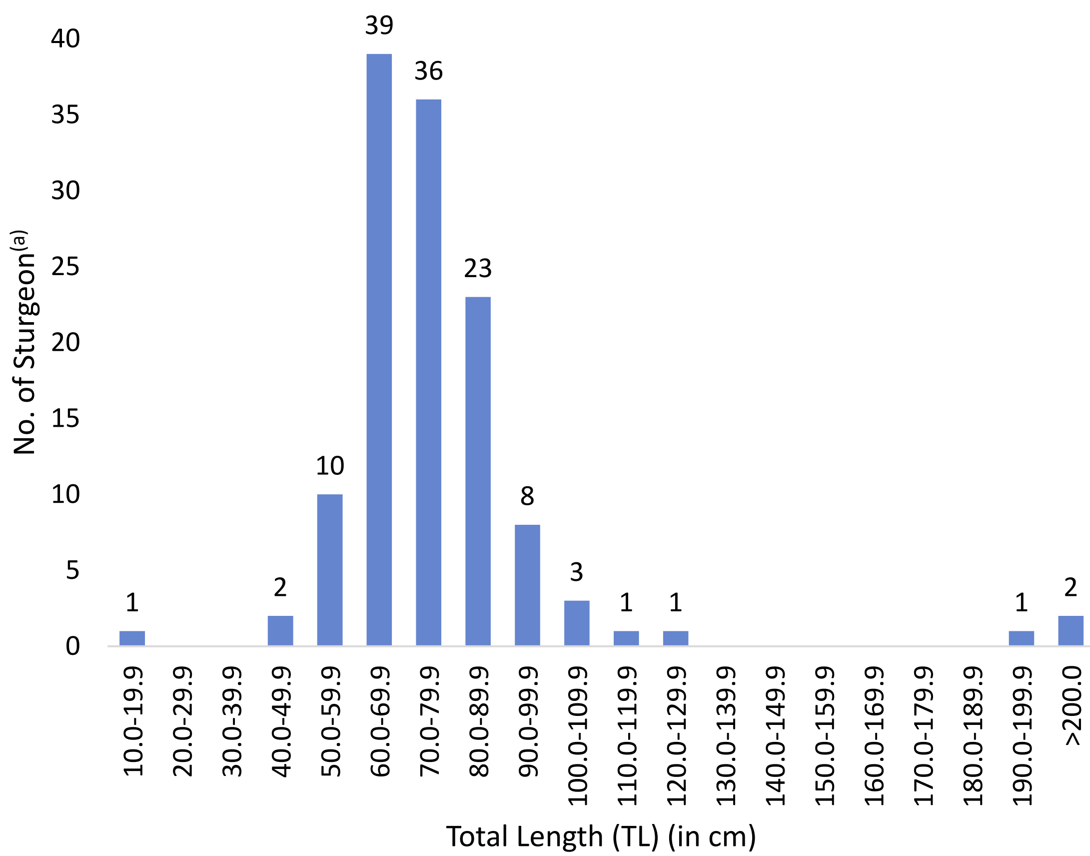
Figure 3 depicts the length-frequency distribution of sturgeon collected at the Salem trash bars from February 2011–May 2020 in 10 cm (4 in.) increments, and Figure 4 depicts the length-frequency distribution by age class for the same time period. Table A1 lists the impingement date, condition, fork length (FL), and TL for each impinged fish.

Impingement at the trash bars will continue to adversely affect Atlantic sturgeon in the action area over the remainder of Salem's renewed facility operating licenses (i.e., through 2036 (Unit No. 1) and 2040 (Unit No. 2)). Based on the data summarized above, the NRC staff anticipates that PSEG will continue to collect an average of 15.1 sturgeon per year at the trash bars while both units are operating (i.e., through 2036) and 7.6 sturgeon per year thereafter and for the remainder of the Unit No. 2 operating period (i.e., through 2040). The NRC staff expects that the condition of impinged sturgeon will be similar to those reported above (i.e., 46% alive, 40% dead due to impingement, and 14% dead due to other factors). In total, this equates to an additional 272 impingements, of which 125 are expected to be alive, 109 are expected to be dead due to impingement, and 38 are expected to be dead due to other factors. Most impingements are likely to be of river-resident subadults or juveniles based on the length-frequency data presented above. Preliminary genetic analysis of PSEG fin clips (discussed in Section 5.0) indicates that the NMFS's (2014) proportional DPS predictions of impinged subadults remain valid. The NRC staff concludes that

[4] The ASSRT (2007) reports Atlantic sturgeon size classes as follows: young of year ≤ 41 cm TL; non-migrant subadult or juvenile > 41 and ≤ 76 cm TL; subadult > 76 cm and ≤ 150 cm TL; and adult > 150 cm TL.

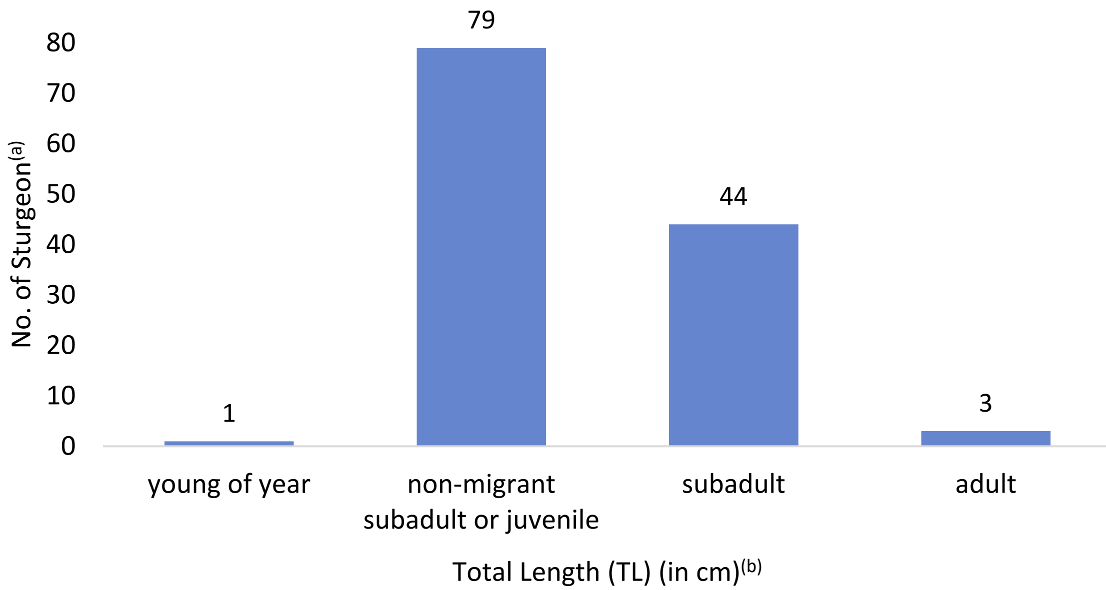
impingement at the Salem trash bars is an adverse effect of the proposed action because it is not discountable, insignificant, or beneficial and would result in both lethal and non-lethal take of Atlantic sturgeon.

Figure 3. Length-Frequency Distribution of Atlantic Sturgeon Collected at the Salem Trash Bars, 2011– Present



(a) This figure depicts 127 of the 141 Atlantic sturgeon collected at the Salem trash bars from 2011-2020. 2020 numbers include impingements through May 31, 2020. Length is not available for the remaining 14 specimens. All specimens collected as partial carcasses are excluded.

Figure 4. Length-Frequency Distribution of Atlantic Sturgeon Collected at the Salem Trash Bars by Age Class, 2011– Present



(a) This figure depicts 127 of the 141 Atlantic sturgeon collected at the Salem trash bars from 2011-2020. 2020 numbers include impingements through May 31, 2020. Length is not available for the remaining 14 specimens. All specimens collected as partial carcasses are excluded.

(b) Age classes are based on the ASSRT (2007) as follows: young of year ≤ 41 cm TL; non-migrant subadult or juvenile > 41 and ≤ 76 cm TL; subadult > 76 cm and ≤ 150 cm TL; and adult > 150 cm TL.

Traveling Screens

With respect to impingement at the traveling screens, the NMFS (2014) anticipated that Salem would impinge an average of 12 Atlantic sturgeon per year at the traveling screens based on an extrapolation of 17 years of impingement sampling data over the period 1976–2013. Since it began reporting collections of the species in February 2011, PSEG has collected five Atlantic sturgeon from the traveling screens. Over the 70-month period since the NMFS issued the biological opinion (i.e., July 2014–May 2020), PSEG has collected four sturgeon during traveling screen sampling, which PSEG performs for about 20 minutes per day, 3 days per week. The proportional conditions of the four Atlantic sturgeon impinged at the traveling screens are:

- 50% alive (2 fish)
- 25% dead due to impingement (1 fish)
- 25% dead due to other factors (1 fish)

Impingement at the traveling screens will continue to adversely affect Atlantic sturgeon in the action area over the remainder of Salem's renewed facility operating licenses. Based on the data summarized above, the NRC staff anticipates that PSEG will continue to collect sturgeon at the traveling screens but that Salem will remain within the limits anticipated in the biological opinion (i.e., 12 sturgeon captured or impinged at the traveling screens with no more than one individual killed or injured due to impingement each year). All impingements at the traveling screens would be of young of the year (i.e., age-0) or age-1 juveniles. The NRC staff concludes that impingement at the Salem traveling screens is an adverse effect of the proposed action because it is not discountable, insignificant, or beneficial and would result in both lethal and non-lethal take of Atlantic sturgeon.

7.2 Entrainment

Entrainment occurs when organisms pass through the screening device and are drawn into the cooling system (79 FR 48299). Entrainable life stages of Atlantic sturgeon (e.g., eggs and larvae) do not occur in the action area. The southern extent of Atlantic sturgeon spawning in the Delaware River is approximately RKM 120 (RM 75), more than 40 RKM (25 RM) upstream of Salem's cooling water intake structure. In Section 7.1.2 of the biological opinion, the NMFS (2014) found that no entrainment of Atlantic sturgeon would occur from the proposed action because eggs and larvae do not occur in the action area. All other life stages are too big to pass through the screen mesh of Salem's cooling water intake structure traveling screens and are, therefore, not subject to entrainment. The NRC staff did not identify any new or additional information that would call into question these assumptions or conclusions. Accordingly, the NRC staff concludes that entrainment of Atlantic sturgeon is not a potential effect of the proposed action.

7.3 Thermal Effects

Salem's discharge of heated effluent creates a thermal plume within the Delaware Estuary. The plume's near-field region is approximately 90 m (300 ft) during ebb and flood tides and 300 m (1,000 ft) during slack tide. Within the transition region, which is approximately 200 m (700 ft), the plume spreads horizontally and stratifies vertically due to the buoyancy of the warmer waters. Thermal plumes can potentially result in heat shock, create barriers to fish passage, or alter other characteristics of the aquatic environment, such as dissolved oxygen levels.

The NMFS (2014) addressed thermal effects on Atlantic sturgeon in Section 7.5 of the biological opinion. The NMFS determined that sturgeon may avoid areas within Salem's thermal plume that are greater than 28 °C (82.4 °F). Individuals are likely to react to such elevated temperatures by swimming around the plume or by traveling deeper within the water column. Given the extremely small percentage of the estuary that may have temperatures elevated above 28 °C (82.4 °F) (i.e., no more than 0.17%), it is extremely unlikely that these minor changes in behavior would preclude any sturgeon from completing normal behaviors, such as resting, foraging, or migrating or that the fitness of any individuals would be affected. There is also not expected to be any increase in energy expenditure that would have any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health. The NRC staff did not identify any new or additional information that would call into question these assumptions or conclusions. Accordingly, the NRC staff concludes that thermal effects on Atlantic sturgeon would be insignificant because they would not be able to be meaningfully measured, detected, or evaluated.

7.4 Exposure to Radionuclides and Nonradiological Contaminants

Radionuclides

Tritium, a radioactive isotope of hydrogen, is the radionuclide of concern with respect to the proposed action because of its ability to assimilate into waterbodies and behave like water. It occurs both naturally and as a by-product of nuclear power reactor operations. Tritium is a relatively weak source of beta radiation, but it can impact living organisms if it is inhaled or ingested. During power operations, Salem may discharge tritium through one of two pathways: (1) as a liquid through effluent releases to the Delaware Estuary or (2) as a gas through the air.

The NMFS (2014) addressed exposure to radionuclides in Section 7.8 of the biological opinion. PSEG's REMP sampling indicates that the radioactivity in edible fish,[5] blue crabs, shoreline and riverbed sediments, and surface water is comparable to pre-operational levels. The NMFS (2014) found it reasonable to anticipate that similar results would be seen if listed species were sampled and, accordingly, Atlantic sturgeon are not expected to contain any detectable levels of radionuclides attributable to Salem's operation. As such, impacts to Atlantic sturgeon from exposure to radionuclides are extremely unlikely or would not be able to be meaningfully measured, detected, or evaluated. The NRC staff did not identify any new or additional information that would call into question these assumptions or conclusions. Accordingly, the NRC staff concludes that the effects of exposure to radionuclides on Atlantic sturgeon would be insignificant and discountable.

Nonradiological Contaminants

The NMFS (2014) addressed exposure to nonradiological contaminants in Section 7.6 of the biological opinion. The NMFS evaluated whether Salem's discharges would remain below U.S. Environmental Protection Agency (EPA) water quality criteria for protection of aquatic life. The two relevant criteria are the acute (criteria maximum concentration (CMC)) and chronic (criteria continuous concentration (CCC)) criteria. The 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. The EPA certifies that the New Jersey water quality criteria meet the CMC and CCC, among other criteria, every three years. In the absence of species-specific toxicity data, the NMFS (2014) determined that pollutants that are discharged with no reasonable potential to cause excursions in water quality standards will not cause effects that impair growth, survival, or reproduction of listed species. Salem's discharge of nonradiological contaminants does not violate the relevant standards. The NRC staff did not identify any new or additional information that would call into question these assumptions or conclusions. Accordingly, the NRC staff concludes that that the effects of exposure to nonradiological contaminants on Atlantic sturgeon would be insignificant.

[5] Sampled edible fish include channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), bluefish (*Pomatomus saltatrix*), white perch (*Morone americana*), summer flounder (*Paralichthys dentatus*), striped bass (*Morone saxatilis*), and black drum (*Pogonias cromis*).

7.5 Reduction in Available Food Resources from Effects on Prey Species

The ability of Atlantic sturgeon to successfully forage within the action area could be affected through impingement and entrainment of potential prey species or through thermal effects on those species. Atlantic sturgeon feed primarily on small benthic invertebrates and, thus, these are the prey species relevant to this discussion.

Impingement and Entrainment of Prey Species

Benthic invertebrates would be susceptible to entrainment but not to impingement due to their small sizes. Many benthic invertebrates avoid impingement through sessile or burrowing behaviors, which keeps them out of the water column where they would otherwise be susceptible to the draw of water into Salem's cooling water intake structure.

The NMFS (2014) addressed the impingement and entrainment of prey species in Section 7.4.1.1 of the biological opinion. Past impingement and entrainment studies at Salem have included at least two macroinvertebrates, scud (*Gammarus* spp.) and opossum (Order Mysida) shrimp, as focus species. Assessments completed on these species concluded that Salem does not and will not have an adverse impact on them. Based on these determinations and life history characteristics of the macroinvertebrate community, the NMFS (2014) found that any loss of potential sturgeon prey species due to impingement and entrainment would be insignificant. The NRC staff did not identify any new or additional information that would call into question these assumptions or conclusions. Accordingly, the NRC staff concludes that the effects of impingement and entrainment of prey species on Atlantic sturgeon would be insignificant.

Thermal Effects on Prey Species

Prey species of Atlantic sturgeon may experience similar effects from Salem's thermal plume as described previously for Atlantic sturgeon themselves (i.e., heat shock, barriers to passage, and altered habitat characteristics). The NMFS (2014) addressed thermal effects on prey species in Section 7.5.1.7 of the biological opinion. Based on a review of thermal studies within the Delaware Estuary, the NMFS (2014) determined that prey species of sturgeon are impacted insignificantly, if at all, by Salem's thermal discharge. The NRC staff did not identify any new or additional information that would call into question these assumptions or conclusions. Accordingly, the NRC staff concludes that thermal effects on prey species would have insignificant impacts on Atlantic sturgeon.

7.6 Capture During Biological Sampling

PSEG performs biological sampling, as required by the NRC and the New Jersey Department of Environmental Protection. This section describes the potential effects of such sampling.

REMP Sampling

The NRC requires power reactor licensees to implement a REMP in accordance with 10 CFR Parts 20 and 50 and to monitor and report measurable levels of radiation and radioactive materials in the site environs. PSEG has established a REMP for the environment around the Salem and Hope Creek site, including nearby portions of the Delaware Estuary.

The NMFS (2014) addressed capture of Atlantic sturgeon during REMP sampling in Section 7.7 of the biological opinion. Because PSEG conducts sampling in areas where Atlantic sturgeon are known to occur and because these fish are vulnerable to gillnet capture, the NMFS anticipated that future captures were possible. Based on the duration of gillnet sets, the constant tending of the net, and past monitoring in similar short-set research activities where few mortalities have occurred, the NMFS (2014) concluded that sturgeon captured during future REMP sampling were very unlikely to suffer serious injury or mortality (likelihood of 1% based on other research using gillnets to capture sturgeon).

At the time that the NMFS issued its biological opinion, only one sturgeon had been captured in 46 years of REMP sampling (1968–2014). That individual was captured on May 16, 2013, and researchers returned it back to the river alive and unharmed (NMFS 2014). The NMFS (2014) anticipated that PSEG would capture one additional Atlantic sturgeon during REMP gillnet sampling over the duration of the Salem and Hope Creek renewed facility operating licenses. The NMFS predicted that while that fish might sustain minor injuries, it would be expected to make a complete recovery without any impairment to its future fitness. To date, PSEG has reported no captures of Atlantic sturgeon during REMP sampling. The NRC staff did not identify any other new or additional information that would call into question the NMFS's previous assumptions or conclusions. Accordingly, the NRC staff concludes that REMP sampling is an adverse effect of the proposed action because it is not discountable, insignificant, or beneficial and would result in take of Atlantic sturgeon. However, all such take is anticipated to be minimal and non-lethal, and the sturgeon are expected to be released back to the river and make a full recovery if harmed.

UBMWP Bottom Trawl and Beach Seine Sampling

Salem's New Jersey Pollutant Discharge Elimination System (NJPDES) permit requires PSEG to implement an UBMWP that includes annual bay-wide bottom trawl surveys, beach seine surveys, monitoring at fish ladder sites, and sampling at restored wetland sites within the Delaware River and Delaware Bay. The UBMWP is a required component of the NJPDES permit, which has no independent utility separate from Salem's renewed facility operating licenses.

The NMFS (2014) addressed the effects of UBMWP[6] activities in Section 7.10 of the biological opinion. The NMFS found that the components of the UBMWP that have the potential to impact sturgeon are the bottom trawl and beach seine surveys, and the effects of these surveys are addressed in Section 7.10.2 of the opinion.

<u>Bottom Trawl Sampling</u>

From 1995–2013, 18 Atlantic sturgeon were captured during bottom trawl sampling. All individuals were released alive at the point of capture. The NMFS (2014) assumed that, based on the rate of historical capture, some level of capture would continue; that such captures may be of juveniles, subadults, or adults; and that these captures would not result in injury or mortality. The NMFS anticipated that PSEG would capture 11 Atlantic

[6] The biological opinion discusses the IBMWP rather than the UMBWP. The UBMWP replaced the IBMWP in 2016. See Footnote 1 on page 1.

sturgeon during bottom trawl sampling over the duration of the Salem and Hope Creek renewed facility operating licenses.

Since the NMFS's issuance of the biological opinion, PSEG has captured 10 Atlantic sturgeon during bottom trawl sampling (see Table A1). All sturgeon were alive and released back to the river unharmed. This capture rate (2 Atlantic sturgeon per year over the 5 sample years since the biological opinion was issued (2015–2019)) is higher than the NMFS's anticipated capture rate of 0.38 sturgeon per year. While year-to-year fluctuations are expected, the higher observed capture rate indicates that more sturgeon may be present in the action area and susceptible to capture in trawl nets than was assumed at the time that the NMFS formulated its biological opinion. Assuming that PSEG captures 2 Atlantic sturgeon per year over the remainder of the renewed facility operating licenses, researchers may capture as many as an additional 42 sturgeon over the remaining 21 sampling years (2020-2040). The NRC staff concludes that UBMWP bottom trawl sampling is an adverse effect of the proposed action because it is not discountable, insignificant, or beneficial and would result in take of Atlantic sturgeon. However, all such take is anticipated to be non-lethal, and sturgeon are expected to be released back to the river unharmed.

<u>Beach Seine Sampling</u>

With respect to beach seine sampling, capture of Atlantic sturgeon in beach seines is rare because sturgeon are a benthic species that prefer to inhabit the bottom of deeper river channels. Through 2014, only one Atlantic sturgeon had been captured during beach seine sampling, and it was released alive and unharmed. Because beach seines are set in shallow sub-tidal, nearshore waters for short durations (15 minutes), the NMFS (2014) anticipated that the likelihood of an Atlantic sturgeon encountering the nets was low. The NMFS anticipated that no more than one sturgeon (either shortnose or Atlantic) would be captured during beach seine sampling over the duration of the Salem and Hope Creek renewed facility operating licenses and that such capture would not result in injury or mortality. To date, PSEG has reported no captures of sturgeon during beach seine sampling, and the NRC staff did not identify any other new or additional information that would call into question the NMFS's previous assumptions or conclusions. Accordingly, the NRC staff concludes that UBMWP beach seine sampling is an adverse effect of the proposed action because it is not discountable, insignificant, or beneficial and would result in take of Atlantic sturgeon. However, all such take is anticipated to be minimal and non-lethal, and sturgeon are expected to be released back to the river unharmed.

7.7 Effects on Designated Critical Habitat

As established in Section 6.0, the entirety of the action area lies within New York Bight Critical Habitat Unit 4. This section considers the potential effects of the proposed action on each of the four PBFs of this critical habitat. Table 5 contains the complete regulatory descriptions of each PBF.

PBF 1: Hard Bottom Substrate in Low Salinity Waters for Growth and Development of Early Life Stages

The first PBF is hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of Atlantic sturgeon fertilized eggs, refuge, growth, and development of early life stages (82 FR 39160). The

Salem action area does not contain the substrates or consistently contain salinities within the range associated with this PBF.

Substrates within the action area include fine-grained silts, clays, and sands (NRC 2011). Hard bottom substrates that are required for egg settlement and development are not present within the action area.

With respect to salinity, the Delaware River estuary can be divided into four longitudinal salinity zones. Starting at the downstream end, the mouth of the Delaware Bay to RKM 55 (RM 34) is considered polyhaline (18–30 ppt); RKM 55–71 (RM 34–44) is mesohaline (5–18ppt); RKM 71–127 (RM 44–79) is oligohaline (0.5–5ppt); and Marcus Hook (RKM 127 (RM 79)) to Trenton is considered fresh (0.0–0.5 ppt). The Salem site lies within the lower reaches of the oligohaline zone at approximately RKM 80 (RM 50). The waters within the action area exhibit varying salinity levels depending on river discharge. The NRC (2011) found that salinity in the action area typically ranges from 5–12 ppt during periods of low flow (usually in the summer) and from 0–5 ppt during periods of high flow. Within these larger patterns, salinity at any specific location also varies with the tides. The region also occasionally stratifies with salinity increasing as much as 2 ppt per meter of water depth (NRC 2011). Thus, the required salinity conditions of this PBF of less than 0.5 ppt are only occasionally present in the action area.

Because PBF 1 requires both appropriate substrate and salinity conditions, the required features of this PBF are not present in the action area. Current literature suggests that Atlantic sturgeon spawn between RKM 120–150 (RM 75–93) and RKM 171–190 (RM 106–118) (NMFS 2014), which further supports this conclusion. Accordingly, the NRC staff concludes that the proposed action would have no effect on PBF 1.

PBF 2: Aquatic Habitat with a Gradual Downstream Salinity Gradient and Soft Substrate for Juvenile Foraging and Development

The second PBF is aquatic habitat with a gradual downstream salinity gradient of 0.5 ppt up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development (82 FR 39160). The Salem action area contains both the salinity gradient and soft substrates associated with this PBF.

The proposed action would not affect river salinity and would, therefore, have no effect on this component of PBF 2.

With respect to soft substrates, Salem's continued withdrawal of cooling water would not affect the surrounding substrates. Discharge of the heated effluent may limit access to soft bottom substrates within the action area in those areas exceeding the Atlantic sturgeon's thermal tolerance. As previously established in Section 7.3, Atlantic sturgeon are likely to avoid waters at temperatures of 28 °C (82.4 °F) or greater. Thermal discharges would cause an extremely small percentage of the estuary to exhibit temperatures above 28 °C (82.4 °F) (i.e., no more than 0.17%) (NMFS 2014). Because the thermal plume is largely confined to the upper portion of the water column, temperatures exceeding this threshold would rarely be present at the bottom of the water column where sturgeon are most likely to occur. If present, elevated temperatures would occur only seasonally for short periods of time and over a very limited area. Therefore, while there may be times when Atlantic sturgeon would not be able to access some portions of the action area that contain PBF 2, these instances would be limited spatially and temporally. Similarly, benthic prey species inhabiting soft substrates may be displaced or otherwise affected by the thermal plume, but such effects would be insignificant, as previously established in Section 7.5 of this assessment.

Because the proposed action is extremely unlikely to affect the value of the habitat to the conservation of the species, the NRC staff concludes that any effects to PBF 2 are discountable.

PBF 3: Water of Appropriate Depth and Absent Physical Barriers to Passage to Support Staging, Resting, Holding, and Migration of Juveniles, Subadults, and Adults

The third PBF is water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support:

(i) Unimpeded movement of adults to and from spawning sites;

(ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and

(iii) Staging, resting, or holding of subadults or spawning condition adults.

Water depths in main river channels must also be deep enough (e.g., at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river (82 FR 39160).

Thermal effluent from nuclear plant discharges can create a physical barrier if the thermal plume creates environmental conditions that impede passage. As explained previously in the discussion of PBF 2, continued discharge of thermal effluent could limit Atlantic sturgeons' access to the area of the river exceeding the species' thermal tolerance. However, sturgeon would rarely encounter temperatures exceeding their thermal tolerance because Salem's thermal plume is largely confined to the surface and only occupies a small region of the estuary. Because there would always be a large zone of passage, the thermal plume would not be a barrier to sturgeon moving between the river mouth and spawning sites. Therefore, it is extremely unlikely that habitat alterations associated with Salem's thermal effluent would impact the ability of any adult Atlantic sturgeon to move through the action area to reach the upstream spawning grounds; affect the seasonal movements of juveniles; or affect staging, resting, or holding of subadults or spawning condition adults.

Because the proposed action is extremely unlikely to affect the value of the habitat to the conservation of the species, the NRC staff concludes that any effects to PBF 3 are discountable.

PBF 4: Water with Temperature, Salinity, and Oxygen Values that Support Spawning, Growth, Development, Recruitment, and Survival

The fourth PBF is water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support:

(i) Spawning;

(ii) Annual and interannual adult, subadult, larval, and juvenile survival; and

(iii) Larval, juvenile, and subadult growth, development, and recruitment (e.g., 13 to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) or greater dissolved oxygen for juvenile rearing habitat) (82 FR 39160).

The water quality conditions of this PBF are interactive, such that both temperature and salinity influence the dissolved oxygen content in a particular area. As previously established, the proposed action affects water temperature through discharge of heated effluent, but it does not affect salinity. Because the action area is tidally influenced, salinity varies significantly with tides and seasons; thus, the dissolved oxygen content of the water within the action area is also highly variable. As reported by NRC (2011), PSEG completed a Clean Water Act Section 316(a) demonstration study in 1999 that found that Salem's thermal discharge had no discernible effect on dissolved oxygen levels in the area. Based on the preceding analyses of PBF 2 and PBF 3, the NRC staff does not expect that thermal discharges alone would affect Atlantic sturgeon growth, development, recruitment, or survival. As previously established, spawning does not take place in the action area; therefore, the features of this PBF relevant to the early life stages of Atlantic sturgeon do not apply to the Salem action area.

With respect to the proposed action's effect on dissolved oxygen content in the Salem action area, the area influenced by Salem's thermal plume is small and largely confined to the surface, so dissolved oxygen in the action area is unlikely to be substantially affected by Salem's continued operation. The NRC (2013) generically determined that effects on aquatic biota due to low dissolved oxygen levels are not expected to extend beyond the thermal mixing zone. Therefore, it is extremely unlikely that habitat alterations associated with Salem's thermal effluent would impact the growth, development, recruitment, or survival of Atlantic sturgeon in the action area.

Because the proposed action is extremely unlikely to affect the value of the habitat to the conservation of the species, the NRC staff concludes that any effects to PBF 4 are discountable.

8.0 Mitigation Strategies

PSEG has engaged Alden Research Lab to investigate potential mitigation strategies to reduce adverse impacts associated with sturgeon impingement at the Salem trash bars. PSEG will share the results of this investigation, once available, with the NRC and the NMFS. PSEG anticipates that Alden Research Lab will complete its final report in August 2020.

9.0 Cumulative Effects

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). When formulating biological opinions, the NMFS considers cumulative effects when determining the likelihood of jeopardy or adverse modification.

In Section 8.0 of its biological opinion, the NMFS (2014) described the cumulative impacts of future recreational and commercial fishing activities in State waters and the discharge of pollutants under National Pollutant Discharge Elimination System permits issued by the responsible New Jersey and Delaware State agencies. The biological opinion's characterization of cumulative effects remains relevant for this review, and the NRC staff did not identify any new or additional information related to cumulative effects.

As part of a separate Federal action, PSEG is preparing to submit applications to the USACE for a proposed marine terminal to support offshore wind construction in the Atlantic Ocean. The proposed marine terminal would be located adjacent to and directly north of Hope Creek on Artificial Island. Because the USACE is a Federal agency that is subject to ESA Section 7, it would initiate consultation with the NMFS, as appropriate, during its review of the permit applications. Because the USACE's issuance of a permit constitutes a Federal activity, effects resulting from the marine terminal are, by definition, not relevant to this cumulative effects discussion.

10.0 Conclusions

Based on the NRC staff's analysis presented in this biological assessment, the staff makes the following conclusions.

10.1 Atlantic Sturgeon

Summary of Effects

The proposed action will result in adverse effects to Atlantic sturgeon in the form of impingement into Salem's cooling water intake structure and capture during biological sampling.

- **Impingement at the Trash Bars:** Impingement will result in both lethal and non-lethal take of Atlantic sturgeon. Salem has exceeded its incidental take statement limit for both causal and non-causal mortalities of Atlantic sturgeon at the trash bars. The NRC staff predicts that, in total, Salem will impinge an additional 272 Atlantic sturgeon at the trash bars over the remainder of the renewed facility operating licenses. Of these 272 sturgeon, 125 are expected to be alive, 109 are expected to be dead due to impingement, and 38 are expected to be dead due to other factors. Most impingements are likely to be of river-resident subadults or juveniles.
- **Impingement at the Traveling Screens:** Impingement will result in both lethal and non-lethal take of Atlantic sturgeon. Salem remains within its incidental take statement limit for impingement of Atlantic sturgeon at the traveling screens. The NRC staff anticipates that PSEG will continue to collect sturgeon at the traveling screens, but that Salem will remain within the limits anticipated in the biological opinion (i.e., 12 sturgeon captured or impinged at the traveling screens with no more than one individual killed or injured due to impingement each year). All impingements at the traveling screens would be of young of the year (i.e., age-0) or age-1 juveniles.
- **Biological Sampling:** Biological sampling will result in non-lethal captures of Atlantic sturgeon. Salem remains within its incidental take statement limit for captures of Atlantic sturgeon during biological sampling. Although captures

during REMP and beach seine sampling are likely to remain within the incidental take statement limits, the NRC predicts that researchers may capture an additional 42 sturgeon during bottom trawl sampling over the remainder of the renewed facility operating licenses.

All other effects of the proposed action on Atlantic sturgeon, including exposure to thermal effects, exposure to radionuclides and nonradiological contaminants, and reduction in available food resources from effects to prey species, would be insignificant or discountable.

Conclusion

Based on its analysis summarized in this biological assessment, the NRC staff concludes that the proposed action *is likely to adversely affect* the Atlantic sturgeon.

10.2 Designated Critical Habitat of the Atlantic Sturgeon

Summary of Effects

The proposed action will result in habitat alterations that may affect PBFs 2, 3, and 4 of the critical habitat of the Atlantic sturgeon in the Delaware River designated as New York Bight Critical Habitat Unit 4. These habitat alterations will primarily result from continued discharge of thermal effluent. However, any effects on the value of the habitat to the conservation of the Atlantic sturgeon, including its ability to support juvenile foraging and development; allow for upstream and downstream passage of juveniles, subadults, and adults; and otherwise support growth, development, recruitment, and survival of the life stages of the species present in the action area, are either extremely unlikely to occur or would be so small that they could not be meaningfully measured, detected, or evaluated. Therefore, all effects to the critical habitat of the Atlantic sturgeon resulting from the continued operation of Salem are discountable or insignificant.

Conclusion

Based on its analysis summarized in this biological assessment, the NRC staff concludes that the proposed action may affect but is not likely to destroy or adversely modify the designated critical habitat of the New York Bight DPS of the Atlantic sturgeon.

11.0 Literature Cited

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Appendix A. Atlantic Sturgeon Impingement and Capture Data

Table A1. All Atlantic Sturgeon Impingements and Captures, 2011–Present

Date	Unit No.	Collection Location	Condition	Causality[a][b]	Fork Length (FL) (in cm)[b]	Total Length (TL) (in cm)[b]	Incidental Take Report	Annual Report
3/18/11	1	trash bars	alive	-	n/a	n/a	[c]	[c]
4/20/11	1	trash bars	alive	-	n/a	n/a	[d]	[d]
4/24/11	1	trash bars	alive	-	n/a	n/a	[d]	[d]
9/7/11	1	trash bars	alive	-	n/a	18.0	[d]	[d]
11/14/12	1	trash bars	dead	n/a[e]	42.5	48.5	ML12355A373	ML13112A018
11/30/12	1	trash bars	alive	-	52.2	59.3	ML13008A320	ML13112A018
1/16/13	1	trash bars	alive	-	44.6	52.2	ML13045A901	ML14078A079
2/11/13	2	trash bars	alive	-	54.2	64.3	ML13093A230	ML14078A079
2/19/13	1	trash bars	alive	-	66.5	76.0	ML13093A248	ML14078A079
3/13/13	1	trash bars	alive	-	40.6	46.6	ML13100A213	ML14078A079
3/14/13	1	traveling screens	alive	-	38.2	44.3	ML13100A211	ML14078A079
3/15/13	1	trash bars	alive	-	47.3	54.6	ML13100A194	ML14078A079
3/18/13	1	trash bars	alive	-	44.9	51.8	ML13100A210	ML14078A079
3/20/13	1	trash bars	alive	-	66.0	74.2	ML13100A212	ML14078A079
3/25/13	1	trash bars	alive	-	67.7	78.4	ML13112A155	ML14078A079
4/3/13	1	trash bars	dead	n/a[e]	66.6	77.3	ML13112A156	ML14078A079
5/16/13	-	REMP sampling	alive	-	n/a	n/a	[d]	[d]
8/7/13	1	trash bars	dead	n/a[e]	91.5	106.7	ML13248A456	ML14078A079
10/28/13	1	trash bars	dead	n/a[e]	61.1	71.3	ML13336A690	ML14078A079
10/28/13	1	trash bars	dead	n/a[e]	n/m[f]	n/m[f]	ML13336A690	ML14078A079

Date	Unit No.	Collection Location	Condition	Causality[a][b]	Fork Length (FL) (in cm)[b]	Total Length (TL) (in cm)[b]	Incidental Take Report	Annual Report
12/13/13	2	trash bars	alive	-	n/m	57.0	ML14016A076	ML14078A079
12/20/13	1	trash bars	alive	-	n/m	57.0	ML14016A070	ML14078A079
12/26/13	1	trash bars	alive	-	72.3	62.5	ML14030A178	ML14078A079
12/26/13	2	trash bars	alive	-	210	190	ML14030A178	ML14078A079
12/26/13	2	trash bars	dead	n/a[e]	62.1	54.8	ML14030A178	ML14078A079
12/27/13	2	trash bars	dead	n/a[e]	67.9	59.5	ML14034A246	ML14078A079
1/6/14	1	trash bars	dead	n/a[e]	52.3	61.1	ML14034A245	ML15111A133
1/8/14	2	trash bars	alive	-	53.5	62.2	ML14034A244	ML15111A133
1/27/14	1	trash bars	alive	-	n/m	64.7	ML14069A165	ML15111A133
1/27/14	2	trash bars	alive	-	n/m	66.0	ML14069A165	ML15111A133
2/12/14	2	trash bars	alive	-	60.5	70.2	ML14086A453	ML15111A133
2/19/14	1	trash bars	dead	n/a[e]	58.0	68.4	ML14086A452	ML15111A133
2/20/14	1	trash bars	dead	n/a[e]	59.1	66.4	ML14085A417	ML15111A133
3/27/14	2	trash bars	alive	-	58.4	67.2	ML14121A254	ML15111A133
3/31/14	2	trash bars	alive	-	n/a	n/a	[g]	ML15111A133
4/3/14	2	trash bars	alive	-	54.0	63.0	ML14133A581	ML15111A133
4/7/14	1	trash bars	alive	-	61.1	70.2	ML14133A583	ML15111A133
4/7/14	1	trash bars	alive	-	59.0	67.6	ML14133A583	ML15111A133
4/7/14	1	trash bars	dead	n/a[e]	60.9	70.2	ML14133A583	ML15111A133
4/9/14	1	trash bars	dead	n/a[e]	60.6	69.3	ML14133A582	ML15111A133
4/18/14	1	trash bars	dead	n/a[e]	59	67.3	ML14142A361	ML15111A133
8/5/14	1	trash bars	dead	non-causal	n/m	76.0	ML14251A025	ML15111A133
12/22/14	1	trash bars	dead	non-causal	61.0	70.1	ML15021A126	ML15111A133

Date	Unit No.	Collection Location	Condition	Causality[a][b]	Fork Length (FL) (in cm)[b]	Total Length (TL) (in cm)[b]	Incidental Take Report	Annual Report
3/25/15	1	trash bars	alive	-	73.7	81.3	ML15118A538	ML16102A277
7/1/15	-	bottom trawl sampling	alive	-	n/a	n/a	[g]	[g]
11/24/15	1	trash bars	dead	non-causal	64.1	74.6	ML15334A114	ML16102A277
12/4/15	1	trash bars	alive	-	53.2	61.5	ML15341A238	ML16102A277
12/18/15	1	trash bars	alive	-	52.6	61.9	ML16005A009	ML16102A277
1/21/16	1	trash bars	alive	-	56.2	65.3	ML16028A271	ML17074A478
1/26/16	1	trash bars	dead	non-causal	45.4	53.1	ML16028A275	ML17074A478
2/2/16	1	trash bars	alive	-	92.7	106.0	ML16035A027	ML17074A478
2/2/16	1	trash bars	alive	-	224.0	248.0	ML16035A029	ML17074A478
2/2/16	1	trash bars	alive	-	55.1	64.2	ML16035A030	ML17074A478
3/23/16	1	trash bars	dead	causal	n/m[f]	n/m[f]	ML16084A611	ML17074A478
3/23/16	1	trash bars	dead	causal	62.0	71.0	ML16084A699	ML17074A478
4/8/16	2	trash bars	dead	non-causal	210.3	213.4	ML16102A307	ML17074A478
4/13/16	-	bottom trawl sampling	alive	-	n/a	n/a	[g]	[g]
5/26/16	2	trash bars	dead	non-causal	84.4	98.4	ML16152A189	ML17074A478
11/14/16	-	bottom trawl sampling	alive	-	n/a	n/a	[g]	[g]
12/9/16	2	trash bars	alive	-	56.0	64.7	ML16347A126	ML17074A478
12/30/16	2	trash bars	alive	-	62.0	72.7	ML17003A253	ML17074A478
2/23/17	2	trash bars	dead	non-causal	83.1	94.0	ML17058A126	ML18337A304
2/23/17	2	trash bars	dead	non-causal	n/m[f]	n/m[f]	ML17058A126	ML18337A304
4/12/17	-	bottom trawl sampling	alive	-	n/a	n/a	[g]	[g]
5/12/17	1	trash bars	dead	non-causal	67.5	74.0	ML17135A107	ML18337A304
5/12/17	1	trash bars	dead	non-causal	n/m[f]	n/m[f]	ML17135A107	ML18337A304

Date	Unit No.	Collection Location	Condition	Causality[a][b]	Fork Length (FL) (in cm)[b]	Total Length (TL) (in cm)[b]	Incidental Take Report	Annual Report
6/2/17	1	traveling screens	dead	non-causal	72.6	80.4	ML17156A568	ML18337A304
8/2/17	-	bottom trawl sampling	alive	-	n/a	n/a	[g]	[g]
3/14/18	1	trash bars	alive	-	n/a	n/a	[g]	ML20034F384
3/28/18	1	trash bars	dead	non-causal	n/m[f]	n/m[f]	ML18337A325	ML20034F384
4/11/18	2	trash bars	alive	-	76.3	83.4	ML18337A326	ML20034F384
4/11/18	1	trash bars	dead	causal	67.5	78.0	ML18337A327	ML20034F384
5/21/18	1	traveling screens	alive	-	35.5	41.5	ML18337A328	ML20034F384
6/12/18	-	bottom trawl sampling	alive	-	n/a	n/a	[g]	ML20034F384
7/13/18	-	bottom trawl sampling	alive	-	n/a	n/a	[g]	ML20034F384
11/4/18	1	trash bars	dead	causal	n/a	n/a	ML18318A350	ML20034F384
11/13/18	1	trash bars	dead	causal	71.3	85.1	ML18337A330	ML20034F384
11/20/18	1	trash bars	alive	-	76.4	86.3	ML18337A331	ML20034F384
11/20/18	1	trash bars	dead	causal	81.3	103.5	ML18337A332	ML20034F384
11/29/18	1	trash bars	dead	causal	62.1	72.3	ML18344A081	ML20034F384
12/1/18	2	trash bars	dead	causal	63.0	73.8	ML18344A078	ML20034F384
12/24/18	1	trash bars	dead	causal	83.5	93.5	ML19007A118	ML20034F384
1/1/19	1	trash bars	dead	causal	62.3	68.6	ML19007A120	ML20121A133
1/7/19	2	trash bars	dead	causal	61.6	72.0	ML19030A824	ML20121A133
1/18/19	1	trash bars	dead	causal	n/m[f]	n/m[f]	ML19030A824	ML20121A133
2/7/19	1	trash bars	dead	non-causal	60.9	70.9	ML19042A299	ML20121A133
2/15/19	1	trash bars	dead	causal	54.2	63.8	ML19050A216	ML20121A133
2/19/19	2	trash bars	dead	causal	69.0	70.1	ML19052A000	ML20121A133
3/8/19	1	trash bars	alive	-	63	74.1	ML19072A286	ML20121A133

Date	Unit No.	Collection Location	Condition	Causality[(a)(b)]	Fork Length (FL) (in cm)[(b)]	Total Length (TL) (in cm)[(b)]	Incidental Take Report	Annual Report
3/8/19	1	trash bars	alive	-	54.3	63	ML19072A286	ML20121A133
3/18/19	1	trash bars	alive	-	71	81.5	ML19085A553	ML20121A133
4/1/19	1	trash bars	alive	-	70.6	78.9	ML19092A306	ML20121A133
4/2/19	1	trash bars	alive	-	55.0	63.5	ML19098A191	ML20121A133
4/15/19	2	trash bars	dead	causal	76.8	89.5	ML19106A434	ML20121A133
4/23/19	2	trash bars	dead	causal	73.0	96.5	ML19116A025	ML20121A133
4/24/19	2	traveling screens	alive	-	37.7	44.4	ML19122A478	ML20121A133
5/14/19	-	bottom trawl sampling	alive	-	n/a	n/a	(g)	(g)
8/5/19	-	bottom trawl sampling	alive	-	43.6	50.5	ML19224A006	ML20121A133
8/7/19	-	bottom trawl sampling	alive	-	n/a	n/a	(g)	(g)
11/30/19	1	traveling screens	dead	causal	n/m	66.0	ML19338E329	ML20121A133
12/11/19	1	trash bars	dead	causal	n/m	66.5	ML19347B139	ML20121A133
12/13/19	1	trash bars	dead	causal	57.8	67.0	ML19350A358	ML20121A133
12/13/19	1	trash bars	dead	non-causal	61.0	71.4	ML19350A358	ML20121A133
12/13/19	2	trash bars	dead	causal	62.0	71.8	ML19350A358	ML20121A133
12/13/19	2	trash bars	dead	non-causal	74.0	86.3	ML19350A358	ML20121A133
12/17/19	1	trash bars	dead	causal	59.7	68.6	ML19352E288	ML20121A133
12/27/19	2	trash bars	alive	-	71.0	80.5	ML20006E313	ML20121A133
12/27/19	2	trash bars	dead	causal	63.0	72.7	ML20006E313	ML20121A133
12/30/19	1	trash bars	dead	causal	63.2	72.0	ML20006E340	ML20121A133
1/17/20	2	trash bars	alive	-	58.0	66.0	ML20021A194	(h)
1/24/20	2	trash bars	dead	causal	43.9	50.7	ML20027C320	(h)
1/31/20	1	trash bars	dead	causal	104.8	118.8	ML20034F375	(h)

Date	Unit No.	Collection Location	Condition	Causality[a][b]	Fork Length (FL) (in cm)[b]	Total Length (TL) (in cm)[b]	Incidental Take Report	Annual Report
3/14/20	2	trash bars	dead	causal	68.0	80.0	ML20079G271	[h]
3/16/20	2	trash bars	alive	-	60.9	68.6	ML20079G229	[h]
3/16/20	2	trash bars	alive	-	83.8	95.2	ML20079G229	[h]
3/16/20	2	trash bars	dead	causal	n/m[f]	n/m[f]	ML20079G229	[h]
3/24/20	2	trash bars	dead	causal	70.5	77.5	ML20085J692	[h]
3/24/20	2	trash bars	dead	causal	68.6	78.7	ML20085J692	[h]
3/24/20	2	trash bars	dead	causal	64.7	73.7	ML20085J692	[h]
3/24/20	1	trash bars	dead	causal	66	74.9	ML20085J692	[h]
3/28/20	1	trash bars	alive	-	69.2	80.6	ML20090C759	[h]
3/28/20	1	trash bars	alive	-	78.7	87.0	ML20090C759	[h]
4/2/20	1	trash bars	alive	-	70.0	81.0	ML20097C863	[h]
4/2/20	1	trash bars	alive	-	73.0	82.6	ML20097C863	[h]
4/2/20	1	trash bars	alive	-	73.6	82.5	ML20097C863	[h]
4/2/20	1	trash bars	alive	-	57.1	65.3	ML20097C863	[h]
4/2/20	2	trash bars	alive	-	58.0	67.0	ML20097C863	[h]
4/2/20	2	trash bars	alive	-	77.0	87.0	ML20097C863	[h]
4/2/20	2	trash bars	alive	-	65.0	75.1	ML20097C863	[h]
4/2/20	2	trash bars	alive	-	n/m[f]	n/m[f]	ML20097C863	[h]
4/2/20	2	trash bars	alive	-	74.4	84.0	ML20097C863	[h]
4/2/20	2	trash bars	alive	-	61.7	70.4	ML20097C863	[h]
4/2/20	2	trash bars	alive	-	68.0	77.2	ML20097C863	[h]

Date	Unit No.	Collection Location	Condition	Causality[(a)(b)]	Fork Length (FL) (in cm)[(b)]	Total Length (TL) (in cm)[(b)]	Incidental Take Report	Annual Report
4/2/20	2	trash bars	alive	-	59.1	65.0	ML20097C863	[(h)]
4/2/20	2	trash bars	alive	-	57.7	68.0	ML20097C863	[(h)]
4/2/20	2	trash bars	alive	-	65.0	74.4	ML20097C863	[(h)]
4/2/20	1	trash bars	dead	causal	60.4	69.6	ML20097C863	[(h)]
4/2/20	1	trash bars	dead	causal	72.0	82.5	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	73.0	84.0	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	59.5	68.0	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	82.0	94.2	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	77.0	85.3	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	71.0	82.0	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	74.0	86.0	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	67.0	76.2	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	causal	66.0	69.3	ML20097C863	[(h)]
4/2/20	2	trash bars	dead	non-causal	82.0	92.4	ML20097C863	[(h)]
4/10/20	2	trash bars	dead	non-causal	83.3	96.2	ML20104B284	[(h)]
4/10/20	1	trash bars	dead	non-causal	58.9	68.0	ML20104B284	[(h)]
4/10/20	1	trash bars	dead	non-causal	70.6	83.0	ML20104B284	[(h)]
4/21/20	1	trash bars	dead	causal	73.0	81.3	ML20120A023	[(h)]
4/21/20	1	trash bars	dead	causal	65.4	73.0	ML20120A023	[(h)]
4/24/20	1	trash bars	dead	causal	62.2	69.9	ML20120A024	[(h)]
4/24/20	1	trash bars	dead	causal	59.1	69.9	ML20120A024	[(h)]

Date	Unit No.	Collection Location	Condition	Causality[(a)(b)]	Fork Length (FL) (in cm)[(b)]	Total Length (TL) (in cm)[(b)]	Incidental Take Report	Annual Report
4/24/20	1	trash bars	dead	non-causal	55.2	61.0	ML20120A024	[(h)]
5/13/20	1	trash bars	alive	-	113.6	129.0	ML20135H201	[(h)]
5/13/20	1	trash bars	alive	-	64.1	69.8	ML20135H201	[(h)]
6/9/20[(i)]	1	trash bars	alive	-	60.4	68.4	ML20163A650	[(h)]

[(a)] The determination of whether mortality is due to impingement can be subjective and is based on the condition of the sturgeon carcass upon retrieval. PSEG Nuclear, LLC (PSEG) generally considers the mortality of fresh dead specimens to be caused by the trash raking operation. PSEG generally considers the mortality of specimens that exhibit some degree of decomposition to have been caused by factors unrelated to trash raking.

[(b)] n/a = not available; n/m = not measured.

[(c)] Incidental take reported in April 14, 2011, email from PSEG to NRC (ML11105A126).

[(d)] Incidental take reported in the National Marine Fisheries Service's (NMFS) July 17, 2014, biological opinion (ML14202A146, Table 11).

[(e)] Causality determinations for Atlantic sturgeon were not required until the NMFS incorporated the species into the incidental take statement of the July 17, 2014, biological opinion.

[(f)] Partial specimen.

[(g)] Incidental take report unavailable.

[(h)] Annual report due May 1, 2021.

[(i)] Data incorporated into and analyzed in this assessment includes all incidental take of Atlantic sturgeon at Salem through May 31, 2020. Thus, the June 9, 2020, incidental take is not reflected in any of the calculations presented in this assessment; however, the take is listed here for completeness.

Table A2. Atlantic Sturgeon Impingement Totals by Year and Location

Incidental Takes	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Location											
Trash Bars	4	2	18	17	4	11	4	11	22	48	141
Traveling Screens	-	-	1	-	-	-	1	1	2	-	5
REMP Sampling	-	-	1	-	-	-	-	-	-	-	1
Bottom Trawl Sampling	-	-	-	-	1	2	2	2	3	-	10
Beach Seine Sampling	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**4**	**2**	**20**	**17**	**5**	**13**	**7**	**14**	**27**	**48**	**157**

Table A3. Atlantic Sturgeon Impingement Totals by Year, Location, and Condition

Incidental Takes	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Location											
Trash Bars	4	2	18	17	4	11	4	11	22	48	141
Live	4	1	12	9	3	6	-	3	6	21	65
Dead	-	1	6	8	1	5	4	8	16	27	76
Non-causal	-	-	-	2	1	3	4	1	3	5	19
Causal[(a)]	-	1	6	6	-	2	-	7	13	22	57
Traveling Screens	-	-	1	-	-	-	1	1	2	-	5
Live	-	-	1	-	-	-	-	1	1	-	3
Dead	-	-	-	-	-	-	1	-	1	-	2
Non-causal	-	-	-	-	-	-	1	-	-	-	1
Causal	-	-	-	-	-	-	-	-	1	-	1
REMP Sampling	-	-	1	-	-	-	-	-	-	-	1
Live	-	-	1	-	-	-	-	-	-	-	1
Dead	-	-	-	-	-	-	-	-	-	-	-
Bottom Trawl Sampling	-	-	-	-	1	2	2	2	3	-	10
Live	-	-	-	-	1	2	2	2	3	-	10
Dead	-	-	-	-	-	-	-	-	-	-	-
Beach Seine Sampling	-	-	-	-	-	-	-	-	-	-	-
Live	-	-	-	-	-	-	-	-	-	-	-
Dead	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**4**	**2**	**20**	**17**	**5**	**13**	**7**	**14**	**27**	**49**	**157**

[(a)] Causality determinations for Atlantic sturgeon were not required until the NMFS incorporated the species into the incidental take statement of the July 17, 2014, biological opinion. Therefore, all impingements previous to this date are assumed causal for the purposes of this summary table.