Review and Analysis of the Salem Generating Station's Draft New Jersey Department of Environmental Protection (NJDEP) New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Surface Water (DSW) Permit NJ0005622 Renewal for The Salem Generating Station in Lower Alloways Creek Township, Salem County, New Jersey

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CEA No. 21527
September 2015

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1.0 INTRODUCTION

I have been retained by the Delaware Riverkeeper Network to prepare this review of the Draft New Jersey Department of Environmental Protection (NJDEP) New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Surface Water (DSW) Permit NJ0005622 Renewal for PSEG Nuclear LLC Salem Generating Station (SGS) in Lower Alloways Creek Township, Salem County, New Jersey and supporting documentation.

I hold a master's degree in fisheries biology from Eastern Kentucky University and a bachelor's degree in biology from the University of Louisville. I have over 30 years of experience in the wetlands, wildlife biology, and environmental permitting industry. My areas of expertise include environmental impact assessment; wetland delineation, enhancement, and creation; flora and fauna studies; natural resource inventories; and environmental permitting. I have 15 years of direct experience with §316(a) and §316(b) projects and issues, including cooling water intake structure assessment, effects of cooling water discharges, and impingement and entrainment studies. My qualifications are contained in my curriculum vitae attached as Appendix A.

I have been recognized as an expert witness in environmental and biological sciences in local, state, and federal courts, and I have provided testimony at deposition and at trial. A list of my testimony at deposition and trial is attached as Appendix B.

A list of the documents that I have relied upon in my investigation and in the preparation of this report is attached as Appendix C.

Compensation to Carpenter Environmental Associates, Inc., for the work that has resulted in this report and for future work will be at the rates that are attached as Appendix D. My time is billed as a consultant.

Either myself, or the staff of Carpenter Environmental Associates, Inc., under my supervision, have done all work that is summarized in this report.

2.0 COOLING WATER INTAKE STRUCTURES

NJDEP states in their draft NJPDES permit action (draft permit action) that the 2006 Comprehensive Demonstration Survey (CDS) was written to comply with the September 2004 Final Section 316(b) Rule (2004 Rule), a different rule than the rule that is applicable today, the August 2014 NPDES Final Regulations to Establish Requirements for Cooling Water Intake Structures (CWIS) at Existing Facilities (2014 rule). As such, the NJDEP reviewed the renewal application based on the 2006 submissions, written to comply to the 2004 Phase II rule and has asserted the need for various additional application components including numerous data updates and a multitude of studies including Entrainment Characterization Study, Comprehensive Technical Feasibility and Cost Evaluation Study, Benefits Valuation Study, Non-water Quality Environmental and Other Impacts Study).[1]

As the NJDEP states in their draft NJPDES permit action, both historical and ongoing data collection efforts and NJPDES permitting decisions at SGS have been focused on the Representative Important Species (RIS) approach.[2,3] In contrast to the RIS approach, the 2014 rule focuses on fragile and non-fragile species. The 2014 rule defines and lists fragile species as:

> *…those species of fish and shellfish that are least likely to survive any form of impingement. For purposes of this subpart, fragile species are defined as those with an impingement survival rate of less than 30 percent, including but not limited to alewife, American shad, Atlantic herring, Atlantic long-finned squid, Atlantic menhaden, bay anchovy, blueback herring, bluefish, butterfish, gizzard shad, grey snapper, hickory shad, menhaden, rainbow smelt, round herring, and silver anchovy.*[4]

PSEG's RIS list includes many species identified on the fragile species list, for example, alewife, American shad, Atlantic herring, Atlantic menhaden, bay anchovy, and blueback herring. The NJDEP draft NJPDES permit action is requiring the PSEG to submit a list of fragile

[1] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[2] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[3] The assumption is that if the RIS are doing well, then the entire community should also be doing well. Thus, a 316(a) demonstration can focus primarily or even entirely on RIS where RIS is defined at 40 CFR Part 125.71.
[4] 40 CFR 125.92(m).

species, not already identified as fragile, within six months from the Effective Date of Permit (EDP), as the data submitted in the 2006 permit application is insufficient.[5]

CEA reviewed the PSEG Nuclear LLC Salem NJPDES Permit Renewal Application for NJPDES Permit No. NJ 0005622, Section 4 - Comprehensive Demonstration Study (CDS), dated February 2006.[6] The CDS evaluated alternative candidate technologies in terms of biological efficacy, availability, engineering/biological advantages, ability to potentially reduce entrainment and impingement, and cost. The analysis provided by PSEG in 2006 was focused primarily on cost analyses. The record for Salem also includes over 25 years of data and analysis regarding Salem's operations and impingement and entrainment impacts, that can be used to support a best professional judgment (BPJ) analysis and determination. In 1993, the NJDEP determined that there was enough scientific, technical and other information to support a BPJ determination when it found "a combination of technological improvements, together with operational measures, were BTA for Salem, based upon a BPJ determination".[7] Since 1993 there has been significantly more data obtained regarding Salem operations.

While more data can always be collected, there is significant information on the record and available to NJDEP regarding SGS's operations, impacts from impingement and entrainment, regarding the fish populations of the Delaware estuary, and regarding the benefit of existing technologies for addressing its adverse environmental impacts – more data is not necessary to support a BPJ determination.

Fish impingement occurs when aquatic organisms, such as larvae or fish, become impinged, or pressed, against the screens of the cooling water intake structure (CWIS), which will be lethal for many species due to asphyxiation.[8] Entrainment occurs when organisms pass through the screens of the CWIS and into the cooling system. Mortality will typically occur as a result of entrainment due to physical impacts in the cooling system piping, pressure changes, thermal shock, or chemical toxemia as a result of being exposed to antifouling agents, such as

[5] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[6] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 4 Comprehensive Demonstration Study (CDS), February 2006.
[7] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[8] United States Environmental Protection Agency (U.S. EPA). Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact. April 1976.

chlorine, that are used to control the growth of algae and bacteria.[9] One of the first steps in determining BTA for a CWIS to minimize adverse environmental impacts (AEI), including impingement and entrainment, is through identification of the spatial and temporal distribution of aquatic species within the area of the proposed CWIS, in this case, the RIS species and the federally endangered sturgeon species within the Delaware River. SGS has a comprehensive data set covering both historical and current periods for previously assessed RIS species which can be integrated with available sturgeon tagging data.[10]

A variety of different technologies exists to protect fish from impingement and entrainment. These technologies range from screening systems that prevent fish from entering the CWIS to cooling systems that dramatically reduce the amount of intake water required.

Existing Technology

SGS is currently permitted to withdraw a monthly average of 3,024 million gallons per day (MGD) for its circulating water intake system. The circulating water system currently employs fish protection technology for impingement that consists of a modified traveling screen system with Ristroph screens and a fish handling and return system that has been in place since 1995. [11] The current modified-Ristroph traveling screens used at the SGS consist of screen mesh panels, composite material fish buckets, neoprene flap seals, and a spray wash system.[12] Ristroph screens typically operate in a continuous fashion to reduce impingement duration. The openings of the screen are ¼ in. wide by ½ in. (6 mm by 12 mm) high.[13] As each bucket passes over the top of the screen, fish that have been collected are rinsed into a trough by a low-pressure spray wash.[14] There is a high pressure spray wash system that removes debris from the screens into the debris return trough. The fish and debris troughs are joined after leaving the building. The

[9] U.S. EPA. Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact. April 1976.
[10] U.S. EPA. Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact. April 1976.
[11] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[12] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 4 Comprehensive Demonstration Study (CDS), February 2006.
[13] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 4 Comprehensive Demonstration Study (CDS), February 2006.
[14] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 4 Comprehensive Demonstration Study (CDS), February 2006.

troughs are bi-directional; they are emptied in the direction of the tide, so that fish and debris will flow away from the CWIS and avoid being re-impinged on the screens.[15] Traveling and fixed screens do not effectively protect smaller aquatic organisms such as eggs or aquatic organisms in their early life stages, that are too small to be screened out and/or that lack motility (ability to move spontaneously and actively), thus resulting in entrainment.[16]

In addition to the circulating water system, SGS employs a service water system (SWS) which is a non-contact cooling water system that uses 60.48 MGD.[17] For the SWS, SGS operates traveling screens that do not have a modified traveling screen design and there is no fish handling system or return. The NJDEP is requiring PSEG to install modified traveling screens and a fish return system (or other allowable control measures under 40 CFR 125.95(c)) at the SWS intake within EDP + 4 years, as appropriate BTA for impingement, as these technologies are currently not being utilized.[18,19] Prior to installation and operation of the modified traveling screens and a fish return system at the service water system, which could take over four years, aquatic species within the Delaware River are susceptible to ongoing higher levels of impingement and entrainment.

Alternative Technology

In screening technology, the size of the opening in the screen mesh can vary, with smaller sized openings known as fine mesh screens, being more effective at reducing entrainment and capturing small aquatic organisms.[20] Fine mesh screens have mesh sizes between 0.5 mm and 2.0 mm.[21] Fine mesh screens mounted on traveling screens are used to exclude eggs, larvae, and

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[15] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 4 Comprehensive Demonstration Study (CDS), February 2006.
[16] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 6 Comprehensive Demonstration Study (CDS), February 2006.
[17] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[18] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[19] It is understood that EDP indicates Effective Date of Permit, although not defined in the NJDEP Draft Surface Water Renewal Permit Action.
[20] USEPA, Preliminary Regulatory Development Section 316B of the Clean Water Act Background Paper Number 3: Cooling Water Intake Technologies, April 4, 1994.
[21] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 6 Comprehensive Demonstration Study (CDS), February 2006.

juvenile forms of fish from intakes.[22] These screens rely on gentle impingement of organisms on the screen surface or retention of larvae within the screens.[23] Velocities too high can result in damage to aquatic organisms or death.[24] The success of an installation using fine mesh screens is contingent on the application of satisfactory handling and recovery facilities to allow the safe return of impinged organisms to the aquatic environment.[25] In situ studies on the use of fine mesh on conventional traveling screens and modified traveling screens have indicated that these mesh screens reduce entrainment.[26] Effective handling and recovery facilities and adequate velocity can be included in CWIS design, thus eliminating design limitations for fine mesh screens. Fine mesh screens clog very quickly and require frequent maintenance.[27] Through effective CWIS operation and maintenance programs, clogging can be reduced.

Wedgewire screens consist of mesh shaped like a wedge (or a "V"), and are often configured in a cylindrical manner.[28] In order for wedgewire screens to be effective at reducing impingement and entrainment, a combination of low through-mesh velocity (typically less than or equal to 0.5 feet per second) and cross-cross current configuration to the ambient flow are required to allow organisms with limited motility to flow past the screens without being entrained.[29] Additionally, the size of the opening in wedgewire screens must be sufficiently small (typically between 0.5 mm and 2.0 mm) to be effective at physically blocking small aquatic organisms in the earliest stages of life from passing through the screen.[30] Testing of wedge-wire screens has demonstrated that fish impingement can be virtually eliminated and that entrainment of fish eggs and larvae reduced.[31]

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[22] USEPA, Preliminary Regulatory Development Section 316B of the Clean Water Act Background Paper Number 3: Cooling Water Intake Technologies, April 4, 1994.
[23] USEPA, Preliminary Regulatory Development Section 316B of the Clean Water Act Background Paper Number 3: Cooling Water Intake Technologies, April 4, 1994.
[24] USEPA, 316(b) Phase II Final Rule – TDD, Attachment A to Chapter 4, Cooling Water Intake Structure Technology Fact Sheets
[25] USEPA, Preliminary Regulatory Development Section 316B of the Clean Water Act Background Paper Number 3: Cooling Water Intake Technologies, April 4, 1994.
[26] USEPA, Preliminary Regulatory Development Section 316B of the Clean Water Act Background Paper Number 3: Cooling Water Intake Technologies, April 4, 1994.
[27] USEPA, 316(b) Phase II Final Rule – TDD, Attachment A to Chapter 4, Cooling Water Intake Structure Technology Fact Sheets.
[28] Field Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intakes. EPRI, Palo Alto, CA: 2005. 1010112.
[29] USEPA, 316(b) Phase II Final Rule – TDD, Attachment A to Chapter 4, Cooling Water Intake Structure Technology Fact Sheets.
[30] PSEG Fossil LLC. Mercer Generating Station 316(b) Demonstration. November 2001. Appendix D.
[31] USEPA, 316(b) Phase II Final Rule – TDD, Attachment A to Chapter 4, Cooling Water Intake Structure Technology Fact Sheets.

Closed cycle cooling transfers a power plant's waste heat to the environment through the recycle and recirculation of cooling water.[32, 33] Closed cycle cooling systems allow a power plant to withdraw small quantities of water from nearby water bodies, and in some cases require no water withdrawal at all.[34] In comparison, once-through cooling withdraws water from a water body, passes it through the cooling system once, and discharges the heated water back into the water body.[35]

Closed cycle cooling can be done through two different processes, wet cooling and dry cooling systems. Dry cooling systems do not utilize water for cooling via evaporation, rather waste heat is transferred through convection and radiation, thus completely eliminating the need for cooling water withdrawals and discharges to and from waterbodies.[36] Wet cooling systems transfer heat primarily through the evaporation of heated cooling water into the air.[37,38] Compared to once-through cooling systems, wet cooling systems are able to reduce the volume of water required to be withdrawn from a water body up to 95%, with similar reductions in impingement and entrainment achievable.[39] Retrofitting a power plant that employs a once-through cooling system to the use of a wet cooling system will also reduce the size of the thermal plume discharged to the water body, as well as reducing the temperature of the plume.[40]

CEA developed Tables 1 and 2 to compare the effectiveness of the technology utilized at the time of study (traveling mesh screen) with the effectiveness of closed cycle cooling systems. CEA based its estimates for entrainment and impingement for closed cycle cooling systems on a

[32] Clean Water Act Section 316(b) Existing Facilities Proposed Rule Qs and As, March 28, 2011.
[33] USEPA, Technical Development Document for the Proposed Section 316(b) Phase II Existing Facilities Rule, EPA-821-R-11 001, March 28, 2011.
[34] USEPA, Technical Development Document for the Proposed Section 316(b) Phase II Existing Facilities Rule, EPA-821-R-11 001, March 28, 2011.
[35] Clean Water Act Section 316(b) Existing Facilities Proposed Rule Qs and As, March 28, 2011.
[36] USEPA, Technical Development Document for the Proposed Section 316(b) Phase II Existing Facilities Rule, EPA-821-R-11 001, March 28, 2011.
[37] USEPA, Technical Development Document for the Proposed Section 316(b) Phase II Existing Facilities Rule, EPA-821-R-11 001, March 28, 2011.
[38] California Ocean Protection Council, Tetra-Tech, Inc., California's Coastal Power Plants: Alternative Cooling System Analysis, February 2008.
[39] California Ocean Protection Council, Tetra-Tech, Inc., California's Coastal Power Plants: Alternative Cooling System Analysis, February 2008.
[40] California Ocean Protection Council, Tetra-Tech, Inc., California's Coastal Power Plants: Alternative Cooling System Analysis, February 2008.

95% reduction on entrainment and impingement and the technology utilized by SGS at the time of study.[41]

With regard to BTA for CWIS and in order to optimize reduction of AEI, NJDEP must include additional provisions for reissuance of the permits involving CWIS, including details of appropriate operation and maintenance (O&M) of CWIS technologies and details of fish escape device O&M.

Sampling

The SGS 2006 CDS does not document impingement and entrainment of Atlantic and shortnose sturgeon life stages and the draft permit issued does not include provisions that will address the known and anticipated adverse impacts to these species. The 2014 Endangered Species Act Section 7 Consultation Biological opinion provided by NOAA NMFS Greater Atlantic Regional Fisheries Office for the Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581 (2014 BO) predicts the death of 61 federally endangered Atlantic sturgeon (all age classes and sub-populations) and 22 federally endangered shortnose sturgeon due to impingement at the trash bars and 26 injured or killed federally endangered Atlantic sturgeon at the traveling screen at SGS throughout the remaining term of the renewed operating licenses. This is a very significant loss to the Delaware River Atlantic sturgeon population, which is estimated to be less than 300 spawning adults that are already highly susceptible to many sources of anthropogenic mortality.[42,43] CEA recommends that additional justification be required to determine that federally endangered species, such as Atlantic and shortnose sturgeon, and the fishery within the Delaware River will not be adversely impacted by the current CWIS design by utilizing available historic and current fisheries data as well as recent sturgeon tagging data.

Supplemental analysis of tagged sturgeon data should be immediately undertaken by PSEG to better establish how both Atlantic and shortnose sturgeon populations select and utilize

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[41] USEPA, Preliminary Regulatory Development Section 316B of the Clean Water Act Background Paper Number 3: Cooling Water Intake Technologies, April 4, 1994.

[42] NOAA. Atlantic Sturgeon New York Bight Distinct Population Segment: Endangered. June 26, 2012.

[43] "Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Atlantic Sturgeon in the Northeast Region". 77 Federal Register 24 (6 February 2012), pp. 5880-5912.

environments within the Delaware River in the vicinity of SGS. In recent years, the number of Atlantic and shortnose sturgeon that have been “tagged” or implanted with acoustic transmitters within Atlantic Coast river systems has increased dramatically. Within the Delaware River, tagged sturgeon are currently tracked using hydrophone sensors placed throughout the river system. As of 2010, the Delaware River had 131 hydroacoustic receivers capable of detecting tagged Atlantic and shortnose sturgeon.[44] Although detection varies in rivers depending on the environmental conditions, hydroacoustic receivers can pick up signals to at least 500 meters.[45] Furthermore, it has been conclusively demonstrated by the Delaware Division of Fish and Wildlife Department of Natural Resources and Environmental Control (DNREC) that increased efficiency and improved tracking of tagged juvenile Atlantic sturgeon has facilitated a more targeted sampling effort that has resulted in a greater catch per unit effort (CPUE) during annual sampling.[46] In addition to DNREC fish and wildlife staff, PSEG should also consult with Atlantic and shortnose sturgeon researchers at Delaware State University and the University of Delaware to establish sampling procedures and protocols that utilize information from tagged sturgeon. The potential wealth of data would ensure a much better understanding of endangered sturgeon activity in the vicinity of SGS and help to better establish appropriate CWIS technologies are in place for their protection.

Reductions in AEI may be realized by seasonal flow reduction during periods when larval and juvenile aquatic species are present and most sensitive to impingement and entrainment. Closed cycle cooling provides significant reductions in impingement, entrainment, and thermal discharges compared with other available CWIS technology and should not be overlooked as a viable alternative for maintaining the health and vitality of the federally endangered species and the fisheries in the Delaware River. The entirety of the fish assemblages and resident aquatic biota of the Delaware River watershed must be used to establish an accurate.

[44] Atlantic Cooperative Telemetry Network; *Collaborative Efforts, Current Status, & Directions*; Brown, Lori. M., Savoy, Thomas F., Manderson, John P., and Fox, Dewayne A.; Delaware State University, Department of Agriculture and Natural Resources; Dover, Delaware.

[45] Pers. Communication DSU researcher.

[46] Fisher, Matthew T.; Delaware Division of Fish and Wildlife-Department of Natural resources and Environmental Control State of Delaware Annual Compliance Report for Atlantic Sturgeon; Submitted to the Atlantic States Marine Fisheries Commission Atlantic Sturgeon Plan Review Team; September 2009.

3.0 THERMAL IMPACTS

<u>Hydrothermal Assessment</u>

The Hydrothermal Assessment for the SGS, prepared by PSEG in 1999, uses hydrographic surveys, in-situ moorings, ambient temperature models, and shipboard surveys to generate thermal mapping models to determine the surficial area for the SGS thermal discharge plume and assess the impacts of changing temperature distributions on Representative Important Species (RIS) in the Delaware Estuary. NJDEP Surface Water Quality Standards (SWQS) criteria and Delaware River Basin Commission's (DRBC) Administrative Manual-Part III, Water Quality Regulations (WQR), which serve as the basis for thermal effluent limitations in the Plant's NJPDES permits, were used to formulate the models and assess the surface dimensions of the thermal discharge plumes. The hydrothermal modeling was based on limited field verified and modeled temperatures for both ambient water and effluent discharge water. Based on the selective information provided by PSEG, it appears that maximum ebb and end-of-flood tides for the modeled data as depicted in the report generated plumes with the greatest lengths, surface areas, elevated water temperatures, and subsequently the greatest impacts to RIS species.

Regulatory Context

Section 3.30.5.C.2 of the Delaware River Basin Commission's (DRBC) Administrative Manual-Part III, WQR (December 4, 2013) lists the Stream Quality Objectives for temperature for Zone 5 of the Delaware River as follows:

Temperature. shall not be raised above ambient by more than

a. *Shall not be raised above ambient by more than*
   1. *4°F (2.2°C) during September through May, nor*
   2. *1.5°F (0.8°C) During June Through August;*

b. *Nor shall maximum temperatures exceed 86°F (30.0°C). [See 4.30.6.F.4]*

Section 4.30.6.F.4 of the Delaware River Basin Commission's (DRBC) Administrative Manual-Part III, WQR (December 4, 2013) defines the Heat Dissipation Areas for Zone 5 of the Delaware River as follows:

Heat Dissipation Areas: The limitations specified above [4.30.6.C.1] may be exceeded by special permit in heat dissipation areas designated on a case-by-case basis, subject to the following conditions:

4. Zones 5 and 6.

> *a. Maximum Length. As a guideline, heat dissipation areas shall not be longer than 3,500 feet, measured from the point where the waste discharge enters the stream.*

Section 4.30.6.F.7 of the Delaware River Basin Commission's (DRBC) Administrative Manual-Part III, WQR (December 28, 2010) states:

Other Considerations.

a. The rate of temperature change in designated heat dissipation areas shall not cause mortality of fish or shellfish.
b. The determination of heat dissipation areas in tidal waters shall take into special consideration the extent and nature of the receiving waters so as to meet the intent and purpose of the criteria and standards, including provisions for the passage of free-swimming and drifting organisms so that negligible or no effects are produced on their populations."

Section 4.30.6.G of the Delaware River Basin Commission's (DRBC) Administrative Manual-Part III, WQR (December 28, 2010) states:

Definitions.

1. *Ambient temperature is the temperature of a water body unaffected by the heated waste discharge or waste discharge complex.*
2. *Natural temperature is the temperature of a waterbody unaffected by artificial sources of waste heat.*
3. *Stream temperature is the temperature of the stream outside of the heat dissipation area.*

SGS's 2015 NPDES Permit Fact Sheet states in Section 9(C)-Section 316(a) Determination that:

Based on a review of the current data and modeling pertaining to the thermal plume as well as the biothermal assessment, the Department has determined that a continued variance under section 316(a) is warranted. A thermal discharge at the Station, which *does not exceed a maximum of 115°F (46.1°C) is expected to assure the protection and propagation of the balanced indigenous population.*

The DRBC issued Docket No. D-68-20 CP (Revisions 2) on September 18, 2001 to PSEG for the Station consistent with the NJPDES permit. The docket specified that the project discharge shall not cause a temperature rise in excess of 1.5°F (24-hour average during June through August) above ambient temperature. Such limitations may be exceeded within a heat dissipation area which shall not exceed a length of 25,300 feet upstream and 21,000 feet downstream from the end of the stations discharge pipes nor extend closer than 1,320 feet to the present eastern boundary of the shipping channel of the Delaware River. The docket also states that the project shall not cause a temperature rise in excess of 4°F (24-hour average during September through May) above ambient temperatures. Such limitations may be exceeded within a heat dissipation area which shall not exceed a length of 3,300 feet upstream and 6,000 feet downstream from the end of the Stations discharge pipes nor extend closer than 3,200 feet to the present eastern boundary of the shipping channel of the Delaware River.

Section Part IV.G.9(C)- Section 316(a) Variance Conditions further states:

The Departments 316(a) determination will include, but not be limited to: 1) a review of whether the nature of the thermal discharge or the aquatic population associated with the Station has changed; 2) whether the protection and propagation of the balanced indigenous population is assured; 3)whether the best scientific methods to assess the effects of the permittee's cooling water system have changed; 4) whether the technical knowledge of stresses cause by the cooling system has changed

The hydrothermal assessment results contained in PSEG's Renewal Application - Salem Generating Station, Permit No. NJ0005622 –Appendix E, 316(a) Demonstration are outdated and do not reflect current surface and subsurface water temperatures within and along the perimeter of the thermal plume.

- The report only documents select lateral, downriver and upriver surface and subsurface temperature profiles for the thermal plume.

- Figures contained within Section E-V of the Report do not provide an adequate means to precisely measure and assess the length, extent, surface and subsurface temperatures of the thermal plume as it relates to DRBC requirements for heat dissipation areas and NJDEP permit effluent limitations.

Excess temperature distribution contour maps and associated discharge centerline cross-sections utilizing updated ambient, influent and effluent temperature data and depicting a modeled worst-case side-by-side comparison of both surface and bottom Delta-T contours for End-of-Ebb, Ebb, End-of-Flood, and Flood tidal phases should be provided to more accurately assess the thermal plume for compliance with DRBC and NJAC permit requirements.

The Salem 316(a) Demonstration Study is outdated and PSEG must be required to update field sampled temperature data, USGS temperature gauge data, and SGS DMR intake and effluent data to conduct new thermal plume modeling and subsequently evaluate thermal plume impacts to RIS. This includes utilizing USGS water temperature data from Reedy Island beyond the 1988-1998 and 2000-2004 data sets to include data from 2004-2014. Coupled with this data should be current shipboard and mooring buoy temperature data to field check new model runs of thermal plume mixing. PSEG must revisit and justify the continued combined use of the two thermal plume model programs (CORMIX and RMA-10) and the linkage procedure to describe the near-field/ zone of initial mixing (ZIM) region, transition region, and far-field thermal plume modeling. PSEG should provide an updated justification as to why the use of multiple modeling software programs are needed to evaluate the different regions of the thermal plume. The justification should utilize updated field verified ambient, influent, and effluent water temperature data. PSEG should provide the following:

- A comparison of each individual model run independent of the other models compared with the models grouped together with the transition programming in order to demonstrate that PSEG does not gain an advantage in using this combination of modeling (i.e. to model shorter plume lengths or smaller temperature gradients within the thermal plume that avoid potential violation of DRBC WQ requirements).

- The results of the thermal plume modeling data in a format that allows a direct comparison to DRBC and NJAC temperature requirements, both with and without the 316(a) variance granted in prior permits. The hydrothermal analysis does not report the results of the thermal modeling in a format that allows for a proper analysis of segmented transects across the sampling area. A clear depiction of surficial and vertical water temperatures within and beyond the edge of the thermal plume for all tidal phases, at appropriate transects, for at least the sustained full-load pattern during summer and winter must be provided that correspond to DRBC WQR temperature and heat dissipation requirements provided above. The failure to model the full extent of the plume during all tidal cycles for all the transects greatly underestimates the impacts to the aquatic biota in the Delaware River as well as the area available for fish passage.

PSEG's draft permit once again proposes to renew the 316(a) thermal variances, inclusive of thermal plume length (up to 7 times the length (3,500 feet) allowed by DRBC WQ requirements). The variance allows for increases above ambient temperature requirements within the boundaries of these exaggerated heat dissipation areas (4.8 miles upstream and 4.0 miles downstream). NJDEP in conjunction with the DRBC must require a new, comprehensive field-sampling program that captures the current prevailing mid-summer field and operating conditions to support a more detailed validation and application of the hydrothermal models provided by updated CORMIX and/or RMA analyses.

The thermal plume model runs and assessments that utilize ambient temperature based on the Ambient Temperature Model (ATM) must be evaluated against real time measured data such as that from USGS gauging stations located above, in the vicinity of, and below SGS's location on the Delaware River. This temperature data combined with updated shipboard and mooring buoy readings and 15 years of DMR influent data can be compared and studied against the model data to better delineate and depict temperature gradients both within and outside of the heat dissipation areas of the thermal plume to ensure there are not additional impacts to RIS species.

Field verified data was collected for the thermal plume generated by heated cooling water from SGS from May 21, 1998 through June 4, 1998.[47] In addition to the historical data provided by PSEG, Table 3 provides CEA's analysis of SGS's influent and effluent data obtained from NJDEP's Dataminer Daily Monitoring Reports (DMRs) from 2000-2015. CEA compared the mean monthly average and mean daily maximum effluent temperatures with DRBC's WQR (Table 3, Figures 1-4). SGS's documented mean monthly average effluent temperature from 2000-2015 exceeds DRBC's WQR during the months of June, July, August and September. AEI to RIS species due to thermal plume impacts must be reevaluated in relation to documented DRBC WQR exceedances during summer months prior to permit issuance to ensure all life stages of marine species, and more precisely RIS species associated with SGS, can be properly evaluated.

Not calculating the extent of the lateral, downriver and upriver surface and subsurface temperature profiles for the modeled thermal plumes as described above results in a data gap that greatly reduces the ability to assess the zone of passage for a number of sensitive aquatic organisms that utilize both the surface waters and shallow shoreline substrates of the Delaware River, namely the pelagic and demersal eggs and larvae of the RIS identified in the PSEG Renewal Application - Salem Generating Station, Permit No. NJ0005622 –Appendix E, 316(a) Demonstration. This results in a failure to meet the conditions set forth in 4.30.6.F.7 of the DRBC Administrative Manual-Part III, WQR.

Ecological Impacts of Thermal Discharges

The potential for impacts to fish populations associated with thermal discharges from SGS was evaluated in SGS's 316(a) Demonstration, sponsored by Dr. Charles C. Coutant and Dr. E. Eric Adams, March 4, 1999 and SGS's 316(b) Comprehensive Demonstration Study, by PSEG Nuclear LLC, February 2006.[48,49] Growth in aquatic species, the presence of juveniles, and spawning only occur at certain times during each year. The fact that these essential growth and life cycles only take place during certain times of the year magnifies the significance of the

[47] PSEG. Renewal Application - Salem Generating Station, Permit No. NJ0005622 –Appendix E, 316(a) Demonstration - March 4, 1999.
[48] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[49] PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 4 Comprehensive Demonstration Study (CDS), February 2006.

impact of the thermal plume from SGS on aquatic species. The following discussion depicts the threats and impacts that the high temperatures of the measured thermal plume in the near-field mixing zone, shoreline, and shallow depths will have on the life stages of the RIS.

RIS are used to assess the wellbeing of the entire aquatic community. The assumption is that if the RIS are doing well, then the entire community should also be doing well.[50] PSEG choose three macroinvertebrate and nine fish species as RIS of the Delaware River community including, scud (*Gammarus spp.)*, opossum shrimp (*Neomysis americana*), blue crab, alewife, American shad, Atlantic croaker, bay anchovy, blueback herring, spot, striped bass, weakfish, and white perch.[51] Atlantic and shortnose sturgeon were not included in the RIS and although allowable take has been permitted in the 2014 BO, SGS must be required to integrate the wealth of data provided by current and ongoing tagged sturgeon surveys to field verify that the 2014 BO and RIS exclusions are warranted.

Finfish

Alewife (Alosa pseudoharengus)

Alewives are a federally listed species of concern.[52] Alewives critical life stages include eggs, larvae, and early juveniles.[53] Larval, juvenile, and adult alewives are pelagic and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[54] Alewife eggs are semi-demersal and slightly adhesive, being easily torn free and carried by currents and therefore are also impacted by elevated subsurface temperatures resulting from SGS's thermal plume.[55]

- Spawning occurs when water temperatures are between 61°F to 66°F. [56] Spawning within the Delaware River occurs from mid-March to early April.[57] The mean daily maximum

[50] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[51] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[52] NOAA National Marine Fisheries Service. Species of Concern: River Herring (Alewife & Blueback herring). May 19, 2009.
[53] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[54] NOAA National Marine Fisheries Service. Species of Concern: River Herring (Alewife & Blueback herring). May 19, 2009.
[55] Smith, C.L. The Inland Fishes of New York State. New York State Department of Environmental Conservation. Albany, NY. August 1985.
[56] NOAA National Marine Fisheries Service. Species of Concern: River Herring (Alewife & Blueback herring). May 19, 2009.

temperature of both SGS's FAC A and FAC B effluent during the month of March and April exceeds alewives spawning temperature range.[58]

- Optimum temperature for alewife eggs is 61°F to 70°F.[59] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April and May exceeds the optimum temperature range for alewife eggs.[60]
- According to PSEG, larvae of alewife occur in the vicinity of SGS during the month of May.[61] Optimum temperature for alewife yolk-sac larva is 59°F to 75°F.[62] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the month of May exceed the optimal temperature range for alewives larvae.[63]
- According to PSEG, young-of-the-year (YOY) alewives occur in the vicinity of SGS from October to December.[64] Preferred temperature for early alewife juveniles is 63°F to 75°F.[65] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the month of October exceeds the preferred temperature range for early alewife juveniles.[66]
- According to PSEG, alewives older than one year occur in the vicinity of SGS from March through May.[67]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), alewife spawning, eggs, larvae, and early juveniles have the known potential to be negatively impacted.[68] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling

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[57] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[58] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[59] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[60] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[61] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[62] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[63] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[64] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[65] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[66] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[67] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[68] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

system has the potential to reduce impingement and entrainment by 95% and protect the lives of tens of thousands of impinged and entrained alewife at SGS per year.[69]

American shad (Alosa sapidissima)

American shad eggs are neutrally buoyant, dispersed through the water column, and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[70,71] American shad larvae, juveniles, and adults are pelagic fish and are directly impacted by elevated surface water temperatures caused by elevated subsurface temperatures resulting from SGS's effluent.[72]

- Spawning occurs when water temperatures are between 54°F and 70°F, peaking around 65°F.[73,74] American shad spawning in the Delaware River occurs from mid-April through July, peaking in early May. [75,76] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April, May, June and July exceeds the temperature range that American shad spawning occurs.[77]
- According to PSEG, following spawning, American shad eggs are dispersed throughout the water column and are gradually transported downstream by freshwater flows.[78] Optimum temperature for American shad egg development is 63°F.[79]
- According to PSEG, following hatching, American shad larvae are continually transported downstream. Optimal temperature range for American shad larvae is 59°F to 77°F.[80]

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69 Entrainment totals are for Alosa spp. as reported in the 2013 BMR.
70 Smith, C.L. The Inland Fishes of New York State. New York State Department of Environmental Conservation. Albany, NY. August 1985.
71 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
72 USFWS. Maryland Fisheries Resource Office. Park, I. et al. U.S. Fish and Wildlife Service Susquehanna River American Shad (*Alosa sapidissima*) Restoration: Potomac River Egg Collection, 2012. August 22, 2012.
73 Smith, C.L. The Inland Fishes of New York State. New York State Department of Environmental Conservation. Albany, NY. August 1985.
74 Virginia Department of Game and Inland Fisheries. American Shad (*Alosa sapidissima*). http://www.dgif.virginia.gov/wildlife/fish/details.asp?fish=010040. 2013.
75 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
76 Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
77 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
78 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
79 Smith, C.L. The Inland Fishes of New York State. New York State Department of Environmental Conservation. Albany, NY. August 1985.

- According to PSEG, American shad YOY occur in the vicinity of SGS from mid-October to December.[81] Optimal temperature range for juvenile American shad is 60°F to 75°F.[82] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the month of October exceeds the optimum temperature for American shad eggs.[83]
- According to PSEG, American shad one year and older occur within the vicinity of SGS from February to early May.[84]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), American shad spawning and YOY have the known potential to be negatively impacted.[85] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system has the potential to reduce impingement and entrainment by 95% and protect the lives of hundreds of thousands of impinged and entrained American shad at SGS per year.

Atlantic croaker (Micropogonias undulatus)

- Atlantic croaker spawn in estuaries at temperatures ranging from 61°F to 77°F. Atlantic croaker spawning begins in late summer and continues on to early spring, peaking in late fall and winter.[86] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of August, September, and October exceeds the temperature range for spawning Atlantic croaker.[87]
- According to PSEG, Atlantic croaker larvae occur in the vicinity of SGS in January and from September through October.[88]
- According to PSEG, Atlantic croaker juvenile occur in the vicinity of SGS from September through April.[89, 90]

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80 Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
81 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
82 Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
83 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
84 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
85 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
86 Atlantic States Marine Fisheries Commission, Life History and Habitat Needs. Atlantic Croaker - *Micropogonias undulates.* Undated.
87 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
88 PSEG. Biological Monitoring Program 2013 Report.

- In the Delaware Estuary, which extends from Cap May, New Jersey, to Trenton, New Jersey, adult Atlantic croaker are found from late spring through mid-fall. [91] Adults are tolerant of temperature ranges from 41°F to 97°F.[92] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of July and August exceeds the temperature range for Atlantic croaker adults.[93]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), Atlantic croaker adults have the known potential to be negatively impacted.[94] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system at SGS has the potential to reduce impingement and entrainment by 95% and protect the lives of millions of impinged and entrained Atlantic croaker at SGS per year.

Bay anchovy (Anchoa mitchilli)

Bay anchovy eggs, larvae, juveniles, and adults are pelagic fish and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[95]

- Spawning occurs throughout much of the Delaware Estuary from May through mid-August with two peaks, one usually in late May and the other usually in mid-July when water temperatures are higher than 63°F.[96] The optimal spawning range is 68-81°F.[97] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of May, June, July and August exceeds the temperature range for bay anchovy spawning.[98]

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[89] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[90] PSEG. Biological Monitoring Program 2013 Report.
[91] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[92] Atlantic States Marine Fisheries Commission, Life History and Habitat Needs. Atlantic Croaker - *Micropogonias undulates.* Undated.
[93] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[94] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[95] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[96] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[97] Smith, C. Lavett. *The Inland Fishes of New York State*. Albany, NY: New York State Department of Environmental Conservation. August 1985.
[98] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

- According to PSEG, bay anchovy eggs occur in the vicinity of SGS from May through early September.[99,100] Hatching time within depends on water temperature.[101] The hatch temperature for bay Anchovy is between 81-82°F.[102] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of May, June, July, August and September exceeds the hatch temperature range for bay anchovy eggs.[103,104]
- According to PSEG, bay anchovy larvae occur in the vicinity of SGS from May through November.[105,106]
- According to PSEG, bay anchovy juveniles occur in the vicinity of SGS from June through April. [107,108]
- According to PSEG, bay anchovy adults occur in the vicinity of SGS from mid-April to November.[109] Optimum growth temperature for bay anchovy is 85°F. [110] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of May, June, July, August, September, and October exceeds the temperature range for bay anchovy adults.[111]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), bay anchovy spawning, eggs, and adults have the known potential to be negatively impacted.[112] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling

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99 PSEG. Biological Monitoring Program 2013 Report.
100 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
101 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
102 Smith, C. Lavett. *The Inland Fishes of New York State*. Albany, NY: New York State Department of Environmental Conservation. August 1985.
103 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
104 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
105 PSEG. Biological Monitoring Program 2013 Report.
106 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
107 PSEG. Biological Monitoring Program 2013 Report.
108 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
109 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
110 ASA Analysis & Communication, Inc., Bridgeport Harbor Generating Station Biothermal Assessment Report, November 2011.
111 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
112 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

system has the potential to reduce impingement and entrainment by 95% and protect the lives of millions to billions of impinged and entrained bay anchovy at SGS per year.

Blueback herring (Alosa aestivalis)

Blueback herring are a federally listed species of concern.[113] Blueback herring's critical life stages include eggs, larvae, and early juveniles.[114] Blueback herring eggs are pelagic to semi-demersal and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[115]

- The mid-Atlantic spawning populations, including the Delaware River, spawn in late April.[116] The optimal spawning temperature range for blueback herring is 70°F to 77°F.[117]
- Optimum temperature for blueback herring eggs is 57°F to 79°F.[118] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of May, June, July, August, September and October exceeds the optimum temperature range for blueback herring eggs.[119]
- According to PSEG, blueback herring larvae occur in the vicinity of SGS in May.[120] Suitable temperature for blueback herring yolk-sac larva is 57°F to 79°F.[121] Suitable temperature for blueback herring post yolk-sac larva is 57°F to 82°F.[122] The mean daily

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[113] NOAA National Marine Fisheries Service. Species of Concern: River Herring (Alewife & Blueback herring). May 19, 2009.
[114] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[115] NOAA National Marine Fisheries Service. Species of Concern: River Herring (Alewife & Blueback herring). May 19, 2009.
[116] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[117] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[118] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[119] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[120] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[121] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[122] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.

maximum temperature of both SGS's FAC A and FAC B effluent during the month of May exceeds the optimum temperature range for blueback herring larvae.[123]

- According to PSEG, blueback herring YOY occur in the vicinity of SGS from November through early December.[124] Preferred temperature for early blueback herring juvenile is 68°F to 82°F.[125]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), blueback herring spawning, eggs and larvae have the known potential to be negatively impacted.[126] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system has the potential to reduce impingement and entrainment by 95% and protect the lives of tens of thousands of impinged and entrained blueback herring at SGS per year.

Spot (Leiostomus xanthurus)

- According to PSEG, spot larvae occur in the vicinity of SGS from March through June.[127, 128]
- According to PSEG, spot YOY occur in the vicinity of SGS from late May through August (spring) and October through December.[129]

Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system has the potential to reduce impingement and entrainment by 95% and protect the lives of tens of thousands of impinged and entrained spot at SGS per year.

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[123] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[124] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[125] Klauda, Ronald Et al. Alewife and Blueback Herring: *Alosa pseudoharengus and Alosa aestivalis.* University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
[126] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[127] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[128] PSEG. Biological Monitoring Program 2012 Report.
[129] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.

Striped bass (Morone saxatilis)

The Delaware River striped bass population is one of the major spawning stocks on the Atlantic coast.[130] Striped bass are pelagic and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[131]

- Spawning in the Delaware River occurs from April through May.[132] Peak spawning activities occur between 59°F and 68°F.[133] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April and May exceeds the temperature range for striped bass spawning.[134]
- According to PSEG, striped bass eggs occur in the vicinity of SGS from early April through mid-May.[135,136] Optimal temperature range for striped bass eggs and larvae is 64°F to 70°F.[137] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April and May exceeds the temperature range for striped bass eggs.[138]
- According to PSEG, striped bass larvae occur in the vicinity of SGS from mid-April through July.[139,140]
- According to PSEG, striped bass juveniles occur in the vicinity of SGS from June through July and from late September through December.[141,142] Striped bass juveniles can tolerate temperatures ranging from 50°F to 81°F; however, optimum temperatures range

[130] Partnership for the Delaware Estuary. 2012. Technical Report for the Delaware Estuary and Basin. PDE Report No. 12-01. 255 pages. www.delawareestuary.org/science_programs_state_of_the_estuary.asp.
[131] Costantini, M., et al. Effect of Hypoxia on Habitat Quality of Striped Bass (Morone saxatilis) in Chesapeake Bay. Can. J. Fish. Aquat. Sci. 65: 989-1002. NRC Canada. 2008.
[132] Partnership for the Delaware Estuary. 2012. Technical Report for the Delaware Estuary and Basin. PDE Report No. 12-01. 255 pages. www.delawareestuary.org/science_programs_state_of_the_estuary.asp.
[133] Shepard, G. NOAA NEFSC – Resource Evaluation and Assessment Division. Striped Bass (Morone saxatilis). December 2006.
[134] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[135] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[136] PSEG. Biological Monitoring Program 2013 Report.
[137] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[138] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[139] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[140] PSEG. Biological Monitoring Program 2013 Report.
[141] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[142] PSEG. Biological Monitoring Program 2013 Report.

from 57°F to 70°F.[143] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of June, July, September and October exceeds the tolerate temperature range and during the months of June, July, September, October, and November exceeds the optimum temperature range for striped bass juveniles.[144]

- According to PSEG, striped bass adults occur in the vicinity of SGS from January through late April.[145] Estuarine striped bass adults can tolerate temperatures ranging from 50°F to 81°F; however, optimum temperatures range from 57°F to 70°F.[146] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the month of April exceeds the optimal temperature range for estuarine striped bass adults.[147]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), striped bass spawning, eggs, juveniles and adults have the known potential to be negatively impacted.[148] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system has the potential to reduce impingement and entrainment by 95% and protect the lives of millions of impinged and entrained striped bass at SGS per year.

Weakfish (Cynoscion regalis)

Juvenile weakfish are semi-pelagic and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[149]

- Weakfish spawn in the Delaware River from May to mid-July.[150] The optimum spawning temperature range is from 61-82°F. [151] The mean daily maximum temperature of both

[143] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[144] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[145] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[146] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[147] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[148] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[149] http://nefsc.noaa.gov/publications/tm/tm161/tables/t44.htm
[150] Mercer, Linda P. *Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic): Weakfish*. U.S. Army Corps of Engineers, Fish and Wildlife Service. August 1989.
[151] Mercer, Linda P. *Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic): Weakfish*. U.S. Army Corps of Engineers, Fish and Wildlife Service. August 1989.

SGS's FAC A and FAC B effluent during the months of May, June, and July exceeds the optimum spawning temperature range for weakfish.[152]

- According to PSEG, weakfish eggs occur in the vicinity of SGS from May through mid-July.[153,154] The optimum hatch temperature range of weakfish eggs is 64-75°F.[155] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of May, June, and July exceeds the optimum hatch temperature range for weakfish hatching.[156]
- According to PSEG, weakfish larvae occur in the vicinity of SGS from May through September.[157,158]
- According to PSEG, weakfish juveniles occur in the vicinity of SGS from June through mid-September.[159,160] Upper optimum growth temperature for juvenile weakfish is 85°F.[161] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of June, July, August and September exceeds the upper optimum growth temperature for juvenile weakfish.[162]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), weakfish spawning, eggs and juveniles have the known potential to be negatively impacted. [163] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system has the potential to reduce impingement and entrainment by 95% and protect the lives of millions of impinged and entrained weakfish at SGS per year.

White perch (Morone americana)

[152] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[153] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[154] PSEG. Biological Monitoring Program 2013 Report.
[155] Mercer, Linda P. *Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic): Weakfish*. U.S. Army Corps of Engineers, Fish and Wildlife Service. August 1989.
[156] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[157] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[158] PSEG. Biological Monitoring Program 2013 Report.
[159] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[160] PSEG. Biological Monitoring Program 2013 Report.
[161] Mercer, Linda P. *Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic): Weakfish*. U.S. Army Corps of Engineers, Fish and Wildlife Service. August 1989.
[162] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[163] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

White perch eggs are pelagic in flowing waters, like the Delaware River, and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[164] White perch adults are pelagic and are also directly impacted by elevated surface water temperatures caused by SGS's effluent.[165]

- Spawning occurs at temperatures ranging from 50°F to 61°F.[166] Optimum spawning occurs at 54°F to 57°F.[167] Spawning in the Delaware River occurs from early April through early June, peaking in May.[168] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April, May and June exceeds the tolerate and optimal temperature ranges for white perch spawning.[169]
- According to PSEG, white perch eggs occur in the vicinity of SGS from April through May. [170] Hatching of white perch eggs occurs between 51°F to 68°F.[171] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April, May and June exceeds the optimum hatching temperature range for white perch eggs.[172]
- According to PSEG, white perch larvae occur in the vicinity of SGS from mid-April through mid-July.[173,174] Suitable temperatures for white perch larvae ranges from 54°F to 68°F.[175] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April, May, June and July exceeds the suitable temperature range for white perch larvae.[176]

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164 Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (*Morone americana*). Undated. P.12- 4.
165 Okoye, A.O., et al. White Perch Fecundity Relationships in Western Albemarle Sound, North Carolina. Journal of North Carolina Academy of Science, 124(2), 2008, pp. 46-50.
166 Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (*Morone americana*). Undated. P. 12-2.
167 Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (*Morone americana*). Undated. P.12- 4.
168 Partnership for the Delaware Estuary. 2012. Technical Report for the Delaware Estuary and Basin. PDE Report No. 12-01. 255 pages. www.delawareestuary.org/science_programs_state_of_the_estuary.asp.
169 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
170 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
171 Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (*Morone americana*). Undated. P.12- 4.
172 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
173 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
174 PSEG. Biological Monitoring Program 2013 Report.
175 Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (*Morone americana*). Undated. P.12- 18.
176 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

- According to PSEG, white perch juveniles occur in the vicinity of SGS from mid-October through January and in June and July.[177,178] Suitable temperatures for white perch juveniles range from 50°F to 86°F.[179] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of June, July, and October exceeds the suitable temperature range for white perch juveniles.[180]
- According to PSEG, white perch adults occur in the vicinity of SGS from January through mid-May.[181] Suitable temperatures for white perch adults range from 50°F to 86°F.[182] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the month of May exceeds the suitable temperature range for white perch adults.[183]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), white perch spawning, eggs, larvae, juveniles and adults have the known potential to be negatively impacted.[184] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system has the potential to reduce impingement and entrainment by 95% and protect the lives of millions of impinged and entrained white perch at SGS per year.

Shortnose Sturgeon (Acipenser brevirostrum)

Independent of an RIS analysis, any potential impact to a federally endangered species, such as the shortnose sturgeon located in the Delaware River and potentially affected by the thermal plume of SGS, must be studied to assess and compensate for the potential take of the species. CEA conducted a thorough review of readily available literature regarding the federally endangered shortnose sturgeon. Information, essential for understanding potential impacts to

177 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
178 PSEG. Biological Monitoring Program 2013 Report.
179 Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (*Morone americana*). Undated. P.12- 18.
180 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
181 Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
182 Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (*Morone americana*). Undated. P.12- 18.
183 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
184 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

shortnose sturgeon life stages caused by thermal discharges, is summarized in the following sections. Information regarding thermal tolerance of shortnose sturgeon eggs, larvae and juveniles is not readily available. CEA finds it difficult to fully understand the impacts of SGS's CWIS on the federally endangered species.

Endangered Species Preservation Act – 1966

On March 11, 1967, the shortnose sturgeon was listed under the Endangered Species Preservation Act (ESPA) and as such, its protection and preservation fall under the following tenets of the Act.[185] The ESPA presented a means to provide limited protections to native animal species.[186] In 1973, Congress passed the Endangered Species Act (ESA) that expanded the limits of protection provided by the ESPA. According to the U.S. Fish and Wildlife Service, "The purpose of the ESA is to protect and recover imperiled species and the ecosystem upon which they depend."[187] Being listed as an endangered species under the ESA means that a species is in danger of extinction throughout all or a significant portion of its range. The ESA protects endangered and threatened species and their habitats by prohibiting the take of listed animals without a permit. Threats to shortnose sturgeon include construction of dams, river pollution, habitat alterations from discharges, dredging or disposal of material into rivers and related development activities involving estuarine/riverine mudflats and marshes.[188] Thermal discharges from SGS pose a threat to shortnose sturgeon populations.

Life History – Spawning

Male and female shortnose sturgeon reach maturity at approximately ages 4 and 7 years, respectively; however, spawning may not occur in males for 1 to 2 years later and up to 5 years later for females.[189] Female shortnose sturgeon average approximately 11 years of age at the time of their first spawning and spawn roughly every 3 years.[190] Male shortnose sturgeon spawn annually.[191]

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[185] Native Fish and Wildlife: Endangered Species. 32 Federal Register 48 (11 March 1967), pp. 4001.
[186] US Fish and Wildlife Service. A History of the Endangered Species Act of 1973. August 2011.
[187] US Fish and Wildlife Service. ESA Basics: 40 years of Conserving Endangered Species. January 2013.
[188] NOAA Fisheries. Shortnose Sturgeon (*Acipenser brevirostrum*). April 5, 2013.
[189] NOAA Fisheries. Shortnose Sturgeon (*Acipenser brevirostrum*). April 5, 2013.
[190] NOAA Fisheries. Shortnose Sturgeon (*Acipenser brevirostrum*). April 5, 2013.
[191] NOAA Fisheries. Shortnose Sturgeon (*Acipenser brevirostrum*). April 5, 2013.

In undammed rivers, like the Delaware, spawning occurs in the farthest accessible reach.[192] Spawning primarily occurs within the non-tidal area of the Delaware River (above the head-of-tide at RM 133).[193] Shortnose sturgeon spawn over hard substrates such as gravel, cobble, rubble or large rocks.[194]

- Spawning migration from overwintering habitats occur when water temperatures reach approximately 45°F to 50°F (late March in the Delaware River), with males migrating prior to females.[195,196]
- Spawning occurs from late March to early May.[197]
- Spawning can occur between 46°F and 77°F, but occur optimally at 50°F to 64°F.[198]

<u>Life History – Eggs</u>

Shortnose sturgeon eggs are demersal and adhesive.[199] Shortnose sturgeon eggs generally hatch after approximately 9-12 days.[200]

<u>Life History – Larvae</u>

Shortnose sturgeon larvae are the most likely life stage to be entrained and/or impinged by water intakes at the SGS as spawning primarily occurs just upstream.[201] Entraining young and vulnerable life stages of shortnose sturgeon directly affect sturgeon populations.[202]

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[192] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[193] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[194] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[195] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[196] National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.
[197] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[198] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[199] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (Acipenser brevirostrum). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[200] Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581July 17, 2014.
[201] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser*

Life History – Juvenile

Juvenile shortnose sturgeon are likely to occur in the vicinity of between April and November.[203] Water temperatures above 82°F can limit juvenile rearing habitat.[204] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of May, June, July, August, September and October exceeds the temperature at which juvenile shortnose sturgeon habitat can become limited.[205]

Furthermore, acoustic tracking of tagged juvenile shortnose sturgeon indicate that juveniles are overwintering in the vicinity of SGS.[206] In the Delaware River, shortnose sturgeon overwinter from early November to mid-April. [207]

Life History – Adults

Shortnose sturgeon in the vicinity of SGS are likely to be using it for migration and for foraging.[208]

Foraging

Shortnose sturgeon are benthic feeders throughout their lives feeding on such prey as small bivalves, gastropods, polychaetes and small benthic fishes by filtering mud and food through their mouths.[209] Shortnose sturgeon prey is typically found within sandy-mud

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brevirostrum). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.

202 National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.

203 Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581July 17, 2014.

204 National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (Acipenser brevirostrum). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.

205 NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

206 Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581July 17, 2014.

207 Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581July 17, 2014.

208 Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581July 17, 2014.

209 Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.

bottoms.[210] Foraging in the Delaware River occurs year round, declining slightly in the winter months.[211] The majority of foraging within the Delaware River occurs after spawning (i.e. summer and early fall).[212] Shortnose sturgeon in the Delaware River use channels and shoals to forage.[213]

Overwintering

Overwintering usually occurs over sandy bottom habitats.[214] Adult shortnose sturgeon are likely to occur in the action area any time water temperatures are greater than 50°F (trigger for movement to overwintering sites) between April and November. [215] Overwintering occurs in the Delaware River from December to March.[216] Juvenile shortnose sturgeon tend to overwinter in a dispersed fashion rather than in dense aggregations like adults.[217]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), shortnose sturgeon juveniles have the known potential to be negatively impacted.

Despite the fact that the biological monitoring, consisting of seine sampling and bottom trawl sampling conducted since 1995, does not target the federally endangered shortnose sturgeon, PSEG contends that the numerous studies performed have demonstrated that the health of the Delaware Estuary has been improving for over thirty years. [218,219]

Atlantic Sturgeon (Acipenser oxyrhynchus)

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[210] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[211] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[212] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[213] National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.
[214] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[215] Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581July 17, 2014.
[216] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[217] Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
[218] PSEG. Biological Monitoring Reports. 1995-2013.
[219] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.

Independent of an RIS analysis, any potential impact to a federally endangered species, such as the Atlantic sturgeon located in the Delaware River and potentially affected by the thermal plume of SGS, must be studied to assess and compensate for the potential take of the species. CEA conducted a thorough review of readily available literature regarding the federally endangered Atlantic sturgeon. Information, essential for understanding potential impacts to Atlantic sturgeon life stages caused by thermal discharges, is summarized in the following sections.

Endangered Species Act of 1973

The Atlantic sturgeon New York Bight (NYB) Distinct Population Segment (DPS) includes all Atlantic sturgeon that are spawned within the watersheds that drain to the Atlantic Ocean from Chatam, MA to the Delaware-Maryland border on Fenwick Island.[220] On February 6, 2012, the NYB DPS of Atlantic sturgeon was listed as endangered under the ESA (effective April 6, 2012) and as such, its protection and preservation fall under the following tenets of the Act.[221] "The purpose of the ESA is to protect and recover imperiled species and the ecosystem upon which they depend."[222] Being listed as an endangered species under the ESA means that a species is in danger of extinction throughout all or a significant portion of its range.[223] The ESA protects endangered and threatened species and their habitats by prohibiting the take of listed animals without a permit.[224] The NYB DPS Atlantic sturgeon are continually and significantly affected by degraded water quality, habitat impacts from dredging, continued bycatch in state and federally managed fisheries, vessel strikes and the lack of regulatory mechanisms to adequately address these threats.[225]

Life History - Spawning

[220] "Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Atlantic Sturgeon in the Northeast Region". 77 Federal Register 24 (6 February 2012), pp. 5880-5912.
[221] "Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Atlantic Sturgeon in the Northeast Region". 77 Federal Register 24 (6 February 2012), pp. 5880-5912.
[222] US Fish and Wildlife Service. ESA Basics: 40 years of Conserving Endangered Species. January 2013.
[223] US Fish and Wildlife Service. ESA Basics: 40 years of Conserving Endangered Species. January 2013.
[224] US Fish and Wildlife Service. ESA Basics: 40 years of Conserving Endangered Species. January 2013.
[225] "Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Atlantic Sturgeon in the Northeast Region". 77 Federal Register 24 (6 February 2012), pp. 5880-5912.

Historically, the Delaware River supported the largest stock of Atlantic sturgeon along the Atlantic coast.[226] Now an endangered species, there are only two known spawning populations of the NYB DPS existing in the Hudson and the Delaware rivers with no indications of recovery.[227] It is believed that the Delaware spawning population is less than 300 spawning adults.[228] The Delaware River spawning population is smaller than that of the Hudson River and highly susceptible to any sources of anthropogenic mortality.[229]

As an anadromous fish, the Atlantic sturgeon spends most of its life at sea and enters freshwater estuaries to spawn.[230] The NYS DPS female Atlantic sturgeon reach sexual maturity between ages 15 and 30 years and male Atlantic sturgeon reach sexual maturity between the ages 8 and 20 years.[231] Atlantic sturgeon do not spawn every year, rather females spawn every 2 to 5 years and males every 1 to 5 years.[232] Male Atlantic sturgeon typically migrate upstream prior to spawning and reside there until fall, while female Atlantic sturgeon will enter the river to spawn and migrate back to sea shortly thereafter.[233] Likely spawning grounds for Atlantic sturgeon in the Delaware River reside between north Philadelphia, PA and Trenton, NJ in freshwater-tidal reaches.[234] Experts are now considering that there may also be a fall spawning season for Atlantic Sturgeon in the Delaware River.[235]

- Atlantic sturgeon within mid-Atlantic estuaries, including the Delaware River, migrate upriver to spawn between April and May.[236]
- Temperatures at which Atlantic sturgeon in the Delaware River spawn range from 55°F to 64°F which occurs between April and May.[237,238] The mean daily maximum

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[226] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[227] "Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Atlantic Sturgeon in the Northeast Region". 77 Federal Register 24 (6 February 2012), pp. 5880-5912.
[228] NOAA. Atlantic Sturgeon New York Bight Distinct Population Segment: Endangered. June 26, 2012.
[229] "Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Atlantic Sturgeon in the Northeast Region". 77 Federal Register 24 (6 February 2012), pp. 5880-5912.
[230] Atlantic Sturgeon Status Review Team. 2007. Status Review of Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.
[231] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[232] Atlantic Sturgeon Status Review Team. 2007. Status Review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.
[233] Atlantic Sturgeon Status Review Team. 2007. Status Review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.
[234] Simpson, P.C., Fox, D.A. Atlantic Sturgeon in the Delaware River: contemporary population status and identification of spawning areas. 2007.
[235] Personal communication from Maya van Rostrum.
[236] Atlantic Sturgeon Status Review Team. 2007. Status Review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.

temperature of both SGS's FAC A and FAC B effluent during the months of April and May exceeds the temperature range for Atlantic sturgeon spawning. [239]

Life History - Eggs

Atlantic sturgeon eggs are demersal and strongly adhesive to hard bottom habitats.[240]

- Optimal hatch temperature ranges from 64°F to 68°F. [241]

Life History – Larvae

Atlantic sturgeon yolk-sac larvae are pelagic for about the first ten days after hatching and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[242] Late-stage larvae settle into a demersal habitat, the habitat they will embrace the remainder of their lives.[243]

- Post yolk-sac larvae optimal temperature for growth is 66°F.[244]

Life History – Juvenile

Juvenile Atlantic sturgeon are between the ages of 1 and 15 years.[245] Juveniles migrate downstream during winter months and upstream during summer months as temperatures fall and

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[237] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[238] USGS. USGS Monthly Statistics. USGS 01477050 Delaware River at Chester, PA. September 1, 2015.
[239] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[240] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[241] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[242] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[243] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[244] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[245] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.

rise, respectively.[246] Juveniles remain in their natal freshwater habitat for approximately one year and migrate seaward between the ages of 2 and 6 years.[247]

- Juvenile Atlantic sturgeon are demersal.[248] Juveniles could be present year round in the vicinity of SGS. [249]
- Juvenile Atlantic sturgeon exhibit a tolerable temperature range of 37°F to 82°F and an optimal temperature of 68°F.[250] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during May through October exceeds the tolerable temperature range and from April through November exceeds the optimum temperature range for Atlantic sturgeon juveniles.[251]
- Juveniles begin to migrate downstream when temperatures reach 68°F (mid-September). Migrations peaks when temperature drop between 54°F and 64°F (October).[252]

Despite the fact that the biological monitoring, consisting of seine sampling and bottom trawl sampling conducted since 1995, does not target the federally endangered Atlantic sturgeon, PSEG contends that the numerous studies performed have demonstrated that the health of the Delaware Estuary has been improving for over thirty years.[253,254] PSEG also contends that the long term trend data shows no decline in juvenile abundance that can be attributable to PSEG-Salem.[255] CEA finds it hard to make such assertions when, in fact, with regard to juvenile Atlantic sturgeon, the Delaware Division of Fish and Wildlife DNREC reported a trending

[246] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[247] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[248] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[249] Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581. July 17, 2014.
[250] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[251] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[252] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
[253] PSEG. Biological Monitoring Reports. 1995-2013.
[254] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
[255] NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.

decline in late stage juvenile Atlantic sturgeon abundance in the Delaware estuary from 1991 through 2009 (Figure 5).[256]

Foraging

Atlantic sturgeon larvae become benthic feeders once the yolk sac is absorbed.[257] Post yolk-sac Atlantic sturgeon larvae remain benthic habitat feeders for the rest of their lives, eating by filtering mud and food.[258] In freshwater, juveniles eat plant and animal matter, sludge worms, chironomid larvae, may fly larvae, isopods, amphipods and small bivalve mollusks.[259] Juveniles compete with other demersal feeding species inclusive of catfish and white perch.[260] Studies have also indicated that Atlantic sturgeon consume mud while foraging within the benthic habitat.[261]

Overwintering

Juveniles that are not ready to leave their natal estuary may overwinter in deep holes and channels once the temperature drops to 68°F.[262]

Adults

Adult Atlantic sturgeon could be present year round in the vicinity of SGS. [263] Adults are likely to be present in the river from mid-April to mid-June. [264]

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[256] Fisher, Matthew T.; Delaware Division of Fish and Wildlife-Department of Natural resources and Environmental Control State of Delaware Annual Compliance Report for Atlantic Sturgeon; Submitted to the Atlantic States Marine Fisheries Commission Atlantic Sturgeon Plan Review Team; September 2009.

[257] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.

[258] Partnership for the Delaware Estuary. 2012. Technical Report for the Delaware Estuary and Basin. PDE Report No. 12-01. 255 pages. www.delawareestuary.org/science_programs_state_of_the_estuary.asp.

[259] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.

[260] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.

[261] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.

[262] Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.

[263] Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581. July 17, 2014.

[264] Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581. July 17, 2014.

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), Atlantic sturgeon spawning, eggs, larvae and juveniles have the known potential to be impacted.[265] CEA finds it difficult to fully understand the impacts of SGS's CWIS on the federally endangered Atlantic sturgeon due to the lack of recent quantitative sampling and tracking data. As a number of Atlantic sturgeon in the Delaware River have been implanted with acoustic transmitters for tracking, PSEG must be required to monitor the yearly activities of the fish within and migrating through the vicinity of SGS to accurately assess population numbers of juvenile and mature sturgeon.[266]

Macroinvertebrates

Blue crab (Callinectes sapidus)

Female blue crabs only mate once in their lives and store the male's sperm for spawning at a later time.[267] Blue crab eggs and adults are demersal.[268]

- Spawning occurs from May through August.[269]
- Blue crab eggs hatch between temperatures of 77°F and 86°F.[270] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of May, June, July, August, September, and October exceeds the hatching temperature range for blue crab eggs.[271]
- Growth occurs when water temperatures are above 59°F.[272] An optimal temperature for juvenile growth has been reported as 73°F. The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the months of April, May, June, July,

[265] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[266] Delaware State University and University of Delaware Atlantic Sturgeon research.
[267] Zinski, Steven C. *BLUECRAB.INFO: The Blue Crab Archives*. Accessed May 23, 2012. Web. <http://www.bluecrab.info/>. 2006.
[268] Zinski, Steven C. *BLUECRAB.INFO: The Blue Crab Archives*. Accessed May 23, 2012. Web. <http://www.bluecrab.info/>. 2006.
[269] Zinski, Steven C. *BLUECRAB.INFO: The Blue Crab Archives*. Accessed May 23, 2012. Web. <http://www.bluecrab.info/>. 2006.
[270] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[271] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[272] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.

August, September, and October and from SGS's effluent for FAC A during November exceeds the optimal growth temperature for blue crabs.[273]

- According to PSEG, blue crab occur in the vicinity of SGS from mid-April through November.[274]
- Water temperature of 91°F is lethal to blue crabs.[275] The mean daily maximum temperature of SGS's effluent during the months of June, July, August and September exceeds the lethal temperature limit for blue crabs.[276]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), blue crab eggs and adults have the known potential to be impacted.[277] Based on the 2013 Biological Monitoring Report data, implementation of a closed cycle cooling system has the potential to reduce impingement and entrainment by 95% and protect the lives of approximately 79,590 impinged blue crab per year.

Opossum shrimp (Neomysis americana)

Juvenile and adult opossum shrimp are considered semi-planktonic and are directly impacted by elevated surface water temperatures caused by SGS's effluent.[278]

- According to PSEG, opossum shrimp occur in the vicinity of SGS from mid-April through mid-December.[279]
- Spawning of opossum shrimp can occur from approximately mid-March through December, although production is generally slow at temperatures lower than 59°F.[280]
- Maximum growth rates occur at approximately 77°F.[281] The mean daily maximum temperature of both SGS's FAC A and FAC B effluent during the

[273] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[274] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[275] PSEG Fossil LLC. Mercer Generating Station 316(a) Demonstration. November 2001.
[276] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[277] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[278] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[279] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[280] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[281] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.

months of May, June, July, August, September, and October exceeds the optimal growth temperature range for opossum shrimp.[282]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), opossum shrimp have the potential to be impacted.[283]

Scud (Gammarus spp.)

The term scud refers to members of the Class crustacae, Order amphipoda, Family gammarus.[284] Scud do not participate in a migration for mating and remain in the same habitat during growth and mating.[285] Mating can occur from late spring to fall months with water temperature being the deciding factor.[286]

- According to PSEG, scud occur in the vicinity of SGS from mid-March through mid-September.[287]

Based on sensitivity to high water temperatures discharged from SGS (Tables 3 and 4), scud have the known potential to be impacted.[288]

<u>Global Warming</u>

In assessing the BTA for SGS, consideration must be given to future impacts due to global warming. The predicted rise in ambient water temperatures will ultimately result in the need for more non-contact cooling water at the SGS. The relationship between the temperature of the incoming cooling water and the amount of cooling water required for non-contact cooling is not linear. This means that even a small rise in incoming ambient water temperature could result in a large increase in the amount of water required for non-contact cooling. The increased volume and flow of water moving through the once-through cooling system will result in increases of impingement and entrainment of aquatic organisms. Furthermore, the greater volumes of water would be discharged into the Delaware River resulting in larger thermal plumes. The plumes would have an increased cross-sectional area to allow for mixing and dissipation of high

[282] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[283] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.
[284] Chan, B. Fly Fisher's Republic. Freshwater Shrimp. July 19, 2006.
[285] Chan, B. Fly Fisher's Republic. Freshwater Shrimp. July 19, 2006.
[286] Chan, B. Fly Fisher's Republic. Freshwater Shrimp. July 19, 2006.
[287] Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
[288] NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

temperature discharge water from the once-through cooling system. RIS species and the overall assemblage of aquatic species would be further impacted than they currently are due to greater early life stage mortality and further restrictions to fish passage.

The Incidental Take Statement (ITS) for the federally endangered shortnose sturgeon and Atlantic sturgeon completed in the 2014 BO highlights predicted environmental changes that have the potential to occur the Delaware River at SGS due to global warming.[289] The conditions noted by the 2014 BO include reduced river discharge and increase temperature. The 2014 BO states the following with regard to the predicted low flow and high temperature conditions:

"Shortnose sturgeon are tolerant to water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats."

"Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all shortnose sturgeon life stages, including adults, may become susceptible to strandings. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing shortnose sturgeon in rearing habitat; however, this would be mitigated if prey species also had a shift in distribution or if developing sturgeon were able to shift their diets to other species."

"Atlantic sturgeon prefer water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats."

[289] Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581. July 17, 2014.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all Atlantic sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat." [290]

As the 2014 BO stated, river discharge and temperature can affect the seasonal and spatial distribution of fish species in the Delaware River. PSEG's analysis, which relies on very limited sturgeon sampling data, cannot accurately discern the interplay between sturgeon populations and weather events in the vicinity of SGS. PSEG must assess potential impacts to both Atlantic and shortnose sturgeon that takes into account the increased occurrence of low flow and high temperature that have the potential to impact sturgeon populations within the vicinity of SGS. As both Atlantic and shortnose sturgeon are federally endangered species, SGS must institute measures that address both below or above average flow and temperature scenarios within the Delaware River in the vicinity of SGS. They should be required to institute the BTA to ensure that the very limited numbers of both sturgeon population life stages are not impacted by impingement, entrainment or thermal plumes that are exacerbated by future river flow and water temperature conditions.

4.0 CONCLUSIONS

As SGS discharges to the Delaware River, an invaluable habitat to both RIS and two additional federally endangered fish species, the shortnose sturgeon (*Acipenser brevirostrum)* and the Atlantic sturgeon (*Acipenser oxyrinchus*), currently available data must be integrated into

[290] Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581. July 17, 2014.

the BTA analysis to more accurately assess AEI. In addition, NJDEP must include additional provisions for reissuance of the permits involving CWIS, including details of appropriate operation and maintenance (O&M) of CWIS technologies and details of fish escape device O&M.

Reductions in AEI may be realized by seasonal flow reduction during periods when larval and juvenile aquatic species are present and most sensitive to impingement and entrainment. The move towards closed cycle cooling would provide up to 95% reductions in impingement, entrainment, and thermal discharges compared with other available CWIS technology and should not be overlooked as a viable alternative for maintaining the health and vitality of the federally endangered species and the fisheries in the Delaware River.

Review of the available reports submitted in support of the issuance of the NJPDES Permit for SGS reveals the need for a reevaluation and depiction of the hydrothermal modeling scenarios that accurately reflect potential plume effects with regard to DRBC Water Quality Standards and further evaluation of the impacts thermal discharges have on the life stages of the aquatic biota and the potential for fish passage specifically targeting the federally endangered Atlantic and shortnose sturgeon populations that are affected by SGS's thermal plume during different life stages.

Hydrological modeling scenarios for the thermal plume associated with once-through non-contact cooling water discharges must be reassessed to include a proper depiction and discussion of plume size, subsequent cross-sectional area calculations and associated near- and far-field assessment of pelagic and demersal RIS communities. DRBC's preexisting determination is over 20 years old and was initially issued on September 27, 1995 Docket No. D-68-20 CP (renewed in 1999 and 2001). The bulk of the temperature data and inputs used for the hydrothermal modeling are from 1968-1998. That means the data being relied on is over 18 years old and outdated, with the majority of field measurements taken over a two week period from May 21st to June 4th 1998. DRBC must request an updated 316(a) characterization and hydrothermal assessment, inclusive of a biothermal assessment, of SGS's thermal discharge utilizing updated field measurements and modeling to evaluate and accurately characterize the current extent and subsequent impacts of SGS's thermal plume on the Delaware River and populations of resident and migratory aquatic species. DRBC cannot issue a continued variance for a heat dissipation area of up to 7 times the mandated water quality guidelines based on such outdated data.

We believe that the reissuance of the NPDES permit must be tied to a new hydrothermal assessment that provides updated measured and modeled surface, sub-surface and cross-sectional data analyses that accurately depict current conditions and impacts to resident and migratory aquatic species of the Delaware River. Additionally, a more targeted impact study based on historic and currently available data for the Atlantic and shortnose populations of the Delaware River fishery within the vicinity of the SGS, and an examination of AEI associated with impingement, entrainment, and thermal discharges of all RIS species that together or separately ensure a BIP, must be considered prior to final decision of permit issuance.

TABLES

Table 1 - Estimated Number of Finfish and Blue Crab Lost Due to Impingement				
Fish Protection Technology	**Total Impingement Finfish - Sampled**	**Total Finfish Impinged in 2013**	**Total Impingement Blue Crab - Sampled**	**Total Blue Crab Impinged in 2013**
Existing 0.125 by 0.5 in Traveling Mesh Screen	60,004	19,000,000	4,988	1,600,000
Closed Cycle Cooling System		950,000		80,000

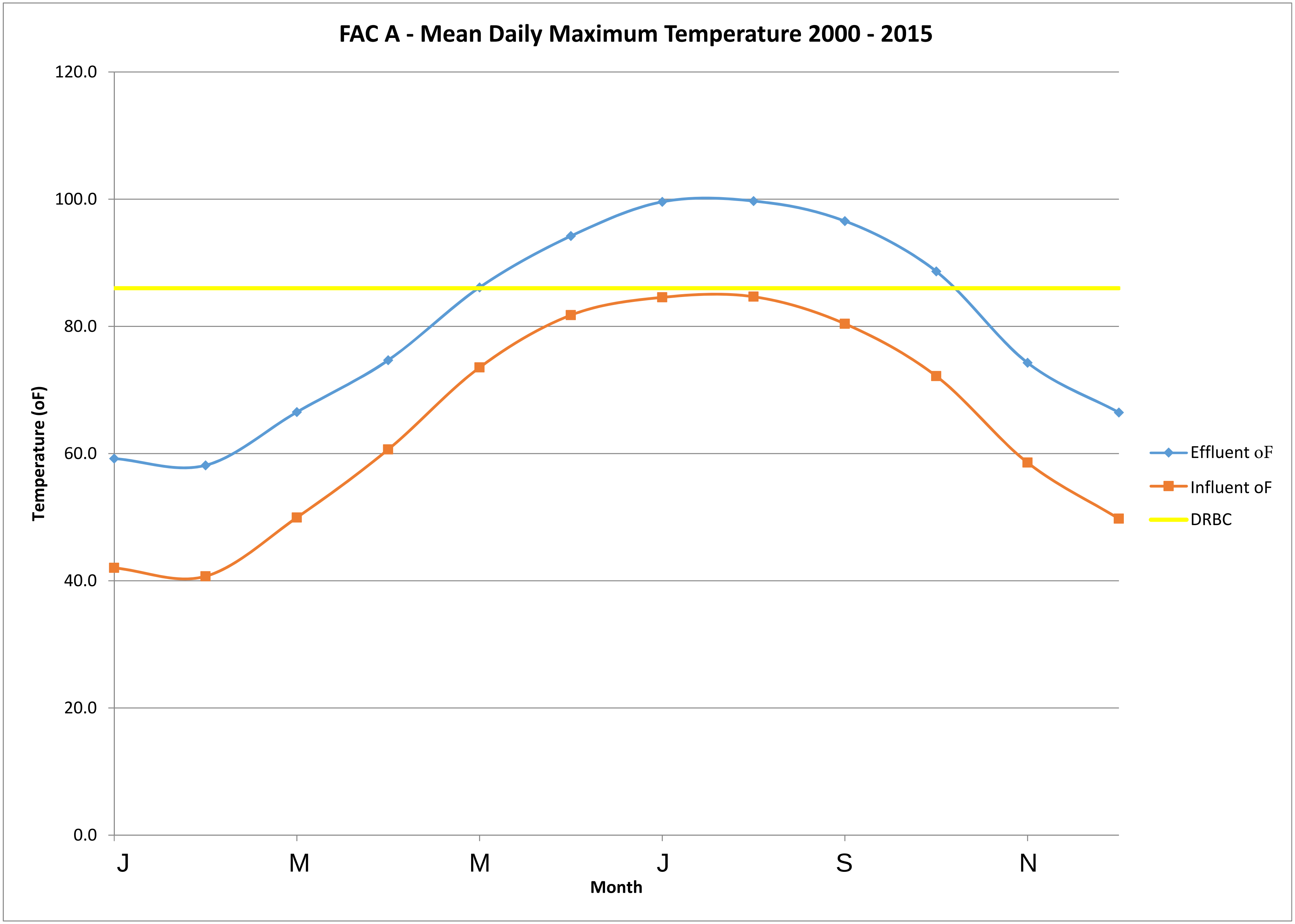
Table 2 - Estimated Number of Life Stages Lost Due to Entrainment								
Fish Protection Technology	Total Entrainment Eggs - Sampled	Total Eggs Entrained in 2013	Total Entrainment Larvae - Sampled	Total Larvae Entrained in 2013	Total Entrainment Juveniles - Sampled	Total Juveniles Entrained in 2013	Total Entrainment Adults- Sampled	Total Adults Entrained in 2013
Existing 0.125 by 0.5in Traveling Mesh Screen	45,018	1,900,000,000	33,546	1,400,000,000	7,999	330,000,000	82	3,400,000
Closed Cycle Cooling System		95,000,000		70,000,000		16,500,000		170,000

Table 3 - Salem Generating Station - DMR Intake & Effluent Temperature Data 2000-2015 - FAC A

	Mean Monthly Average		Mean Daily Max		Standards
Month	**Intake T (^oF)**	**Effluent T (^oF)**	**Intake T (^oF)**	**Effluent T (^oF)**	**DRBC Max T (^oF)**
January	38.1	54.4	42.0	59.2	86
February	37.7	54.1	40.7	58.2	86
March	44.2	59.7	49.9	66.5	86
April	54.4	66.8	60.6	74.7	86
May	65.9	78.9	73.5	**86.1**	86
June	76.0	**90.4**	81.8	**94.2**	86
July	81.8	**95.6**	84.6	**99.6**	86
August	81.8	**96.3**	84.7	**99.7**	86
September	75.9	**90.8**	80.4	**96.6**	86
October	65.3	77.6	72.2	**88.6**	86
November	53.3	67.9	58.6	74.3	86
December	43.6	59.0	49.8	66.5	86
Source: NJDEP Dataminer DMR data for Mercer Generating Station, July 2000 - June 2015					
Note: NJDEP Dataminer contained no data for the time period May 2014 through April 2015					
Note: Bolded effluent temperatures exceed the DRBC Regulations Maximum Temperature					

Table 4 - Salem Generating Station - DMR Intake & Effluent Temperature Data 2000-2015 - FAC B					
	Mean Monthly Average		Mean Daily Max		Standards
Month	Intake T (^oF)	Effluent T (^oF)	Intake T (^oF)	Effluent T (^oF)	DRBC Max T (^oF)
January	38.1	54.1	42.0	59.2	86
February	37.7	53.7	40.7	57.6	86
March	44.2	59.3	49.9	66.2	86
April	54.4	67.2	60.6	74.1	86
May	66.3	79.6	72.1	**88.1**	86
June	76.0	**90.7**	80.6	**95.7**	86
July	81.8	**95.9**	84.6	**99.8**	86
August	81.8	**96.4**	84.7	**99.4**	86
September	75.9	**91.0**	80.4	**96.5**	86
October	65.0	78.5	72.2	**89.0**	86
November	53.3	66.7	58.6	72.9	86
December	43.6	59.4	49.8	67.1	86
Source: NJDEP Dataminer DMR data for Mercer Generating Station, July 2000 - June 2015					
Note: NJDEP Dataminer contained no data for the time period May 2014 through April 2015					
Note: Bolded effluent temperatures exceed the DRBC Regulations Maximum Temperature					

FIGURES



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CEA ENGINEERS, P.C.

CEA #21527

Figure 1

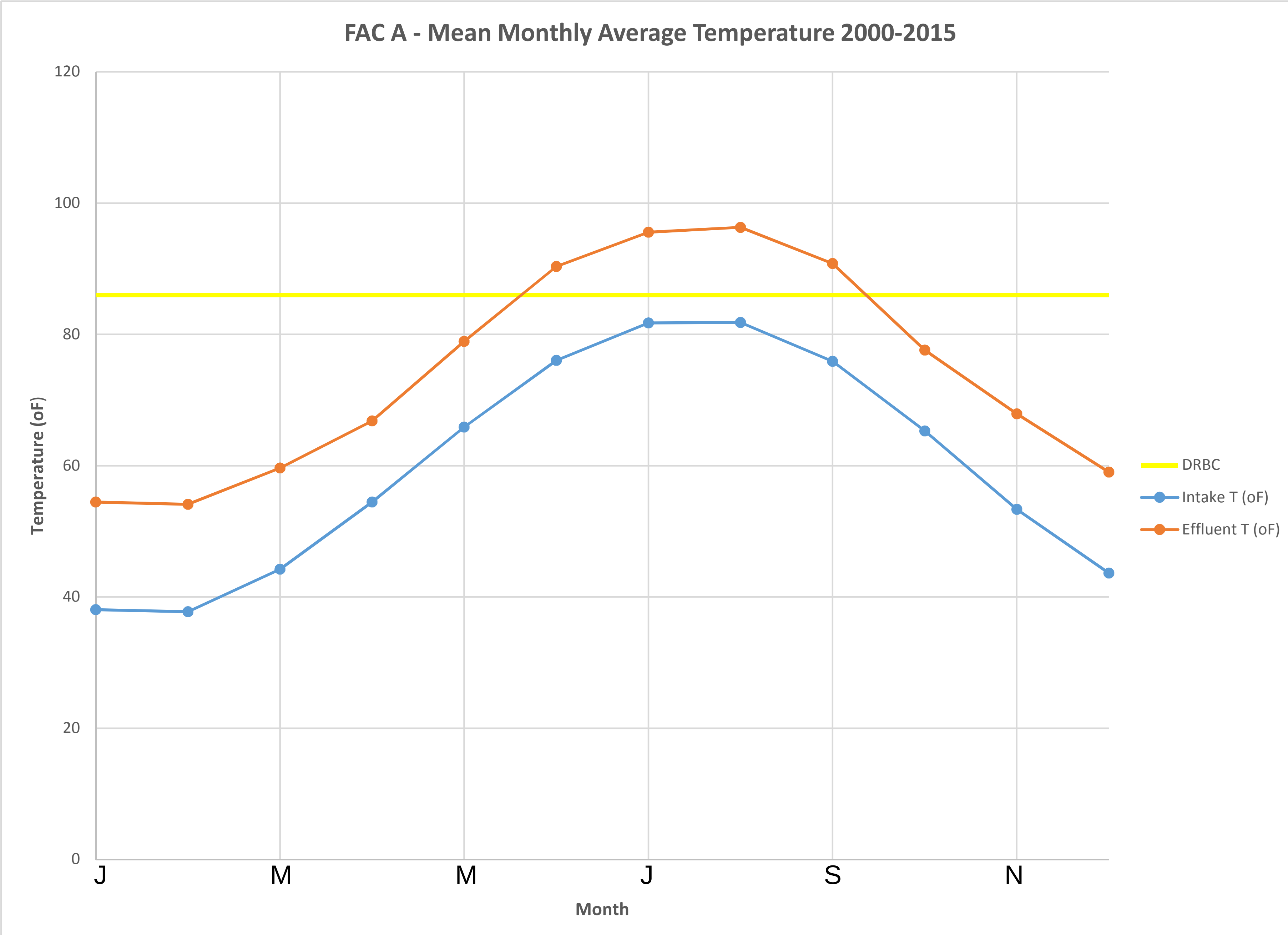

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Figure 2

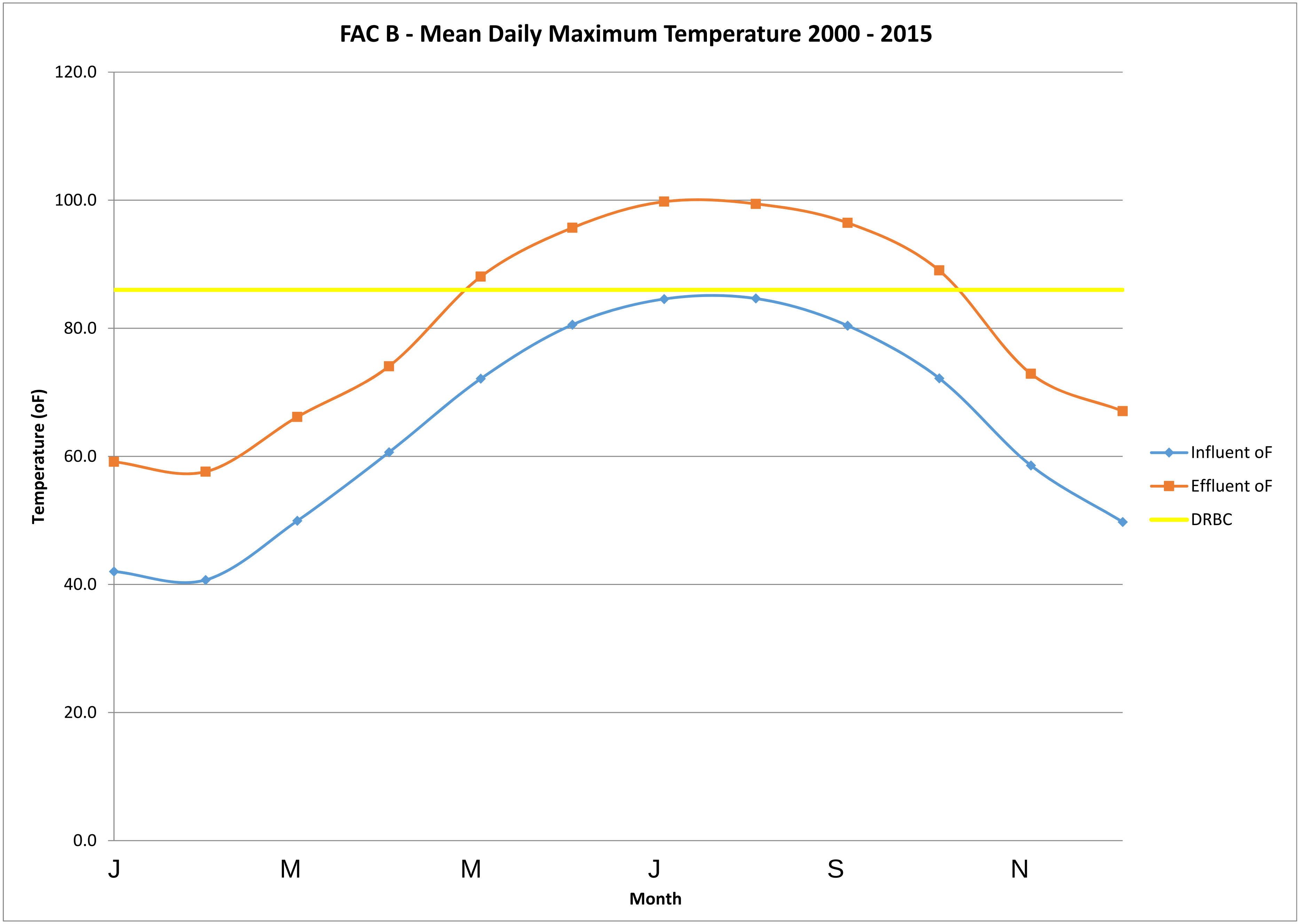

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Figure 3

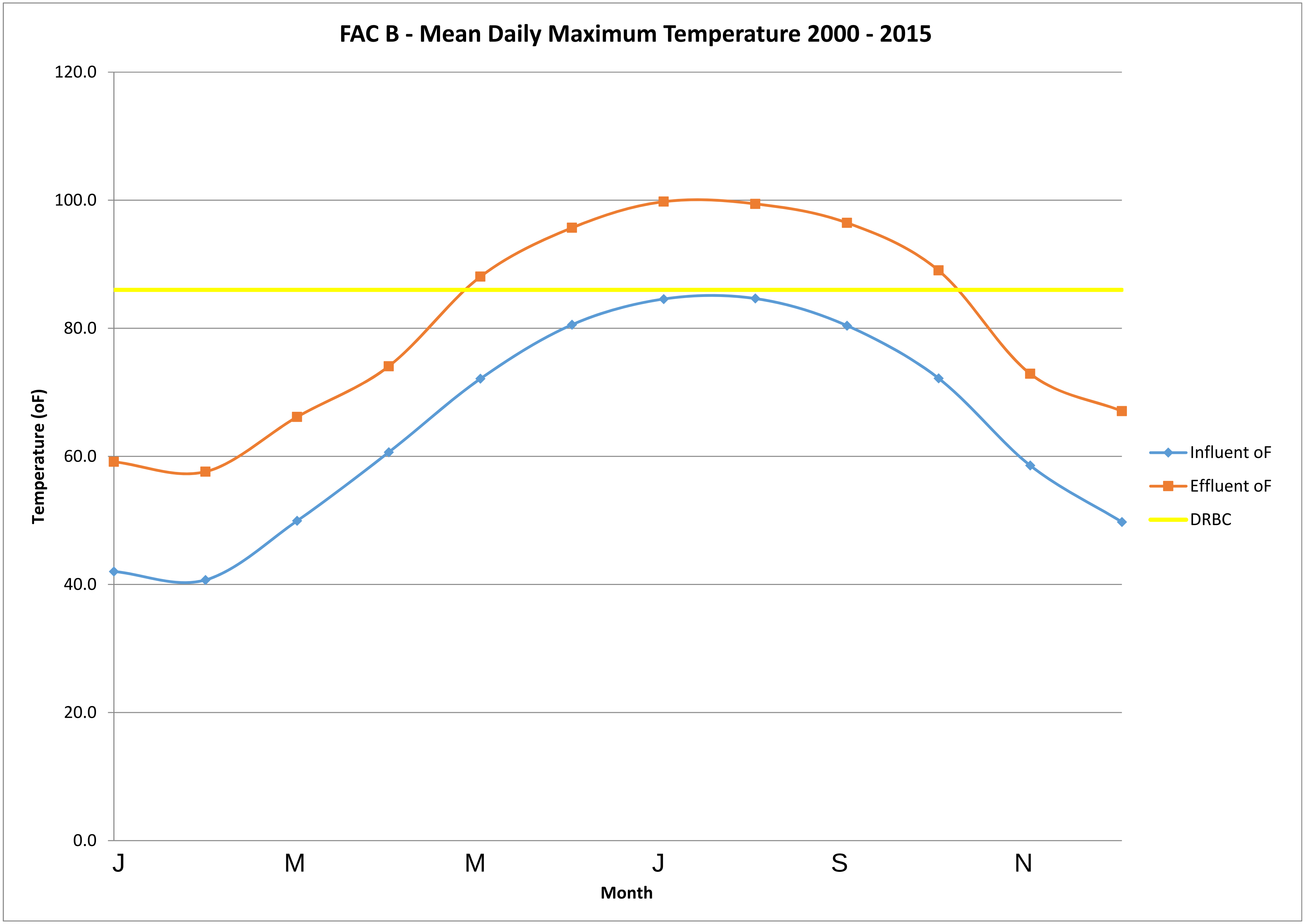

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Figure 4

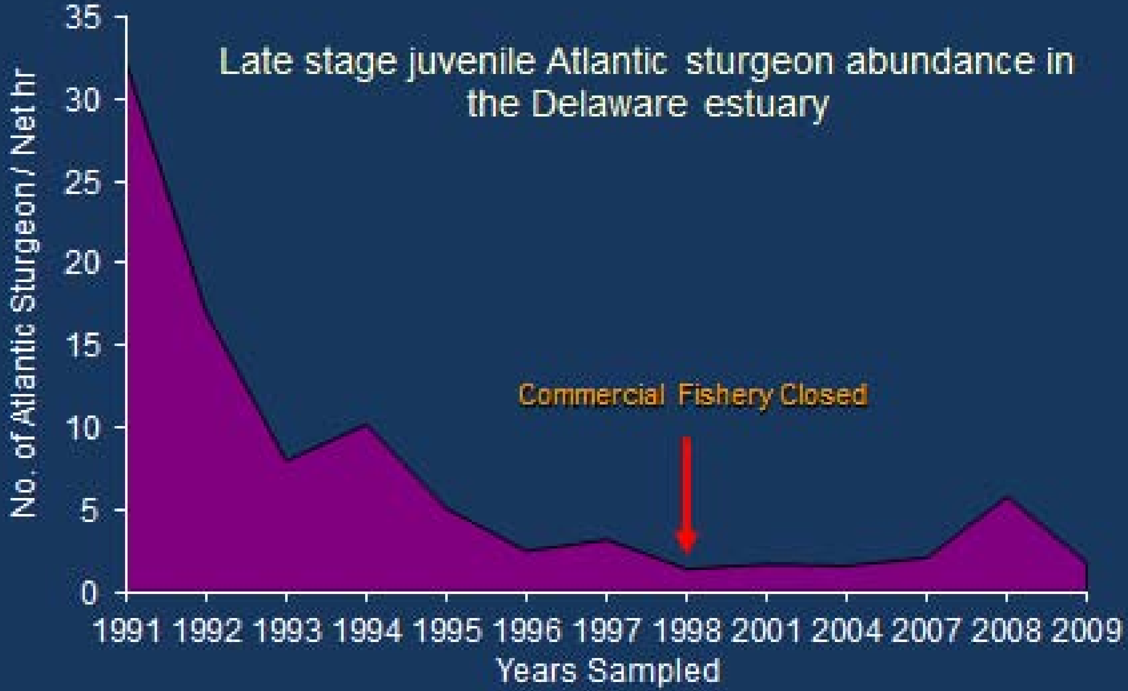
Late stage juvenile Atlantic sturgeon abundance in the Delaware estuary
Commercial Fishery Closed
No. of Atlantic Sturgeon / Net hr
35
30
25
20
15
10
5
0
1991 1992 1993 1994 1995 1996 1997 1998 2001 2004 2007 2008 2009
Years Sampled

Figure 5

APPENDIX A

RALPH E. HUDDLESTON, JR.

EDUCATION

- Eastern Kentucky University: Master of Science, Fisheries Biology, 1982
- University of Louisville: Bachelor of Arts, Biology, 1976

CONTINUING PROFESSIONAL EDUCATION

- Rutgers University: Coastal Vegetation Identification
- Methodology of Delineating Wetlands
- Advanced Wetland Delineation
- Wetland Systems of the Northeast

AFFILIATIONS

- American Fisheries Society
- Society of Wetland Scientists

EXPERTISE

- Wetlands and Ecological Investigations
- Delineation
- Enhancement and creation studies
- Permitting, stream sampling and analysis
- Natural Resource Inventories
- Litigation Support

SKILLS AND EXPERIENCE

Ralph E. Huddleston, Jr., has over 30 years of experience in the wetlands and environmental permitting industry. His areas of expertise include environmental impact assessment; wetland delineation, enhancement and creation; flora and fauna studies; natural resource inventories; and environmental permitting. He regularly provides expert witness testimony in the environmental and biological sciences in local, state and federal courts.

REPRESENTATIVE PROJECTS

COOLING WATER INTAKE STRUCTURES

Proposed Athens Generating Project Evaluation, Riverkeeper Inc./Scenic Hudson, Athens, New York.

A new electric generating station was proposed for construction along the Hudson River. Mr. Huddleston assessed the environmental impacts of the proposed facility on the Hudson River, particularly its fisheries. Mr. Huddleston also evaluated the proposed cooling water intake structures for the facility in relation to the Clean Water Act requirement that CWIS reflect the best technology available (BTA) for minimizing environmental impacts. Mr. Huddleston provided testimony at an administrative hearing on the expected adverse impacts of the facility on the Hudson River fisheries, as well as the proposed CWIS.

Fish Entrainment Prevention Barrier Evaluation, Riverkeeper, Inc., Stony Point, New York.

Riverkeeper, Inc. initiated litigation against Orange and Rockland Utilities (O&R) alleging that the cooling water intake structure (CWIS) at the Lovett Generating Station (Lovett) did not reflect best technology available for minimizing adverse environmental impacts as required by the Clean Water Act. A Federal court mandated that Lovett mitigate the CWIS to attain acceptable environmental impact levels. Mr. Huddleston served as a technical advisor to Riverkeeper, Inc. throughout the installation, removal, and performance of the mitigative measures at Lovett. Mr. Huddleston identified several issues of concern, including the high potential for impingement and entrainment of fish larvae and eggs. The issues of concern must be addressed prior to support of the mitigative measures at the Lovett facility.

In the Matter of Mirant Bowline, LLC for a State Pollutant Discharge Elimination System Permit pursuant to Environmental Conservation Law Article 17 and Title 6 of the

Official Compilations of Codes, Rules & Regulations of the State of New York (6NTCRR) Parts 750 et seq., Riverkeeper, Inc. Haverstraw, New York.
The Bowline Generating Station (Bowline 3) proposed the construction of a new unit along the Hudson River with a hybrid cooling and filter fabric Gunderboom around the water intake structure. The Clean Water Act (CWA) requires that cooling water intakes reflect the Best Available Technology (BAT) for minimizing adverse environmental impacts. Mr. Huddleston determined that the Gunderboom was an experimental technology and not a BAT. Mr. Huddleston also directed in-river experiments that were conducted to determine whether the Gunderboom would be subject to clogging by organisms. Mr. Huddleston provided testimony at an administrative hearing, and ultimately the Administrative Law Judge determined that the Gunderboom could not be considered a BAT.

Salem Generating Station Cooling Water Intake Structure Evaluation, Delaware Riverkeeper Network, Salem, New Jersey.
Mr. Huddleston reviewed Salem's permit application, New Jersey Pollutant Discharge Elimination System (NJPDES) permit, and conducted a Best Technology Available (BTA) analysis. Mr. Huddleston determined that each of the technologies designated as BTA by the NJDEP could only serve to reduce fish mortality associated with impingement, while over 99% of fish losses at Salem were associated with entrainment. His conclusions that the intake flow of the facility must be reduced in order to minimize fish entrainment resulted in a recommendation for a closed-cycle cooling system at the Salem facility. Mr. Huddleston prepared comments to the NJDEP detailing the deficiencies in the draft NJPDES permit and Salem's BTA analysis.

Salem Generating Station Wetland Restoration Program Evaluation, Delaware Riverkeeper Network, Salem, New Jersey, Delaware Estuary.
Under a grant received from the United States Environmental Protection Agency (EPA) to evaluate the effectiveness of the wetland restoration and enhancement program in and around the Delaware Estuary, Mr. Huddleston evaluated data provided by PG&E regarding the response of vegetation to PG&E's wetland restoration/enhancement efforts that included restoring the tidal influence to salt hay farms and treatment of Phragmites dominated wetlands to reduce Phragmites densities. Mr. Huddleston also evaluated the possible increase in fish migration and spawning as a result of the installation of fish ladders in tributaries to the Delaware Estuary. He determined that there was little benefit from

Phragmites removal, but vegetation and fish responded positively to mitigation at the former salt hay farm sites. There was no evidence in an Estuary-wide increase in fish populations as a result of the restoration and enhancement program.

Trout Unlimited Catskill Mountain Chapter and Theodore Gordon Flyfishers, et. al. v. The City of New York et. al., Trout Unlimited Catskill Mountain Chapter and Theodore Gordon Flyfishers, Catskill Region, New York.
Trout Unlimited Catskill Mountain Chapter and Theodore Gordon Flyfishers brought a Clean Water Act (CWA) citizen suit against The City of New York for discharge without a permit into the Shandaken Tunnel. The Shandaken Tunnel discharges to Esopus Creek, a well known trout fishery in a separate watershed. The discharge from the City of New York resulted in highly turbid water being discharged into Esopus Creek resulting in a dimished trout fishery. Mr. Huddleston provided litigation support to Trout Unlimited during trial after initial negotiations with New York City were unsuccessful. He presented an opinion based upon historical documentation that flows from the Shandaken Tunnel were critical to the sport fishery of Esopus Creek as claimed by the City. The United States District Court ruled that the City was liable for violations of the CWA for operating the Tunnel without a permit. The Court also assessed penalties and ordered the City to obtain a permit in a timely fashion. The New York State Department of Environmental Conservation (NYSDEC) was ordered to issue a NPDES permit within 18 months. The draft permit was issued and Mr. Huddleston assisted in the preparation of comments to the NYSDEC regarding the lack of enforceable permit conditions for turbidity.

WETLANDS

Chester Industrial Park, Wetland Habitat Restoration. Chester, New York.
As part of a negotiated settlement of a Notice of Violation (NOV) with the New York State Department of Environmental Conservation (NYSDEC), Mr. Huddleston investigated the historical delineation of the wetlands and designed a wetland restoration plan to address 10 acres of concern. After the NYSDEC approval of the plan, Mr. Huddleston oversaw the successful implementation of the restoration effort that included site grading, stormwater management, construction and planting of the wetlands, three years of status reporting, and maintenance recommendations. His efforts resulted in a successful settlement of

all outstanding issues and the creation of 10 acres of functional and mapped NYSDEC freshwater wetlands.

Wetlands Delineation/Mitigation, Richmond Valley Estates. Staten Island, New York.
The NYSDEC issued a NOV for the non-permitted clearing of vegetation and earth within regulated freshwater wetland and wetland adjacent area. Mr. Huddleston delineated on-site wetland boundaries to determine the extent of clearing and excavation activities within regulated wetland and adjacent areas. Mr. Huddleston worked directly with the NYSDEC to develop a mitigation plan t. Mr. Huddleston oversaw the implementation of the approved mitigation plan. After one year, the plan was deemed successful, and the violation was closed.

Toys "R" Us Distribution Center. Henry County, Georgia.
Mr. Huddleston delineated on-site wetlands for a one-million-square-foot distribution center proposed on a 157-acre site. . Mr. Huddleston oversaw the design of an 8.75-acre mitigation area/stormwater detention basin for the establishment of new wetlands. The design minimized the disturbance to the on-site wetlands while assuring that usable site area was maximized. In addition to providing new wetlands to offset disturbed wetlands, the mitigation design also provided required stormwater control. CEA prepared and submitted applications for submittal to the Georgia Environmental Protection Division (GAEPD). GAEPD expedited the review and approval of the required Nationwide Permit #26 and a Georgia Stream Encroachment Permit applications.

Waterfront Commons Mitigation Design. Staten Island, New York.
Mr. Huddleston was responsible for overseeing the development of a 4.8-acre wetland mitigation design in conjunction with an Army Corps of Engineers (ACOE) Individual Permit and NYSDEC Tidal Wetlands Permit. The mitigation involved the creation and enhancement of tidal and freshwater wetlands within a 30-acre parcel containing coastal upland, historically disturbed, freshwater wetlands and tidal wetland communities along the Arthur Kill.

Wetland Permitting/Mitigation, C & S Grocers. Chester, New York.
Mr. Huddleston directed efforts for obtaining an ACOE Nationwide Permit and NYSDEC Freshwater Wetlands Permit in conjunction with a warehouse expansion project. The permit

application process included conducting wetland delineations and preparing a wetland mitigation plan. The mitigation plan was designed for the enhancement of adjacent freshwater wetlands associated with historically disturbed, fallow agricultural land. The mitigation plan and the permit application were approved, and the permits were issued for the expansion.

Wetland Permitting, The Shoppes at Union Square. Newburgh, New York.

Mr. Huddleston supervised the preparation of NYSDEC Protection of Waters Permit and ACOE Nationwide Permit applications in conjunction with a stream crossing for a commercial development. The permit application process included conducting a freshwater wetland delineation, a Phase I Bog Turtle site assessment and agency negotiations. Mr. Huddleston worked with the project architects to minimize any potential impacts to the stream and associated wetlands. The project is currently under review.

Wetland Delineation/Mitigation, Proposed Motorsports Entertainment Facility and Retail Center. Staten Island, New York.

Mr. Huddleston supervised coordination efforts with the multi-disciplinary project team to delineate tidal and freshwater wetlands, assess site flora and fauna, and design mitigation plans for a 675-acre parcel in Staten Island, New York. Mr. Huddleston contributed to the composition of environmental impact statements prepared for the proposed facility. He also provided project planning assistance to counsel and played an integral role in agency negotiations to obtain required NYSDEC and ACOE Permits.

Seton Hall Prep, Old Growth Forest Survey. Essex County, New Jersey.

Mr. Huddleston oversaw the development and implementation of field protocols to conduct a survey to determine the presence of old growth forest within a 45-acre parcel. Survey methodologies included the use of grid sampling to assess vegetative strata and clinometer measurements to determine the presence/absence of specimen trees.

ECOLOGICAL ASSESSMENTS

Scenic Development Natural Resource Inventory. Ramapo, New York.

Mr. Huddleston oversaw the design and implementation of a natural resource inventory for the characterization of ecological communities within a 200-acre parcel. Site surveys were conducted over four seasons to assess the native flora and fauna, as well as the presence of threatened and endangered species. Mr. Huddleston directed the composition of the wetland and wildlife sections incorporated into a Draft Environmental Impact Statement (DEIS).

Tetz Asphalt Plant Draft Environmental Impact Statement (DEIS) Review, International Union of Operation Engineers. Middletown, New York.
The Tetz Concrete and Gravel facility proposed the expansion of the current operation to include an asphalt plant. Mr. Huddleston reviewed and evaluated the DEIS under the New York State Environmental Quality Review Act (SEQRA). He determined that the DEIS was incomplete and could not be used as a basis for decisions regarding the environmental impacts for the proposed asphalt plant. Mr. Huddleston prepared comments for submission to the Middletown Planning Board and the US Army Corps of Engineers ACOE, and he also provided oral and written testimony to the local planning board. The ACOE issued a wetlands violation notice to the applicant, and the planning board denied the expansion.

LITGATION SUPPORT

General Electric (GE) Westchester County Hanger Environmental Assessment Form (EAF) Review, Hudson Riverkeeper Inc. Westchester County, New York.
GE proposed the construction of a 75,000-square foot airplane hanger at the Westchester County Airport. Mr. Huddleston reviewed GE's EAF and supporting materials for completeness and adherence to applicable regulations and standards under the SEQRA. After review of the EAF, he determined that the project could have the potential to significantly impact the Kensico Reservoir. The EAF also failed to provide mitigation for wetland disturbances and contained no Stormwater Pollution Prevention Plan (SWPPP). Mr. Huddleston provided litigation support during the lawsuit brought against the Westchester County Legislature for inadequate environmental assessment. The State Supreme Court ruled that the Westchester County Legislature failed to conduct a complete environmental assessment of the effects of the proposed hanger, and they mandated that additional studies be conducted. GE ultimately abandoned the project.

American Canoe Association; Professional Paddlesports Association; Conservation Council of North Carolina; United States of America v. Murphy Farms, Inc., d/b/a Murphy Family Farms and D.M. Farms of Rose Hill, L.L.C., US District Court for the Eastern District of North Carolina Southern Division, 7-98-CV-4-V(1); 7-98-CV-19-F(1); & 5-98-CV-209-F(1).
Mr. Huddleston provided litigation support to the American Canoe Association and US Department of Justice (USDOJ) in a Clean Water Act (CWA) Citizen Suit against five-related hog Confined Feeding Operations (CAFOs) in Rose Hill, North Carolina, that allegedly discharged swine wastes to waters of the US without a National Pollutant Discharge Elimination System (NPDES) Permit. Mr. Huddleston assisted in the evaluation of Murphy's waste management practices and demonstrated that Murphy failed to prevent or mitigate discharges of hog waste to waters of the US. The substance of the suit was settled after the 4th Circuit ruled that a NPDES Permit was required.

New York City Bluebelt Proceedings, The City of New York Law Department, Staten Island, New York.
The city of NY initiated the acquisition of approximately 130 properties located on Staten Island to form a "Bluebelt" of protected wetlands. Mr. Huddleston supervised the analysis and preparation of reports detailing the development potential of each property in the City's Bluebelt eminent domain proceedings based on the interpretation and application of wetland, wetland adjacent area, and zoning regulations. These reports were used by the city's appraiser to determine a fair market value for each property. Mr. Huddleston also provided expert witness testimony during trials.

PUBLICATIONS

1. Bell, B., R. Cardenas, R. Huddleston, and R. Martin, *Procedure for Evaluation of the Impact of Intermittently Discharged Industrial Wastes on Municipal Treatment Facilities*, In: Industrial Wastes, J. Alleman and J. Kavanaugh, Eds., Ann Arbor Science Publishers, Ann Arbor, MI, 1982.

2. Cardenas, R., and R. Huddleston, *Toxicity of Heavy Metals in Anaerobic Digestors*, Presented at the WPCF National Meeting, 1978, In: Proceedings.

APPENDIX B

COURT	TYPE	ACTION NO.	YEAR
United States District Court Southern District of New York	Affidavit	91 Civ. 8688 (GLG)	1993
Supreme Court of the State of New York, County of Albany	Deposition Testimony	01-02-ST-3754	1995
NYSDEC Region 2 Wetlands Appeal Board	Testimony		1996
U.S. District Court for the Eastern District of North Carolina Southern Division	Deposition Testimony	7-98-CV-4-V(1)	1998
State of New York, New York State Board on Electric Generating Siting and the Environment	Testimony	97-F-1563	1999
Supreme Court of the State of New York, County of Richmond (Sitting in County of Kings)	Testimony	2757-94	1999
NYSDEC, New York State Board on Electric Generation Siting and the Environment	Testimony	99-F-1164	2001
State of Florida Division of Administrative Hearings	Deposition Testimony	01-1949/01-0772	2001
United States District Court Southern District of New York	Deposition Testimony	)4 Civ. 2741 (WWC	2001
U.S. District Court, District of Columbia	Deposition Testimony	1:00CV02827	2001
U.S. District Court, S.D.N.Y.	Deposition Testimony	00 Civ. 5395 (JSM)	2002
United States District Court Northern District of New York	Deposition Testimony	00-CV-511 (FJS/RFT)	2002
Texas State Office of Administrative Hearings	Deposition Testimony	582-09-3322	2009
Supreme Court of the State of New York, County of Richmond	Testimony	(CY) 4004/08	2011
Supreme Court of the State of New York, County of Queens	Testimony	18025/07	2011

APPENDIX C

Appendix C - References Relied Upon

ASA Analysis & Communication, Inc., Bridgeport Harbor Generating Station Biothermal Assessment Report, November 2011.
Atlantic Cooperative Telemetry Network; Collaborative Efforts, Current Status, & Directions; Brown, Lori. M., Savoy, Thomas F., Manderson, John P., and Fox, Dewayne A.; Delaware State University, Department of Agriculture and Natural Resources; Dover, Delaware.
Atlantic States Marine Fisheries Commission. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. January 2009.
Atlantic Sturgeon Status Review Team. 2007. Status Review of Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.
California Ocean Protection Council, Tetra-Tech, Inc., California's Coastal Power Plants: Alternative Cooling System Analysis, February 2008.
CFR Title 40. Chapter I. Subchapter D. Part 125. Subpart J. §125.92.
Chan, B. Fly Fisher's Republic. Freshwater Shrimp. July 19, 2006.
Clean Water Act Section 316(b) Existing Facilities Proposed Rule Qs and As, March 28, 2011.
Costantini, M., et al. Effect of Hypoxia on Habitat Quality of Striped Bass (Morone saxatilis) in Chesapeake Bay. Can. J. Fish. Aquat. Sci. 65: 989-1002. NRC Canada. 2008.
Coutant, Dr. Charles C., Dr. E. Eric Adams. Appendix E. 316(a) Demonstration Study. PSE&G Renewal Application. Salem Generating Station. Permit No. NJ0005622. March 4, 1999.
Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Atlantic Sturgeon in the Northeast Region. 77 Federal Register 24 (6 February 2012), pp. 5880-5912.
Endangered Species Act Section 7 Consultation Biological opinion. NOAA NMFS Greater Atlantic Regional Fisheries Office. Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581July 17, 2014.
Field Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intakes. EPRI, Palo Alto, CA: 2005. 1010112.
Fisher, Matthew T.; Delaware Division of Fish and Wildlife-Department of Natural resources and Environmental Control State of Delaware Annual Compliance Report for Atlantic Sturgeon; Submitted to the Atlantic States Marine Fisheries Commission Atlantic Sturgeon Plan Review Team; September 2009.
Hamilton-Setzler, E. M. University of Maryland Center for Environmental and Estuarine Studies: Chesapeake Biological Laboratory. White Perch (Morone americana). Undated. P.12- 4.
Klauda, Ronald Et al. Alewife and Blueback Herring: Alosa pseudoharengus and Alosa aestivalis. University of Maryland Agricultural Experiment Station Wye Research and Education Center. Undated.
Mercer, Linda P. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic): Weakfish. U.S. Army Corps of Engineers, Fish and Wildlife Service. August 1989.
National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (Acipenser brevirostrum). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.
Native Fish and Wildlife: Endangered Species. 32 Federal Register 48 (11 March 1967), pp. 4001.
NJDEP Dataminer DMR data for Salem Generating Station 2000-2015.

NJDEP. Draft Surface Water Renewal Permit Action. Category: B -Industrial Wastewater. NJPDES Permit No. NJ0005622. PSEG Nuclear LLC Salem Generating Station. Lower Alloways Creek Twp, Salem County. June 30, 2015.
NOAA Fisheries. Shortnose Sturgeon (Acipenser brevirostrum). April 5, 2013.
NOAA National Marine Fisheries Service. Species of Concern: River Herring (Alewife & Blueback herring). May 19, 2009.
NOAA. Atlantic Sturgeon New York Bight Distinct Population Segment: Endangered. June 26, 2012.
NOAA. http://nefsc.noaa.gov/publications/tm/tm161/tables/t44.htm
Okoye, A.O., et al. White Perch Fecundity Relationships in Western Albemarle Sound, North Carolina. Journal of North Carolina Academy of Science, 124(2), 2008, pp. 46-50.
Partnership for the Delaware Estuary. 2012. Technical Report for the Delaware Estuary and Basin. PDE Report No. 12-01. 255 pages. www.delawareestuary.org/science_programs_state_of_the_estuary.asp.
PSEG Fossil LLC. Mercer Generating Station 316(a) Demonstration. November 2001.
PSEG Nuclear LLC, Salem NJPDES Permit Renewal Application, NJPDES Permit No. NJ 0005622, Section 4 Comprehensive Demonstration Study (CDS), February 2006.
PSEG. Biological Monitoring Program Reports. 1995-2013.
PSEG. Renewal Application - Salem Generating Station, Permit No. NJ0005622 –Appendix E, 316(a) Demonstration - March 4, 1999.
Shepard, G. NOAA NEFSC – Resource Evaluation and Assessment Division. Striped Bass (Morone saxatilis). December 2006.
Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (Acipenser brevirostrum). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.
Simpson, P.C., Fox, D.A. Atlantic Sturgeon in the Delaware River: contemporary population status and identification of spawning areas. 2007.
Smith, C.L. The Inland Fishes of New York State. New York State Department of Environmental Conservation. Albany, NY. August 1985.
United States Environmental Protection Agency (U.S. EPA). Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact. April 1976.
US Fish and Wildlife Service. A History of the Endangered Species Act of 1973. August 2011.
US Fish and Wildlife Service. ESA Basics: 40 years of Conserving Endangered Species. January 2013.
USEPA, 316(b) Phase II Final Rule – TDD, Attachment A to Chapter 4, Cooling Water Intake Structure Technology Fact Sheets
USEPA, Preliminary Regulatory Development Section 316B of the Clean Water Act Background Paper Number 3: Cooling Water Intake Technologies, April 4, 1994.
USEPA, Technical Development Document for the Proposed Section 316(b) Phase II Existing Facilities Rule, EPA-821-R-11 001, March 28, 2011.
USFWS. Maryland Fisheries Resource Office. Park, I. et al. U.S. Fish and Wildlife Service Susquehanna River American Shad (Alosa sapidissima) Restoration: Potomac River Egg Collection, 2012. August 22, 2012.
USGS. USGS Monthly Statistics. USGS 01477050 Delaware River at Chester, PA. September 1, 2015.
Virginia Department of Game and Inland Fisheries. American Shad (Alosa sapidissima). http://www.dgif.virginia.gov/wildlife/fish/details.asp?fish=010040. 2013.
Zinski, Steven C. BLUECRAB.INFO: The Blue Crab Archives. Accessed May 23, 2012. Web. <http://www.bluecrab.info/>. 2006.