Logan, Dennis

From: Logan, Dennis
Sent: Friday, July 30, 2010 3:13 PM
To: Duda, Steve; 'Dillard, Steve'
Cc: 'Spangler, Nicole'
Subject: Salem Hope Creek: comments and edits on chapter 4 sections.
Attachments: 4.11.2 - Cumulative -Estuarine aquatic (2) DTL.docx; 4.5.1, 4.5.2, 4.5.3 - Aquatic Resources (3) DTL.docx; 4.5.4 Heat Shock (2) DTL.docx; 4.5.5 - Total Aquatic Impacts DTL.docx; 4.7 T&E Species DTL.docx

Biologists,

Here are some comments and suggested edits on Chapter 4 sections that we can talk about next week. I am still looking at the biological assessment.

Have a good weekend,
Dennis

4.11.2 Cumulative Impacts on Estuarine Aquatic Resources

This section addresses past, present, and future actions that have created or could result in cumulative adverse impacts on the aquatic resources of the Delaware Estuary, the geographic area of interest for this analysis. Cumulative impacts on freshwater aquatic resources other than the Delaware River are discussed with terrestrial resources in Section 4.11.3.

A wide variety of historical events have cumulatively affected the Delaware Estuary and its resources. Europeans began settling the estuary region early in the 17th century. By 1660 the English had established multiple small settlements, and major changes in the environment began. Philadelphia had 5,000 inhabitants by 1700 and became the predominant city and port in America. Agriculture grew throughout the region, and the clearing of forest led to erosion. Dredging, diking, and filling gradually altered extensive areas of shoreline and tidal marsh. By the late 1800s, industrialization had altered much of the watershed of the upper estuary, and fisheries were declining due to overfishing as well as pollution from ships, sewers, and industry. By the 1940s, anadromous fish were blocked from migrating upstream to spawn due to a barrier of low oxygen levels in the Philadelphia area. This barrier combined with small dams on tributaries nearly destroyed the herring and shad fisheries. A large increase in industrial pollution during and after World War II resulted in the Delaware River near Philadelphia becoming one of the most polluted river reaches in the world. Major improvements in water quality began in the 1960s through the 1980s as a result of State, multi-State, and Federal action, including the Clean Water Act and the activities of the Delaware River Basin Commission (Delaware Estuary Program, 1995).

Comment [DTL11]: Is all information in this paragraph from this source? If so, cite correctly.

In addition to past events, a variety of current and likely future activities and processes also have cumulative impacts on the aquatic resources of the Delaware Estuary to which the proposed action may contribute. Stressors associated with the proposed action and other activities or processes that may contribute to cumulative impacts on the aquatic resources of the estuary include the following:

- continued operation of the once-through cooling system for Salem Units 1 and 2
- continued operation of the closed-cycle cooling system for HCGS
- construction and operation of proposed additional unit at Salem/HCGS site
- continued withdrawal of water to support power generation, industry, and municipal water suppliers
- fishing pressure
- habitat loss and restoration
- changes in water quality
- climate change.

Each of these stressors may influence the structure and function of estuarine food webs and result in observable changes to the aquatic resources in the Delaware Estuary. In most cases, it is not possible to determine quantitatively the impact of individual stressors or groups of stressors on aquatic resources. The stressors affect the estuary simultaneously, and their effects are cumulative. A discussion follows of how the stressors listed above may contribute to cumulative impacts on aquatic resources of the Delaware Estuary.

Continued Operation of the Salem Once-Through Cooling System

Based on the assessment presented in Section 4.5 of this draft SEIS, the NRC staff concludesd that entrainment, impingement, and thermal discharge impacts on aquatic resources from the operation of Salem Units 1 and 2 collectively have not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of Salem. The continued operation of Salem during the renewal term would continue to contribute to cumulative impacts on the estuarine community of fish and shellfish. As discussed in Sections 4.5.2 through 4.5.5, there has been extensive, long-term monitoring of fish and invertebrate populations of the Delaware Estuary. The data collected by these studies reflect the cumulative effects of multiple stressors acting on the estuarine community. For example, data from 1970 through 2004 were analyzed using commonly accepted techniques for assessing species richness (the average number of species in the community) and species density (the average number of species per unit volume or area). This analysis found that in the vicinity of Salem and HCGS since 1978, when Salem began operation, finfish species richness has not changed, and species density has increased (PSEG, 2006a). Operation of Salem during the relicensing period likely would continue to contribute substantially to cumulative impacts on aquatic resources in conjunction with HCGS and other facilities that withdraw water from or discharge to the Delaware Estuary. However, given the long-term improvements in the estuarine community during recent decades while these facilities were operating, their cumulative impacts are expected to be limited, with effects on individual species populations potentially ranging from negligible to noticeable.

Continued Operation of the HCGS Closed-Cycle Cooling System

As discussed in Section 4.5.1, the closed-cycle cooling system used by HCGS substantially reduces the volume of water withdrawn by the facility and similarly reduces entrainment, impingement, and thermal discharge effects. Accordingly, the impacts of these effects from operation of the HCGS cooling system during the relicensing period would be limited, and the incremental contribution of HCGS to cumulative impacts on the estuarine community would be minimal. The analysis of cumulative effects on the aquatic community discussed above incorporates the effects of both HCGS and Salem. Operation of HCGS during the relicensing period would continue to contribute to cumulative impacts in conjunction with Salem and other facilities that withdraw water from or discharge to the Delaware Estuary. As described above for Salem, these cumulative impacts are expected to be limited, with effects on individual species populations potentially ranging from negligible to noticeable.

Comment [DTL12]: Awkward. Even so, The chapter on impingement, entrainment, and thermal effects do not explicitly talk much about Hope Creek. We need to talk about how we are going to weave all this together.

Construction and Operation of Proposed Additional Unit at Salem/HCGS Site

If PSEG decides to proceed and construct a new nuclear power unit at the Salem/HCGS site, it would contribute to cumulative impacts on aquatic resources during construction and operation. The impacts of this action on aquatic resources during the construction period may be substantial in the immediate vicinity of the construction activities but would be limited in extent and unlikely to significantly contribute to cumulative impacts on the estuarine community. The contribution from the long-term operation of the new facility to cumulative impacts on the estuarine community likely would be minor given the expected use of a closed-cycle cooling system. The specific impacts of this action ultimately would depend on the actual design, operating characteristics, and construction practices proposed by the applicant. Such details are not available at this time, but if a combined license application is submitted to NRC, the detailed impacts of this action at the Salem/ HCGS site then would be analyzed and addressed in a separate NEPA document prepared by NRC.

Comment [DTL13]: This is true of direct and indirect effects. We need to expand this discussion to cumulative, though.
Also we must link our discussion to NRC's definitions of small, moderate and large levels of impact and say why what we expect fits into one of those definitions.

Comment [DTL14]: Just curious: Are we using this symbol to represent the three units?

Continued Water Withdrawals and Discharges

No large industrial facilities lie dDownstream of Artificial Island~~, there are no large industrial facilities~~ on either side of the estuary south to the mouth of Delaware Bay. An oil refinery lies uUpstream of Artificial Island~~, there is an oil refinery~~ in Delaware approximately 8 mi (13 km) to the north, and ~~there are~~ many industrial facilities are upstream from there (PSEG, 2009a). Many of these facilities are permitted to withdraw water from the river and to discharge effluents to the river. In addition, water is withdrawn from the nontidal, freshwater reaches of the river to supply municipal water throughout New Jersey, Pennsylvania, and New York (DRBC 2010). In the tidal portion of the river, water is used for power plant cooling systems as well as industrial operations. DRBC-approved water users in this reach include 22 industrial facilities and 14 power plants in Delaware, New Jersey, and Pennsylvania (DRBC, 2005). Of these facilities, Salem uses by far the largest volume of water, with a reported water withdrawal volume in 2005 of 1,067,892 million gallons (4,025,953 million liters) (DRBC, 2005). This volume exceeds the combined total withdrawal for all other industrial, power, and public water supply purposes in the tidal portion of the river. The volume of water withdrawn by HCGS in 2005 was much lower, at 19,561 million gallons (73,745 million liters).

These activities are expected to continue in the future, and water supply withdrawals likely will increase in the future in conjunction with population growth. Because water withdrawals from the Delaware River will continue, and are likely to increase, during the relicensing term, this activity will continue to contribute to cumulative effects in the estuary. Similarly, ongoing discharges of effluents to the river and estuary will continue to have cumulative effects. Withdrawals and discharges are regulated by Federal and State agencies as well as by the DRBC, limiting the magnitude of their effects. Permit requirements are expected to limit adverse effects from withdrawals and discharges, and cumulative impacts from these activities on the aquatic resources of the Delaware Estuary are expected to be minimal.

Fishing Pressure

The majority of the RS and EFH species at Salem are commercially or recreationally important and, thus, are subject to effects from the harvesting of fish stocks. Losses from fish populations due to fishing pressure are cumulative in conjunction with losses due to entrainment and impingement at Salem and Hope Creek as well as other water intakes. In most cases, the commercial or recreational catches of RS are regulated by Federal or State agencies, but losses of some RS continue to occur as bycatch caught unintentionally when fishing for other species. The extent and magnitude of fishing pressure and its relationship to cumulative impacts on fish populations and the overall aquatic community of the Delaware Estuary are difficult to determine because of the large geographic scale of the fisheries and the natural variability that occurs in fish populations and the ecosystem. Fishing pressure (and protection of fisheries through catch restrictions) has the potential to influence the food web of the Delaware Estuary by affecting fish and invertebrate populations in areas extending from the Atlantic Ocean and Delaware Bay through the estuary and upriver.

Habitat Loss and Restoration

As described above, alterations to terrestrial, wetland, shoreline, and aquatic habitats have occurred in the Delaware Estuary since colonial times. Development, agriculture, and other upland habitat alterations in the watershed have affected water quality. The creation of dams and the filling or isolation of wetlands to support industrial and agricultural activities have dramatically changed patterns of nutrient and sediment loading to the estuary. Such activities also have reduced productive marsh habitats and limited access of anadromous fish to upstream spawning habitats. In addition, historic dredging and deposition activities have altered estuarine environments and affected flow patterns, and future activities, such as dredging to deepen the shipping channel through the estuary, may continue to influence estuarine habitats. Development along the shores of the estuary in some places also has resulted in the loss of shoreline habitat.

Although habitat loss in the vicinity of the Delaware Estuary remains a concern, habitat restoration activities have had a beneficial effect on the estuary and are expected to continue during the license renewal term as a requirement of the Salem NJPDES permit (see Section 4.5.5). In addition, NRC expects ??? wetland permitting regulations ~~are expected~~ to limit future losses of wetland habitat to development in the watershed. Thus, the net cumulative impacts on aquatic habitats associated with the estuary are likely to be minimal in the future, and restoration activities are expected to provide ongoing habitat improvements.

Comment [DTL15]: To whom?

Comment [DTL16]:

Water Quality

In general, there is evidence to conclude that water quality in the Delaware River Basin, including the estuary, is improving. Upgrades to wastewater treatment facilities and improved agricultural practices during the past 25 years have reduced the amount of untreated sewage, manure, and fertilizer entering the river and contributed to reductions in nutrients and an apparent increase in dissolved oxygen. Chemical contaminants persist in sediments and the tissues of fish and invertebrates, and nonpoint discharges of chemicals still occur (Kauffmann, Belden, and Homsey, 2008). Water quality in the Delaware Estuary likely will continue to be a concern; however, improvement may continue in many components and the incremental contribution of Salem and HCGS to adverse effects on water quality is expected to be minimal.

Comment [8]:

Comment [DTL19]:

Climate Change

Comment [DTL110]: i

The potential cumulative effects of climate change on the Delaware Estuary, whether from natural cycles or related to anthropogenic activities, could result in a variety of changes that would affect aquatic resources. The environmental changes that could affect estuarine systems include sea level rise, temperature increase, salinity changes, and wind and water circulation changes. Changes in sea level could result in dramatic effects on tidal wetlands and other shoreline communities. Water temperature increases could affect spawning patterns or success, or influence species distributions when cold-water species move northward while warm-water species become established in new habitats. Changes in estuarine salinity patterns could influence the spawning and distribution of RS and the ranges of exotic or nuisance species. Changes in precipitation patterns could have a major effect on water circulation and change the nature of sediment and nutrient inputs to the system. This could result in changes to primary production and influence the estuarine food web on many levels. Thus, the extent and magnitude of climate change impacts may make this process an important contributor to cumulative impacts on the aquatic resources of the Delaware Estuary, and these impacts could be substantial over the long term.

Final Assessment of Cumulative Impacts on Aquatic Resources

Aquatic resources of the Delaware Estuary are cumulatively affected to varying degrees by multiple activities and processes that have occurred in the past, are occurring currently, and are likely to occur in the future. The food web and the abundance of RS and other species have been substantially affected by these stressors historically. The impacts of some of these stressors associated with human activities have been and can be addressed by management actions (e.g., cooling system operation, fishing pressure, water quality, and habitat restoration). Other stressors, such as climate change and increased human population and associated development in the Delaware River Basin, cannot be directly managed and their effects are more difficult to quantify and predict. It is likely, however, that future anthropogenic and natural environmental stressors would cumulatively affect the aquatic community of the Delaware

Estuary sufficiently that they would noticeably alter important attributes, such as species ranges, populations, diversity, habitats, and ecosystem processes. Based on this assessment, the NRC staff concludes that cumulative impacts during the relicensing period from past, present, and future stressors affecting aquatic resources in the Delaware Estuary would range from SMALL to MODERATE. The incremental contribution from the continued operation of Salem and HCGS to impacts on aquatic resources of the estuary would be SMALL for most impacts.

References

Delaware Estuary Program. 1995. *Comprehensive Conservation and Management Plan for the Delaware Estuary*. WHO PUBLISHED THIS AND WHERE. January.

Kauffmann, G., A. Belden, and A. Homsey. 2008. *Technical Summary: State of the Delaware River Basin Report*. July 4. Accessed 9 July 2010 at www.wra.udel.edu/files/DRBCStateoftheBasinReport_07042008.

4.5 Aquatic Resources

4.5.1 Categorization of Aquatic Resources Issues

The Category 1 and Category 2 issues related to aquatic resources and applicable to HCGS and Salem are listed in Table 4-1 and discussed below. Section 2.1.6 of this report describes the HCGS and Salem cooling water systems, and Section 2.2.5 describes the potentially affected aquatic resources.

Table 4-1. Aquatic Resources Issues.

Issues	GEIS Section	Category
For All Plants		
Accumulation of contaminants in sediments or biota	4.2.1.2.4	1
Entrainment of phytoplankton and zooplankton	4.2.2.1.1	1
Cold shock	4.2.2.1.5	1
Thermal plume barrier to migrating fish	4.2.2.1.6	1
Distribution of aquatic organisms	4.2.2.1.6	1
Premature emergence of aquatic insects	4.2.2.1.7	1
Gas supersaturation (gas bubble disease)	4.2.2.1.8	1
Low dissolved oxygen in the discharge	4.2.2.1.9	1
Losses from parasitism, predation, and disease among organisms exposed to sublethal stresses	4.2.2.1.10	1
Stimulation of nuisance organisms	4.2.2.1.11	1
For Plants with Cooling-Tower-Based Heat Dissipation Systems[a]		
Entrainment of fish and shellfish in early life stages	4.3.3	1
Impingement of fish and shellfish	4.3.3	1
Heat shock	4.3.3	1
For Plants with Once-Through Heat Dissipation Systems[b]		
Entrainment of fish and shellfish in early life stages	4.2.2.1.2	2
Impingement of fish and shellfish	4.2.2.1.3	2
Heat shock	4.2.2.1.4	2

(a)Applicable to HCGS
(b)Applicable to Salem

The NRC staff did not identify any new and significant information related to Category 1 aquatic resources issues during the review of the applicant's ERs for Salem (PSEG, 2009a) and HCGS (PSEG, 2009b), the site audit, or the scoping process. Consequently, there are no impacts related to the generic, Category 1 issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be warranted.

Entrainment of fish and shellfish in early life stages, impingement of fish and shellfish, and heat shock are Category 1 issues at power plants with closed-cycle cooling systems and are

Category 2 issues at plants with once-through cooling systems. Hope Creek uses a closed-cycle cooling system with a cooling tower. This type of cooling system substantially reduces the volume of water withdrawn by the plant and, consequently, also substantially reduces entrainment, impingement, and thermal discharge effects (heat shock potential). Entrainment, impingement, and heat shock are Category 1 issues for Hope Creek and do not require further analysis to determine that their impacts during the relicensing period would be SMALL. In contrast, the cooling water system at Salem is a once-through system, and for such systems entrainment, impingement, and heat shock are Category 2 issues that require site-specific analysis. The remainder of Section 4.5 discusses these Category 2 issues for Salem.

4.5.2 Entrainment of Fish and Shellfish in Early Life Stages

Entrainment occurs when early life stages of fish and shellfish are drawn into cooling water intake systems along with the cooling water. Cooling water intake systems are designed to screen out larger organisms, but small life stages, such as eggs and larvae, can pass through the screens and be drawn into the plant condensers. Once inside, organisms may be killed or injured by heat, physical stress, or chemicals.

Regulatory Background

Section 316(b) of the Clean Water Act of 1977 (CWA) requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impacts (33 USC 1326). In July 2004, the U.S. Environmental Protection Agency (EPA) published the Phase II Rule implementing Section 316(b) of the CWA for Existing Facilities (69 FR 41576). The rule became effective on September 7, 2004 and included numeric performance standards for reductions in impingement mortality and entrainment that would demonstrate that the cooling water intake system constitutes BTA for minimizing impingement and entrainment impacts. Existing facilities subject to the rule were required to demonstrate compliance with the rule's performance standards during the renewal process for their National Pollutant Discharge Elimination System (NPDES) permit through development of a Comprehensive Demonstration Study (CDS). EPA officially suspended the Phase II rule on July 9, 2007, leaving permit writers to utilize Best Professional Judgment (BPJ) for determining BTA in compliance with Section 316(b).

Comment [DL1]: Actually, it didn't leave permit writers in this conditions. EPA instructed permit writers to use BPJ.

EPA delegated authority for NPDES permitting to the New Jersey Department of Environmental Protection (NJDEP) in 1984. In 1990, NJDEP issued a draft permit that proposed closed-cycle cooling as BTA for Salem under the New Jersey Pollutant Discharge Elimination System (NJPDES). In 1993 NJDEP concluded that the cost of retrofitting Salem to closed-cycle cooling would be wholly disproportionate to the environmental benefits realized, and a new draft permit was issued in 1994 (PSEG, 1999a). The 1994 final NJPDES permit stated that the existing cooling water intake system was BTA for Salem, with certain conditions (NJDEP, 1994).

Conditions of the 1994 permit included improvements to the screens and Ristroph buckets, a monthly average limitation on cooling water flow of 3,024 million gallons per day (MGD), and a pilot study for the use of a sound deterrent system. In addition to technology and operational measures, the 1994 permit required restoration measures that included a wetlands restoration and enhancement program designed to increase primary production in the Delaware Estuary and fish ladders at dams along the Delaware River to restore access to traditional spawning runs for anadromous species such as blueback herring and alewife. A Biological Monitoring Work Plan (BMWP) also was required to monitor the efficacy of the technology and operational measures employed at the site and the restoration programs funded by PSEG (PSEG, 1999a).

The BMWP included monitoring plans for fish utilization of restored wetlands, elimination of impediments to fish migration, bay-wide trawl survey, and beach seine survey, in addition to the entrainment and impingement abundance monitoring (NJDEP, 1994). The main purpose of these studies was to monitor the success of the wetland restoration activities and screen modifications undertaken by PSEG.

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

The IBMWP was submitted to NJDEP in April 2002 and approved in July 2003. A reduction in the frequency of monitoring at fish ladder sites that successfully pass river herring was submitted in December 2003 and approved in May 2004. In 2006 PSEG submitted a revised IBMWP that proposed a reduction in sampling at the restored wetland sites. Sampling would be conducted at representative locations instead of at every restoration site (PSEG, 2006a).

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

Entrainment Studies

Prior to construction of the Salem facility, baseline biological studies were begun in 1968 to characterize the biological community in the Delaware Estuary. The study area consisted of the estuary 10 mi to the north and south of Salem. In 1969 with the passing of the National Environmental Policy Act (NEPA), the study program was expanded to include ichthyoplankton and benthos studies and to gather information on the feeding habits and life histories of the common species. In 1973 the Atomic Energy Commission (AEC) published its Final Environmental Statement (FES) for Salem, which concluded that the effects of impingement and entrainment on the biological community of the Delaware Estuary would not be significant (PSEG, 1999a).

The Salem facility began operation in 1977, and monitoring has been performed on an annual basis since then to evaluate the impacts on the aquatic environment of the Delaware Estuary from entrainment of organisms through the cooling water system. Methods and results of these studies are summarized in several reports, including the 1984 316(b) Demonstration (PSEG, 1984), the 1999 316(b) Demonstration (PSEG, 1999a), and the 2006 316(b) Demonstration (PSEG, 2006a). In addition, biological monitoring reports were submitted to NJDEP on an annual basis from 1995 through the present (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c).

The 1977 316(b) rule included a provision to select Representative Important Species (RIS) to focus the investigations, and previous demonstrations evaluated RIS as well as additional target species (PSEG, 1984; PSEG, 1999a). The 2006 CDS used the term Representative Species (RS) to comprise both RIS and target species and to be consistent with the published Phase II Rule. RS were selected based on several criteria ~~including:~~ including susceptibility to impingement and entrainment at the facility, importance to the ecological community, recreational or commercial value, and threatened or endangered status (PSEG, 2006a).

The 1984 316(b) Demonstration was a 5-year study from 1978 to 1983 that focused on nine RS, including seven fish species and two macroinvertebrates. These species ~~were:~~ are weakfish (*Cynoscion regalis*), bay anchovy (*Anchoa mitchilli*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), opossum shrimp (*Neomysis americana*), and scud (*Gammarus* sp.) (PSEG, 1984).

In 1999 PSEG submitted a 316(b) demonstration that included the same RS fish species as the previous studies and added the blue crab (*Callinectes sapidus*). Scud and opossum shrimp were removed from the list of RS because they have high productivity, high natural mortality, and assessments completed prior to PSEG's 1999 NJPDES application concluded that Salem does not and will not have an adverse environmental impact on these macroinvertebrates (PSEG, 1999a).

The 316(b) demonstration submitted during the 2006 NJPDES renewal process included an estimation of entrainment losses for the RS developed from data collected during annual entrainment monitoring conducted in accordance with the IBMWP. A revised RS list was developed that included the nine finfish and the blue crab from previous studies and added the Atlantic silverside (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and bluefish (*Pomotomus saltrix*) (PSEG, 2006a).

Entrainment samples typically were collected from the circulating water system intake bays 11A, 12B, or 22A or at discharge standpipes 12 or 22. From August 1977 through May 1980, intake samples were collected from the circulating water after it passed through the travelling screens and the circulating water pumps. In June 1980 the sample location was changed to the discharge pipes (PSEG, 1984). Beginning in 1994, samples were collected from either intake bay 12 B or 22A (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c).

Samples were collected by pumping water through a Nielsen fish pump through a 1.0 meter diameter, 0.5 mm mesh, conical plankton net in an abundance chamber. A total sample volume of 50 to 100 m^3 was filtered at a rate not to exceed 2.0 m^3/minute. Sample contents were rinsed into a jar and preserved for laboratory analysis. Ichthyoplankton collected was identified to the lowest practical taxon and life stage, counted, and a subset was measured (PSEG, 1984).

From August 1977 to April 1978 entrainment samples were collected monthly from September through May and twice monthly from June through August. In 1979 samples were collected once monthly in March, April, October, and November, twice monthly in May, August, and

September and four times monthly in June and July. In 1980 through 1982 additional samples were collected every fourth day from May through October. Samples were collected every 4 hrs during a 24-hr period (PSEG, 1984). In 1994 and 1995 samples were collected three times a day, once a week from January through December (PSEG, 1994, PSEG, 1996). Beginning in April 1996 samples were typically collected three times a week in the summer months (April through September) and once a week throughout the remainder of the year (PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c). Six samples were collected during each 24-hr sampling period.

Ichthyoplankton samples also were collected from June through August in 1981 and 1982 adjacent to the intake structure in five horizontal offshore strata to develop model inputs for bay anchovy and weakfish. These samples were collected with a conical plankton net 0.5 m wide with a mesh size of 0.5 mm (PSEG, 1984).

Entrainment survival studies were conducted from 1977 through 1982. Survival studies were conducted twice in 1977 and three times in 1978. In 1979 no samples were collected for survival studies. In 1980 sampling was conducted from April through October with 10 events. In 1981 and 1982 the sampling schedule was expanded to include four times monthly in June and July, twice monthly in May and August, and once each in September and October with 11 events occurring in May through October of 1981 and 12 events in June through September of 1982. Sampling locations for the survival studies were the same as for the abundance studies. Intake and discharge locations were sampled with a lag to account for plant transit time with duplicate sampling gear to account for sampling induced mortality (PSEG, 1984).

Samples were collected using a centrifugal fish transfer pump and a one-screen larval table until 1980. After 1980 a low velocity flume was used to allow for a larger sample volume. Specimens were taken to an onsite laboratory where their condition was recorded. Individuals were classified as live, stunned, or dead according to pre-established criteria. Live and stunned specimens were held for 12 hr to determine latent mortality (PSEG, 1984).

In addition, tests were conducted from 1979 through 1981 to quantify mortality caused by the collection equipment. Tests were conducted with alewife, blueback herring, white perch, weakfish, spot, *N. americana*, and *Gammarus* spp. Mortality rates due to the larval table, the low velocity flume, and the fish pump combined with the larval table were estimated separately. Entrainment simulation tests also were conducted from 1974 through 1982 to quantify the effects of pressure and temperature changes on entrained organisms (PSEG, 1984).

For the 1984 316(b) Demonstration, weekly entrainment densities (numbers of organisms per volume of water) were estimated based on densities in both the intake and the estuary. These projected densities then were used along with estimated weekly mortality rates to project annual entrainment losses due to the facility. Weekly mortality rates were estimated from the results of the onsite studies, simulation studies conducted in the laboratory, and literature values. Mortality rates were calculated for the effects of mechanical and chemical stresses separately from thermal stresses. Total entrainment mortality was estimated based on the following equation (PSEG, 1984).

$$M_T = 1 - (1 - M_n) \times (1 - M_t)$$

where

M_T = total entrainment mortality rate

M_n = nonthermal mortality rate

M_t = thermal mortality rate

Projected entrainment losses for each species were calculated on a daily basis using the following equation. Daily entrainment losses were then summed on a weekly basis and projected based on plant operating schedules (PSEG, 1984).

$$\text{Daily Entrainment loss} = CWS1_i + SWS1_i + CWS2_i + SWS2_i$$

$$CWS1_i = K1 \times Density_i \times (F_i - R \times F_i)/(1 - R + R \times F_i)$$

$$SWS1_i = K2 \times Density_i \times (1 - R)$$

where

$CWS1_i$ = entrainment loss at Unit No. 1 CWS on the ith day

$SWS1_i$ = entrainment loss at Unit No. 1 SWS on the ith day

$CWS2_i$ = entrainment loss at Unit No. 2 CWS on the ith day

$SWS2_i$ = entrainment loss at Unit No. 2 SWS on the ith day

K1 = plant withdrawal at Unit No. 1 CWS on the ith day
= 11.672 m^3/sec x 86400 seconds x the number of CWS pumps operating in Unit No. 1

K2 = plant withdrawal at Unit No. 1 SWS on the ith day
= 0.686 m^3/sec x 86400 seconds x the number of SWS pumps operating in Unit No. 1

$Density_i$ = estimated entrainment density on the ith day

F_i = estimated total entrainment mortality at Unit No. 1 CWS on the ith day

R = recirculation factor

The 1999 316(b) Demonstration used data from entrainment monitoring that was conducted annually from 1995 through 1998 in accordance with the BMWP. PSEG calculated total entrainment loss by species and life stage by summing the individual occurrences in samples taken at the intakes for both the circulating water system (CWS) and the service water system (SWS) for Units 1 and 2; using correction factors for collection efficiency, recirculation (re-entrainment), and mortality; and then scaling for plant flow using the following equation (PSEG, 1999a).

Comment [DL2]: Is the *E* in the equations that follows?

$$E = \sum_{i=1}^{K} \sum_{j=1}^{365} D_{ij} \bullet C^{-1} \bullet \left(\frac{f_{ij}-Rf_{ij}}{1-R+Rf_{ij}} \right) \bullet Q_{ij}$$

where

i	=	i^{th} water system, i.e., Unit 1 CWS, Unit 1 SWS, Unit 2 CWS, and Unit 2 SWS
j	=	j^{th} day of the year
D_{ij}	=	average concentration (number per m^3 of intake water)
C	=	collection efficiency
f_{ij}	=	daily through-plant mortality
R	=	recirculation factor
Q_{ij}	=	average daily plant flow for j^{th} water system (m^3)

This calculation provided estimated entrainment for each species and life stage during the sampling period. These data were used to compute densities for each week of the year, which then were scaled up based on weekly flow through the facility to estimate total entrainment losses for each year by species (Table 4-2). The years 1978 through 1981 were a transitional period between the beginning of commercial operation of Salem Unit 1 in 1978 and Unit 2 in 1982 (PSEG, 1999a).

In the 2006 316(b) Demonstration, PSEG estimated annual entrainment losses for the years 2002 through 2004 by using entrainment density data from sampling conducted at the intakes and scaling for total water withdrawal volume using the same methodology as described above for the 1999 316(b) study (Table 4-3). Entrainment losses were calculated by assuming an entrainment mortality rate of 100 percent (PSEG, 2006a). From 1978 through 1998 (Table 4-2) and 2002 through 2004 (Table 4-3), bay anchovy was the species with the greatest entrainment losses for all life stages (PSEG, 1999a; PSEG, 2006a).

Results of the annual entrainment monitoring for the RS at Salem from 1995 through 2008 were reported in annual biological monitoring reports for 1995 through 2008 (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c). Total annual entrainment was reported by species and life stage based on mean density expressed as number of organisms per 100 cubic meters (n/100 m^3) of water withdrawn through the intake screens (Table 4-4).

Table 4-5 provides a list of species collected during the annual entrainment monitoring conducted at Salem from 1995 through 2008 and their average densities in cooling water during that period. On average, the RS constituted approximately 75 percent of total entrainment abundance based on average densities for these species from 1995 through 2008, and bay anchovy alone made up about 50 percent of total entrainment during this period.

Table 4-2. Estimated Annual Entrainment Losses for Representative Species (RS) at Salem, 1978 to 1998

Comment [DL3]: Generally tables should be able to stand alone.

Year	Estimated Annual Entrainment Losses (in Millions)										
	Alewife	American shad	Atlantic croaker	Bay anchovy	Blueback herring	Striped bass	Spot	Weakfish	White perch	Atlantic menhaden	Silversides
1978	0.008	0.004	0.784	7,962.1	0.775	0.026	5.096	399.818	0.000	0.000	79.935
1979	0.050	0	14.515	3,535.1	0.019	0.020	1.095	23.193	0.625	0.072	18.083
1980	0.860	0.015	0.756	15,155.9	2.813	0	10.296	256.708	27.514	4.277	145.109
1981	2.002	0	8.157	11,714.1	11.853	0	5.418	45.765	0.969	9.207	113.240
1982	0	0	0	3,712.9	0.017	0	29.963	74.457	18.857	4.157	22.201
1985	0.163	0.126	0.933	29,463.7	1.151	0	0.184	63.616	0.447	0	0
1986	0.348	0.059	0.492	45,248.6	1.594	0	0.858	110.397	0.654	0	0
1987	0	0.062	0.000	40,172.4	0.082	0	0.055	61.267	0.628	0	0
1988	0.749	0	1.710	22,331.5	2.988	0	73.502	57.063	8.968	0	0
1989	0.541	0	56.341	10,163.5	2.395	47.946	1.027	3.026	192.131	0	0
1990	0.101	0	123.375	7,678.4	0.260	1.313	4.395	6.685	2.626	0	0
1991	0	0	131.798	19,506.6	0	0.778	1.096	72.478	1.108	0	0
1992	0.319	0	71.352	1,570.5	0.864	1.728	0.000	10.375	3.393	0	0
1993	0.676	0	75.030	11,774.2	2.340	108.065	0.585	122.672	37.635	0	0
1994	0.697	0	24.783	1,120.3	2.623	7.490	46.859	88.781	66.927	0	0
1995	0.477	0.014	31.454	1,404.5	0.082	0.579	0.071	335.083	2.039	177.221	31.019
1996	0.083	0.028	4.385	70.6	0.425	7.289	0.025	14.258	16.800	3.039	1.227
1997	0.053	0.747	71.819	1,811.8	0.318	6.505	0.007	12.601	7.865	16.668	6.919
1998	14.480	0	132.130	2,003.7	59.282	448.563	0.020	76.343	412.839	480.557	51.528

Source: NJPDES Application (PSEG, 1999a)

Comment [DL4]: Atlantic silverside I think unless this is multiple species, in which case you should say so.

Table 4-3. Estimated Annual Entrainment and Annual Entrainment Losses for RS at Salem, 2002-2004

	Total Entrained (in millions)			Entrainment Losses (in millions)		
Taxon	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Alewife	9.8	5.2	2.5	9.4	4.5	2.4
American shad	0	0	0	0	0	0
Atlantic croaker	448.0	211.5	213.2	182.5	86.4	87.9
Bay anchovy	946.4	366.4	2,343.2	946.4	366.4	2,343.2
Blueback herring	1.1	1.7	1.1	1.0	1.6	0.934
Spot	2.3	0.047	0	0.454	0.009	0
Striped bass	403.6	120.3	35.7	159.5	37.6	14.3
Weakfish	29.2	11.9	46.8	19.2	8.5	32.8
White perch	18.7	19.5	25.8	18.0	13.9	23.9
Atlantic silverside	44.8	3.6	10.1	44.8	3.6	10.1
Atlantic menhaden	190.3	4.9	6.8	190.3	4.9	6.8

Source: Comprehensive Demonstration Study (PSEG, 2006a)

Table 4-4. Entrainment Densities for Representative Species (RS) at Salem, 1995-2008

	Density (n/100 m³)													
Taxon	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Alewife	0.01						0.05	<0.01	0.11	0.02	<0.01	0.02	0.05	<0.01
American shad		0.01	0.01			0.00								
Atlantic croaker	3.03	1.60	8.19	9.48	15.45	6.70	4.17	12.52	2.62	5.05	5.56	10.51	5.88	7.74
Atlantic menhaden	2.91	0.38	0.46	1.68	2.23	1.34	1.04	4.92	0.20	0.47	1.06	5.01	1.47	16.21
Atlantic silverside	0.13	0.29	0.69	0.22	2.20	0.36	0.09	0.95	0.15	0.47	0.55	0.29	0.12	0.10
Bay anchovy	66.55	17.43	42.95	61.88	292.14	12.72	8.86	24.18	13.15	100.52	54.57	101.45	174.66	41.87
Blueback herring		0.02		0.00	0.01	0.09	0.03	0.01	<0.01	0.02	<0.01	<0.01	0.01	<0.01
Blueback herring/alewife	0.01	0.12		2.06	0.02	0.05	0.01	0.11	0.07	0.07	0.05		0.03	0.72
Bluefish	0.01					0.00								<0.01
Spot	0.01			0.00	0.09	0.09	0.01	0.10	<0.01		0.25	<0.01	0.03	0.14
Striped bass	0.03	1.55	0.02	11.50	0.03	13.97	9.07	7.20	5.07	1.84	4.03	0.55	42.34	1.72
Weakfish	11.86	3.69	0.76	1.99	6.61	2.48	2.25	0.64	0.43	1.10	2.09	0.70	1.44	0.52
White perch	0.02	0.88		4.49	0.11	6.15	0.06	0.10	0.44	0.64	0.24	0.55	1.19	0.01
White perch/striped bass	0.06	1.10		3.63	0.00			<0.01	0.87	0.44	0.40	0.11	10.69	0.02
Eggs	47.54	0.51	21.41	41.84	278.18	0.35	2.97	8.42	2.06	74.22	28.56	78.20	149.59	23.82
Larvae	48.46	26.52	31.66	78.64	97.93	47.13	29.13	67.53	46.10	51.12	62.67	82.92	103.57	39.65
Juveniles	11.84	7.87	19.15	13.11	21.17	11.10	7.27	16.74	5.67	7.84	9.46	15.99	10.79	21.86
Adults	0.14	0.07	0.20	0.23	0.29	0.18	0.13	0.15	0.15	0.20	0.27	0.26	0.25	0.19

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c)

NOTE WHAT BLANKS MEAN.

Table 4-5. Species Entrained at Salem During Annual Entrainment Monitoring, 1995-2008

Common Name	Scientific Name	Average Density (n/100 m^3)
Bay anchovy	***Anchoa mitchilli***	**72.35**
Naked goby	*Gobiosoma bosc*	27.58
Striped bass	***Morone saxatilis***	**7.07**
Atlantic croaker	***Micropogonias undulatus***	**7.04**
Atlantic menhaden	***Brevoortia tyrannus***	**6.91**
Weakfish	***Cynoscion regalis***	**2.81**
Goby	Gobiidae	2.61
White perch/striped bass	***Morone* spp.**	**1.57**
White perch	***Morone americana***	**1.15**
Atlantic silverside	***Menidia menidia***	**0.66**
Unidentifiable silverside	Antherinidae	0.47
Blueback herring/alewife	***Alosa spp.***	**0.37**
Silversides	*Menidia* spp.	0.22
Northern pipefish	*Syngnathus fuscus*	0.18
American eel	*Anguilla rostrata*	0.13
Unidentifiable fish		0.13
Summer flounder	*Paralichthys dentatus*	0.12
Hogchoker	*Trinectes maculatus*	0.10
Spot	***Leiostomus xanthurus***	**0.09**
Inland silverside	*Menidia beryllina*	0.08
Herrings	Clupeidae	0.08
Black drum	*Pogonias cromis*	0.07
Carps and minnows	Cyprinidae	0.06
Gizzard shad	*Dorosoma cepedianum*	0.06
Unidentifiable larvae		0.06
Atlantic herring	*Clupea harengus*	0.06
Alewife	***Alosa pseudoharengus***	**0.05**
Smallmouth flounder	*Etropus microstomus*	0.04
Rough silverside	*Membras martinica*	0.03
Blueback herring	***Alosa aestivalis***	**0.03**
Yellow perch	*Perca flavescens*	0.03
Spotted hake	*Urophycis regia*	0.02
Killifishes	*Fundulus* spp.	0.02
Mummichog	*Fundulus heteroclitus*	0.01
Northern searobin	*Prionotus carolinus*	0.01
Quillback	*Carpiodes cyprinus*	0.01
Unidentifiable eggs		0.01
Silver perch	*Bairdiella chrysoura*	0.01
Winter flounder	*Pleuronectes americanus*	0.01
Threespine stickleback	*Gasterosteus aculeatus*	0.01
Atlantic needlefish	*Strongylura marina*	0.01
Unidentifiable		0.01
Blackcheek tonguefish	*Symphurus plagiusa*	0.01
Oyster toadfish	*Opsanus tau*	0.01

Common Name	Scientific Name	Average Density (n/100 m^3)
Common carp	*Cyprinus carpio*	0.01
American shad	***Alosa sapidissima***	**0.01**
Striped cusk-eel	*Ophidion marginatum*	0.01
Windowpane	*Scophthalmus aquosus*	0.004
Green goby	*Microgobius thalassinus*	0.004
Northern puffer	*Sphoeroides maculatus*	0.004
Feather blenny	*Hypsoblennius hentz*	0.004
American sand lance	*Ammodytes americanus*	0.004
Bluefish	***Pomatomus salatrix***	**0.003**
Unidentifiable juvenile		0.003
Striped searobin	*Prionotus evolans*	0.003
Conger eel	*Conger oceanicus*	0.003
Inshore lizardfish	*Synodus foetens*	0.003
Unidentifiable drum	Sciaenidae	0.003
Eastern silvery minnow	*Hybognathus regius*	0.003
Perches	Percidae	0.003
Northern kingfish	*Menticirrhus saxatilis*	0.003
Bluegill	*Lepomis macrochirus*	0.002
Banded killifish	*Fundulus diaphanus*	0.002
Unidentifiable sucker	Catostomidae	0.002
Striped anchovy	*Anchoa hepsetus*	0.002
Northern stargazer	*Astroscopus guttatus*	0.002
White crappie	*Pomoxis annularis*	0.002
Tautog	*Tautoga onitis*	0.002
Unidentifiable porgy	Sparidae	0.001
Spanish mackerel	*Scomberomorus maculatus*	0.001
Black sea bass	*Centropristis striata*	0.001
Sheepshead minnow	*Cyprinodon variegauts*	0.001
Striped killifish	*Fundulus majalis*	0.001
Unidentifiable sunfish	Centrarchidae	0.001
White sucker	*Catostomus commersoni*	0.001
Channel catfish	*Ictalurus punctatus*	0.001

(1) Species in **bold** are RS at Salem.

(2) Average density expressed as number of organisms entrained (n) per 100 cubic meters (m^3) of water withdrawn through the intake screens.

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c)

Due to the differences in calculation methods and mortality rate estimates used during the more than 30 years since Salem Unit 1 began commercial operation in 1978, it is difficult to compare entrainment across the studies. The NRC staff used entrainment density as a metric to evaluate trends in entrainment and abundance of RS in water of the Delaware Estuary at the Salem intake over the operational period 1978 through 2008 (Table 4-6). Throughout this period, the species most entrained was the bay anchovy.

Table 4-6. Entrainment Densities for RS at Salem, 1978-2008

Taxon	Density (n/100 m³) 1978	1979	1980	1981	1982	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Alewife			0.03				0.01		0.01						
Alosa sp.										0.14	0.01		0.02	0.15	0.11
American shad															
Atlantic croaker	0.10	0.02	0.02	1.24		0.02	0.07		0.07	2.76	0.72	3.47	2.51	2.71	1.19
Atlantic menhaden		0.02	0.25	1.13	0.27										
Atlantic silverside															
Bay anchovy	349.64	1848.55	845.68	706.22	148.12	1799.26	2527.17	2094.53	618.68	314.27	243.26	416.78	111.59	416.25	27.22
Blueback herring	0.06		0.07	0.12		0.03			0.04						
Blueback herring/alewife															
Morone sp.										0.21	0.01		0.03	0.90	0.01
Bluefish															
Silversides	6.32	15.33	4.77	4.04	0.86										
Spot	0.07	0.10	1.53	0.86	3.69	0.04	0.01		1.64	0.02	0.16	0.09		0.01	1.17
Striped bass	0.05									1.87	0.01	0.03	0.06	3.63	0.29
Weakfish	16.31	3.35	5.15	1.20	2.63	1.77	4.50	3.09	1.11	0.08	0.28	1.43	0.25	1.91	2.46
White perch			0.09		0.26		0.01	0.01	0.10	4.16	0.03	0.01	0.07	0.46	0.81
White perch/striped bass															

Taxon	Density (n/100 m³) 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Alewife	0.01						0.05	< 0.01	0.11	0.02	< 0.01	0.02	0.05	< 0.01
Alosa sp.	0.01	0.13		1.58										
American shad	0.01					0.00								
Atlantic croaker	3.07	1.64	12.48	8.52	15.45	6.70	4.17	12.52	2.62	5.05	5.56	10.51	5.88	7.74
Atlantic menhaden	2.90	0.37	0.86	3.19	2.23	1.34	1.04	4.92	0.20	0.47	1.06	5.01	1.47	16.21
Atlantic silverside					2.20	0.36	0.09	0.95	0.15	0.47	0.55	0.29	0.12	0.10
Bay anchovy	64.18	17.63	52.89	53.31	292.14	12.72	8.86	24.18	13.15	100.52	54.57	101.45	174.66	41.87
Blueback herring		0.02		0.10	0.01	0.09	0.03	0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	< 0.01
Blueback herring/alewife					0.02	0.05	0.01	0.11	0.07	0.07	0.05		0.03	0.72
Morone sp.	0.06	1.11		2.92										0.02
Bluefish						0.00								< 0.01
Silversides	0.99	0.30	0.96	0.87										
Spot	0.01	0.03		0.00	0.09	0.09	0.01	0.10	< 0.01		0.25	< 0.01	0.03	0.14
Striped bass	0.03	1.58	0.03	9.92	0.03	13.97	9.07	7.20	5.07	1.84	4.03	0.55	42.34	1.72
Weakfish	11.78	3.75	0.77	1.80	6.61	2.48	2.25	0.64	0.43	1.10	2.09	0.70	1.44	0.52
White perch	0.02	0.90		3.73	0.11	6.15	0.06	0.10	0.44	0.64	0.24	0.55	1.19	0.01
White perch/striped bass					0.00			< 0.01	0.87	0.44	0.40	0.11	10.69	

Source: Biological Monitoring Program Annual Reports (PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c)

NOTE WHAT BLANKS MEAN

Entrainment Reductions

Due to the potential for entrainment to have adverse effects on the aquatic environment in the vicinity of Salem, and in response to the requirements of the 1994 NJPDES permit, PSEG has employed technological and operational changes to reduce entrainment and impingement and mitigate their effects on the Delaware Estuary. While improvements to the cooling water intake system were targeted mainly toward reducing impingement mortality, improvement in entrainment rates also has resulted. In response to the requirements of the 1994 NJPDES permit, PSEG made modifications to the trash racks, intake screens, and fish return system (PSEG, 1999a).

Improved intake screen panels were installed that use a thinner wire in the mesh (14 gage instead of 12 gage), which in combination with smaller screen openings allowed for a 20 percent decrease in through-screen velocity. Lower velocities through the screens allow more small fish to be able to swim away from the screens and escape entrainment. Screen openings also were reduced in size from 3/8 in. (10 mm) square mesh to 1/4 in. (6 mm) wide by 1/2 in. (13 mm) high rectangular mesh. The smaller screen openings reduce the size of organisms that can be drawn through the screens, thus reducing entrainment. The smaller screen mesh excludes more organisms, which then may be impinged and could be returned to the estuary alive (PSEG, 1999a). While impingement mortality rates for these smaller organisms generally are higher than for larger organisms, they are lower than estimated entrainment mortality rates (PSEG, 1999a).

4.5.3 Impingement of Fish and Shellfish

Impingement occurs when fish and shellfish are held against the intake screens by the force of the water being drawn into the cooling system. Impingement mortality can occur directly as a result of the force of the water, or indirectly due to stresses from the time spent on the screens or as a result of being washed off the screens.

Regulatory Background

Impingement and entrainment are both regulated by Section 316(b) of the CWA through the NPDES permit renewal process. A history of NPDES permitting at Salem can be found in Section 4.5.2 under the heading Regulatory Background.

Impingement Studies

PSEG has performed annual impingement monitoring at the Salem plant since 1977 in order to determine the impacts that impingement at Salem might have on the aquatic environment of the Delaware Estuary. The monitoring program described in the early 316(b) demonstration focused on seven target fish species. The two macroinvertebrates included in the entrainment study program are too small to be impinged and, therefore, were not included in the impingement study program. The fish species ~~are:~~ are weakfish (*Cynoscion regalis*), bay anchovy (*Anchoa mitchilli*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), spot (*Leiostomus xanthurus*), and Atlantic croaker (*Micropogonias undulatus*~~*undulates*~~) (PSEG, 1984).

Comment [DL5]: check throughout

Impingement abundance samples were collected at the cooling water system (CWS) and service water system (SWS) intakes from May 1977 through December 1982. CWS samples were collected at least 4 times per day at 6 hr intervals three days a week from May 1977 through September 1978. In September 1978 sampling frequency was increased to a minimum of ten samples per day six days a week. In spring of 1980, sampling frequency was reduced to four times a day, but remained at six days a week (PSEG, 1984).

Impinged organisms are washed off the CWS intake screens and returned to the Delaware Estuary through a fish return system. Impingement samples were collected in fish counting pools constructed for this purpose that are located adjacent to the fish return system discharge troughs at both the northern and southern ends of the CWS intake structure. Screen-wash water was diverted into the counting pools for an average sample duration of 3 min (depending on debris load, sampling time varied from 1 to 15 min). Water then was drained from the pools, and organisms were sorted by species, counted, measured, and weighed (PSEG, 1984).

Impingement abundance samples were collected from the SWS intake screens by a high-pressure spray wash into collection baskets through a trough. Screen washes were conducted at either 12 hr or 24 hr intervals depending on debris loads. Samples were collected from the SWS three times a week from April 1977 through September 1979. Organisms were sorted, counted, and weighed (PSEG, 1984).

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

Because individual organisms that are impinged on the intake screens are washed off and returned to the estuary, studies of impingement mortality rates also were conducted from May 1977 through December 1982. Studies were conducted to estimate the percentage of impinged individuals that do not survive being impinged and washed from the intake screens (initial mortality) and the percentage that exhibit delayed mortality and do not survive for a longer period of at least 2 days (extended or latent mortality). Studies of initial mortality were conducted at a rate of three times per week until October 1978, after which samples were collected six times per week if impingement levels for target species exceeded predetermined levels. Initial mortality studies were conducted using the same counting pools as the abundance samples. Screen-wash water was diverted into the counting pool, samples were held for 5 min, the water was drained from the pool, and organisms were sorted as live, damaged, or dead. Each subset was identified to species and the total number and weight, maximum and minimum lengths, and length frequency distribution were recorded. Studies of latent mortality were conducted using the organisms classified as live or damaged in the studies of initial mortality. At the beginning of the latent mortality studies, only organisms classified as live were used, but damaged fish also were evaluated after November 1978. Latent mortality studies were conducted at least weekly and entailed holding impinged organisms in aerated tanks for 48 hrs. Organisms were monitored continuously for the first 30 min, at hour intervals for the next 4 hrs, and then at approximately 24-hr intervals. Control specimens also were collected with a seine and subjected to the same survival study (PSEG, 1984).

Impingement mortality was found to be seasonally variable and dependent on several environmental factors, including temperature and salinity. Initial and latent mortality rates were estimated on a monthly basis and summed to provide a total mortality rate (PSEG, 1984). Estimated impingement mortality rates by species evaluated are summarized in Table 4-7.

Table 4-7. Estimated Impingement Mortality Rates by Species at Salem, 1977-1982

Taxon	Estimated Impingement Mortality (percent)
Spot	30.2 – 67.7
Blueback herring	71.9 - 100
Alewife	72.6 – 100
American ~~Shad~~shad	20.8 – 100
Atlantic croaker	38.8 – 87.9
Striped bass	10.0 – 84.8
White perch	29.4 – 52.9
Bay anchovy	77.0 – 95.1
Weakfish	71.2 – 78.3
Source: PSEG, 1984	

PSEG submitted a 316(b) demonstration in 1999 as part of the application for NJPDES permit renewal (PSEG, 1999a). This demonstration assessed the effects of Salem's cooling water intake structure on the biological community of the Delaware Estuary (PSEG, 1999a). It focused on the same RS fish species as the earlier studies and added the blue crab (*Callinectes sapidus*). Impingement losses at Salem were estimated using impingement density (the number of impinged individuals collected divided by the total volume sampled, expressed as number/m^3) and adjusting for impingement survival, collection efficiency, and recirculation factor. This result was then scaled by month using the water withdrawal rates and summed for the year to provide annual impingement losses for the facility. Estimated annual impingement losses for the RS at Salem from 1978 through 1998 are summarized in Table 4-8. Bay anchovy was the dominant species lost to impingement from 1978 to 1998, constituting 46 percent of the RS impingement loss. Weakfish was the next dominant species lost, making up 20 percent of the RS impingement losses (PSEG, 1999a).

Impingement monitoring was conducted annually in accordance with the BMWP from 1995 through 2002. In 2002, the IBMWP was developed to include improvements to the BMWP. These monitoring plans include provisions to quantify impingement and entrainment losses at Salem, as well as fish populations in the Delaware Estuary and the positive effects of the restoration program (PSEG, 2006a).

Table 4-8. Estimated Annual Impingement Losses for RS at Salem, 1978 to 1998

	Estimated Annual Impingement Losses									
Year	Alewife	American Shad	Atlantic croaker	Bay anchovy	Blueback herring	Blue crab	Spot	Striped bass	Weakfish	White perch
1978	17,057	4,549	125,822	2,623,694	438,248	111,627	84,519	3,213	6,391,256	254,688
1979	11,513	2,144	8,494	1,321,105	651,005	97,434	292,471	9,625	580,628	541,715
1980	11,301	6,382	93,232	11,046,658	460,638	501,000	146,794	4,350	1,821,462	403,453
1981	647,832	8,820	14,996	11,264,933	364,803	347,436	857,167	1,895	1,818,578	344,726
1982	46,951	9,406	2,975	3,846,612	418,130	122,032	979,961	542	967,867	261,912
1983	19,584	5,359	2,326	3,784,994	224,303	100,953	681,704	924	1,038,356	143,904
1984	128,002	3,266	853	2,444,847	1,335,665	87,890	316,579	430	357,125	300,333
1985	4,676	11,033	275,670	3,771,190	162,478	1,011,790	183,679	193	1,263,119	582,528
1986	20,788	11,007	233,915	2,011,567	467,361	1,228,076	52,445	2,875	756,956	1,033,048
1987	74,461	24,120	1,245,098	3,346,956	157,496	834,857	2,204	6,673	1,095,105	715,912
1988	31,082	35,182	4,046	4,657,784	357,896	1,247,649	1,917,236	10,450	427,218	646,825
1989	137,998	65,138	24,168	781,653	891,085	344,310	119,381	26,006	184,538	760,842
1990	50,074	15,393	5,787	1,373,446	168,555	178,511	120,833	28,003	170,778	768,431
1991	21,275	22,874	45,535	1,719,784	137,107	307,591	134,807	10,089	575,349	688,724
1992	23,847	64,807	55,267	1,286,667	120,649	370,591	2,999	20,966	841,319	1,158,199
1993	23,267	22,087	176,279	596,243	100,999	387,190	16,869	74,100	723,366	1,043,913
1994	22,946	6,315	31,538	178,764	31,835	491,199	247,677	23,612	2,130,349	1,266,489
1995	14,745	7,940	610,261	363,601	143,846	1,012,348	27,435	10,812	890,341	321,359
1996	1,321	829	21,010	18,802	5,548	83,457	7,281	9,191	130,459	75,006
1997	5,899	819	266,558	309,018	50,879	475,443	30,245	12,779	1,582,441	228,996
1998	8,037	2,214	2,370,135	1,104,126	57,267	280,741	2,654	10,660	1,572,811	124,351

Source: PSEG, 1999a

The 316(b) demonstration submitted during the 2006 NJPDES renewal process (PSEG, 2006a) included the CDS as required by the Phase II rule and a demonstration that the plant satisfies the impingement mortality and entrainment reductions required by the rule. The CDS included an estimation of impingement losses for the RS developed from data collected during annual impingement monitoring conducted in accordance with the IBMWP. A revised RS list was developed for the IBMWP and subsequently used in the 2006 CDS that included the nine finfish and the blue crab from previous studies and added the Atlantic silverside (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and bluefish (*Pomotomus saltrix*) (PSEG, 2006a).

Estimated annual impingement and impingement losses for the study period 2002 to 2004 are summarized in Table 4-9. Atlantic croaker was the species most impinged in 2002 and the RS most often lost to impingement that year. White perch was the RS most impinged in 2003 and 2004, while weakfish was the species most often lost to impingement in those years.

Table 4-9. Estimated Annual Impingement and Annual Impingement Losses for RS at Salem, 2002-2004

	Total Impingement			Impingement Losses		
Taxon	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Alewife	87,001	31,275	134,149	10,996	16,360	63,492
American shad	5,879	31,584	227,103	1,672	15,354	72,486
Atlantic croaker	21,313,809	620,754	3,260,494	6,332,522	143,298	332,644
Bay anchovy	424,168	475,799	544,177	197,496	326,839	341,135
Blueback herring	184,095	133,328	1,110,952	28,113	50,790	265,866
Spot	1,131	2,714	366	253	721	133
Striped bass	101,208	776,934	505,340	5,351	167,332	66,007
Weakfish	722,090	3,129,152	3,531,713	428,300	1,953,299	2,118,736
White perch	2,044,207	9,424,768	11,181,299	163,505	773,818	970,462
Atlantic silverside	509,142	220,114	156,495	138,270	44,951	48,609
Atlantic menhaden	534,646	31,211	20,420	360,931	21,769	15,724
Blue crab	2,739,118	356,983	831,320	172,725	27,483	57,931
Bluefish	45,292	31,311	44,533	3,884	7,592	17,433

Source: PSEG, 2006a

Table 4-10 provides a summary of annual impingement densities based on monitoring results for RS at Salem from the annual monitoring reports for the period 1995 through 2007. Impingement densities were calculated by relating impingement abundance to the circulating water flow and extrapolating to the number of organisms impinged per million m^3 for every week of each year (PSEG, 1999a). The four most commonly impinged species were Atlantic croaker (23 percent), blue crab (21 percent), white perch (19 percent), and weakfish (14 percent). Table 4-11 provides a list of species collected and average densities impinged during this period.

Table 4-10. Impingement Densities for RS at Salem, 1995-2008

	Density ($n/10^6 m^3$)													
Taxon	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Blue crab	1901.05	620.48	2033.08	824.27	636.84	393.89	606.88	502.13	76.41	171.28	1895.82	694.73	797.66	640.45
Alewife	3.09	5.47	10.8	12.09	15.78	27.41	20.55	13.91	4.84	25.99	8.19	2.41	7.66	0.66
American shad	3.1	2.63	1.00	3.39	14.5	3.82	0.57	0.79	6.43	43.24	10.11	4.01	16.98	1.7
Atlantic croaker	887.71	112.71	623.81	1489.08	625.94	403.53	412.56	3820.65	101.22	626.74	845.57	1405.31	951.09	545.25
Atlantic menhaden	14.72	9.9	38.36	78.79	15.78	20.5	25.55	88.9	6.26	4.82	22.22	44	27.49	57.85
Atlantic silverside	44.15	12.61	40.7	43.54	111.15	49.67	42.28	78.46	35.67	25.71	24.08	46.89	44.52	56.28
Bay anchovy	136.82	66.52	229.13	367	127.83	122.62	84.1	74.09	89.5	93.89	49.33	202.44	132.62	72.27
Blueback herring	30.78	8.64	126.62	107.8	110.7	73.14	81.06	31.05	23.27	156.55	19.75	25.37	17.76	7.34
Bluefish	2.69	8.88	6.41	4.79	2.55	6.00	1.14	7.89	8.14	11.67	2.06	7.44	2.95	5.7
Spot	10.28	3.38	88.74	3.94	0.53	7.28	0.05	0.34	0.8	0.14	55.11	10.38	3.73	23.65
Striped bass	64.89	82.05	62.91	28.61	52.83	102.49	54.62	20.04	159.93	110.86	29.72	10.22	47.88	32.56
White perch	641.12	543.08	1625.16	425.98	384.33	273.32	263.56	427.71	1771.18	2113.19	1042.62	360.51	429.81	662.14
Weakfish	1071.27	441.89	1370.74	528.95	228.01	369.57	524.64	172.98	530.71	725.72	930.88	343.81	379.65	304.8

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c)

Table 4-11. Species Impinged at Salem and Average Impingement Densities, Based on Annual Impingement Monitoring for 1995-2007

Common Name[1]	Scientific Name[1]	Average Density ($n/10^6$ m^3) [2]
Atlantic croaker	***Micropogonias undulatus***	**917.94**
Blue crab	***Callinectes sapidus***	**842.50**
White perch	***Morone americana***	**783.12**
Weakfish	***Cynoscion regalis***	**565.97**
Hogchoker	*Trinectes maculatus*	231.95
Spotted hake	*Urophycis regia*	135.03
Bay anchovy	***Anchoa mitchilli***	**132.01**
Striped bass	***Morone saxatilis***	**61.40**
Blueback herring	***Alosa aestivalis***	**58.56**
Atlantic silverside	***Menidia menidia***	**46.84**
Gizzard shad	*Dorosoma cepedianum*	42.11
Atlantic menhaden	***Brevoortia tyrannus***	**32.51**
Threespine stickleback	*Gasterosteus aculeatus*	27.64
Striped cusk-eel	*Ophidion marginatum*	20.78
Spot	***Leiostomus xanthurus***	**14.88**
Alewife	***Alosa pseudoharengus***	**11.35**
Northern searobin	*Prionotus carolinus*	10.53
American shad	***Alosa sapidissima***	**8.02**
Yellow perch	*Perca flavescens*	7.71
Black drum	*Pogonias cromis*	6.29
Atlantic herring	*Clupea harengus*	6.05
Eastern silvery minnow	*Hybognathus regius*	5.60
Bluefish	*Pomatomus saltatrix*	5.59
American eel	*Anguilla rostrata*	5.32
Channel catfish	*Ictalurus punctatus*	4.90
Silver perch	*Bairdiella chrysoura*	4.62
Summer flounder	*Paralichthys dentatus*	4.48
Northern kingfish	*Menticirrhus saxatilis*	4.29
Oyster toadfish	*Opsanus tau*	3.68
Northern pipefish	*Syngnathus fuscus*	3.59
Red hake	*Urophycis chuss*	3.26
Naked goby	*Gobiosoma bosc*	3.25
Winter flounder	*Pleuronectes americanus*	2.59
Windowpane	*Scophthalmus aquosus*	2.41
Mummichog	*Fundulus heteroclitus*	2.13
Smallmouth flounder	*Etropus microstomus*	2.00
Bluegill	*Lepomis macrochirus*	1.89
Striped searobin	*Prionotus evolans*	1.81
Scup	*Stenotomus chrysops*	1.38
Harvestfish	*Peprilus alepidotus*	1.01
Striped killifish	*Fundulus majalis*	1.00
Butterfish	*Peprilus triacanthus*	0.87
Black sea bass	*Centropristis striata*	0.83

Common Name[1]	Scientific Name[1]	Average Density ($n/10^6\ m^3$) [2]
Brown bullhead	*Ameiurus nebulosus*	0.76
River herring	*Alosa* spp.	0.75
Unknown spp.	Unknown spp.	0.52
Sea lamprey	*Petromyzon marinus*	0.52
Skilletfish	*Gobiesox strumosus*	0.51
Rainbow smelt	*Osmerus punctatus*	0.48
Northern stargazer	*Astroscopus guttatus*	0.45
Fourspine stickleback	*Apeltes quadracus*	0.44
Conger eel	*Conger oceanicus*	0.43
Striped mullet	*Mugil cephalus*	0.43
Temperate bass	*Morone* sp.	0.38
Rough silverside	*Membras martinica*	0.36
Striped anchovy	*Anchoa hepsetus*	0.36
Inland silverside	*Menidia beryllina*	0.33
White mullet	*Mugil curema*	0.32
Spotfin butterflyfish	*Chaetodon ocellatus*	0.28
Atlantic needlefish	*Strongylura marina*	0.27
Yellow bullhead	*Ameiurus natalis*	0.26
Crevalle jack	*Caranx hippos*	0.25
Black crappie	*Pomoxis nigromaculatus*	0.24
Banded killifish	*Fundulus diaphanus*	0.24
Silver hake	*Merluccius bilinearis*	0.23
Lookdown	*Selene vomer*	0.20
Blackcheek tonguefish	*Symphurus plagiusa*	0.20
Permit	*Trachinotus falcatus*	0.16
Common carp	*Cyprinus carpio*	0.14
Sheepshead minnow	*Cyprinodon variegatus*	0.14
Pumpkinseed	*Lepomis gibbosus*	0.14
Northern puffer	*Sphoeroides maculatus*	0.14
Sheepshead	*Archosargus probatocephalus*	0.13
Florida pompano	*Trachinotus carolinus*	0.13
Fourspot flounder	*Paralichthys oblongus*	0.12
Smooth dogfish	*Mustelus canis*	0.12
Tessellated darter	*Etheostoma olmstedi*	0.12
Lined seahorse	*Hippocampus erectus*	0.11
Inshore lizardfish	*Synodus foetens*	0.11
Pinfish	*Lagodon rhomboides*	0.11
Golden shiner	*Notemigonus crysoleucas*	0.11
Atlantic spadefish	*Chaetodipterus faber*	0.10
White crappie	*Pomoxis annularis*	0.10
Unidentifiable Fish	Unidentifiable fish	0.10
White catfish	*Ameiurus catus*	0.10
White sucker	*Catostomus commersoni*	0.09
Spotfin killifish	*Fundulus luciae*	0.09
Pigfish	*Orthopristis chrysoptera*	0.09
Feather blenny	*Hypsoblennius hentz*	0.09
Spanish mackerel	*Scomberomorus maculatus*	0.09

Common Name[1]	Scientific Name[1]	Average Density ($n/10^6\ m^3$) [2]
Bluespotted cornetfish	*Fistularia tabacaria*	0.09
Spottail shiner	*Notropis hudsonius*	0.08
Goosefish	*Lophius americanus*	0.08
Atlantic thread herring	*Opisthonema oglinum*	0.07
Green sunfish	*Lepomis cyanellus*	0.07
Redfin pickerel	*Esox americanus*	0.07
Spotfin mojarra	*Eucinostomus argenteus*	0.07
Redeared sunfish	*Lepomis microlophus*	0.07
Tautog	*Tautoga onitis*	0.06
Fat sleeper	*Dormitator maculatus*	0.06
Largemouth bass	*Micropterus salmoides*	0.06
Cownose	*Rhinoptera bonasus*	0.06
Satinfin shiner	*Cyprinella analostana*	0.06
Rainbow trout	*Oncorhynchus mykiss*	0.06
Redbreast sunfish	*Lepomis auritus*	0.06
Green goby	*Microgobius thalassinus*	0.06
Eastern mudminnow	*Umbra pygmaea*	0.06
Mud sunfish	*Acantharchus pomotis*	0.05
Atlantc sturgeon	*Acipenser oxyrhynchus*	0.05
Atlantic cutlassfish	*Trichiurus lepturus*	0.05
Southern kingfish	*Menticirrhus americanus*	0.05

(1) Species in **bold** are RS at Salem.
(2) Average density expressed as number of fish impinged (n) per million (10^6) cubic meters (m^3) of water withdrawn through the intake screens.
Source: Biological Monitoring Program Annual Reports (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c)

Due to the differences in methods used during the more than 30 years since Salem Unit 1 began commercial operation in 1978, it is difficult to compare impingement estimates across studies. The NRC staff used impingement density as a metric to evaluate trends in impingement and abundance of RS in water withdrawn at the Salem intake over the operational period 1978 through 2008 (Table 4-12).

Table 4-12. Impingement Densities for RS at Salem, 1978-2008

	Density ($n/10^6$ m^3)															
Taxon	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alewife	0.26	0.95	0.89	26.35	2.02	0.75	3.81	0.13	0.75	2.04	0.94	3.70	1.33	0.75	0.89	0.91
American shad	0.12	0.39	0.41	0.38	0.69	0.38	0.20	0.48	0.64	1.04	1.57	2.78	0.70	1.14	4.04	0.95
Atlantic croaker	7.04	0.42	5.89	0.70	0.15	0.30	0.09	9.36	7.23	43.97	0.42	1.66	0.25	3.21	7.55	11.22
Atlantic menhaden	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Atlantic silverside	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bay anchovy	228.56	204.95	459.35	406.60	97.15	142.69	106.59	81.99	55.35	78.23	94.96	19.52	36.61	40.94	17.09	16.44
Blue crab	56.97	44.45	151.83	66.59	16.33	16.24	19.73	141.62	181.63	109.58	160.39	47.22	38.04	45.42	75.99	65.48
Blueback herring	28.28	27.13	17.98	14.93	17.79	10.80	54.15	4.54	10.04	4.40	7.90	27.43	4.70	6.19	5.27	2.77
Bluefish	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spot	15.42	52.60	17.58	45.34	60.92	47.50	32.48	4.37	3.85	0.09	96.29	7.08	5.43	5.38	0.12	0.98
Striped bass	0.83	2.58	0.64	0.18	0.09	0.04	0.08	0.13	0.39	1.95	1.62	3.84	3.84	2.08	3.59	15.85
Weakfish	910.81	149.03	105.78	78.91	43.69	49.78	30.34	55.38	36.60	52.25	18.39	7.27	10.70	25.20	48.07	40.86
White perch	32.27	69.78	33.33	33.24	25.47	20.91	23.30	25.69	75.29	49.20	38.93	52.33	57.08	52.80	55.23	123.43

	Density ($n/10^6$ m^3)														
Taxon	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Alewife	0.65	3.09	5.47	10.8	12.09	15.78	27.41	20.55	13.91	4.84	25.99	8.19	2.41	7.66	0.66
American shad	0.32	3.1	2.63	1	3.39	14.5	3.82	0.57	0.79	6.43	43.24	10.11	4.01	16.98	1.7
Atlantic croaker	3.59	887.71	112.71	623.81	1489.08	625.94	403.53	412.56	3820.65	101.22	626.74	845.57	1405.31	951.09	545.25
Atlantic menhaden	—	14.72	9.9	38.36	78.79	15.78	20.5	25.55	88.9	6.26	4.82	22.22	44	27.49	57.85
Atlantic silverside	—	44.15	12.61	40.7	43.54	111.15	49.67	42.28	78.46	35.67	25.71	24.08	46.89	44.52	56.28
Bay anchovy	5.11	136.82	66.52	229.13	367	127.83	122.62	84.1	74.09	89.5	93.89	49.33	202.44	132.62	72.27
Blue crab	88.60	1901.05	620.48	2033.08	824.27	636.84	393.89	606.88	502.13	76.41	171.28	1895.82	694.73	797.66	640.45
Blueback herring	1.30	30.78	8.64	126.62	107.8	110.7	73.14	81.06	31.05	23.27	156.55	19.75	25.37	17.76	7.34
Bluefish	—	2.69	8.88	6.41	4.79	2.55	6	1.14	7.89	8.14	11.67	2.06	7.44	2.95	5.7
Spot	26.78	10.28	3.38	88.74	3.94	0.53	7.28	0.05	0.34	0.8	0.14	55.11	10.38	3.73	23.65
Striped bass	0.73	64.89	82.05	62.91	28.61	52.83	102.49	54.62	20.04	159.93	110.86	29.72	10.22	47.88	32.56
Weakfish	132.51	1071.27	441.89	1370.74	528.95	228.01	369.57	524.64	172.98	530.71	725.72	930.88	343.81	379.65	304.8
White perch	96.26	641.12	543.08	1625.16	425.98	384.33	273.32	263.56	427.71	1771.18	2113.19	1042.62	360.51	429.81	662.14

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; PSEG, 1997; PSEG, 1998; PSEG, 1999b; PSEG, 2000; PSEG, 2001; PSEG, 2002; PSEG, 2003; PSEG, 2004a; PSEG, 2005; PSEG, 2006b; PSEG, 2007b; PSEG, 2008; PSEG, 2009c)

Comment [DL6]: Anything we can say about trends? Particularly in relation to Salem-Hope Creek?

Impingement Reductions

Due to the potential for impingement to have adverse effects on the aquatic environment in the vicinity of Salem, and in response to the requirements of the 1994 NJPDES permit, PSEG has taken steps to reduce impingement mortality and its effects in the Delaware Estuary. PSEG has made many improvements to the cooling water intake system at Salem over the years, including modifications to the intake screens and fish return system (PSEG, 1999a).

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

Estimates of impingement mortality with the modified screens were compared to estimated mortality with the original screens to assess the reduction in impingement mortality due to the screen modifications. Data from impingement studies conducted in 1995, 1997, and 1998 were used for this assessment of the modified screens. These data were compared to data collected in 1978 through 1982 when impingement survival studies were conducted for the original screen configuration. A side-by-side comparison also was conducted in 1995 when only one of the units had the modified intake system. Table 4-13 provides a comparison of estimated impingement mortality rates for the original screens versus the modified screens (PSEG, 1999a).

Results from the comparison of 1997 and 1998 data for the modified screens to data from 1978 to 1982 for the original screens indicate that the modified intake system provides reductions in impingement mortality. White perch, bay anchovy, Atlantic croaker, spot, and *Alosa* species (blueback herring, alewife, and American shad combined) had lower mortality rates for all months studied during the 1997 and 1998 studies compared to those estimated for the 1978 to 1982 study of the original screens. In contrast, weakfish had higher mortality rates for the modified screens in June and July, but lower in August and September. This difference may result from the much smaller size of the weakfish impinged in June and July – impingement mortality rates for smaller fish generally are higher than for larger fish (however, they are lower than estimated entrainment mortality rates, and the modifications to improve impingement survival increase this difference). The 1995 side-by-side study showed higher survival rate estimates for weakfish with the modified screens (PSEG, 1999a).

Table 4-13. Comparison of Impingement Mortality Rates (percent) for Original Screens (1978-1982 and 1995 Studies) and Modified Screens (1995 and 1997-1998 Studies)

		Original Screens		Modified Screens	
Taxon	**Month**	**1978-1982**	**1995**	**1995**	**1997-1998**
Weakfish	June	39	33	17	79
	July	51	31	18	82
	August	52	51	25	38
	September	40	-	-	12
	October	53	-	-	-
White perch	January	13	-	-	-
	February	16	-	-	-
	March	12	-	-	-
	April	15	-	-	7
	October	21	-	-	-
	November	16	-	-	7
	December	8	-	-	2
Bay anchovy	April	-	-	-	54
	May	81	-	-	55
	June	89	-	-	78
	July	90	-	-	80
	August	85	-	-	-
	September	72	-	-	-
	October	65	-	-	35
	November	32	-	-	28
Atlantic croaker	April	-	-	-	42
	May	-	-	-	34
	June	-	-	-	28
	July	-	-	-	35
	October	-	-	-	5
	November	-	-	-	2
	Dec-Jan	49	-	-	15
Spot	June	31	-	-	-
	July	48	-	-	-
	August	47	-	-	-
	October	38	-	-	-
	November	19	-	-	7
	December	29	-	-	-
Alosa species	Mar-Apr	89	-	-	18
	Oct - Dec	31	-	-	22

Note: Mortality rate estimates for *Alosa* species for original screens are based on blueback herring only while estimates for modified screens are based on *Alosa* species (blueback herring, alewife, and American shad combined). Estimates include initial and 48-hr latent mortalities.

Source: PSEG, 1999a

INDICATE MEANING OF DASH.

4.5.4 Heat Shock (submitted previously)

References for Sections 4.5.2, 4.5.3, and 4.5.5

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PSEG) 2009b. Hope Creek Generating Station, License Renewal Application, Appendix E - Applicant's Environmental Report – Operating License Renewal Stage. Lower Alloways Creek Township, New Jersey. August, 2009.

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4.5.4 Heat Shock

Heat shock is defined as "acute thermal stress caused by exposure to a sudden elevation of water temperature that adversely affects the metabolism and behavior of fish and can lead to death" (NRC 2009). Heat shock can occur at power plants when the cooling water discharge elevates the temperature of the surrounding water.

The NRC considers heat shock to be a Category 1 issue at power plants with closed-cycle cooling systems. HCGS uses closed-cycle cooling; therefore, if NRC finds no new and significant information, site-specific evaluation is not required to determine that impacts to fish and shellfish from heat shock associated with the continued operation of HCGS during the renewal term would be SMALL. In contrast, heat shock is a Category 2 issue at power plants with once-through cooling systems. Salem has a once-through cooling system; therefore, heat shock is considered a Category 2 issue for Salem, and a site-specific analysis is required to determine the level of impact that heat shock may have on the aquatic environment. The potential for heat shock at Salem is discussed below.

Regulatory Background

The Delaware River Basin Commission (DRBC) is a federal interstate compact agency charged with managing the water resources of the Delaware River Basin without regard to political boundaries. It regulates water quality in the Delaware River and Delaware Estuary through DRBC Water Quality Regulations, including temperature standards. The temperature standards for Water Quality Zone 5 of the Delaware Estuary, where the Salem discharge is located, state that the temperature in the river outside of designated heat dissipation areas (HDAs) may not be raised above ambient by more than 4°F (2.2°C) during non-summer months (September through May) or 1.5°F (0.8°C) during the summer (June through August), and a maximum temperature of 86°F (30.0°C) in the river cannot be exceeded year-round (DRBC 2001 and 2008). HDAs are zones outside of which the DRBC temperature-increase standards shall not be exceeded. HDAs are established on a case-by-case basis. The thermal mixing zone requirements and HDAs that had been in effect for Salem since it initiated operations in 1977 were modified by the DRBC in 1995 and again in 2001 (DRBC 2001), and the 2001 requirements were included in the 2001 NJPDES permit. The HDAs at Salem are seasonal. In the summer period (June through August), the Salem HDA extends 25,300 ft upstream and 21,100 ft downstream of the discharge and does not extend closer than 1320 ft from the eastern edge of the shipping channel. In the non-summer period (September through May), the HDA extends 3300 ft upstream and 6000 ft downstream of the discharge and does not extend closer than 3200 ft from the eastern edge of the shipping channel (DRBC 2001).

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

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

In 2006 PSEG submitted an NJPDES permit renewal application with a request for renewal of the Section 316(a) variance. The variance renewal request summarizes studies that have been conducted at the Salem plant, including the 1999 Section 316(a) Demonstration, and evaluates the changes in the thermal discharge characteristics, facility operations, and aquatic environment since the time of the 1999 Section 316(a) Demonstration. PSEG determined that Salem's thermal discharge had not changed significantly since the 1999 application and that the thermal variance should be continued. In 2006 NJDEP administratively continued Salem's NJPDES permit (NJ0005622), including the Section 316(a) variance. No timeframe has been determined for issuance of the new NJPDES permit.

Characteristics of the Thermal Plume

Cooling water from Salem is discharged through six adjacent 10-ft-diameter pipes spaced 15 ft apart on center that extend approximately 500 ft from the shore (PSEG 1999). The discharge pipes are buried for most of their length until they discharge horizontally into the water of the estuary at a depth at mean tidal level of about 31 ft. The discharge is approximately perpendicular to the prevailing currents. Figure 4.5.4-1 provides a plan view of the Salem discharge, and Figure 4.5.4-2 is a section view. At full power, Salem is designed to discharge approximately 3200 million gallons per day (MGD) at a velocity of about 10 ft/s. The location of the discharge and its general design characteristics have remained essentially the same over the period of operation of the Salem facility.

The thermal plume at Salem can be defined by the regulatory thresholds contained in the DRBC water quality regulations consisting of the 1.5°F isopleth of ΔT during the summer period and the 4°F isopleth of ΔT during non-summer months. Thermal modeling to characterize the thermal plume has been conducted numerous times over the period of operation of Salem. Since Unit 2 began operation in 1981, operations at Salem have been essentially the same and studies have indicated that the characteristics of the thermal plume have remained relatively constant.

Comment [DL1]: Have we defined this?

The most recent thermal modeling was conducted during the 1999 Section 316(a) Demonstration. Three linked models were used to characterize the size and shape of the thermal plume: an ambient temperature model, a far-field model (RMA-10), and a near-field model (CORMIX). The plume is narrow and approximately follows the contour of the shoreline at the discharge. The width of the plume varies from about 4000 feet on the flood tide to about 10,000 feet on the ebb tide. The maximum plume length extends to approximately 43,000 feet upstream and 36,000 feet downstream (PSEG 1999). Figures 4.5.4-3 through 4.5.4-6 depict the expansion and contraction of the surface and bottom plumes through the tidal cycle. Table

4.5.4-1 includes the surface area occupied by the plume within each ΔT isopleth through the tidal cycle.

The thermal plume consists of a near-field region, a transition region, and a far-field region. The near-field region, also referred to as the zone of initial mixing, is the region closest to the outlet of the discharge pipes where the mixing of the discharge with the waters of the Delaware Estuary is induced by the velocity of the discharge itself. The length of the near-field region is approximately 300 ft during ebb and flood tides and 1000 ft during slack tide. The transition region is the area where the plume spreads horizontally and stratifies vertically due to the buoyancy of the warmer waters. The length of the transition region is approximately 700 ft. In the far-field region, mixing is controlled by the ambient currents induced mainly by the tidal nature of the receiving water. The ebb tide draws the discharge downstream, and the flood tide draws it upstream. The boundary of the far-field region is delineated by a line of constant ΔT.

Table 4.5.4-1 Surface Area within Each ΔT Contour through the Tidal Cycle

	Ebb: 6/2/1998 at 0830 hrs		End of Ebb: 6/2/1998 at 0000 hrs		Flood: 6/4/1998 at 1630 hrs		End of Flood: 5/31/1998 at 1600 hrs	
ΔT (°F)	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area
>13	0.08	0.00002	0.00	0.00000	0.00	0.00000	0.00	0.00000
>12	0.46	0.00010	0.47	0.00010	0.21	0.00004	0.00	0.00000
>11	0.98	0.00020	2.15	0.00045	0.61	0.00013	0.00	0.00000
>10	1.66	0.00034	2.15	0.00045	1.15	0.00024	0.85	0.00018
>9	2.22	0.00046	2.15	0.00045	1.82	0.00038	1.93	0.00040
>8	3.19	0.00066	2.15	0.00045	2.64	0.00055	1.93	0.00040
>7	4.32	0.00090	5.10	0.00106	3.59	0.00075	1.93	0.00040
>6	5.61	0.00116	11.32	0.00235	4.68	0.00097	1.93	0.00040
>5	36.60	0.00760	21.43	0.00445	56.58	0.01174	2.14	0.00044
>4	150.08	0.03115	45.11	0.00936	245.94	0.05105	205.37	0.04263
>3	631.42	0.13106	739.88	0.15357	585.78	0.12158	920.75	0.19111
>2	1947.91	0.40430	2519.94	0.52303	2212.75	0.45927	2093.04	0.43442
>1.5	3156.56	0.65517	3725.19	0.77319	3703.61	0.76871	3596.95	0.74657

Notes:
Plant Conditions: Low flow (140,000 gpm/pump), high ΔT (18.6°F)
Total surface area of the estuary is 481,796 acres
Reasonable worst-case tide phases were selected based on analysis of time-temperature curves.
Running tides (e.g., ebb and flood) include area approximation of the intermediate field.
Source: PSEG 1999
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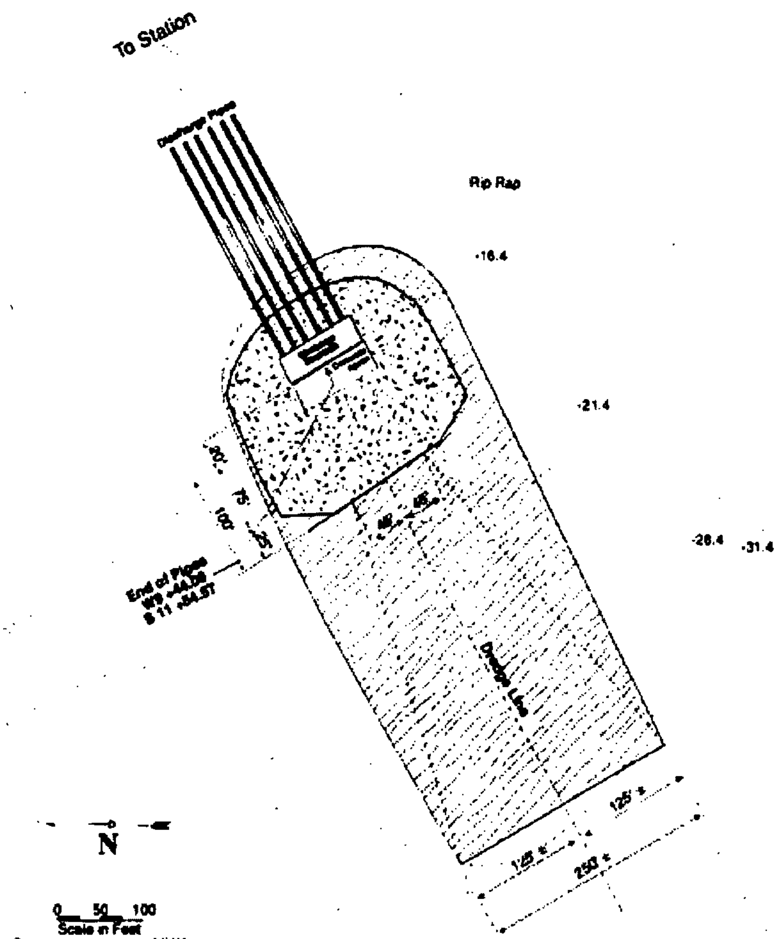

Figure 4.5.4-1 Plan View of Salem discharge pipes (From PSEG 1999)

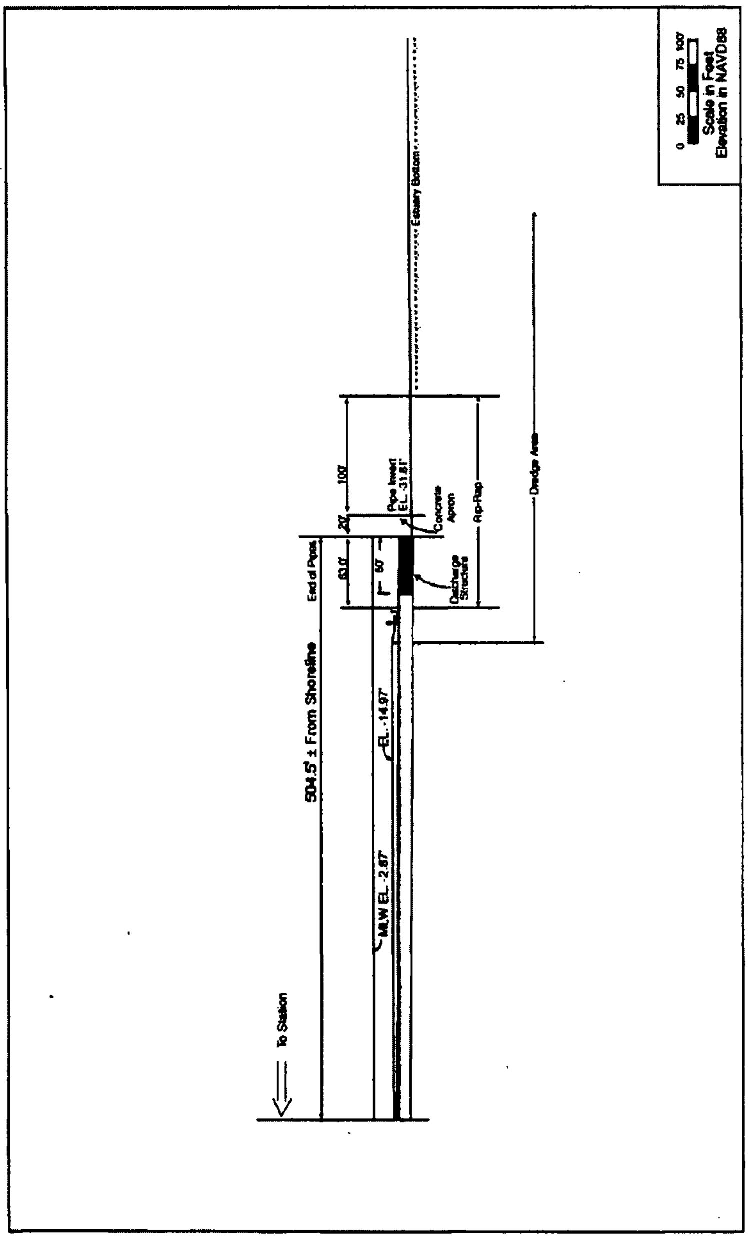

Figure 4.5.4-2 Section View of Salem discharge pipes (From PSEG 1999)

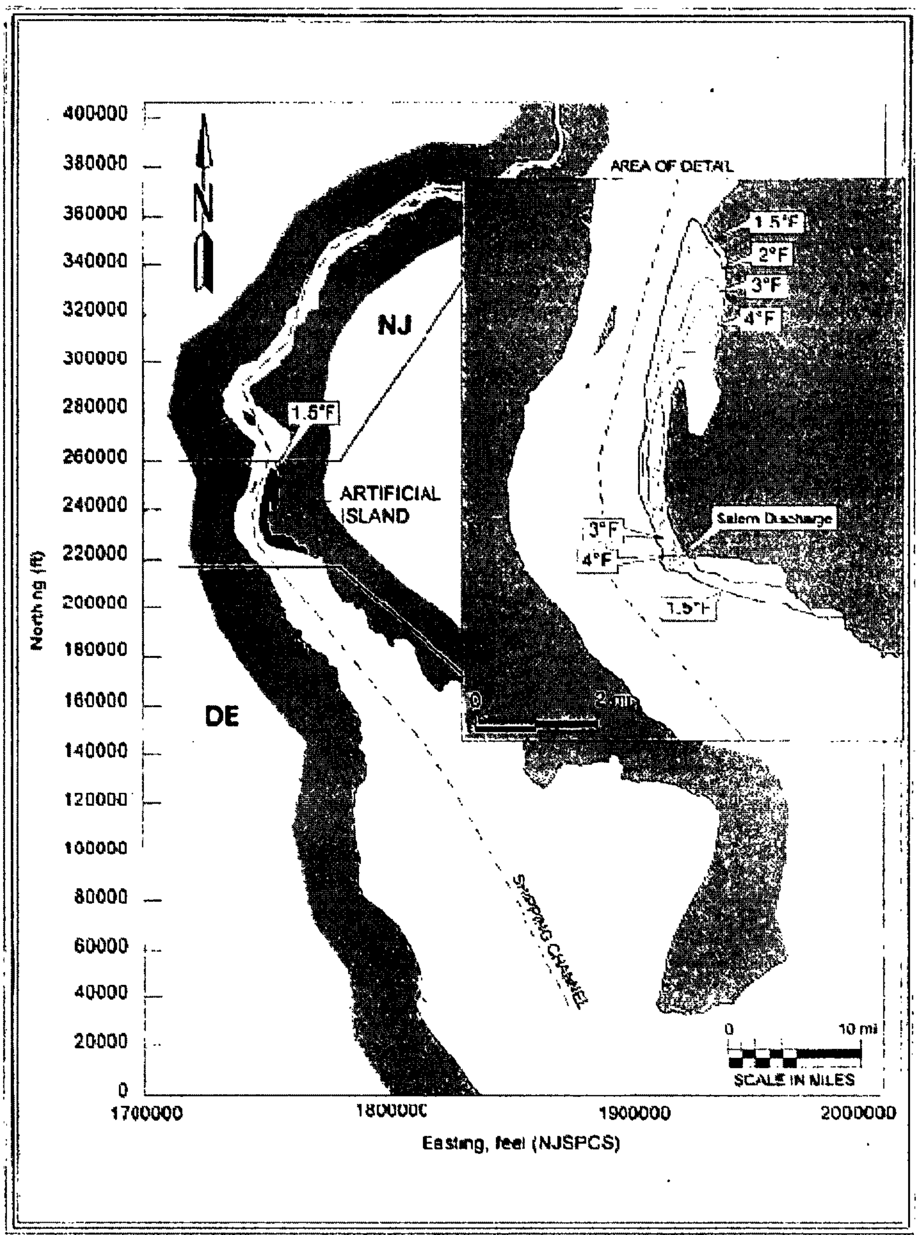

Figure 4.5.4-3 Surface ΔT isotherms for Salem's longest plume at end of flood on May 31, 1998 (From PSEG 1999)

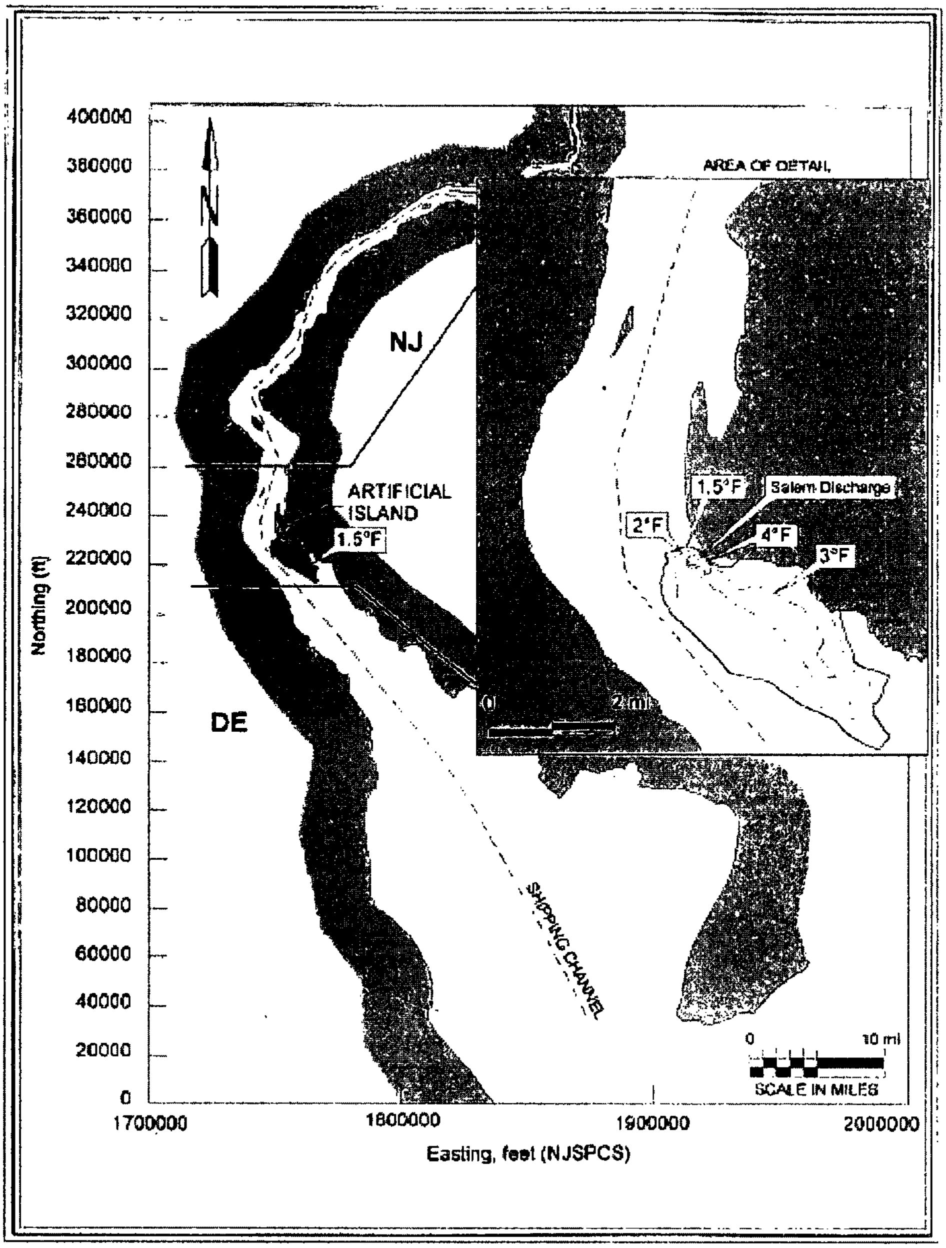

Figure 4.5.4-4 Surface ΔT isotherms for Salem at end of ebb on June 2, 1998 (From PSEG 1999)

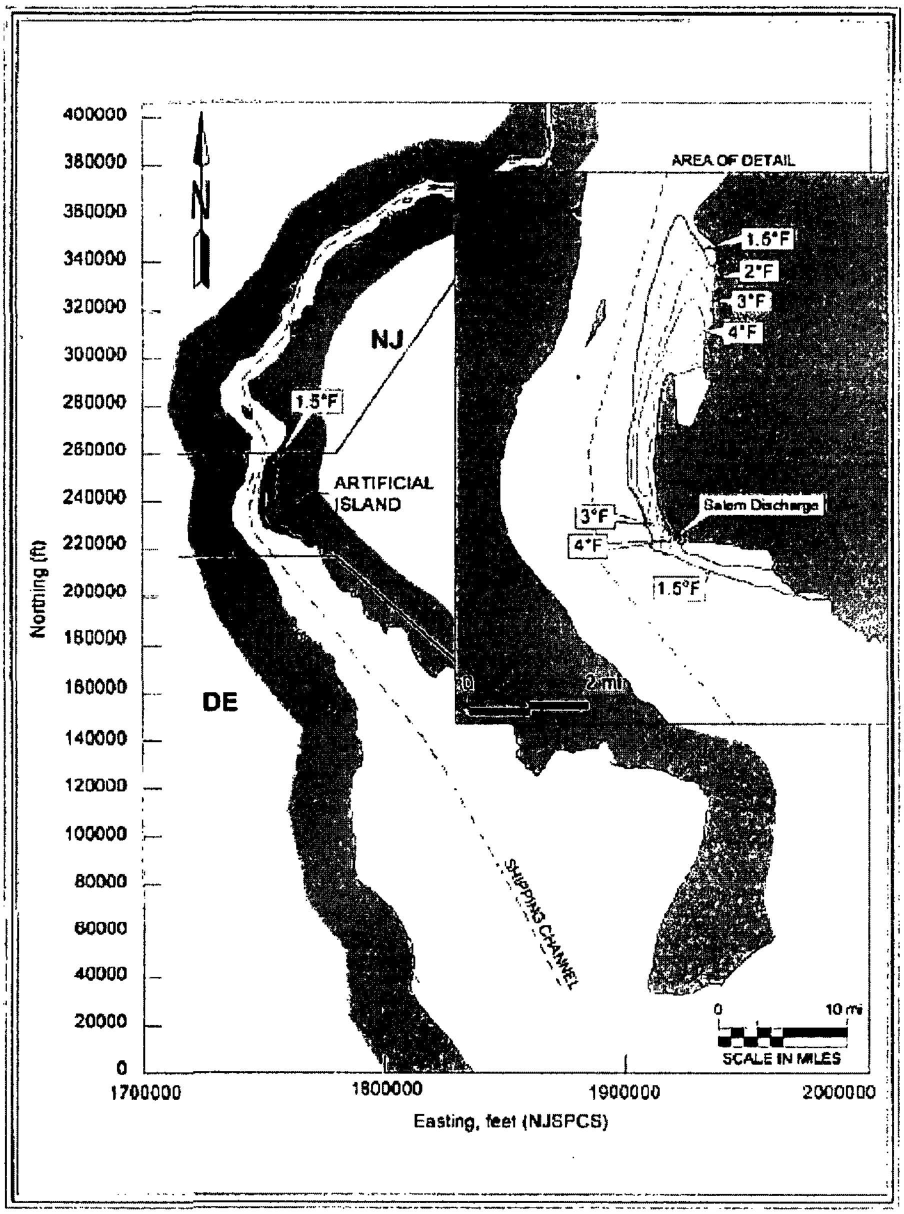

Figure 4.5.4-5 Bottom ΔT isotherms for Salem's longest plume at end of flood on May 31, 1998 (From PSEG 1999)

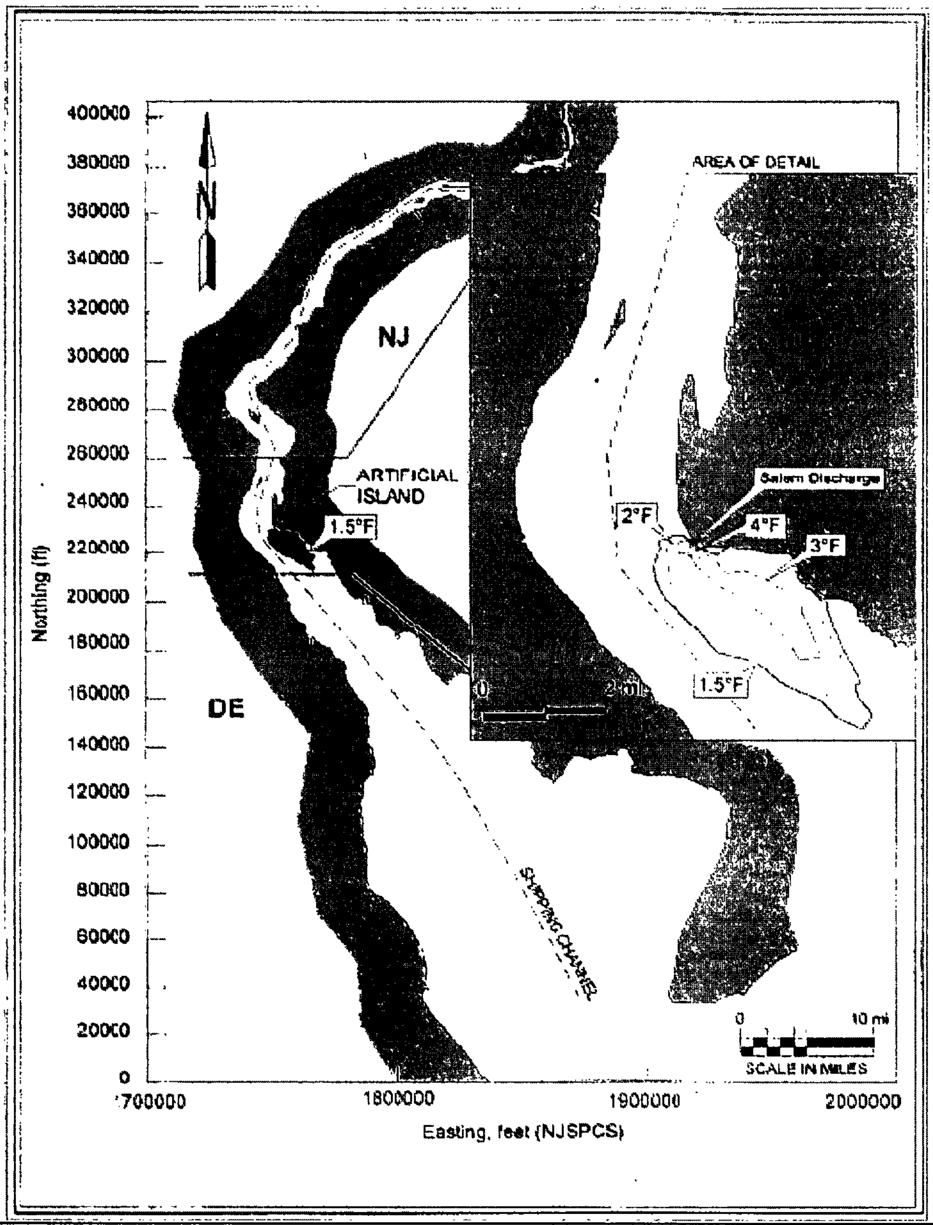

Figure 4.5.4-6 Bottom ΔT isotherms for Salem at end of ebb on June 2, 1998 (From PSEG 1999)

Thermal Discharge Studies

Extensive studies were conducted at Salem between 1968 and 1999 to determine the effects of the thermal plume on the biological community of the Delaware Estuary. Initial studies were conducted in 1968 to determine the location and design for the outfall that would best minimize the potential for adverse environmental effects. Several hydrothermal and biothermal studies subsequently have been conducted in support of requests for variance from thermal discharge limitations pursuant to Section 316(a). The Section 316(a) Demonstrations from 1974 through 1979 evaluated information on the life history, geographical distribution, and thermal tolerances of the representative important species (RIS) compared to the characteristics of the projected thermal plume. Supplements included information on the potential for Salem's thermal plume to promote the presence of undesirable organisms; use of the area in the vicinity of the Salem facility as spawning and nursery habitat; attraction of fish to the thermal plume and the potential for cold shock; effects of thermal plume entrainment on ichthyoplankton and zooplankton; effects of the plume on migration of anadromous fishes; and effects of the thermal plume on macroinvertebrates, such as blue crabs, oysters (*Crassostrea virginica*), and shipworms (Teredinidae), and other benthos (PSEG 1975).

In 1995, PSEG applied to the DRBC for revision of the Salem Docket to provide seasonal HDAs to assure compliance with DRBC's water quality regulations. PSEG used mathematical modeling and statistical analyses to characterize the maximum size of the summer thermal plume (June through August) and non-summer thermal plume (September through May) in terms of the 24-hr average ΔT between the thermal plume and ambient water temperatures. PSEG also updated the information collected on the thermal tolerances, preferences, and avoidances of the RIS and conducted an evaluation of the potential for the thermal plume to have adverse effects on these species. The assessment indicated that Salem's thermal plume and the proposed HDAs would not have the potential to adversely affect aquatic life or recreational uses in the Delaware Estuary, and the DRBC granted the requested HDAs.

In 1999 PSEG submitted an application to renew the NJPDES permit for Salem, and the Section 316(a) Demonstration included provided another thermal plume characterization, biothermal assessment, and detailed analysis of the potential effects of Salem's thermal plume on the aquatic community. NJDEP reviewed this Section 316(a) Demonstration, determined that a "thermal discharge at the Station, which does not exceed a maximum of 115 °F, is expected to assure the protection and propagation of the balanced indigenous population," and included a Section 316(a) variance in Salem's 2001 NJPDES permit (NJDEP 2001b).

The 1999 Section 316(a) Demonstration includes the most detailed and most recent evaluation of the potential effects of the thermal discharge on the aquatic environment near Salem. This evaluation includes a four-part assessment of the potential for the discharge to negatively affect the balanced indigenous community of the Delaware Estuary, including consideration of the following factors: (1) the vulnerability of the aquatic community to thermal effects; (2) the potential for the survival, growth, and reproduction of the RIS to be affected; (3) the potential for effects of other pollutants to be increased by heat; and (4) evidence of prior appreciable harm from the thermal discharge (PSEG 1999).

Conclusions of the vulnerablity analysis indicate that the location and design of Salem's discharge minimize the potential for adverse environmental effects. The high exit velocity produces rapid dilution, which limits high temperatures to relatively small areas in the zone of initial mixing in the immediate vicinity of the discharge. Fish and other nektonic organisms are essentially excluded from these areas due to high velocities and turbulence. The offshore location and rapid dilution of the thermal discharge also places the highest temperature plumes in an area of the Estuary where productivity is lowest (PSEG 1999).

The RIS evaluation in the 1999 Section 316(a) Demonstration included an assessment of the potential for the thermal plume to adversely affect survival, growth, and reproduction of the selected RIS. The RIS included alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic croaker (*Micropogonias undulatus*), bay anchovy (*Anchoa mitchilli*), blueback herring (*Alosa aestivalis*), spot (*Leiostomus xanthurus*), striped bass (*Morone saxatilis*), weakfish (*Cynoscion regalis*), white perch (*Morone americana*), blue crab (*Callinectes sapidus*), opossum shrimp (*Neomysis americana*), and scud (*Gammarus daiberi, G. fasciatus, G. tigrinus*). For each of the RIS, temperature requirements and preferences as well as thermal limits were identified and compared to temperatures in the thermal plume to which these species may be exposed (PSEG 1999).

This biothermal assessment concluded that Salem's thermal plume would not have substantial effects on the survival, growth, or reproduction of the selected species from heat-induced mortality. Scud, blue crab, and juvenile and adult American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, and spot have higher thermal tolerances than the temperature of the plume in areas where their swimming ability would allow them to be exposed. Juvenile and adult weakfish and bay anchovy could come into contact with plume waters that exceed their tolerances during the warmer months, but the mobility of these organisms is expected to allow them to avoid contact with these temperatures (PSEG 1999).

The biothermal assessment also concluded that less-mobile organisms, such as scud, juvenile blue crab, and fish eggs, would not be likely to experience mortality from being transported through the plume. American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, spot, and weakfish are not likely to spawn in the vicinity of the discharge. Scud, juvenile blue crab, and eggs and larvae that do occur in the vicinity of the discharge have higher temperature tolerances than the maximum temperature of the centerline of the plume in average years. Opossum shrimp, weakfish, and bay anchovy may experience some mortality during peak summer water temperatures in warm years (approximately 1 to 3 percent of the time) (PSEG 1999).

Interactions of heat with other pollutants were also evaluated in the 1999 Section 316(a) Demonstration. The assessment concluded that the thermal plume has no observable effects on the dissolved oxygen level near the Salem discharge. In addition, the assessment indicates that there is no potential for plume interaction with other contaminants in the ~~Estuary~~ estuary from other industrial, municipal, or agricultural sources such as PCB's, DDT, dieldrin, PAHs, PCE, DCE, and copper due to the low concentrations of such contaminants in the vicinity of Salem (PSEG 1999).

As part of the 1999 Section 316(a) Demonstration, an analysis of the biological community in the Delaware Estuary was conducted to determine whether there has been evidence of changes within the community that could be attributable to the thermal discharge at Salem. PSEG concluded that observed changes in the species composition or overall abundance in organisms in the Estuary since Salem began operation are within the range expected to occur as a result of natural variation or changes in water quality. There were no indications of increases in populations of nuisance species or stress-tolerant species and there were statistically significant increases in the abundance of juveniles for almost all species of RIS evaluated. A declining trend for blueback herring was determined to be a coast-wide trend and not related to Salem's operation (PSEG 1999).

Conclusions

PSEG has conducted extensive studies of the thermal plume at Salem that have consistently demonstrated that the thermal discharge from operation of the Salem facility has not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of the outfall. The NRC staff considered the results of these studies, the fact that PSEG was granted a thermal variance in accordance with Section 316(a) of the CWA in 1994, and the fact that this variance remains a part of the current NJPDES permit, issued to PSEG in 2001 and administratively continued in 2006. The NRC staff concludes that impacts to fish and shellfish from heat shock at Salem during the renewal term would be SMALL and would warrant no additional mitigation.

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4.5.5 Total Impact on Aquatic Resources

The principal means by which the Salem facility may affect aquatic resources of the Delaware Estuary are the processes of entrainment and impingement of organisms at the cooling water intake and the discharge of thermal effluent. These processes simultaneously and cumulatively affect the aquatic community of the estuary, so assessment of their collective impacts is warranted. Because the Salem facility has been operating for more than 30 years, the total impacts of its operation are integrated and reflected in the condition of the ecosystem of the estuary. By evaluating total impacts from the historical, long-term operation of the facility and the beneficial effects of ongoing restoration activities, total impacts on the estuary from future operation during the relicensing period can be assessed.

Comment [DL1]: Much of this section is about field studies, which implicitly include the effects of both Salem and Hope Creek. We need to discuss this.
Also this section has a lot of passive voice, unknown actors, etc., and needs serious editing.

Comment [DL2]: We have to say something about Hope Creek as well.

Impact Assessment

As part of the 2006 NJPDES application, PSEG prepared an assessment of Adverse Environmental Impact for the Salem facility that analyzed the composition of the fish community in the vicinity, trends in the relative abundance of the RS, and the long-term sustainability of fish stocks in the estuary. The assessment demonstrated that the Salem cooling water intake system has not caused and is unlikely to cause in the future substantial harm to the sustainability of populations of important aquatic species, including threatened or endangered species, or to the structure and function of the ecosystem in the Delaware Estuary (PSEG, 2006a).

Estimates of production lost due to impingement and entrainment at Salem were calculated for the 13 RS, or target species, of PSEG's monitoring program (i.e., American shad, alewife, Atlantic croaker, bay anchovy, blueback herring, spot, striped bass, weakfish, white perch and blue crab, plus Atlantic menhaden, Atlantic silverside, and bluefish). These species make up more than 98 percent of the age-0 biomass lost to impingement and entrainment. Production lost was calculated using data on biomass lost to impingement and entrainment from 2002 through 2004 and adding a projected production foregone for those organisms through the first year of life. Production foregone was projected using literature estimates of growth rates. Biomass lost to impingement and entrainment was estimated to be 138,057 lbs wet weight/yr. Production forgone was estimated to be 4,664,837 lbs wet weight/yr. Production lost was therefore estimated to be 4,802,894 lbs wet weight/yr. Production lost was also calculated separately for river herring to facilitate direct comparisons of loss to production gained from restoration activities (fish ladders). The production of river herring lost to impingement and entrainment was estimated to be 6,093 lbs wet weight/yr (PSEG, 2006a).

Data on the composition of the fish community in the Delaware Estuary over the period from 1970 through 2004 were analyzed for species richness and species density. Species richness is defined as the number of different species present in a community regardless of area analyzed, and species density is the number of species per unit of area or volume. Nearfield sampling using a 16 ft bottom trawl was conducted in most years since 1970. Data from 1970 to 1977, the pre-operational period, was compared to data from 1986 to 2004, the operational period. Both species richness and species density are generally higher in the 1986 to 2004 data than the 1970 to 1977 data, but there is no evident long-term trend in species richness or species density in the vicinity of Salem (PSEG, 2006a).

Abundance data for the RS at Salem were evaluated to determine whether long-term population trends exist. Several monitoring programs have been conducted in the Delaware Estuary for

Comment [DL3]: By whom? ACTIVE VOICE

Comment [DL4]: By whom? Active voice many years. Data from four monitoring programs were used for the analysis of trends: the DNREC Juvenile Trawl Survey, the NJDEP Beach Seine Survey, the PSEG Bay-wide Bottom Trawl Survey, and the PSEG Beach Seine Survey.

Comment [DL5]: By whom? Active Voice.

Results of the analysis indicate that seven species (alewife, American shad, Atlantic croaker, blue crab, striped bass, weakfish, and white perch) have increased in abundance, one species has shown declines (spot), and the remaining four species (Atlantic menhaden, Atlantic silversides, bay anchovy, and blueback herring) show no clear long-term trends (PSEG, 2006a). Spot is the only species that was shown to have apparent long-term declines in abundance in the Delaware Estuary over the period of operation of Salem. However, this species also has declined in the Chesapeake Bay since the 1970s, indicating that its decline is widespread and not due to the operation of Salem.

Comment [DL6]: Whose analyses?

Comment [DL7]: By whom. Also bad grammar.

Comment [DL8]: According to whom?

PSE&G (2006a) performed a stock jeopardy analysis to determine whether Salem has an impact on the long-term sustainability of fish stocks. The models used in this analysis evaluate the effect of impingement and entrainment losses on spawning stock biomass (SSB) and spawning stock biomass per recruit (SSBPR). These metrics are commonly used by fisheries managers to establish maximum fishing rates for managed fish populations. The stock jeopardy analysis compared estimated impacts of Salem on these metrics with the impacts of fishing on the same metrics. PSE&G (2006a) concluded~~The analysis concluded~~ that for those species analyzed the effects of impingement and entrainment are negligible compared to the effects of ~~fishing, and~~ fishing and that reducing or eliminating impingement and entrainment at Salem would not measurably increase the reproductive potential or spawning stock biomass of any of these species. ~~(PSEG, 2006a).~~

Comment [DL9]: assess?

Comment [DL10]: Where did this come from. I don't think this is a common tool.

Restoration

In addition to the changes in technology and operations of the Salem facility, PSEG has implemented restoration activities that enhance the fish and shellfish populations in the Delaware Estuary. In compliance with Salem's 1994 and 2001 NJPDES permits PSEG implemented the Estuary Enhancement Program (EEP), which has preserved and/or restored more than 20,000 ac of wetland and adjoining upland buffers (PSEG, 2009a).

In particular, 4,400 acres of formerly diked salt hay farms were restored to reestablish conditions suitable for the growth of low marsh vegetation such as saltmarsh cord grass (*Spartina alterniflora*) and provide for tidal exchange with the estuary. These restored wetlands increase the production of fish and shellfish by increasing primary production in the detrital based food web in the Delaware Estuary. Both primary and secondary consumers benefit from this increase in production, including many of the RS at Salem. PSEG (2006a) estimated the increase in production of secondary consumers due to this restoration to be at least 18.6 million lbs/yr ~~(PSEG, 2006a)~~. These secondary consumers include species of fish and shellfish affected by impingement and entrainment at Salem, as well as other species.

Comment [DL11]: When you do edits, add International Units.

The EEP also included the installation of 13 fish ladders at impoundments in New Jersey and Delaware (PSEG, 2009a). The fish ladders eliminate blockages to spawning areas for anadromous fish species such as alewife and blueback herring (both RS at Salem). Fish ladders were constructed in New Jersey at Sunset Lake, Stewart Lake (two ladders), Newton Lake and Cooper River Lake, and in Delaware at Noxontown Pond, Silver Lake (Dover), Silver Lake (Milford), McGinnis Pond, Coursey Pond, McColley Pond, Garrisons Lake, and Moore's Lake (PSEG, 2009a). Most anadromous fish exhibit spawning site fidelity, returning to the same areas where they hatched to spawn. Therefore, PSEG undertook a stocking program that transplanted gravid adults into the newly accessible impoundments to induce future spawning runs (PSEG, 2009a).

Along with the active restoration programs described above, the EEP has provided funding for many other programs in the area, including some managed by NJDEP and the Delaware Department of Natural Resources and Environmental Control (DNREC). Examples of these funded programs are restoration of three areas in Delaware dominated by common reed (*Phragmites australis*), State-managed artificial reef programs, revitalization of 150 ac of State-managed oyster habitat, and restoration of 964 ac of degraded wetlands at the Augustine Creek impoundment (PSEG, 2009a).

Comment [DL12]: pse&g provided the funding thgough the eep, no. Make sure you accurately express the actors in the sentences.

A requirement of the 2001 NJPDES permit for Salem was to evaluate and quantify the increased production associated with PSEG's restoration activities and compare it to the production lost due to entrainment and impingement at the facility. Section 7 of the 2006 permit renewal application (PSEG, 2006a) includes this assessment. Estimates of increased production associated with the restoration of the three salt hay farms and 12 fish ladder sites were included in this evaluation. The restoration of marshes dominated by common reed, upland buffer areas, and artificial reefs were not included in this evaluation.

Comment [DL13]: active voice please

PSEG (2006a) used an Aggregated Food Chain Model (AFCM) to estimate the annual production (lbs wet weight/yr) of secondary consumers attributable to the restoration of the salt hay farm sites ~~(PSEG, 2006a)~~. This method used data for the biomass of above-ground vegetation collected during the annual monitoring from 2002 through 2004 to estimate primary production (production of above-ground marsh vegetation). This primary production was then converted to production of secondary consumers through three trophic transfers: vegetation to detrital complex (dissolved and particulate organic matter, bacteria, fungi, protozoa, nematodes, rotifers, copepods, and other microscopic organisms) to primary consumers (zooplankton and macroinvertebrates) to secondary consumers (age-0 fish).

This method underestimates the total production that could be attributed to the salt hay marsh restoration in that it does not include below-ground production or recycled production (production attributable to consumption of a secondary consumer by a primary consumer). The production of secondary consumers attributable to the restoration of the salt hay marsh sites was calculated to be 11,228,415 lbs wet weight/yr (PSEG, 2006a).

Comment [DL14]: Our observation or someone elses? ACTIVE VOICE

Comment [DL15]: Should this be "PSEG (2008) estimates ..." Did PSEG do the work or their consultants, If the latter, shouldn't we be citing them?

Comment [DL16]: by whom

Annual production of river herring (blueback herring and alewife) attributable to the installation of fish ladders was estimated using results from surveys of juvenile fish in the impoundments, which were then converted to weight using an age-1 average weight. The production of river herring due to the fish ladders was estimated to be 944 lbs wet weight/yr (PSEG, 2006a).

Comment [DL17]: by whom? These are only summarized in PSEG 2006, no? who did the studies?

Comment [DL18]: by whom?

The increase in production attributable to the salt hay farms is estimated to be 2.3 times the annual production lost from impingement and entrainment at Salem. The installation of fish ladders at 12 impoundments in New Jersey and Delaware is estimated to be 1/6 of the production of river herring lost to impingement and entrainment at the facility.

Comment [DL19]: by whom. not by us.

Comment [DL20]: by whom? ACTIVE VOICE

Conclusions

Entrainment, impingement, and heat shock all affect the aquatic resources of the Delaware Estuary. PSEG has conducted extensive studies of the effects of entrainment (Section 4.5.2) and impingement (Section 4.5.3) at Salem over the more than 30-yr period during which it has been operating, and the effects of the thermal discharge similarly have been extensively studied

(Section 4.5.4). Multiple long-term, large-scale studies of the estuary by PSEG and State and Federal agencies have documented the ecological condition of the estuary through time and allowed the analysis of long-term trends in populations of RS. The studies have demonstrated that these processes of entrainment, impingement, and thermal discharge collectively have not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of Salem according those authors' definitions of adverse effect.

Comment [DL21]: concluded, no?

The NRC staff considered the results of these studies, the fact that PSEG was granted a thermal variance in accordance with Section 316(a) of the CWA in 1994, and the fact that this variance remains a part of the current NJPDES permit, issued to PSEG in 2001 and administratively continued in 2006. The NJDEP, not the NRC, is responsible for issuing and enforcing NPDES permits. NRC assumes that NJDEP will continue to apply the best information available to the evaluation and approval of future NPDES permits. The NRC staff concludes that impacts to fish and shellfish from entrainment, impingement, and heat shock at Salem during the renewal term would be SMALL and would not warrant additional mitigation beyond the EEP .

4.7 Threatened or Endangered Species

Potential impacts to threatened or endangered species are listed as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The GEIS section and category for this issue are listed in Table 4.7-1.

Table 4.7-1. Category 2 Issues Applicable to Threatened or Endangered Species During the Renewal Term

Issue	GEIS Section	Category
Threatened or endangered species	4.1	2

This site-specific issue requires consultation with appropriate agencies to determine whether threatened or endangered species are present and whether they would be adversely affected by continued operation of the nuclear facility during the license renewal term. The presence of threatened or endangered species in the vicinity of the site of the Salem and HCGS facilities is discussed in Sections 2.2.7.1 and 2.2.7.2. In 2009, the NRC staff contacted the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (FWS) to request information on the occurrence of threatened or endangered species in the vicinity of the site and the potential for impacts on those species from license renewal. NMFS identified in its response a species federally listed as endangered, the shortnose sturgeon (*Acipenser brevirostrum*), and a candidate species, the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), as having the potential to be affected by the proposed action (NMFS 2010a). Additionally, NMFS identified four Federally listed sea turtle species, the threatened loggerhead (*Caretta caretta*), and the endangered Kemp's ridley (*Lepidochelys kempi*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*), as having the potential to be adversely affected by the proposed action. These six species, their habitats, and their life histories are described in Section 2.2.7.1.

In correspondence between FWS and PSEG prior to the NRCs request for information on Federally listed species potentially affected by the proposed action, FWS indicated that there were no Federally listed species under its jurisdiction present on the Salem and HCGS site. FWS did identify two species Federally listed as threatened that potentially could occur along the transmission lines: the bog turtle (*Clemmys muhlenbergii*) and swamp pink (*Helonias bullata*) (FWS 2009a).

The NRC staff has prepared a Biological Assessment (BA) for NMFS that documents its review of the potential for the proposed action to affect the Federally listed species under the jurisdiction of NMFS. The BA is provided in Appendix D of this draft SEIS. During informal consultation with FWS regarding the potential for effects on terrestrial threatened or endangered species, the staff determined that a BA for FWS was not needed because there was no likelihood of adverse effects on potentially occurring Federally listed species under the jurisdiction of FWS.

4.7.1 Aquatic ~~Threatened or Endangered~~ Species of Special Concern in the Delaware Estuary

Comment [DTL11]: Atlantic sturgeon is neither threatened nor endangered, but we must and do discuss it because it is a candidate for listing. Therefore, the present section heading is inaccurate.

Pursuant to consultation requirements under Section 7 of the Endangered Species Act of 1973, the NRC staff requested in a letter to NMFS dated December 23, 2009 (NRC 2009) that NMFS provide information on federally listed endangered or threatened species, as well as proposed or candidate species. In its response on February 11, 2010, NMFS stated that the shortnose sturgeon, the Atlantic sturgeon, and four sea turtle species are known to occur in the Delaware River and estuary in the vicinity of Salem and HCGS, and that no critical habitat is currently designated by NMFS near these facilities (NMFS 2010a).

Consultation between NMFS and NRC with regard to the cooling water intake system (CWIS) for Salem and HCGS has been ongoing since before each facility began operation. In 1980, a Biological Opinion issued by NMFS concluded that the continued operation of these facilities was not likely to jeopardize the shortnose sturgeon. After sea turtles were impinged on the intake trash bars at the Salem facility, consultation was reinitiated in 1988 to evaluate the effects of these takes on the sea turtle species involved. (Takes are considered to include mortalities as well as turtles that are impinged but removed alive and released.) In 1991, NMFS issued a Biological Opinion thatwhich found that continued operation of Salem and HCGS would affect threatened or endangered sea turtles but was not likely to jeopardize any populations, and and issued an incidental take statement was issued for Kemp's ridley, green, and loggerhead turtles and shortnose sturgeon. The number of turtles impinged in 1991 was unexpectedly high, exceeding the incidental take allowed and resulting in additional consultation. An opinion issued Iin 1992 NMFS revised the incidental take statement. The impingement of sea turtles exceeded the allowable take in 1992 as well, prompting additional consultation with NMFS (NMFS 1999 and 2010b). A 1993 Biological Opinion required the tracking of all loggerhead sea turtles taken at the CWIS. Also in 1993, PSEG implemented a policy of removing the ice barriers from the trash racks on the intake structure during the period between May 1 and October 24, which resulted in substantially lower turtle impingement rates at Salem (one in 1993 and one in 1995).

In 1999, NRC requested that these studies be eliminated due to the reduction in the number of turtles impinged after the 1993 change in procedure regarding the removal of ice barriers. NMFS responded in 1999 with a letter and an incidental take statement stating that these studies could be discontinued because it appeared that the reason for the relatively high impingement numbers previously was the ice barriers that had been left on the intake structure during the warmer months (NMFS 1999). This letter allowed an annual incidental take of 5 shortnose sturgeon, 30 loggerhead sea turtles, 5 green sea turtles, and 5 Kemp's ridley sea turtles. In addition, the statement required ice barrier removal by May 1 and replacement after October 24, and it required that in the warmer months the trash racks must be cleaned weekly and inspected every other hour, and in the winter they should be cleaned every other week. The statement requires that if a turtle is killed, the racks must be inspected every hour for the rest of the warm season. Dead shortnose sturgeon are required to be inspected for tags, and live sturgeon are to be tagged and released (NMFS 1999).

No threatened or endangered species have been impinged at the Hope Creek intake structure, and NMFS does not require monitoring beyond normal cleaning operations for Hope Creek (NMFS 1993). Table 4.7-2 summarizes information on the incidental take by impingement at the Salem intakes of sturgeon and sea turtles during the monitoring period 1978 – 2008.

The NRC staff evaluated the potential effects of entrainment, impingement, and thermal discharges on these and other important species in Sections 4.5.2, 4.5.3, and 4.5.4. Based on an evaluation of entrainment data provided by PSEG, there is no evidence that the eggs or larvae of either sturgeon species are commonly entrained at Salem and HCGS. Neither of the sturgeon species is on the list of species that has been collected in annual entrainment monitoring during the 1978 – 2008 period (Table 4.5-6). The life histories of these sturgeon, described in Section 2.2.7.1, suggest that entrainment of their eggs or larvae is unlikely. Shortnose sturgeon spawn upstream in freshwater reaches of the Delaware River and are most abundant between Philadelphia and Trenton. Their eggs are demersal and adhere to the

Comment [DTL12]: Could we use a more precise word here?

Comment [DTL13]: Whose opinion is this. PSEG's, NRC's, or NMFS's. And also give reference.

substrate, and ~~their~~ juvenile stages tend to remain in freshwater or fresher areas of the estuary for 3 to 5 years before moving to more saline areas such as the nearshore ocean. Thus, shortnose sturgeon eggs or larvae are unlikely to be present in the water column at the Salem or HCGS intakes well downstream of the spawning areas. Similarly, the life history of the Atlantic sturgeon makes entrainment of its eggs or larvae very unlikely.

~~Impingement data provided by the applicant suggest that~~ Both sturgeon species and three of the four turtle species have been impinged at Salem (Table 4.7-2). Atlantic sturgeon were collected in impingement studies in a single year, 2006 (PSEG biological monitoring reports 1995-2006). ~~Impingement data for the shortnose sturgeon show that f~~From 1978 to 2008, 18 shortnose sturgeon~~fish~~ were impinged at the Salem intakes, of which 16 died. Between 1978 and 2008, 24 Kemp's ridley sea turtles were impinged, of which ten died. Three green turtles (one died) and 68 loggerhead turtles (25 died) also were impinged. Impingement of the turtles was greatest in 1991 and 1992 (Table 4.7-2). After PSEG modified its use of the ice barriers in 1993, turtle impingement numbers returned to levels much lower than in 1991. From 1994 through 2008, ~~there were~~ Salem impinged six sea turtles ~~impinged~~ (all loggerheads), and four of these died. Also during this 15-yr period, 11 shortnose sturgeon were impinged, of which eight died.

Table 4.7-2. Impingement data for shortnose sturgeon and three sea turtle species with recorded impingements at Salem intakes, 1978-2008.

Year	Impingement Numbers by Species[1]			
	Shortnose sturgeon	**Kemp's ridley sea turtle**	**Green sea turtle**	**Loggerhead sea turtle**
1978	2 (2)	0	0	0
1979	0	0	0	0
1980	0	1	1	2 (2)
1981	1 (1)	1 (1)	0	3 (2)
1982	0	0	0	1 (1)
1983	0	1 (1)	0	2 (2)
1984	0	1	0	2 (2)
1985	0	2 (1)	0	6 (5)
1986	0	1 (1)	0	0
1987	0	3 (1)	0	3
1988	0	2 (1)	0	8 (6)
1989	0	6 (2)	0	2
1990	0	0	0	0
1991	3 (3)	1	1	23 (1)
1992	2 (2)	4 (2)	1 (1)	10
1993	0	1	0	0
1994	2 (2)	0	0	1
1995	0	0	0	1 (1)
1996	0	0	0	0
1997	0	0	0	0
1998	3 (1)	0	0	1 (1)
1999	1	0	0	0

Year	Impingement Numbers by Species[1]			
	Shortnose sturgeon	Kemp's ridley sea turtle	Green sea turtle	Loggerhead sea turtle
2000	1 (1)	0	0	2 (1)
2001	0	0	0	1 (1)
2002	0	0	0	0
2003	1 (1)	0	0	0
2004	1 (1)	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	1 (1)	0	0	0
2008	1 (1)	0	0	0
Total	18 (16)	24 (10)	3 (1)	68 (25)

(1) Numbers in parentheses indicate the number of individuals out of the yearly total shown that were either dead when found at the intakes or died afterward. Impingements of Atlantic sturgeon or leatherback sea turtles were not reported in the data on which this table was based.

Source: PSEG (2010).

Section 4.5.4 discusses ~~The~~ potential impacts of thermal discharges on the aquatic biota of the Delaware Estuary ~~is discussed in Section 4.5.4~~, and NRC staff expect impacts on fish and invertebrates, including those preyed upon by sturgeon and sea turtles, ~~are expected~~ to be minimal. The high exit velocity of the discharge produces rapid dilution, which limits high temperatures to relatively small areas in the zone of initial mixing in the immediate vicinity of the discharge. Fish and many other organisms are largely excluded from these areas due to high velocities and turbulence. Shortnose and Atlantic sturgeon and the four sea turtle species have ~~very~~ little potential to experience adverse effects from exposure to the temperatures at the discharge because of their life history characteristics and their mobility. Sturgeon spawning and nursery areas do not occur in the area of the discharge in the estuary, and adult sturgeon forage on the bottom while the buoyant thermal plume rises toward the surface. Sea turtles prefer warmer water temperatures, occur in the region only during warm months, and are unlikely to be sensitive to the localized area of elevated temperatures at the discharge. NMFS (1993) considered the possibility that the warm water near the discharge could cause sea turtles to remain in the area until surrounding waters are too cold for their safe departure in the fall, but it concluded that this scenario was not supported by any existing data ~~(NMFS 1993)~~.

The NRC staff reviewed information from the site audit, the applicant's Environmental Reports for Salem and HCGS, biological monitoring reports, other reports, and coordination with NMFS, FWS, and State regulatory agencies in New Jersey and Delaware regarding listed species. The NRC staff concludes that the impacts on federally listed threatened or endangered aquatic species of the Delaware Estuary during an additional 20 years of operation of the Salem and HCGS facilities would be SMALL.

4.7.2 Terrestrial and Freshwater Aquatic Special Status ~~Threatened or Endangered~~ Species

Two Federally-listed terrestrial or freshwater aquatic species that ~~are Federally listed have the potential to~~ might occur near the Salem and HCGS facilities and their associated transmission line ROWs are~~:~~ the bog turtle and swamp pink. Section 2.2.7.2 discusses ~~The~~ characteristics,

Comment [DTL14]: The above does not really discuss Hope Creek and should do so.

We also need to say that the appendix contains NRC's biological assessment.

Comment [DTL15]: We discuss state species here as well as Federally-listed endangered and threatened species.

habitat requirements, and likelihood of occurrence of these species ~~are discussed in Section 2.2.7.2~~. Coordination correspondence between PSEG (dates) and FWS (2009a) indicates that no Federally listed species occur on the site of the Salem and HCGS facilities, but that the bog turtle and swamp pink potentially could occur within the transmission line ROWs ~~(FWS 2009a)~~.

Comment [DTL16]: No?

FWS coordinated with PSEG to review all of its transmission line spans in New Jersey and transmitted to PSEG the known locations of the presence or potential presence of Federally listed species along each span. FWS (2009a) also recommended to PSEG conservation measures for each Federally listed species that potentially could occur along its transmission line spans ~~(FWS 2009a)~~. In October 2009, PSEG (2009) confirmed to FWS its commitment to protecting both Federally and State listed threatened or endangered species along PSEG transmission line ROWs~~, and it~~and adopted the conservation measures recommended by FWS for each species ~~(PSEG 2009)~~. Based on PSEG's adoption of these conservation measures, FWS in November 2009 concurred that "continued vegetation maintenance activities within the transmission system are not likely to adversely affect federally listed or candidate species." (FWS 2009b) Thus, the Federally listed species potentially occurring in the transmission line ROWs for Salem and HCGS in New Jersey would not be adversely affected by future vegetation maintenance activities. The FWS New Jersey Field Office also coordinated with the FWS Chesapeake Bay Field Office regarding the transmission line ROW from HCGS that crosses the river and traverses New Castle County in Delaware. FWS (2009b) concluded that "no proposed or federally listed endangered or threatened species are known to exist" within that ROW area ~~(FWS 2009b)~~.

Comment [DTL17]: Where does this go?

The ROW maintenance procedures agreed upon for protection of the bog turtle ~~include:~~include use of a certified bog turtle surveyor to examine spans containing known or potential habitat, to flag areas of potential habitat plus a 150-ft buffer, and to be on site during maintenance activities in flagged areas; performance of maintenance activities by hand in flagged areas, including selective use of specific herbicides; no use of herbicide in known nesting areas, which include all flagged areas around extant occurrences; timing restrictions to avoid disturbance during nesting season; and provision of the surveyor's reports to FWS (PSEG 2009). The ROW maintenance procedures agreed upon for protection of the swamp pink ~~include:~~ include use of a qualified botanist to survey suitable forested wetland habitat on and adjacent to the ROW for the plant; flagging of a 200-ft radius area around any identified populations of swamp pink; avoidance of any maintenance activities within the flagged areas without FWS approval; limitation of herbicide use within 500 ft of a population to manual applications to woody stumps only; and provision of the surveyor's reports to FWS (PSEG 2009).

Comment [DTL18]: Make the construction of items in this list parallel.

Comment [DTL19]: Make construction of items in this list parallel.

The NRC staff reviewed information from the site audit, Environmental Reports for Salem and HCGS, other reports, and coordination with FWS and State regulatory agencies in New Jersey and Delaware regarding listed species. The NRC staff concludes that the impacts on Federally listed terrestrial and freshwater aquatic species from an additional 20 years of operation and maintenance of the Salem and HCGS facilities and associated transmission line ROWs would be SMALL.

References:

Delaware Department of Natural Resources and Environmental Control (DNREC). 2009. Letter from E. Stetzar, biologist/environmental review coordinator, Natural Heritage and Endangered Species, Division of Fish and Wildlife, to E. J. Keating, PSEG Nuclear LLC. Letter responded to request from PSEG for information on rare, threatened, and endangered species and other significant natural resources relevant to operating license renewal for Salem and HCGS, and it specifically addressed the ROW alignment extending from Artificial Island, NJ across the

Delaware River to end in New Castle County, DE. April 21. Copy of letter provided in Appendix C of Applicant's Environmental Report for Salem (PSEG 2009a).

PSEG Nuclear, LLC (PSEG). 2009a. Salem Nuclear Generating Station, Units 1 and 2, License Renewal Application, Appendix E - Applicant's Environmental Report – Operating License Renewal Stage. Lower Alloways Creek Township, New Jersey. August, 2009. ADAMS Nos. ML092400532, ML092400531, ML092430231.

National Marine Fisheries Service (NMFS). 1993. Biological Opinion, Endangered Species Act Section 7 consultation with the Nuclear Regulatory Commission regarding the Salem and Hope Creek Nuclear Generating Stations in Salem, NJ. NMFS Northeast Regional Office, Silver Spring, MD.

National Marine Fisheries Service (NMFS). 1999. Letter to Thomas H. Essig, Acting Chief, Generic Issues and Environmental Projects Branch, Division of Nuclear Reactor Program Management, Office of Nuclear Reactor Commission, regarding consultation and biological opinion on the operation of Salem and HCGS and endangered and threatened species. OFFICE.

National Marine Fisheries Service (NMFS). 2010. Letter to Bo Pham, Chief, Project Branch 1. Division of License Renewal, Office of Nuclear Reactor Regulation, regarding information on the presence of species listed as threatened or endangered by NOAA's National Marine Fisheries Service in the vicinity of Salem and Hope Creek generating stations. OFFICE.

New Jersey Department of Environmental Protection (NJDEP). 2008. Letter from H. A. Lord, data request specialist, Natural Heritage Program, to L. Bryan, Tetra Tech NUS, Inc. Letter responded to request for rare species information for the Salem and HCGS site and transmission line ROWs in Camden, Gloucester, and Salem Counties. OFFICE.

Comment [DTL110]: Etc. ...

New Jersey Department of Environmental Protection (NJDEP). 2009. Letter from C. D. Jenkins, Chief, Endangered and Nongame Species Program, to E. J. Keating, PSEG Nuclear LLC, Hancocks Bridge, NJ. Letter responded to request from PSEG for information on listed species or critical habitat at the Salem and Hope Creek Generating Stations and along associated transmission corridors. April 2.

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PSEG Nuclear, LLC. 2010. Tables summarizing impingement data for shortnose sturgeon, Atlantic sturgeon, and loggerhead, green, and Kemp's ridley sea turtles. Provided by PSEG on May 3 in response PSEG-4 to NRC request for additional information (RAI) dated April 16, 2010.

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