Baseline Scenario. To estimate E&I under the Project Scenario, we assume an 87.4 percent reduction with closed cycle technology.[6]

Entrainment mortality accounts for over 99 percent of the fish killed at Salem (Table 1).[7] Entrained organisms under the baseline scenario average 14.7 billion a year, and impinged organisms 6.6 million per year. This equates to 356 million and 3 million adult equivalents, respectively, for a total of 360 million A1E fish killed in an average year.[8]

Table 1. Average Annual E&I at the Salem Nuclear Generating Station under the Baseline and Project Scenarios

		Baseline Scenario	Project Scenario	Fish Saved
Number of Organisms	Entrained	14,660,056,000	1,847,167,000	12,812,889,000
	Impinged	6,634,000	836,000	5,798,000
	Total	**14,666,689,000**	**1,848,003,000**	**12,818,687,000**
	% Entrained	99.95%		87.40%
	% Impinged	0.05%		
Equivalent Adults	Entrained	356,320,000	44,900,000	311,430,000
	Impinged	3,190,000	400,000	2,780,000
	Total	**359,510,000**	**45,300,000**	**314,210,000**
	% Entrained	99.11%		87.40%
	% Impinged	0.89%		

Sources: EPA Case Study, and US EPA. 2002. *316(b) Phase II EBA, Part C: National Benefits Chapter*. Page C2-1. Available online at: http://permanent.access.gpo.gov/websites/epagov/www.epa.gov/waterscience/316b/econbenefits/c2.pdf

Note: figures may not sum due to rounding.

Based on the figures presented above, the Baseline Scenario results in approximately 314,210,000 more E&I deaths per year (in terms of fish that would otherwise have survived to adulthood) than the Project Scenario, on average. In terms of the number of organisms entrained or impinged at any life stage, the Project Scenario reduces mortality by over 12 billion. E&I at Salem varies considerably, year-to-year, based on intake and production levels at the facility as well as inter-annual population fluctuations for individual species (Figure 1). The vast majority of fish losses at Salem are Bay Anchovy, one of the most abundant species in the Bay, and a primary food source for many other fish inhabiting the river, including weakfish, bluefish and striped bass.

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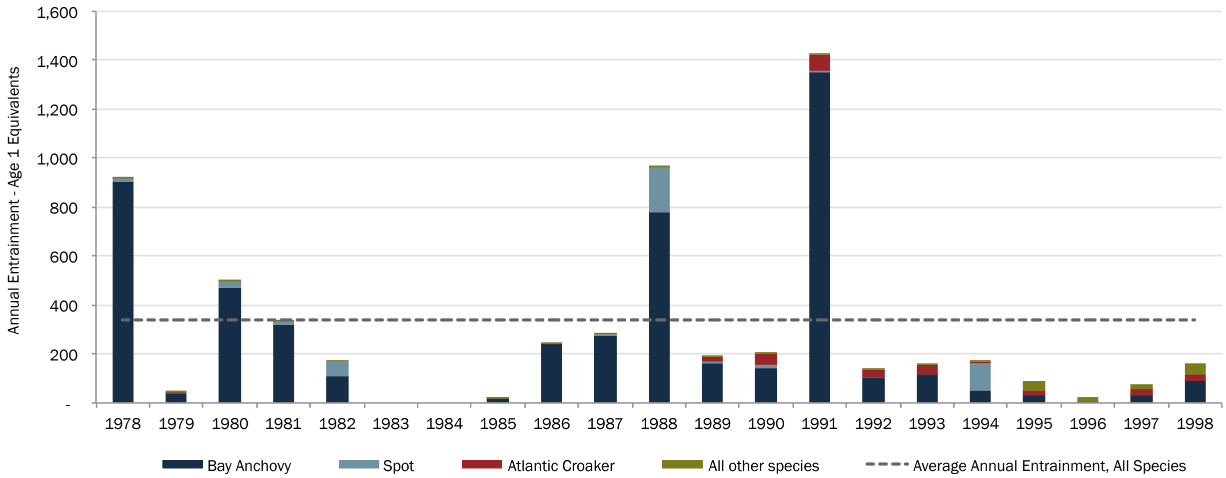
[6] EPA Benefits Analysis. Page 3-9. Note, however, that other studies (such as Versar. 1986. *Technical Review and Evaluation of Thermal Effects Studies and Cooling Water Intake Structure Demonstration of Impact for the Salem Nuclear Generating Station*) assume 95 percent reduction in E&I with closed-cycle cooling – commensurate with the average flow reductions that the facility would experience with the new technology. In light of this information, our estimates are conservative and likely underestimate the true number of fish saved.

While these estimates encompass only the period between 1978 -1998, they remain the most detailed available, and still accurately reflect current rates E&I at the plant. E&I data for 2004-2006, summarized in the 2015 Draft Permit, show similar magnitudes and patterns of mortality.

[7] Based on the mortality factors calculated by PSEG and included in the EPA Case Study, we assume 100 percent entrainment mortality.

[8] PSEG likely underestimates true E&I at Salem (see EPA Case Study, page B3-25).

Figure 1. EPA's Estimates of Annual Entrainment at the Salem Station, by Species, Expressed as Numbers of Age 1 Equivalents (1978 -1998)



Source: ECONorthwest based on data from the EPA Case Study

Note:

Estimates of Non-RIS species only became available after 1995

The station was shut down for the majority of 1996

'All other species' includes: Alewife, American Shad, Atlantic Menhaden, Blueback Herring, Silversides, Striped Bass, Weakfish, White Perch, Non-RIS Fishery Species, and Non-RIS Forage Species.

These annual mortality estimates are large enough to have population-level impacts.[9] Annual cooling water demand at Salem alone, for example, accounts for a 31 percent direct reduction in the local Bay Anchovy population.[10] Furthermore, these losses of aquatic organisms do not occur in isolation and instead are exacerbated by other forms of harm in the Delaware Estuary, including dredging by the Army Corps and other once-through cooling facilities. The EPA highlighted the Delaware River system as having large cumulative impacts from facilities with CWIS, with intake flows consuming roughly 20 percent of the total annual river flow.[11] Previous research suggests that cooling water intakes at Salem and the Delaware City Refinery (located across the river from Salem), together, can kill more than half of the striped bass population of

[9] See, for example:

- Versar. 1986. *Technical Review and Evaluation of Thermal Effects Studies and Cooling Water Intake Structure Demonstration of Impact for the Salem Nuclear Generating Station*. Prepared for the New Jersey Department of Environmental Protection.
- Carpenter Environmental Associates, Inc. 2003. *Evaluation of Special Conditions Contained in Salem Nuclear Generating Station NJPDES Permit to Restore Wetlands, Install Fish Ladders, and Increase Biological Abundance Within the Delaware Estuary*. Prepared for Delaware Riverkeeper Network.
- Kahn, D. 2008. Delaware Division of Fish and Wildlife. *Impacts of Impingement and Entrainment Mortality by the Delaware City Refinery on Fish Stocks and Fisheries in the Delaware River and Bay*.

[10] Fletcher. 1990. *Flow Dynamics and Fish Recovery Experiments: Water Intake Systems*. Transactions of the American Fisheries Society.

[11] EPA Benefits Analysis. Page 2-18.

the Delaware River in a given year. Similarly, the two facilities combined have been estimated to kill up to 23 percent of all the Weakfish found in the River.[12]

3.2 Biophysical Effects within the Context of Climate Change

Over the past 40 years, average annual temperatures in the northeast US have increased by about 1.1°C, which has contributed to more frequent days with very high temperatures and rising sea surface temperatures.[13] In the coming decades, temperatures in the northeast US are expected to increase an additional 1.4–2.2°C in the winter and 0.8–1.9°C in the summer. These rising temperatures will increase the importance and value of avoiding additional temperature increases for vulnerable aquatic organisms.

Water at the Salem discharge point is 0 to 15 °F (0 to 8.3 °C) warmer than the estuary water to which it is being discharged, and the average temperature increase at the discharge is from 8 to 10 °F (4 to 6 °C).[14] The Delaware River Basin Commission (DRBC) temperature standards for Water Quality Zone 5 of the Delaware Estuary (where the Salem discharge is located) state that the temperature in the river may not be raised above ambient by more than 4 degrees Fahrenheit (°F; 2.2 degrees Celsius [°C]) during non-summer months (September through May) or 1.5°F (0.8°C) during the summer (June through August). However, Salem has received a variance and has been exempt from these temperature standards since it began operation in 1977.[15] Salem's thermal plume under the Baseline Scenario is likely to contribute to increased mortality as water in the Delaware River increases in temperature due to climate change.

4 Economic Value of Benefits and Costs

In this section, we describe the economic value of the potential benefits and costs associated with using closed-cycle cooling technology at Salem. In economic terms, the objective of this section is to calculate the total economic value of these benefits and costs. It is crucial when conducting a benefit-cost analysis to make every attempt to estimate the value of all substantial benefits and costs, as otherwise the results are biased towards the subset of effects that can be

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[12] Kahn, D. 2008. Delaware Division of Fish and Wildlife. *Impacts of Impingement and Entrainment Mortality by the Delaware City Refinery on Fish Stocks and Fisheries in the Delaware River and Bay*. Available at: https://delaware.sierraclub.org/sites/delaware.sierraclub.org/files/documents/2012/06/Kahn%202008.pdf

[13] Karl, T., J. Melillo, and T. Peterson. 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press.

[14] U.S. Nuclear Regulatory Commission. 2011. *Essential Fish Habitat Assessment - Salem Nuclear Generating Station Units 1 and 2 Hope Creek Generating Station*. Available online at: http://pbadupws.nrc.gov/docs/ML1103/ML110320668.pdf

[15] NOAA National Marine Fisheries Service. 2014. *Endangered Species Act Section 7 Consultation Biological Opinion - Continued Operation of Salem and Hope Creek Nuclear Generating Stations NER-2010-6581*. Available online at:
https://www.greateratlantic.fisheries.noaa.gov/protected/section7/bo/actbiops/salemhcnmfsfinalbiopjuly172014.pdf

easily monetized. The Office of Management and Budget (OMB) provides clear guidance to all federal agencies concerning regulatory analysis in Circular A-4.[16]

> *"Where all benefits and costs can be quantified and expressed in monetary units, benefit-cost analysis provides decision makers with a clear indication of the most efficient alternative, that is, the alternative that generates the largest net benefits to society... When important benefits and costs cannot be expressed in monetary units, BCA is less useful, and it can even be misleading, because the calculation of net benefits in such cases does not provide a full evaluation of all relevant benefits and costs."*

The U.S. Environmental Protection Agency (EPA) references Circular A-4 and uses similar principles to develop its *Guidelines for Preparing Economic Analyses.*[17]

> *"Estimating benefits in monetary terms allows the comparison of different types of benefits in the same units, and it allows the calculation of net benefits – the sum of all monetized benefits minus the sum of all monetized costs – so that proposed policy changes can be compared to each other and to the baseline scenario."*

Particularly in a context where the benefits and costs are widespread and not captured by markets, careful and comprehensive steps must be taken to fully capture all substantial benefits and costs. Under such conditions, non-consumptive uses can be a substantial share of the value, but market-based prices for these values do not typically exist.

Figure 2 demonstrates the major components contributing to total economic value. The left side of Figure 2 shows use value. Direct use value describes the value associated with the direct use of a particular good or service. In this case, direct uses could include commercial and recreational uses of fish in and around Salem. Indirect use value describes goods and services that are inputs to other final goods and services directly used by people. In this case, indirect use values for example could include the value of forage fish lost to E&I that would have otherwise supported fish populations that people directly consume.

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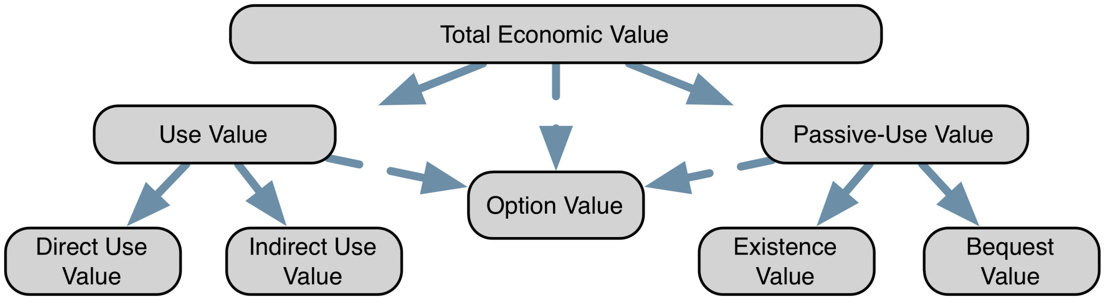
[16] Office of Management and Budget. 2003. Circular A-4. http://www.whitehouse.gov/omb/circulars_a004_a-4.

[17] U.S. Environmental Protection Agency. 2010. Guidelines for Preparing Economic Analyses. December. http://yosemite.epa.gov/ee/epa/eed.nsf/pages/guidelines.html.

Figure 2. Components of Total Economic Value



Source: ECONorthwest

The right side of Figure 2 shows passive-use value (sometimes called non-use value), which represents nature's values that exist when there is no direct or indirect use of an ecosystem by humans. For example, if a person who does not engage in fishing and does not consume fish would nonetheless be willing to pay higher energy bills to reduce fish losses, then we would refer to that willingness to pay as passive or non-use value. EPA describes passive use values as:

> *"... the value that individuals may attach to the mere knowledge of the existence of a good or resource, as opposed to enjoying its direct use. It can be motivated for a variety of reasons, including bequest values for future generations, existence values and values of paternalistic altruism for others' enjoyment of the resource."* [18]

Passive-use values are less obvious than use values, but – in some instances – can represent a greater total value because they incorporate demands from a larger population. Figure 2 separates passive-use value into two categories. One, called existence value, comes from people's desire for the continued existence of a species, landscape, or some other aspect of an ecosystem, or of the ecosystem as a whole. The other, called bequest value, arises because people desire to ensure that the ecosystem will be available for enjoyment by future generations. The middle of Figure 2 shows another component of the total value, called option value. An option value refers to the benefit of maintaining an opportunity to derive services from an ecosystem in the future. It can originate from either side of Figure 2.

For passive-use values, survey-based stated preference techniques are typically necessary because they are considered by economists to be the only available tools for such values. EPA states in its *Guidelines*:

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[18] U.S. Environmental Protection Agency. 2010. Guidelines for Preparing Economic Analyses. December. http://yosemite.epa.gov/ee/epa/eed.nsf/pages/guidelines.html.

"Revealed preference methods cannot capture nonuse values, such as those associated with the existence of biological diversity... stated preference methods may be employed when researchers want to identify the widest possible spectrum of values, both use and nonuse."[19]

OMB recognizes that stated preference techniques might be the only available means to appropriate value estimates, and these techniques have applied widely and rigorously:

"Stated Preference Methods (SPM) have been developed and used in the peer-reviewed literature to estimate both "use" and "non-use" values of goods and services. They have also been widely used in regulatory analyses by Federal agencies, in part, because these methods can be creatively employed to address a wide variety of goods and services that are not easy to study through revealed preference methods... A stated-preference study may be the only way to obtain quantitative information about non-use values…"[20]

The biological effects of Salem's once-through cooling technologies are precisely of the nature that necessitate consideration of non-market values as recommended by OMB and EPA guidelines. By affecting such basic levels of important species, once-through cooling can have widespread and uncertain effects, both spatially and throughout trophic levels of important aquatic ecosystems. Of high relevance to the Salem context, once-through cooling likely affects federally-listed endangered species such as the Shortnose sturgeon, Atlantic sturgeon and the green sea turtle, as well as more common species (such as blueback herring and alewife) that have experienced widespread declines from historical levels. Economic research on passive-use values suggests particularly high value for rare species, as further described below. These Salem characteristics combined with OMB and EPA guidance, as well as economic theory, all dictate that any benefit-cost analysis for Salem must include passive-use values.

The remainder of this section of the report has three parts. In the first part, we identify and summarize the economic benefits associated with the Project Scenario relative to the Baseline Scenario. In the second part, we identify and describe the costs associated with the two scenarios. In the third part, we bring benefits and costs together to discuss the net differences between the two scenarios in economic terms.

4.1 Project Benefits

In this section, we describe the economic value of the benefits associated with the Project Scenario relative to the Baseline Scenario. As described above, the total economic value of the benefits associated with a particular biophysical effect has many components. For discussion of benefits, we begin with summarization of previous benefit estimates produced by PSEG and the

[19] U.S. Environmental Protection Agency. 2010. Guidelines for Preparing Economic Analyses. December. http://yosemite.epa.gov/ee/epa/eed.nsf/pages/guidelines.html.

[20] OMB Circular A-4.

U.S. EPA. Then, as a separate validation exercise, we apply the results of a stated preference survey completed by the EPA (the *EPA Survey)* to further demonstrate the economic value of E&I reduction. We also briefly consider valuation based on Habitat Equivalency Analysis and the associated replacement costs sometimes used to represent benefit values.

4.1.1 Previous Benefit Estimates

PSEG Benefit Estimate

The 2006 PSEG permit application states an intention of looking at market and non-market, including passive-use values, but only quantifies market-based consumptive values for fish. Relying primarily on commercial landing prices and values for recreational sportfishing, they estimate the total benefit to be gained from the installation of closed-cycle cooling at Salem, over a 34-year assessment period, at $7.67 million (2015$).[21]

In addition to basing its calculations on artificially low E&I figures, the overriding presumption of this market-based approach is that all other species either entrained or impinged are not economically significant. With this omission, PSEG does not provide sufficient data to estimate the overall benefits to society of the Project Scenario, as required by OMB and EPA guidelines. The 2006 application predates EPA's 2014 rule and the applicable guidance documents, and does not contain the necessary components pursuant to the 2014 rule; accordingly, in its draft NJPDES permit the New Jersey Department of Environmental Protection requires that the application be revised and updated "… *to include an analysis of social benefits. …"The dollar values in the social benefits analysis should be based on the principle of willingness-to-pay (WTP), which captures monetary benefits by measuring what individuals are willing to forgo in order to enjoy a particular benefit. While the Director must consider benefit and cost information, the Director will also determine if this information is of sufficient rigor to make a decision on entrainment controls on the basis of this information. For instance, the Director may decide not to rely on benefit-cost information in establishing the entrainment controls when the benefits analysis includes only a qualitative discussion of nonuse benefits. Willingness-to-pay for nonuse benefits can be measured using benefits transfer or a stated preference survey. However, the rule does not require the Director to require a facility owner or operator to conduct or submit a stated preference survey to assess benefits.""*[22]

However, there are other sources of information that can be used to address these gaps and inform present day decision-making. Specifically, a nationwide stated preference survey conducted by the EPA, expressly for the purpose of evaluating the social benefits associated with reduced E&I mortality, provides information sufficient to assess the magnitude of these omitted benefit categories. Additionally, comparing PSEG's existing estimates with other estimates (based on more rigorous analysis of Salem's E&I data and potential commercial and recreational values), suggests that PSEG's treatment of these categories is also insufficient, and

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[21] PSEG Nuclear LLC. 2006. *NJPDES Permit Application – Attachment 6-22 Detailed Benefit Results*.

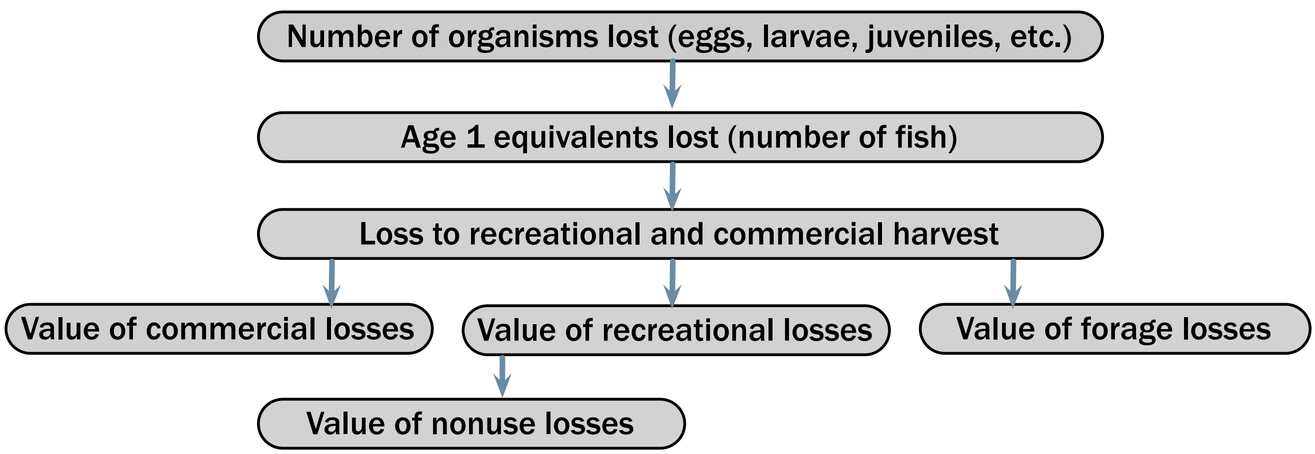
[22] New Jersey Department of Environmental Protection. 2015. PSEG NUCLEAR LLC SALEM GENERATING STATION NJPDES - Surface Water Renewal Permit Action. Page 61. Available online at: http://www.nj.gov/dep/dwq/pdf/salem-draft-2015.pdf

the estimates off by orders of magnitude. We examine these analyses and data sources in greater depth in the following sections.

EPA Benefit Estimates

In 2002, as part of its 316(b) rulemaking, the EPA produced a series of case studies focused on specific regions and facilities to illustrate appropriate approaches to economic valuation of reduced losses from E&I. One of these case studies focused on Delaware Bay, with Salem as the primary extrapolation model. In addition to detailed consideration of E&I data, summarized previously, it also included a more comprehensive consideration of benefits than PSEG's permit application. EPA's approach and valuation categories are shown in Figure 3.

Figure 3. EPA's general approach to the valuation of fish losses from E&I



Source: Adapted from EPA Case Study

In addition to estimating market-based values for species with commercial and recreational uses (using methods similar to those applied in PSEG's 2006 permit application), EPA also considered the value of forage species and passive-use benefits. This is appropriate given that only 3.3 percent of total baseline A1E mortality in the Delaware Estuary can be assigned a direct use value from recreational or commercial fishing.[23] EPA used two general methods to estimate the indirect value of forage species. The first involved conversion of the estimated increase in forage species to an equivalent amount of higher trophic level species, and the second considers the cost of replacing the individuals through hatchery production.[24]

Absent a full stated preference survey (considered to be the most accurate method of measuring passive-use benefits) at the time, EPA used three alternate means to estimate non-use values. These include assignment based on use values, benefits transfer, and habitat replacement costs. Under the first method, they assume that non-use benefits are a fixed proportion of the total of

[23] EPA Benefits Analysis. Page 3-8

[24] EPA Benefits Analysis

the previous three benefits categories – in this case, it was a 50 percent "rule of thumb" portion of the recreational fishing benefit.[25]

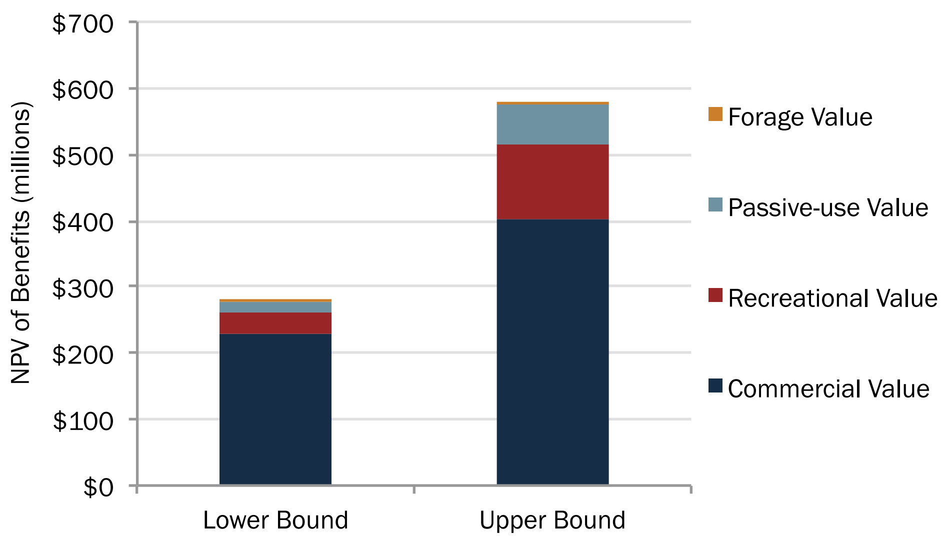
The results of EPA's valuation exercise are shown in Table 2 and Figure 4. Annual values for the benefits of reduced E&I at Salem were estimated as being between $18 and $38 million. The stream of annual benefits, over the course of 20 years, discounted at a rate of 3 percent, would sum to $279 and $577 million.

Table 2. EPA's estimate of the benefits of reduced E&I at Salem (2015$)

Valuation Category and Method	Estimate	Annual Value Estimate			20-Yr Net Present Value		
		Impingement	Entrainment	Total	Impingement	Entrainment	Total
Commercial: Total Surplus (*Direct Use, Market*)	Low	$250,000	$14,700,000	$14,940,000	$3,831,000	$225,260,000	$228,938,000
	High	$430,000	$25,720,000	$26,150,000	$6,589,000	$394,128,000	$400,717,000
Recreational (*Direct Use, Nonmarket*)	Low	$20,000	$2,120,000	$2,140,000	$306,000	$32,486,000	$32,793,000
	High	$80,000	$7,470,000	$7,550,000	$1,226,000	$114,469,000	$115,695,000
Nonuse (*Passive Use, Nonmarket*)	Low	$10,000	$1,060,000	$1,070,000	$153,000	$16,243,000	$16,396,000
	High	$40,000	$3,730,000	$3,770,000	$613,000	$57,158,000	$57,771,000
Forage (*Indirect Use, Nonmarket*)							
Production Foregone	Low	$0	$80,000	$80,000	$0	$1,226,000	$1,226,000
	High	$0	$140,000	$140,000	$0	$2,145,000	$2,145,000
Replacement		$0	$180,000	$180,000	$0	$2,758,000	$2,758,000
Total (Com + Rec + Nonuse + Forage)	Low	$280,000	$17,950,000	**$18,230,000**	$4,291,000	$275,062,000	**$279,353,000**
	High	$560,000	$37,100,000	**$37,660,000**	$8,581,000	$568,513,000	**$577,094,000**

Source: EPA Case Study

Figure 4. EPA's estimate of the benefits of reduced E&I at Salem (2015$)



Source: ECONorthwest based on data from the EPA Case Study

Note: figures may not sum due to rounding.

4.1.2 Total Economic Value Based on Results from the EPA Survey

In 2014, the US EPA published standards for cooling water intake structures as part of its responsibilities under Section 316(b) of the Clean Water Act, at 76 FR 22174. As part of its analyses, the agency conducted a stated preference survey to estimate the total willingness to

[25] EPA Case Study

pay (WTP) for improvements to fishery resources affected by E&I at 316(b) facilities. The results of the analysis provide a relatively comprehensive account of passive-use values associated with changes in E&I.[26]

Objectives. The US EPA states "[the *EPA Survey*] *presents data collected from a stated preference study that EPA conducted regarding total (use plus non-use) benefits from reductions in fish mortality at cooling water intake structures*."[27] In other words, the *EPA Survey* was implemented to quantify the total economic value associated with reducing E&I at cooling water intake structures by installing filters and closed-cycle cooling systems.

Survey Design. The *EPA Survey* used a choice experiment format in which "*respondents are presented with a set of multi-attribute alternatives and asked to select their preferred alternative, much as one might choose a preferred option in a public referendum*."[28] Respondents were shown two hypothetical policy options, as well as a status quo option, and were asked to choose the policy they prefer. Each policy option was accompanied by five associated effect categories: (1) commercial fish populations, (2) total fish populations, (3) fish saved from water intakes (based on age-one-equivalents), (4) conditions of aquatic ecosystems, and (5) increases in household cost of living. For example, relative to the status quo scenario, one of the hypothetical scenarios may increase commercial fish harvests by 3 percent and total fish populations by 4 percent. It may prevent the loss of 5 percent of E&I-related fish loss, and improve the conditions of aquatic ecosystems by 2 percent. However, in addition to these improvements in biophysical conditions, the cost of living for each household would increase by $48 per year.[29] There were a total of 72 unique Option A vs. Option B pairs sent out to survey respondents. There were five sample populations for the survey: (1) Northeast, (2) Southeast, (3) Inland, (4) Pacific, and (5) National. Each survey used regional values in describing how the hypothetical policies would affect biophysical variables for the region as a whole.

Survey Implementation. The US EPA pre-tested drafts of the survey instrument with six focus groups (8-10 participants each) and a set of eight, one-on-one cognitive interviews.[30] Once the US EPA finalized the survey instrument, it mailed out a total of 7,840 regional versions of the survey to households across the four regions, as well as 960 national versions of the survey to households across the country. Table 3 summarizes the states included in each of the regions, the target sample size, the number of households surveyed, the number of completed surveys received, and the response rate.

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[26] EPA Benefits Analysis

[27] EPA Survey

[28] EPA Survey

[29] EPA Survey

[30] EPA Survey

Table 3. Summary of Survey Implementation Statistics

Survey Region	States Included	Target Sample Size	Number of Households Surveyed	Completed Surveys Received	Response Rate
Northeast	CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT	417	1,440	421	31 percent
Southeast	AL, FL, GA, LA, MS, NC, SC, TX, VA	562	1,920	506	30 percent
Pacific	CA, OR, WA	289	1,040	311	32 percent
Inland	AR, AZ, CO, ID, IA, IL, IN, KS, KY, MI, MN, MO, MT, ND, NE, NM, NV, OH, OK, SD, TN, UT, WI, WV, WY	732	2,480	787	36 percent

Source: EPA Benefits Analysis. Page 11-9.

Notes: Undeliverable surveys are not incorporated into the response rate.

Survey Analysis. The *EPA Survey* used a mixed logit model to calculate region-specific estimates of marginal household WTP for reductions in E&I-related losses. Put simply, the model assumes that the preferences of each region's respondents fall within a distribution, and uses differences in their WTP (represented by a policy's increase in cost of living) and differences in fish-related benefits (represented by a reduction in E&I losses) to isolate average annual household WTP values for marginal changes in E&I losses. The models develop estimates for household willingness to pay for each category of effects and at each regional scale, including national. The amounts of household willingness to pay for the four categories of effects are considered non-additive.

Survey Results. The *EPA Survey* provided results that focused on the survey results from the northeast region. Table 4 summarizes the results for the northeast region across the four categories of effects. The category of interest for application to E&I mortality is "fish saved", as this is the category of effect that EPA estimates.[31] The implicit price for fish saved represents the amount the average household is willing to pay for a 1 percent reduction in fish mortality from water intakes. It is $1.53 (2015$), with a 95 percent confidence interval of $1.01–$2.02. In other words, the results show that the average household in the northeast would be willing to pay $1.53 per year for a 1 percent decrease in E&I-related fish loss, within northeast waterways, relative to a baseline of 1.1 billion fish lost per year.[32] Results from the national survey (which quoted a baseline loss of 2.5 billion fish per year) are also shown in Table 4. According to the most recent data from the US Census, there are 23,750,310 households in the northeast region, and 91,158,236 households in the rest of the country (minus Alaska and Hawaii).[33]

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[31] EPA is able to estimate the change in "fish saved" with closed cycle cooling, but does not currently estimate changes in the other attribute categories. Therefore if there are separate, additional improvements in the other attributes as well, the value estimate for "fish saved" alone is an underestimate of value.

[32] U.S. EPA. 2011. *Supporting Statement for Information Collection Request for Willingness to Pay Survey for Section 316(b) Existing Facilities Cooling Water Intake Structures: Instrument, Pre-Test, and Implementation*. These totals may differ from more current estimates of E&I, and figures can vary based on which facilities are included (just power plants or all facilities with CWIS, for example),

[33] U.S. Census Bureau. 2009-2013 American Community Survey 5-Year Estimates. *S1101: Households and Families*.

Table 4. Annual Household WTP for E&I-related Changes in Fish Populations for the Northeast Region and the U.S (2015$)

Survey Population	Attribute	Implicit Price	95 percent Confidence Interval
Northeast	Commercial fish population	$10.92	$6.84 - $15.75
	Fish population (all fish)	$3.28	-$4.80 - $11.54
	Fish saved	$1.53	$1.01 - $2.19
	Aquatic ecosystem condition	$10.35	$1.53 - $20.15
National	Commercial fish population	-$0.86	$2.35 - $5.83
	Fish population (all fish)	$0.43	$6.17 - $11.96
	Fish saved	$0.30	$0.69 - $1.13
	Aquatic ecosystem condition	-$13.04	-$3.73 - $5.51

Source: EPA Benefits Analysis. Page 11-29.

Notes: The implicit prices and the 95 percent confidence interval represent the amount a household would be willing to pay, each year, for a 1 percent change in the attribute, relative to baseline attribute levels. The EPA focus is on the attribute "fish saved". EPA has not estimated changes in the other attributes and does not use them for reduced E&I WTP estimation, although they suggest that a focus on "fish saved" alone is likely an underestimate.

We apply the results from the *EPA Survey's* analysis of surveys from the northeast region and the rest of the nation (using results from the national survey) to quantify the total economic value to northeastern and U.S. households of the benefits related to E&I reductions under the Project Scenario. Since the *EPA Survey* did not differentiate between the types of values households derive from changes in E&I, the estimates of household WTP can be interpreted in terms of total economic value. As stated in the *EPA Survey*, the stated preference survey and analysis were conducted specifically to quantify the value of all benefits (use and non-use) associated with changes in E&I.[34] However, we note that the survey does not account for effects on a number of non-fish species as well as effects on threatened, endangered, and other protected species, for example.

As previously stated, the Baseline Scenario results in approximately 314,210,000 more E&I-related A1E fish deaths per year than the Project Scenario, on average. Based on the *EPA Survey's* baseline E&I estimate across the northeast region and the rest of the U.S, preventing this level of mortality would generate annual household benefits between $11 and $29 million dollars, with a mean estimate of $19 million a year. Over 20 years at a 3 percent discount rate, and taking into account projected population increases, the value would be $172 million, $308 million, and $468 million, net present value (NPV), corresponding to the low, mean, and high WTP values shown in Table 4. [35]

[34] EPA Survey

[35] U.S. Census Bureau. 2014. *National Population Projections*. Available online at: http://www.census.gov/population/projections/data/national/2014.html