Chapter C1: Case Study Introduction

Introduction

Part C of this Economic and Benefits Analysis (EBA) presents a summary of the results of the § 316(b) benefits case studies and the extrapolation of these results to other facilities nationwide. This chapter provides an overview of the case study objectives, selection, and design. *Chapter C2: Summary of Case Study Results* summarizes case study results, *Chapter C3: National Extrapolation of Baseline Economic Losses* presents the results of the national extrapolation of baseline losses, and *Chapter C4: Benefits* discusses potential economic benefits of the proposed rule based on case study results. Case study methods and results are presented in detail in the Case Study Document.

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C1-1 Why Case Studies were Undertaken

It is difficult to develop a national aggregate estimate of potential economic benefits of the proposed rule, particularly since many impacts and benefits are site-specific, and there are more than 500 facilities that are in the scope of the proposed rule. However, to the extent that the impacts and benefits associated with a specific case study facility are similar to other facilities in similar environments, results can be extrapolated to other, similar sites. EPA used this approach to estimate the potential national benefits of the proposed rule.

C1-2 What Sites were Chosen and Why

The case studies were designed to capture some of the site-specific aspects of ecological and economic impacts as well as to develop information that could be extrapolated to other, similar sites to estimate national benefits. Site-specific information is critical in predicting impacts and potential benefits of the proposed rule, since existing studies demonstrate that impacts and benefits are highly variable across facilities and environmental settings. Even similar facilities on the same waterbody can have very different impacts depending on the aquatic ecosystem in the vicinity of the facility.

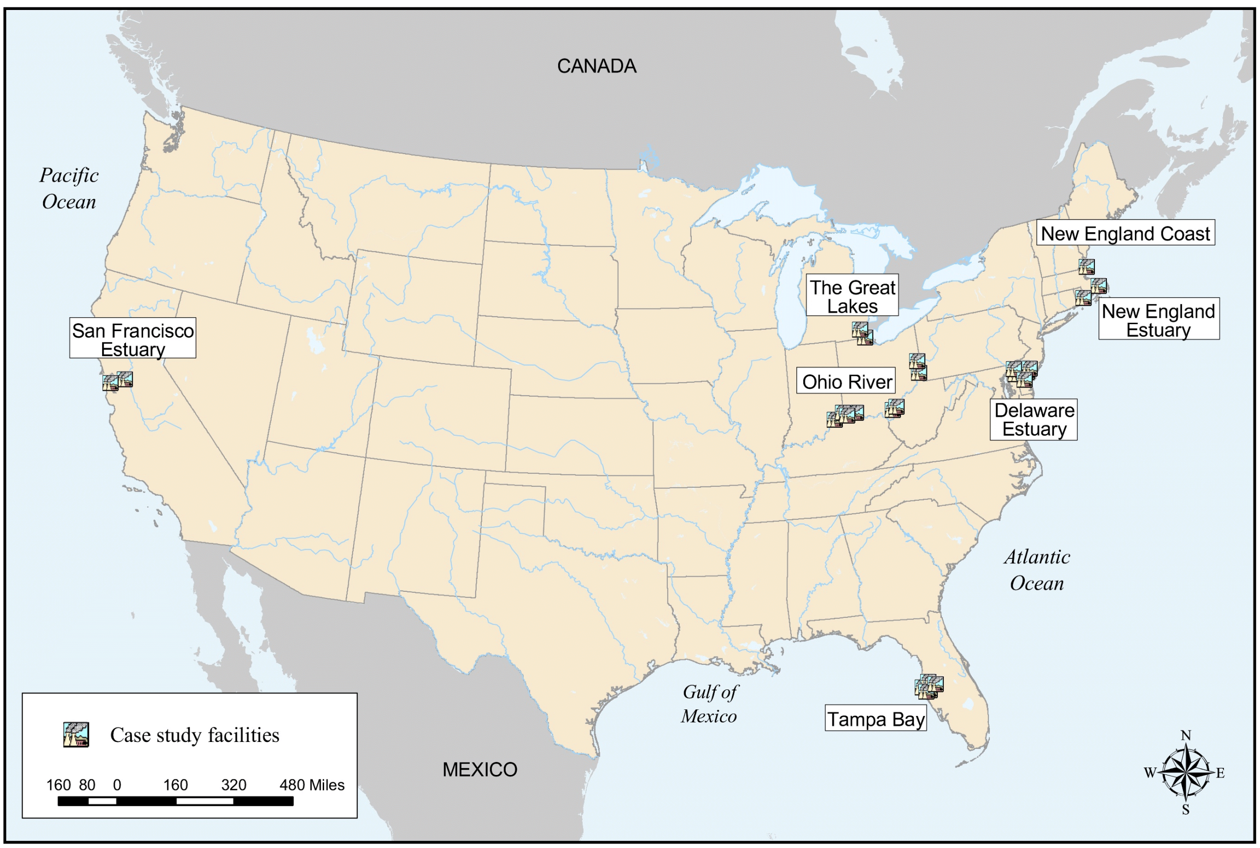
EPA selected case studies to represent a range of intake characteristics and environmental conditions throughout the United States. Important intake-specific characteristics relating to location, design, construction, and capacity include:

- Cooling water intake structure (CWIS) size and scale of operation (e.g., flow volume and velocity);
- CWIS and/or operational practices in place (if any) for impingement and entrainment(I&E) reduction at baseline (i.e., absent any new regulations);
- CWIS intake location in relation to local zones of ecological activity and significance (e.g., depth and orientation of the intake point, and its distance from shore); and
- CWIS flow volumes in relation to the size of the impacted waterbody.

Environmental factors that influence the magnitude of impacts and the potential benefits of reducing impacts include the types of waterbodies impacted, the aquatic species that are affected in those waterbodies, and the people who use and/or value the status of the water resources and aquatic ecosystems affected. The most important site-specific environmental factors are:

- The aquatic species present near a facility;
- The ages and life stages of the aquatic species present near the intakes;
- The timing and duration of species' exposure to the intakes;
- The ecological value of the impacted species in the context of the aquatic ecosystem;
- Whether any of the impacted species are threatened, endangered, or otherwise of special concern and status (e.g., depleted commercial stocks); and
- Local ambient water quality issues that may also affect the fisheries and their uses.

Figure C1-1: Location of Case Study Facilities



Source: U.S. EPA analysis, 2002.

The case study sites used for extrapolation are considered representative of the majority of steam electric generators in the United States. The map in Figure C1-1 indicates the locations of the case study facilities in relation to other facilities nationwide.

C1-3 Steps Taken in the Case Studies

Each case study was a comprehensive analysis of historical ecological impacts, potential reductions in these impacts resulting from the proposed rule, and the anticipated economic benefits of reducing impacts. Data gathering and analytical steps are described in detail in Chapter A5 of Part A of the Case Study Document and summarized below in Figure C1-2. The major steps were as follows.

- EPA compiled any economic, technical, and biological data available from previous § 316(b) studies and from results of EPA's survey of the industry for the § 316(b) rulemaking.

- This information was supplemented as needed by data in the scientific literature and government reports on the environmental settings and socioeconomic characteristics of the case study sites.

- EPA compiled life history data from local fishery surveys, facility monitoring, and the scientific literature for all species identified as vulnerable to I&E based on previous intake or waterbody monitoring. This information was used to implement biological models to express annual counts of impinged and entrained organisms as numbers of age 1 equivalents, pounds of fishery yield, and production foregone, as described in Chapter A5 of Part A of the Case Study Document.

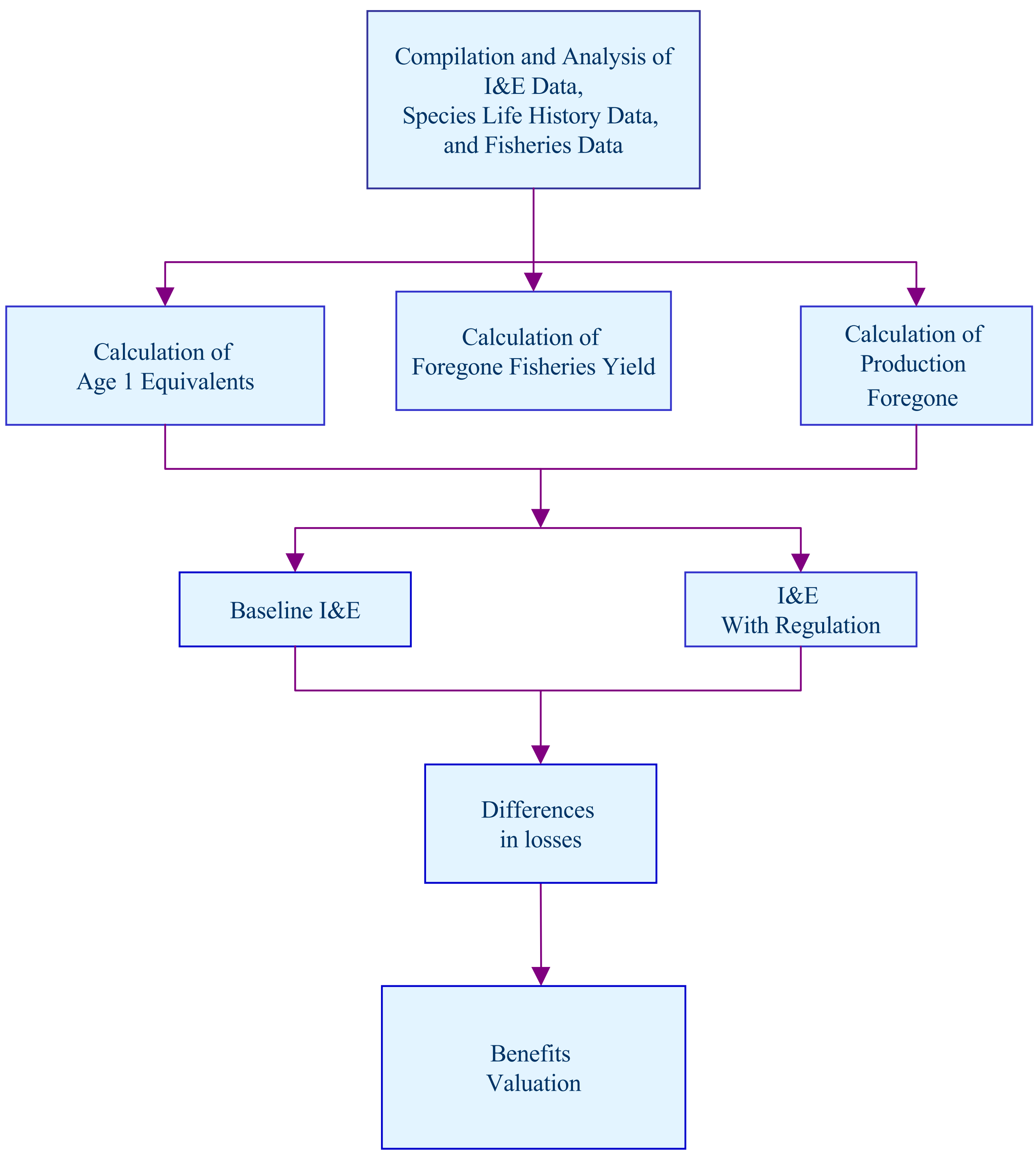
- Once historical I&E losses were quantified, EPA estimated potential reductions in I&E with the proposed rule, and estimated human use and nonuse benefits expected to result from the predicted reductions in I&E.

C1-4 Summary of Case Study Analyses

Table C1-1 summarizes the analyses conducted in the different case studies. Three studies (Delaware Estuary, Tampa Bay, and Ohio River) evaluated multiple CWIS within a single waterbody to develop an indication of potential cumulative impacts at the watershed scale. One study (San Francisco Estuary) examined impacts to threatened and endangered species and the potential economic benefits associated with protecting rare species. Several studies focused on discrete technology or operational alternatives such as once-through versus closed-cycle cooling (Brayton Point), offshore versus shoreline intake locations (Pilgrim and Seabrook), and use of a barrier net to reduce impingement (J.R. Whiting).

All studies applied benefits transfer techniques to estimate the economic value of losses to commercial and recreational fisheries, but several studies also applied other standard, well-accepted economic techniques that are new to the analysis of § 316(b) I&E losses to capture other economic values, including societal revealed preference techniques (San Francisco Bay/Delta), a random utility model (RUM) of recreational behavior (Delaware Estuary, Ohio River, and Tampa Bay) and habitat-based replacement cost (HRC) analysis (J.R. Whiting, Monroe, Brayton Point, and Pilgrim). The RUM approach evaluates changes in consumer valuation of water resources expected to result from reductions in I&E-related fish losses. The HRC technique assigns economic value to I&E losses based on the combined costs of implementing restoration actions to produce the organisms that were lost, administering the programs, and monitoring the production resulting from restoration actions.

Figure C1-2: Steps in § 316(b) Case Study Data Gathering and Analysis



Source: U.S. EPA analysis, 2002.

<table>
<tr><th colspan="2">Table C1-1: Case Study Sites</th></tr>
<tr><th>Facilities Evaluated</th><th>Type of Study</th></tr>
<tr><td colspan="2">CS-1: Delaware Estuary Watershed Study</td></tr>
<tr><td>Salem
Hope Creek
Deepwater
Edgemoor</td><td>Mid-Atlantic Estuary
Watershed-Scale Study
▸ Cumulative Impacts
RUM Analysis
Electricity Region: MACC, Mid-Atlantic Area Council</td></tr>
<tr><td colspan="2">CS-2: Tampa Bay Watershed Study</td></tr>
<tr><td>PL Barlow
FJ Gannon
Hookers Point
Manatee
Big Bend</td><td>Southern Gulf Coast Estuary
Watershed-Scale Study
▸ Cumulative Impacts
RUM Analysis
Electricity Region: FRCC, Florida Reliability Coordinating Council</td></tr>
<tr><td colspan="2">CS.-3: Ohio River Watershed Study</td></tr>
<tr><td>W.H. Sammis, OH
Cardinal, OH
Kyger Creek, OH
Tanners Creek, IN
Clifty Creek, IN
P. Sporn, WV
Kammer, WV</td><td>Large River
Watershed-Scale Study
▸ Cumulative Impacts
RUM Analysis
Electricity Region: ECAR, East Central Area Reliability Coordination Agreement</td></tr>
<tr><td colspan="2">CS-4: San Francisco Bay / Delta</td></tr>
<tr><td>Pittsburg
Contra Costa</td><td>Threatened and Endangered Species
Western Estuary
Societal Revealed Preference Analysis
Electricity Region: WSCC, Western Systems Coordinating Council</td></tr>
<tr><td colspan="2">CS-5: New England Estuary (Mount Hope Bay)</td></tr>
<tr><td>Brayton Point</td><td>New England Estuary
Fish Population Decline
▸ Once Through v. Wet Cooling
Habitat-based Replacement Cost Analysis
Electricity Region: NPCC, Northeast Power Coordinating Council</td></tr>
<tr><td colspan="2">CS-6: New England Coast</td></tr>
<tr><td>Seabrook
Pilgrim</td><td>Intake Location Study
▸ Off-Shore v. Shoreline
Habitat-based Replacement Cost Analysis of Pilgrim
Electricity Region: NPCC, Northeast Power Coordinating Council</td></tr>
<tr><td colspan="2">CS-7: Great Lakes</td></tr>
<tr><td>JR Whiting</td><td>Technology Study
▸ Impingement Deterrent Net
Habitat-based Replacement Cost Analysis
Electricity Region: ECAR, East Central Area Reliability Coordination Agreement</td></tr>
<tr><td colspan="2">CS-8: Large River Tributary to Great Lakes</td></tr>
<tr><td>Monroe</td><td>Intake Flow Study
▸ Intake Flow exceeds the waterbody flow most of year
Habitat-based Replacement Cost Analysis
Electricity Region: ECAR, East Central Area Reliability Coordination Agreement</td></tr>
</table>

Source: U.S. EPA analysis, 2002.

C1-5 Data Uncertainties Leading to Underestimates of Case Study Impacts and Benefits

EPA's estimates of case study impacts and the potential economic benefits of the proposed rule are subject to considerable uncertainties. As a result, the Agency's estimated benefits could be either over- or underestimated. However, because of the many factors omitted from the analysis (typically because of data limitations), and the manner in which several key uncertainties were addressed, EPA believes that its analysis is likely to lead to potentially significant underestimates of baseline losses in most cases, and therefore underestimates of regulatory benefits. These factors are discussed in the Case Study Document and summarized below.

C1-5.1 Data Limitations

EPA's analysis is based on facility-provided biological monitoring data. These facility-furnished data typically focus on a subset of the fish species impacted by I&E, resulting in an underestimate of the total magnitude of losses.

Industry biological studies often lack a consistent method for monitoring I&E. Thus, there are often substantial uncertainties and potential biases in the I&E estimates. Comparison of results between studies is therefore very difficult and sometimes impossible, even among facilities that impinge and entrain the same species.

The facility-derived biological monitoring data often pertain to conditions existing many years ago (e.g., the available biological monitoring often was conducted by the facilities 20 or more years ago, before activities under the Clean Water Act had improved aquatic conditions). In those locations where water quality was relatively degraded at the time of monitoring relative to current conditions, the numbers and diversity of fish are likely to have been depressed during the monitoring period, resulting in low I&E. In most of the nation's waters, current water quality and fishery levels have improved, so that current I&E losses are likely to be greater than available estimates for depressed populations.

C1-5.2 Estimated Technology Effectiveness

I&E benefits are dependent in the technologies that are installed, the proper use of those technologies, the degree to which the technologies are maintained and repaired, and the commitment of the facility to optimizing the technologies for their given location. Potential latent mortality rates are unknown for most technologies. The only technology effectiveness that is certain is reductions in I&E with cooling towers. If the towers are running, I&E reductions can be estimated with some certainty. EPA's analyses assumes that installed technologies will be operate at the maximum efficiency assumed by EPA in its estimates of technology effectiveness. To the degree that this is not the case, benefits could be lower.

C1-5.3 Potential Cumulative Impacts

I&E impacts often have cumulative impacts that are usually not considered. Cumulative impacts refer to the temporal and spatial accumulation of changes in ecosystems that can be additive or interactive. Cumulative impacts can result from the effects of multiple facilities located within the same waterbody and from individually minor but collectively significant I&E impacts taking place over a period or time. Because of time and funding constraints, EPA was able to estimate potential cumulative impacts for only three of its case studies (Delaware Estuary, Ohio River, Tampa Bay).

Relatively low estimates of I&E impacts may reflect a situation where cumulative I&E impacts (and other stresses) have appreciably reduced fishery populations so that there are fewer organisms present in intake flows.

In many locations (especially estuary and coastal waters), many fish species migrate long distances. As such, these species are often subject to I&E risks from a large number cooling water intake structures. EPA's analyses reflect the impacts of a limited set of facilities on any given fishery, whereas many of these fish are subjected to I&E at a greater number of cooling water intake structures than are included in the boundaries of the Agency's case studies.

C1-5.4 Recreational Benefits

Recreational values were underestimated for a number of reasons. These include:

- The proportion of I&E losses of fishery species that were valued as lost recreational catch was determined from stock-specific fishing mortality rates, which indicate the fraction of a stock that is harvested. Because fishing mortality rates are typically less than 20 percent, a large proportion of the losses of fishery species was not valued in the benefits transfer and RUM analyses.
- Only selected species were evaluated because I&E or valuation data were limited.
- In applying benefits transfer to value the benefits of improved recreational angling, the Agency assigned a monetary benefit to only the increases in consumer surplus for the baseline number of fishing days. Changes in participation (except where the RUM is estimated) are not considered. Thus, benefits will be understated if participation increases in response to increased availability of fishery species as a result of reduced I&E. This approach omits the portion of recreational fishing benefits that arise when improved conditions lead to higher levels of participation. Empirical evidence suggests that the omission of increased angling days can lead to an underestimate of total recreational fishing benefits. Where EPA has been able to apply its RUM analyses, the recreational angling benefits are more indicative of the full range of beneficial angling outcomes.

C1-5.5 Secondary (indirect) Economic Impacts

Secondary impacts are not calculated (effects on marinas, bait sales, property values, and so forth are not included, even though they may be significant and applicable on a regional scale).

C1–5.6 Commercial Benefits

Commercial benefits were underestimated for the following reasons:

- The proportion of I&E losses of fishery species that were valued as lost commercial catch was determined from stock-specific fishing mortality rates, which indicate the fraction of a stock that is harvested. Because fishing mortality rates are typically less than 20 percent, a large proportion of the losses of fishery species was not valued in the benefits transfer analyses.
- In most cases, invertebrate species (e.g, lobsters, mussels, crabs, shrimp) were not included because of a lack of I&E data and/or life history information.
- I&E impacts and associated reductions in fishery yields are probably understated even for those species EPA could evaluate because of a lack of monitoring data to capture population variability and cumulative I&E impacts over time.
- Current fishing mortality rates (and resulting estimates of yield) often reflect depleted fisheries, not what the fisheries should or could be if not adversely impacted by I&E and other stressors. As such, yield estimates may be artificially low because of significantly curtailed recreational and/or commercial catch of key species impinged and entrained (e.g., winter flounder in Mount Hope Bay).

C1-5.7 Forage Species

Benefits for forage species are underestimated for many reasons. These reasons include:

- Forage species often make up the predominant share of losses due to I&E. However, I&E losses of forage species are usually not known because many facility studies focus only on commercial and recreational fishery species.
- Even when forage species are included in loss estimates, the monetary value assigned to forage species is likely to be understated because the full ecological value of the species as part of the food web is not considered.

- Forage losses are often valued at only a fraction of their potential full value because of partial "replacement" cost (even if feasible to replace).
- The value of production foregone includes only the value of added biomass to landed recreational and commercial species is considered. The inherent value of forage species is not included in the benefits estimates.
- In one valuation approach EPA applied to forage species, only a small share of these losses is valued — namely, the contribution of the forage species to the increased biomass of landed recreational and commercial species.
- This does not apply to benefits derived by the habitat-based replacement cost approach, which provides a more comprehensive indication of the benefits of reducing I&E on all species, including forage fish. EPA has applied this approach to a limited number of settings, and in those settings the findings suggest benefits appreciably greater than derived from the more conventional, partial benefits approaches applied by the Agency.

C1-5.8 Nonuse Benefits

EPA's benefit estimate of nonuse benefits is understated using the 50 percent rule because the recreational values used are likely to be understated. The 50 percent rule itself is conservative (e.g., it only reflects nonuse component of total value to recreational users; it does not reflect any nonuse benefits to recreational nonusers). In addition, the rule does not capture impacts on threatened and endangered species.

C1-5.9 Incidental Benefits

EPA's estimates of benefits are underestimates for some options because EPA has not accounted for thermal impact reductions, which will occur in all options where once-through facilities are replaced with recirculating water regimes (e.g., sites going to cooling towers).

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Appendix to Chapter C1

Introduction

In developing the national benefits estimates for *Chapter C4: Benefits*, EPA used the sample weights estimated during the sampling design for the 316(b) questionnaires. These weights were used to generate benefits estimates for all 550 in-scope facilities based on the baseline losses for 539 in-scope facilities for which questionnaire data was available. This appendix presents the unweighted benefits estimates in the tables below.

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The reported percent reduction in baseline losses for each facility reflects EPA's assessment of (1) regulatory baseline conditions at the facility (i.e., current practices and technologies in place), and (2) the percent reductions in impingement and entrainment that EPA estimated would be achieved at each facility that the Agency believes would be adopted under each regulatory option.

C1-A.1 Options with Benefit Estimates

EPA estimated benefits for the following six options. These options include:

- **Option 1:** Track I of the waterbody /capacity-based option;
- **Option 2:** Track I and II of the waterbody /capacity-based option;
- **Option 3:** (the Agency's proposed rule), impingement and entrainment controls everywhere with exceptions for low-flow facilities on lakes and rivers;
- **Option 3a:** impingement and entrainment controls everywhere with no exceptions;
- **Option 4:** requires all Phase II existing facilities to reduce intake capacity commensurate with the use of closed-cycle, recirculating cooling systems; and
- **Option 5:** requires that all Phase II existing facilities reduce intake capacity commensurate with the use of dry cooling systems.
- **Option 6:** similar to Option1, but requires reduction commensurate with the use of closed-cycle, recirculating systems for all facilities on estuaries, tidal rivers, and oceans

National estimates including weights can be found in *Chapter C4: Benefits*, and a complete description of the options detailed in the following tables can be found in Part A, Chapter A1 of this document.

C1-A.2 Impingement Reductions and Benefits

Table C1-A-1 presents the percentage reductions in impingement that are expected to occur under the six options listed above and Table C1-A-2 presents the benefit value associated with those reductions.

Table C1-A-1: Unweighted Impingement Reductions for Various Options - By Reduction Level

Waterbody Type	Number of In-Scope Facilities	Baseline Impingement Loss	Percentage Reductions						
			Option 1	Option 2	Option 3	Option 3a	Option 4	Option 5	Option 6
Estuary - Non-Gulf	78	$52,463	64.5%	47.5%	33.2%	25.0%	40.9%	97.5%	84.2%
Estuary - Gulf	30	$4,097	63.2%	45.9%	26.5%	30.0%	45.3%	96.7%	79.4%
Freshwater	393	$40,417	47.3%	47.3%	47.3%	46.7%	59.0%	98.0%	47.8%
Great Lake	16	$31,506	80.0%	80.0%	80.0%	77.0%	88.6%	96.3%	79.4%
Ocean	22	$14,174	73.2%	59.0%	50.6%	47.2%	59.7%	88.8%	78.9%
Total	**539**	**$142,656**							

Source: U.S. EPA analysis, 2002.

Table C1-A-2: Unweighted Impingement Benefits for Various Options - By Benefit Level (in thousands, $2001)

Waterbody Type	Number of In-Scope Facilities	Baseline Impingement Loss	Benefits						
			Option 1	Option 2	Option 3	Option 3a	Option 4	Option 5	Option 6
Estuary - Non-Gulf	78	$52,463	$33,834	$24,909	$17,418	$13,125	$21,470	$51,141	$44,148
Estuary - Gulf	30	$4,097	$2,588	$1,882	$1,087	$1,230	$1,856	$3,961	$3,253
Freshwater	393	$40,417	$19,117	$19,117	$19,117	$18,855	$23,828	$39,605	$19,304
Great Lake	16	$31,506	$25,205	$25,205	$25,205	$24,260	$27,900	$30,326	$25,018
Ocean	22	$14,174	$10,369	$8,359	$7,171	$6,686	$8,467	$12,585	$11,182
Total	**539**	**$142,656**	**$91,113**	**$79,472**	**$69,998**	**$64,156**	**$83,520**	**$137,619**	**$102,905**

Source: U.S. EPA analysis, 2002.

C1-A.3 Entrainment Reductions and Benefits

Table C1-A-3 presents the percentage reductions in impingement that are expected to occur under the six options listed above and Table C1-A-4 presents the benefit value associated with those reductions.

Table C1-A-3: Unweighted Entrainment Benefits for Various Options - By Reduction Level

Waterbody Type	Number of In-Scope Facilities	Baseline Entrainment Loss	Entrainment Percentage Reductions						
			Option 1	Option 2	Option 3	Option 3a	Option 4	Option 5	Option 6
Estuary - Non-Gulf	78	$876,002	67.2%	59.1%	48.5%	47.1%	79.2%	97.5%	78.0%
Estuary - Gulf	30	$103,593	66.9%	52.3%	47.0%	47.8%	79.3%	96.7%	78.3%
Freshwater	393	$95,660	12.4%	12.4%	12.4%	44.2%	72.7%	98.0%	9.8%
Great Lake	16	$43,448	57.8%	57.8%	57.8%	57.8%	88.6%	96.3%	57.3%
Ocean	22	$259,656	74.2%	58.9%	45.0%	45.0%	74.1%	88.8%	74.1%
Total	**539**	**$1,378,359**							

Source: U.S. EPA analysis, 2002.

Table C1-A-4: Unweighted Entrainment Benefits for Various Options - By Benefit Level (in thousands, $2001)

Waterbody Type	Number of In-Scope Facilities	Baseline Entrainment Loss	Entrainment Benefit						
			Option 1	Option 2	Option 3	Option 3a	Option 4	Option 5	Option 6
Estuary - NonGulf	78	$876,002	$588,552	$517,960	$424,708	$412,696	$693,420	$853,940	$683,494
Estuary - Gulf	30	$103,593	$69,324	$54,206	$48,645	$49,508	$82,186	$100,175	$81,160
Freshwater	393	$95,660	$11,883	$11,883	$11,883	$42,277	$69,575	$93,738	$9,410
Great Lake	16	$43,448	$25,092	$25,092	$25,092	$25,092	$38,474	$41,820	$24,899
Ocean	22	$259,656	$192,560	$152,869	$116,796	$116,796	$192,296	$230,553	$192,296
Total	**539**	**$1,378,359**	**$887,410**	**$762,010**	**$627,123**	**$646,368**	**$1,075,951**	**$1,320,227**	**$991,259**

Source: U.S. EPA analysis, 2002.

C1-A.4 Benefits Associated with Various Percentage Reductions

Table C1-A-5 presents the national benefits that would occur with various percentage reductions.

Table C1-A-5: Summary of Unweighted Potential Benefits Associated with Various Impingement and Entrainment Reduction Levels (All 539 In-Scope Facilities)

Reduction Level	Benefits (in thousands, $2001)	
	Impingement	Entrainment
10%	$14,266	$137,836
20%	$28,531	$275,672
30%	$42,797	$413,508
40%	$57,063	$551,344
50%	$71,328	$689,180
60%	$85,594	$827,016
70%	$99,859	$964,851
80%	$114,125	$1,102,687
90%	$128,391	$1,240,523

Source: U.S. EPA analysis, 2002.

C1-A.5 Benefits Associated with the Proposed Option

Table C1-A-6 presents the benefits that would occur with various percentage reductions

Table C1-A-6: Summary of Unweighted Potential Benefits from Impingement and Entrainment Controls Associated with the Proposed Rule (Option 3)

Waterbody Type	Number of In-Scope Facilities	Benefits (in thousands, $2001)	
		Impingement	Entrainment
Estuary - NonGulf	78	$17,418	$424,708
Estuary - Gulf	30	$1,087	$48,645
Freshwater	393	$19,117	$11,883
Great Lake	16	$25,205	$25,092
Ocean	22	$7,171	$116,796
Total	**539**	**$69,998**	**$627,123**

Source: U.S. EPA analysis, 2002.

Under today's proposal, facilities can choose the Site-Specific Determination of Best Technology Available in § 125.94(a) in which a facility can demonstrate to the Director that the cost of compliance with the applicable performance standards in § 125.94(b) would be significantly greater than the costs considered by EPA when establishing these performance standards, or the costs would be significantly greater than the benefits of complying with these performance standards. EPA expects that if facilities were to choose this approach, then the overall national benefits of this rule will decrease markedly. This is because under this approach facilities would choose the lowest cost technologies possible and not necessarily the most effective technologies to reduce impingement and entrainment at the facility. See *Chapter C4: Benefits* for additional information on the certainty of each of the other options.