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Technical Comments on the Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System — Proposed Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities

Notice of Data Availability Related to Impingement Mortality Control Requirements (Federal Register V77, N112; June 11, 2012) and EPA's Stated Preference Survey (Federal Register V77, N113; June 12, 2012)

2012 TECHNICAL REPORT

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EPRI Project Managers
D. Dixon
D. Bailey

ELECTRIC POWER RESEARCH INSTITUTE

3420 Hillview Avenue
Palo Alto, CA 94304-1338
USA

PO Box 10412
Palo Alto, CA 94303-0813
USA

800.313.3774
650.855.2121

askepri@epri.com

www.epri.com

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Veritas Economic Consulting, LLC

NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

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Alden Research Laboratory Inc.
30 Shrewsbury Street
Holden, MA

Principal Investigators
J. Black
R. Tuttle

ASA Analysis & Communication Inc.
5 Fairlawn Drive, Suite 205
PO Box 57
Washingtonville, NY 10992

Principal Investigator
W. Dey

Veritas Economic Consulting, LLC
1851 Evans Road
Cary, NC 27513

Principal Investigators
M. Bingham
J. Kinnell
Z. Li
A. Miedema
D. Hamilton
T. Bingham

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Product Description

This report presents the Electric Power Research Institute's (EPRI's) technical comments on the U.S. Environmental Protection Agency's (EPA's) June 11, 2012 Notice of Data Availability (NODA) Related to Impingement Mortality Control Requirements and its June 12, 2012 NODA Related to EPA's Stated Preference Survey. These NODAs provide additional information to support EPA's effort to develop a final Rule that implements the requirements of the Clean Water Act's §316(b) for existing facilities with cooling water intake structures (CWIS).

Background

Section 316(b) requires that the location, design, construction, and capacity of CWIS reflect the best technology available for minimizing adverse environmental impact. EPA proposed a revised Existing Facility Rule in April 2011 (76 FR 22174, April 20, 2011). The proposed Rule presents standards and reporting requirements for reducing mortality resulting from impingement and entrainment of fish and shellfish. As a result of comments received from industry, environmental groups, state agencies, and the public, EPA has acquired new data and is considering new approaches related to impingement mortality control requirements as presented in the June 11 NODA. This NODA describes the new data that EPA has received and the new approaches and issues it is considering and has requested public comment on them. In the June 12 NODA, EPA provides preliminary information on a stated preference survey that it conducted following publication of the proposed rule. Stated preference surveys have been used to try to determine the economic value of goods or services by modeling responses to hypothetical choices. EPA solicits comments on the preliminary results of its survey and on what role, if any, the survey should play in EPA's assessment of the benefits of regulatory options for the final rule, pending completion of the survey and external peer review.

Objective

EPRI's objective is to provide technical comments on the information in each NODA based on the best available scientific and engineering data. EPRI's technical comments discuss the potential consequences, positive and negative, if components of the information in each NODA are included in the final Clean Water Act §316(b) Rule for Existing Facilities.

Approach

EPRI conducts research with the goal of identifying and compiling the best available scientific and engineering data on CWIS and their impacts on aquatic communities. This positions EPRI to respond in depth to each of the alternatives and issues that EPA raises in the NODAs. Much of the technical information provided in this report results from EPRI's Fish Protection Research Program, which has been ongoing since the 1980s. EPRI's R&D has focused on developing fish protection technologies and assessing their performance, developing methods and supporting data to conduct impingement and entrainment sampling, developing tools and information to support assessing the impacts of CWIS operation on aquatic life, conducting economic impact analyses, assessing the national magnitude of impingement and entrainment at power plants, and maintaining a technical library on all research results developed by EPRI, other research organizations, state and federal agencies, and the industry. EPRI does not advocate or lobby for any specific approach; however, we note the potential technical, environmental, and economic consequences of regulatory approaches that may be implemented.

Results

EPRI's review of each NODA has the following summary results:

- Information is submitted relative to the impingement mortality requirements including potential problems with biological performance monitoring, potential costs for the 0.5 fps approach velocity compliance approach, performance of fish-friendly traveling water screens, improved computational methods to obtain credit for existing impingement mortality reduction technologies and other technical information on the compliance approaches EPA is considering.
- The EPA Stated Preference Survey is flawed in many aspects and significant additional effort would be required for it to provide sound technical information to support public policy.

Applications, Value, and Use

EPRI's intent in submitting the comments described here is that the EPA will consider them in developing a final Clean Water Act §316(b) Rule for Existing Facilities that is based on the best available scientific, economic, and engineering data, is protective of the environment, and is in the best interest of the U.S. public.

Keywords

Clean Water Act Section 316(b)
Fisheries
Impingement and Entrainment
Nonuse economic benefits

Executive Summary

EPRI has reviewed the U.S. Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System – Cooling Water Intake Structures at Existing Facilities; Notice of Data Availability (NODA) Related to Impingement Mortality Control Requirements as released in the Federal Register, June 11, 2102 (V77, N112, 34315-34326) and the EPA supporting technical documents available on its website and in the public docket. EPRI has also reviewed the NODA Related to EPA's Stated Preference Survey as released June 12, 2102 (V77, N113) and its supporting documents. EPRI's detailed comments are presented in this report. Our key findings as a result of our review are as follows:

- EPRI's research on fish protection at cooling water intake structures (CWIS) has found that site-specific factors, including CWIS design and operation, water body type, local hydraulics, fish and shellfish species, and waterborne debris influence the selection of technologies for reducing impingement and entrainment of fish and shellfish in an integrated manner. EPRI has not identified an individual technology that can address both impingement and entrainment in a cost-effective manner at all U.S. power plants.
- The proposed biological performance criteria, even if EPA expands its model database for fish protection–modified traveling water screens and calculates new performance criteria, will likely result in significant compliance problems because there are many confounding factors outside the control of the screen operator that will compromise impingement survival and cause violations. These factors include random experimental error, lack of experimental control, water quality issues, and the health of the impinged fish. EPRI notes that EPA is attempting to apply the regulatory model it has long used for chemical substances, whose behavior is predictable based on the laws of physics, to biological organisms, whose behavior is volitional in accordance with cues received from their internal and external environment. This behavior, at least in the field, is unpredictable.

  Fish protection–modified traveling water screens, based on data collected in laboratory simulations of actual field operation where the confounding factors that occur in the field can be controlled, have a very high level of performance for nonfragile species equaling and, in many cases, exceeding the annual and monthly impingement survival performance criteria that EPA presented in the proposed Rule.

- Optimal site-specific performance of "fish protection–modified" traveling water screens and fish returns can be achieved through design and operation specifications and post-installation visual observation and adjustment rather than post-installation biological performance studies. Conducting biological survival studies to "optimize" screen and fish return performance will have the same problems that will occur in assessing performance relative to biological performance criteria—many confounding variables will preclude the ability to obtain meaningful results. As EPRI notes, because impingement is episodic, zero and low impingement numbers will be very common, and it will be difficult to obtain a sufficient sample size to ascertain statistical differences between operational practices as well as to overcome the confounding variables that will further compromise results. Use of hatchery fish, if approved by local permit authorities and resource agencies, may overcome this sample size problem; however, the value and effectiveness of these studies for optimizing screen and fish return performance is questionable. Design specifications for fish protection–modified screens include: smooth woven, molded polymer, and drilled plastic mesh; continuous screen rotation, "Fletcher-modified" fish buckets for low turbulence; low-pressure wash to stimulate fish to flop off the screen and reduce friction (not physically move them); properly oriented spray nozzles so as not to wash fish from the buckets if high pressure is on the ascending screen face; a flap seal to ensure that fish enter the return buckets; and a fish return system designed and installed according to the specifications of the American Society of Civil Engineers (ASCE 1982).
- Although the performance database for molded polymer, rotary, and vacuum screens is limited, available information indicates similar performance to traditional "Ristroph-modified" traveling water band screens. Furthermore, if these new screens incorporate the "Ristroph"-related modifications, EPRI estimates, based on engineering analysis of the fish collection and transfer process, that they should perform as well as traditional band screens modified with fish protection and a fish return system.
- In general, closed-cycle recirculating systems operate at the highest possible cycles of concentration (COC) since they reduce the cost of energy (operation of makeup water and blowdown pumps) and the use of cooling tower chemicals. On a site-specific basis, however, there may be other considerations, depending on other uses of the recirculated water at the facility.

- Closed-cycle cooling recirculating systems include facilities with cooling towers or cooling lakes or ponds that recirculate the cooling water that passes through the condensers until there is a need to replace water loss from (1) evaporation, (2) consumptive water use to meet other facility water needs (at some facilities), and/or (3) blowdown to control the buildup of solids in the recirculated water. "Helper" cooling towers that are used to comply with thermal mixing zone standards are not closed-cycle "recirculating" systems nor are facilities that use a closed-cycle operating mode during only a portion of a calendar year.
- There are a number of technical factors that warrant consideration relative to a facility's ability to "minimize" makeup water flow. These factors include:
  - Use of cooling tower makeup water – For coal-fired generating units, numerous facility water needs can be met with closed-cycle cooling water, depending on the level of integration of such water needs into the recirculating water system. Although separating these water uses from the recirculating system could be done to minimize use of makeup water, withdrawing additional water for flue gas desulphurization, ash handling, or other service water needs would still be necessary, resulting in no net change in the overall facility's water withdrawal relative to impingement mortality and entrainment.
  - Reduced heat transfer and corrosion – Increasing the COC to reduce intake flow can cause scaling and fouling of the condenser. This can result in reduced heat transfer and generating efficiency and potentially cause increased corrosion of materials, depending on the nature of the solids present.
- EPRI has identified three technical considerations relative to the computational methodology proposed in the NODA. They include:
  - Use of an arithmetic average – The use of the arithmetic average may be misleading in many cases by either overestimating or underestimating the magnitude of annual impingement. This inaccuracy can occur as a result of a high level of impingement mortality in one month followed by a low level of impingement mortality in the next month (examples are provided).
  - Adjustment for existing impingement mortality technologies – Use of adjustments in the form of absolute numbers rather than proportional adjustments, as proposed in the NODA, can result in either over- or underestimation of impingement mortality. Further, the proposal to treat adjustments for existing technology as fixed rather than

relative can become an issue in cases where interannual variability is large. If the adjustment is estimated in a successful spawning year (which consequently results in high impingement) and then is subsequently applied in a year of low impingement, the result will be an underestimation of impingement mortality.

    - Low monthly impingement and false positives – Currently, the proposed methodology does not account for the fact that low monthly impingement might result in a high probability of exceeding the 31% monthly limit by chance even when the technology is performing at a level that is better than the monthly limit.

- Reverse flow studies at four West Coast facilities have indicated high levels of impingement mortality reduction performance. The most recent study demonstrated a reduction in excess of 95% in total impingement mortality.

- Repeating impingement mortality reduction studies can result in the loss of large numbers of fish. A California facility conducting studies to quantify the impingement mortality reduction of an offshore velocity cap was ordered by the permitting authority to cease the study due to the large number of fish lost while operating without the technology. EPA may want to consider the potential negative impact of such studies once a facility has made a demonstration in the absence of significant changes in the technology's operation or species of concern.

- In the absence of assessing the occurrence of adverse environmental impact (AEI) with the assessment tools that are available, establishing a low or *de minimis* impingement and entrapment level is a policy decision. EPRI also notes, based on our review of the technical literature regarding the occurrence of AEI caused by CWIS and our finding that the evidence is extremely limited, that evidence supports EPA's statement that some "facilities [with low impingement numbers] are not likely having an adverse effect on aquatic life." EPRI is prepared, if EPA requests, to analyze the data in our national database of power plant impingement and entrainment information to assist EPA in identifying *de minimis* impingement values.

EPRI's review indicates that the Stated Preference Survey results presented in the second NODA are not reliable estimates of survey respondents' willingness to pay (WTP) for reducing impingement and entrainment (I&E) impacts that can be extrapolated to the unsurveyed population. Key findings arising from EPRI's review of this NODA include the following:

- EPRI used the survey data to develop preliminary, independent econometric models using an approach similar to that presented in the NODA as well as alternative methods. EPRI reproduced the models presented in the NODA and also produced new models with more variables that are significant (for example, 74% of the variables are significant in EPRI's new models compared to 46% in the NODA models). EPRI's new models also have greater overall significance than the NODA models. Additionally, EPRI's new models have lower estimates of the amount that survey respondents are willing to pay to reduce I&E impacts. They also indicate the existence of survey-induced bias toward the survey's hypothetical I&E regulations. The presence of this survey-induced bias raises questions regarding the validity and, therefore, the usefulness of the study's WTP estimates.

- The Stated Preference Survey's experimental design leads to overestimating survey respondents' WTP to reduce I&E impacts. The survey's experimental design is not adequate to evaluate the implications of important real-world regulatory outcomes on survey respondents' WTP. One common case is where there is a reduction in I&E, but no observable changes in fish populations or aquatic conditions. Other outcomes that may accompany I&E reductions include the negative environmental and social impacts that would occur at many facilities that retrofit with cooling towers. These outcomes cannot be controlled for in modeling the survey data, but they are likely to occur in real-world regulatory outcomes. This results in an upward bias (that is, overestimate) in the study's WTP estimates.
- There is substantial evidence that awareness of I&E impacts among the general public is quite low, suggesting that the Stated Preference Survey's results are not applicable to the great majority of U.S. residents. However, no efforts have been undertaken by EPA in this or other survey efforts to identify demographic groups who are aware that I&E occurs. That information is required for producing reliable extrapolations of survey results to the unsurveyed population.
- EPRI developed econometric models that combine the regional data EPA provided. These combined regional-data models indicate that there are demographic differences in both the WTP estimates and bias toward the survey's hypothetical I&E regulations. Some of these relationships can be identified with the existing survey data. However, as identified in these comments, the unsurveyed population has a very low awareness of I&E impacts. Given this low incidence of awareness, the Stated Preference Study's sample size and experimental design are inadequate to quantify the demographic differences in WTP estimates that are required to extrapolate the survey results to the unsampled population.
- The results from EPRI's modeling efforts also support using a more global public surveying and modeling design. As described in **EPRI's** previous comments (EPRI 2010b and 2011g), such a

design would force respondents to choose from multiple categories of goods based on their ability to pay (that is, use discretionary or re-allocated income for private or other public benefits such as health care, public safety, and education) and would not be overly focused on any single good such as reductions in I&E impacts.

- Overall, EPRI's review suggests that significant additional effort would be necessary for the Stated Preference Study to provide sound information to support public policy.

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Section 1: Introduction

The Electric Power Research Institute, Inc. (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States, and international participation extends to 40 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass. EPRI does not advocate any regulatory or policy action. This document presents the results of EPRI's review of the additional approaches EPA is considering related to impingement mortality control requirements that will have significant impacts on U.S. power plants.

The regulations being developed by the U.S. Environmental Protection Agency (EPA) under §316(b) of the Clean Water Act. Section 316(b) requires that the location, design, construction and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact. More than 1,500 industrial facilities use large volumes of cooling water from lakes, rivers, estuaries or oceans to cool their plants, including steam electric power plants, pulp and paper makers, chemical manufacturers, petroleum refiners, and manufacturers of primary metals like iron, steel and aluminum. In 1995, the EPA began a three-phased process to develop the rules related to §316(b). The final Phase I Rule, for new facilities, was published on 18 December 2001 (66 FR 65255) and was amended on 19 June 2003 (68 FR 36749). The final Phase II Rule, for existing electric generating facilities was published on 9 July 2004 (69 FR 41575). The Phase II Rule applied to existing facilities whose construction commenced prior to 17 January 2002 and that have cooling water intake structures with a design capacity greater than or equal to 50 million gallons per day (MGD), and use 25 % or more of the water withdrawn for cooling purposes. The Phase III rule, for smaller (<50 MGD) power plants and certain industrial facilities, was published 16 June 2006 (71 FR 35005).

EPA's regulations establishing requirements for cooling water intake structures (CWIS) at Phase II and III existing facilities were challenged by industry and environmental stakeholders. On judicial review, provisions were remanded to

EPA. In response to the decision, EPA suspended the Phase II rule on 9 July 2007 (72 FR 37107).

EPA proposed a revised Existing Facility Rule in April 2011 (76 FR 22174, April 20, 2011). The proposed Rule applies to all existing power generating facilities and existing manufacturing and industrial facilities that withdraw more than 2 million gallons per day (MGD) of water from waters of the U.S. and use at least twenty-five (25) percent of the water they withdraw exclusively for cooling purposes. The proposed rule constitutes EPA's response to the remand of the Phase II existing facility rule and the remand of the existing facilities portion of the Phase III rule. The proposed Rule presents standards for reducing mortality resulting from impingement and entrainment of fish and shellfish. EPA requested public review and comment on the proposed Rule and the supporting technical documents. EPRI's comments on the proposed Rule are contained in EPRI (2011a, Report 1019858).

Notice of Data Availability on Impingement Mortality-Related Requirements

On June 11, 2012, EPA released a Notice of Data Availability (NODA) on Impingement Mortality Related Requirements (FR 77, N112 34315). EPA received extensive comments on the April 2011 proposed existing facility Rule and this NODA makes these data available and discusses the relevance of these data to the analyses conducted by EPA. EPA solicits comment both on the information presented in this NODA and the record supporting this NODA. This NODA is intended to apprise the public of the new information, make this information available for public review and provide an opportunity to comment on the new information that the EPA will consider in making its decisions for the final rule.

In this NODA EPA reports that several industry stakeholders stated that, despite EPA's best intentions, the proposed rule applied a one-size-fits-all approach for impingement mortality (IM). While all of the suggested changes to the EPA proposal seek to provide additional flexibility through a variety of approaches, most of the comments had several elements in common:

- Commenter's suggested defining modified traveling screens as a pre-approved technology or otherwise streamlining the NPDES process for facilities using the candidate technology upon which BTA is based. Thus, EPA would designate certain technologies or certain conditions as complying with the impingement requirement;
- Providing a mechanism to identify other technologies that perform comparably to modified traveling screens;
- Modifying the proposal so that facilities that have already reduced the rate of impingement may obtain credit towards the IM limit;
- Developing a more tailored approach to protecting shellfish;
- Creating alternatives for facilities with very low impingement levels or mortality rates; and

- Providing additional clarity on species of concern as it pertains to demonstrating compliance with the IM limitations.

In addition, EPA also reported that they received a number of comments suggesting that it adopt a site-specific approach to reducing impingement mortality similar to the proposed approach for addressing entrainment, rather than uniform national requirements for IM and a site-specific approach for entrainment only. In addition, EPA is also considering providing a number of flexibilities to the uniform national performance or technology based standards for IM, such as the site-specific approach for measuring compliance with IM limits.

EPA has now organized their additional approaches, as well as modifications to the initial two approaches in the proposed Rule, into the following seven topical areas for review and comment:

1. Site Specific Approach for Reducing Impingement Mortality
2. Closed-Cycle Re-circulating Systems
3. Measurement of Intake Velocity
4. Impingement Mortality Limitations
5. Credit for Existing or Newly Installed Technologies
6. Facilities with Low Impingement Rates
7. Species of Concern

Notice of Data Availability on EPA's Stated Preference Survey

In addition to its proposed Rule, the EPA also developed an Information Collection Request (ICR) to conduct a stated preference survey to determine how much respondents are willing to pay to reduce impingement and entrainment impacts (USEPA 2010). As part of its ICR, the EPA requested comments on it proposed Willingness to Pay Survey, and EPRI provided comments (EPRI 2010b). In 2011, the EPA issued another ICR seeking approval from the Office of Management and Budget (OMB) to conduct the stated preference survey (USEPA 2011a). EPRI also provided comments on this ICR (EPRI 2011g).

On June 12, 2012, the EPA released a NODA related to its Stated Preference Survey (Federal Register V77, N133; June 12, 2012). In this second NODA, the EPA presents the results of the stated preference survey described in its two previous ICR's and subsequently administered (USEPA 2012). The EPA selected a total target sample of 2,000 completed surveys across four regions and a national sample. The EPA allocated these surveys across regions based on an experimental design which presents a set of three hypothetical choices to each respondent. Figure 1 presents an example of the choice question format in the Stated Preference Survey.

As Figure 1-1 shows, the choices presented to respondents are profiles which include a monetary payment and improvement in environmental variables including reductions in I&E (called "fish saved" and fish_saved) and improvements in fish populations ("fish populations" and fish_pop), commercial fish ("commercial fish" and com_fish) populations, and overall aquatic health ("aquatic conditions" and aq_cond). Responses to the choice experiment are modeled for a Northeast, Southeast, Inland, Pacific, and National region using mixed logit techniques. Although many environmental variables are insignificant, in all cases "fish saved" is statistically significant. The EPA approximated survey respondents' willingness to pay (WTP) for a 1% change in fish saved from I&E by conducting simulations for alternative uncertainty distributions of resulting preference coefficients. Ultimately, EPA estimated that WTP for a 1% reduction in the number of fish impinged and entrained varies between $0.75 and $2.52 per household per year for the four regions surveyed, and averages at $1.13 per household per year for the National region (Exhibit II-10 in USEPA 2012).[1]

Although the EPA calculations do not go beyond this, their discussion on extrapolation suggests that these survey results could potentially be directly applied to the unsurveyed population. Based on such an approach, an I&E reduction associated with EPA Policy Options 2 and 3 in the proposed Rule (i.e., an approximately 90% reduction in I&E resulting from closed-cycle cooling) is worth over $100 per household per year. This implies $10 billion in annual benefits across all US households and over $200 billion in present-value benefits if the annual benefits are discounted at 3% over 30 years.

[1] "National" refers to the survey administered to a national sample and is referred to as a region for convenience.

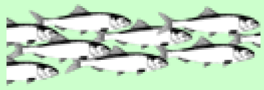
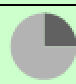
Policy Effect US	Current Situation (No policy)	Option A US	Option B US
 **Fish Populations (all fish) (in 3-5 Years)**	39% 100% is populations without human influence)	40% (100% is populations without human influence)	43% (100% is populations without human influence)
 **Fish Saved per Year (Out of 2.7 billion fish lost in water intakes)**	0% No change in status quo	25% 0.7 billion fish saved	50% 1.4 billion fish saved
 **Condition of Aquatic Ecosystems (in 3-5 Years)**	46% (100% is pristine condition)	47% (100% is pristine condition)	48% (100% is pristine condition)
$ Increase in Cost of Living for Your Household	$0 No cost increase	$24 **per year** ($2 per month)	$48 **per year** ($3 per month)

Figure 1-1
Example of the Choice Question Format in the Stated Preference Survey

In this set of comments, EPRI addresses the information in each NODA including each alternative under consideration by noting the fundamental scientific and engineering questions and issues raised by the new alternatives as well as several fundamental econometric and economic questions raised by the NODA on the Stated Preference Survey. This discussion is presented in the following sections: Section 2 presents EPRI comments on the impingement mortality-related information; Section 3 presents EPRI's comments on the Stated Preference Survey information; Section 4 contains the references cited in our comments; and Section 5 presents a list of the new EPRI technical reports on §316(b)-related issues which can provide additional technical support to EPA as it finalizes the Rule. EPRI refers to these documents in the comments presented herein.

Section 2: EPRI's Response to EPA's New Impingement Mortality-Related Requirements

In this section, EPRI provides technical and engineering information specific to each of the new regulatory alternatives EPA is considering related to impingement mortality control requirements.

Site-Specific Approach under Consideration

EPA is now considering whether to adopt an approach that would allow establishment of impingement controls on a site-specific basis either generally or limited to those circumstances in which the facility demonstrated that the national controls were not feasible. Under such an approach, the facility could demonstrate to the Director that site-specific factors warrant a site-specific BTA for both entrainment and IM. The comprehensive study and other planning requirements could be enhanced to include information that the permitting authority would use to determine site-specific BTA for both entrainment and IM. The decision criteria for choosing BTA would be the same for IM and for entrainment, and EPA expects that permitting authorities and facilities would view the two together in an integrated planning and decision making framework. EPA requests comment on such an approach and further information on why uniform controls should not be adopted.

Unlike chemicals and elements (whose behavior is governed by the laws of physics and much more predictable), fish and shellfish are volitional and the choices they make or behaviors they exhibit are influenced by their interaction with their external and internal environment. External cues include, for example, water quality, temperature, quantity, depth, and velocity; habitat both physical (e.g., substrate type) and biological (e.g., aquatic vegetation); availability of food and presence of predators. Internal cues include their ability to interact with their environment as governed by their life stage capabilities (e.g., swimming ability); their ability to detect changes and respond to external changes such as velocity, flow, noise and visual cues; reproductive needs and the presence of injury, disease, and parasites. Species differences and geographic difference further add to a complexity of fish and shellfish behavior. A cooling water intake structure design adds to the complexity of stimuli that influence fish behavior and CWIS designs differ within and among water body types. The behavior of chemicals and elements is predictable – and treatment processes to control them can be defined and applied fairly universally. Fish and shellfish behavior is essentially unpredictable – if it were predictable or if they behaved like conservative elements or chemicals, impingement and entrainment would be a chronic issue at CWIS. Power plant impingement monitoring has clearly demonstrated that impingement is an episodic process and that entrainment is also highly dependent upon intake location and seasonality relative to reproductive processes.

A plant's CWIS was designed to minimize blockage by debris according to local hydraulics, weather, and permitting requirements (e.g., protection of navigation rights). Facilities have used canals, recessed forebays, shoreline intakes, submerged and surface intakes, curtains weirs, velocity caps, traveling and fixed screens, barracks, and no screens (rare at power plants but potentially common for plants with low volume CWIS in other industrial categories) to name some intake technologies. Many plants, in response to historical §316(b)-related permit requirements, have further modified their CWIS by installing louvers, barrier nets, behavioral barriers, cylindrical and flat panel wedge wire or even moving the intake to locations to minimize fish and shellfish impacts. As in the past, in the future as the industry(s) attempts to comply with the final EPA §316(b) regulatory requirements, minimizing debris impacts on cooling flow will be paramount in selection and installation of a fish protection technology.

This complexity of physical, biological and CWIS engineering characteristics varies on a site-specific basis and increases the challenge in finding a regulatory solution to minimize impingement and entrainment across all possible scenarios. EPRI's R&D on fish protection technologies and field experience has confirmed the site-specific nature of technology selection to minimize impingement and entrainment mortality. While EPA has found that fish protection modified traveling water screens are BTA and one approach among several being considered for impingement reduction, no such technology exists for entrainment reduction. EPA has already noted this and proposed that entrainment reduction technologies be identified on a site-specific best professional judgment (BPJ) basis by permitting authorities. As the Rule's compliance schedule is currently proposed, impingement mortality technology requirements would have to be implemented prior to identifying and installing an entrainment technology. In this format, it is highly probable that the compliance technology installed for reducing impingement could be negated by the technology required for addressing entrainment – creating stranded costs for the power company, their investors and, most importantly, the public they serve. From a technical standpoint, an integrated site-specific process for identifying a technology for reducing impingement and entrainment would preclude these costs.

EPRI also notes that each of the seven issues raised by EPA in the NODA has a site-specific component question. This includes minimizing flow for closed-cycle re-circulating systems (CCRS), measuring intake velocity, establishing impingement mortality limitations, estimating credit for existing fish protection technologies, developing low or "*de minimis*" impingement levels and identifying species of concern. Identifying a "*de minimis*" level of impingement has important implications in this discussion relative to identifying fish protection compliance on a site-specific basis. EPA is considering a policy approach to minimize impingement and entrainment whether or not either or both cause an adverse environmental impact (AEI) at the aquatic organism population level. As EPRI has noted, scientific evidence for the occurrence of AEI as manifested by reduction in fishery populations or yield is extremely limited (EPRI 2011b, Report 1023094). EPA notes, however, relative to very low levels of impingement the following:

> *Under such low impingement rate conditions, technology performance is unlikely to be meaningfully evaluated. Moreover, in EPA's view, these facilities are not likely having an adverse effect on aquatic life. It is probable that in most cases requiring additional technology would not be necessary to further minimize adverse environmental impacts.*

The EPA further notes:

> *EPA solicits comment on the data and approaches under consideration for facilities that already have very low impingement rates. EPA also solicits comment on whether EPA should identify in the final rule a specific upper limit on what could be considered a very low level of impingement mortality, or if this should be left to the discretion of the permitting authority. In addition, as noted above, EPA is soliciting comment on recommendations it received following proposal that EPA consider a regulation under which impingement requirements (like entrainment requirements) would be established on a site-specific basis. If EPA adopted the approach proposed for entrainment, the permit writer could weigh site-specific costs and benefits, among the factors being assessed, in the decision whether to require further impingement controls [underline is emphasis added].*

These statements imply that there is some level of impingement that does not cause AEI at the population or community level, and EPRI research and experience confirms this to be true. A site-specific approach would allow for the use of scientific information for determining whether or not there is a low or "*de minimis*" level of impingement that would not reasonably result in AEI.

Closed-Cycle Re-circulating Systems (CCRS)

EPA may consider revising the definition of CCRS to provide existing facilities flexibility in demonstrating they already have a properly operated CCRS, such as a minimum level of flow reduction or water usage, a minimum level of cycles of concentration, and/or a narrative set of requirements demonstrating site-specific minimized make-up and blowdown flows…(EPA) request additional comment and supporting data, specifically including ways to define CCRS that accommodates those existing CCRS systems that are properly operated.

EPA is also considering adopting the same definition of closed-cycle cooling for the existing facilities rule that it used for the new facilities (and Phase II) rule… In the Phase II rule EPA included as a compliance option a demonstration that the facility "[has] reduced or will reduce [its] flow commensurate with a closed-cycle recirculating *system."EPA requests comment on using similar language for a compliance option in this rule.*

While EPRI is not proposing a definition, our comments identify some technical considerations relative to the EPA's development of a definition. EPRI notes that in general it is not in a facility's interest to withdraw makeup water and discharge cooling water blowdown beyond the minimum necessary to satisfy permit conditions, protect cooling system materials and provide water for ancillary systems that may rely on this water. Exceeding these requirements results in costs that include the power to operate water pumps, and the cost of additional chemicals to protect system services and control fouling.

The EPA in the NODA (pg. 34319, first column last paragraph) discusses the observation that cooling water at some facilities passes through a cooling tower but not recycled. EPRI points out there are a number of facilities that employ use of cooling towers solely for the purpose of meeting thermal discharge requirements and are not intended to provide fish protection at the cooling water intake structure. Such cooling towers are commonly referred to as "helper towers." In many cases such cooling towers only operate during hot summer periods when the NPDES thermal discharge permit limit would otherwise be violated. Such cooling systems would therefore not be considered a CCRS. In a few instances (such as Prairie Island and Vermont Yankee Nuclear Stations), facilities have gates and valves that allow them to operate in either a once-through or closed-cycle cooling mode but once again when such facilities are operating in the once-through mode they are not operating as a CCRS.

Minimizing Closed-cycle Cooling Water Flow – EPA in the NODA, in the same paragraph mentioned above states "EPA has found several instances where a cooling tower has been installed but not operated to **minimize** the volume of water withdrawn." EPRI points out that there are a number of technical considerations for facilities that operate a CCRS that impact system optimization other than minimization of water withdrawals. These considerations include:

- Intake size
- Intake water quality
- Makeup water used for non-cooling water purposes
- Chemical treatment to control cycles of concentration
- Cooling tower and circulating water system impacts
- Solids buildup
- Circulating water pump use
- Reuse of blowdown water within the plant

Each of these topics is subsequently discussed:

Intake Size - For conversions from once-through cooling (OTC) to CCRS, there will certainly be a reduction in intake flow. For plants with an existing CCRS, the intake structure is designed to match plant makeup water needs, which may include a multitude of systems that include:

- Cooling tower makeup water (largest user of water)
- Auxiliary cooling makeup (usually part of the cooling tower loop but not always)
- Boiler feedwater (some plants use potable water as a source for this need)
- Gas turbine air intake cooling (combined cycle plants)
- Gas Turbine power assist (steam addition)
- Service water for plant housekeeping (some plants use potable water as a source for this need)
- Limestone/lime preparation water for FGD (coal plants sometimes use cooling tower blowdown for this purpose)
- FGD makeup (coal plants sometimes use cooling tower blowdown for this purpose)
- Bottom ash sluice water/fly ash wetting water (coal plants sometimes use cooling tower blowdown for this purpose)

The combination of systems that may interact or be incorporated into the CCRS directly affects the system's ability to minimize cooling water makeup withdrawal and still supply water for these other systems. As noted in these lists facilities vary in terms of whether or not these makeup water needs are met through withdrawal of surface water or water from other sources (e.g., groundwater, water from municipal water supplies) and whether or not they are integrated into the closed-cycle cooling system.

Intake Water Quality - This is always a concern in power plants. Water quality can have a direct impact on loss of overall plant efficiency. Higher cycles of concentration (COC) will require the plant to operate with circulating water with higher levels of chemical constituents (naturally occurring in source water or otherwise). Higher levels of chemical constituents, for example, can cause mineral scale on heat transfer surfaces and/or fouling, some forms of corrosion are related to mineral scale deposits, and corrosion rates are accelerated at higher salt levels. The degree of concern is specific to the actual chemistry of the source water. Some source waters are not a problem if COC is increased from 2 to 3, while others may be problematic. The higher the COC, the more vigilant a plant must be on controlling cooling tower chemistry and monitoring for scaling, fouling and corrosion. Increasing the COC generally will increase the amount of monitoring, treatment and chemicals and maintenance that will be needed to prevent impacts to plant efficiency and availability.

Another aspect of intake water quality is low level metal concentrations (in source water). The cooling tower will concentrate these metals, however, activities like chlorination and other chemical additives can change the form of the metal from ionic to metal oxides or to complexed metal (naturally occurring constituents and some additives will compound with metal ions). Some of the metal oxides and complexed metals can mix with circulating water solids and remain in the system.

Makeup Water Used for Non-Cooling Purposes - As discussed above, makeup water is required for a number of plant needs that include:

- Boiler feedwater
- Gas turbine air intake cooling (combined cycle plants)
- Gas Turbine power assist (steam addition)
- Service water for plant housekeeping
- Limestone/lime preparation water for FGD (coal plants)
- FGD makeup (coal plants)
- Bottom ash sluice water/fly ash wetting water (coal plants)

These needs are typically met by using the same water withdrawn for cooling. Depending on the plant and its degree of integration (with respect to water use), the cooling tower typically uses 70% to 90% of the water required to operate the plant. For coal-fired plants, the FGD is the second largest water consumption (reagent preparation and FGD makeup). The FGD can comprise 5% to 15% of the total water demand. Ash systems are usually the third largest water consumption at 1% to 5%. In plants employing integrated water management, FGD and ash system water is often supplied (partially or completely) by cooling tower blowdown.

Chemical Treatment to Control COC - Chemical treatment is practiced in nearly all cooling towers to control mineral scale, corrosion, fouling (from suspended matter) and biofouling. At higher COC, the potential for mineral scale, corrosion and fouling to occur is greater while bacterial control is not related to COC. Chemicals used to control mineral scale, corrosion and non-biological fouling must be reported to the NPDES permitting authority for approval and be deemed "safe" to discharge in blowdown.

Chlorine (sodium hypochlorite aka bleach) is generally added to cooling towers to control biofouling that includes bacteria and algae. COC does not affect chlorine addition frequency or concentration. Some cooling towers are operated such that blowdown is stopped during chlorination and restarted when the chlorine residual reaches non-detectable levels (usually within 30-60 minutes). Some facilities de-chlorinate blowdown using a chemical (like sodium bisulfite). In general, higher COC require lower amounts of chemicals because they remain in the system longer. At higher levels of COC, however, water chemistry must be monitored more closely to control scaling and fouling.

Cooling Tower and Circulating Water System Impacts - High COC operation may require different circulating water materials of construction and modifications to the cooling tower in some systems. If a cooling system is designed for low COC operation, increasing COC could require changes to some system materials of construction as a result of higher TDS, for example, condenser tubing and support hardware in the cooling tower may have to be changed to prevent excessive corrosion. Also, higher COC may require different cooling tower fill. Fill provides heat transfer surfaces in cooling towers. Newer towers have compact film-fill which is more efficient, however, higher COC can increase fouling and solids retention. In some cases, the fill might have to be replaced with a less efficient fill – a more-open design to accommodate solids passage. Depending on fill selection, this might reduce overall cooling tower heat rejection efficiency.

Solids Buildup - At higher COC solids buildup is a concern. Solids present an additional problem in that they can settle out in equipment like cooling tower fill (this is where heat transfer takes place), condenser and heat exchangers inlet boxes, circulating water lines, and tubes/pipe (usually not a problem if designed properly). Solids enter the tower in the makeup water as well as in the air drawn into the tower (airborne silt). Settled solids present two problems (1) loss of heat transfer and (2) corrosion. Solids can reduce heat transfer by settling out on tube/plate surfaces. Corrosion can occur beneath solids deposits (this is a very common corrosion mechanism). If the source water has high levels of suspended matter, treatment may be required to clarify the water prior to cycling it in the cooling tower. This overall problem is highly dependent on the source water. For example, when rivers run at seasonal high flows, solids loading is typically much higher.

Condenser Cooling System Design and Condenser Delta Temperature - Retrofitting a plant with a once-through cooling system with a CCRS can be a problem for many plants or very expensive (EPRI 2011c, Report 1022491). The original condenser was designed for a given circulating water rate and temperature differential. Inserting a cooling tower in the circuit sometimes presents problems with the pressure required to lift the circulating water to the height of the tower; i.e., the circulating water pumps might not have adequate pressure. The cooling tower must match the existing plant's flow and temperature differential, therefore, the cooling tower is almost always not optimally sized.

An optimal cooling tower can mean a lot of things – most of which have either no impact or minimal impact on water withdrawal. They include:

- Sized to minimize power usage (no impact on water withdrawal)
- Sized to minimize the cooling tower footprint (no impact on water withdrawal)
- Sized to minimize the number of cooling tower cells (minimal impact on water withdrawal)
- Sized to minimize the approach temperature (minimal impact on water withdrawal)

Optimizing a cooling tower to minimize water withdrawal requires operating at higher COC. As discussed previously, high COC operation can impact solids buildup in the cooling system, accelerate corrosion and fouling, require different changes to materials of construction for the cooling system (that is in contact with higher TDS water) and modifications to cooling tower (e.g., fill, wetted hardware)

Reuse of Blowdown Water within the Plant - In large coal-fired plants employing integrated water management, cooling tower blowdown is typically used as supply water for the FGD and ash system needs. This type of "reuse" is beneficial in that it minimizes the need for additional freshwater; however, this can also give the impression that the cooling tower is not optimized for water use. The cooling tower may not be operated to optimize COC if additional water would otherwise be required for FGD and ash system makeup. If the cooling tower were increased to a higher COC, additional fresh water would be needed for the FGD and ash systems, with the result that there would be no net reduction in the amount of water withdrawn from the source waterbody, even though there would be a reduction in withdrawal of the cooling tower makeup water. The result of doing this would provide no reduction in impingement mortality and entrainment. Some plants reuse boiler blowdown (as well as stormwater) in the cooling tower. This can offset the need for cooling tower makeup, but typically not to a significant extent.

Measurement of Intake Velocity

EPA solicits data…on the measurement of intake velocity and associated… assumptions and solicits comment on making this clear in the final regulatory text or preamble to the final rule.

EPA will continue to consider comments from the proposal on…[the issue of the location for velocity compliance measurement] and may modify the monitoring requirements as appropriate.

EPA solicits comment on the data and possible changes to the rule language for the intake velocity design standard to reflect such modifications [i.e., need for screen blockage and monitoring may be unnecessary].

EPRI has had some issues in interpreting this request and some of our members have expressed similar confusion. We understand EPA's dilemma in that the Rule will address other industrial categories and many plants in those categories do not have screens. We have no experience in the design and operation of CWIS in other industrial categories and, therefore, cannot offer a potential technical definition that could assist EPA. EPRI notes, however, that impingement is defined by EPA as those organisms that are trapped on a 3/8" mesh net/screen (or equivalent mesh as ½" x ¼" is now the smoothtop mesh that is standard in the industry to minimize fish injury during impingement) and it is this impact that EPA is attempting to minimize. In the absence of screens (we are not aware of any power plant not having some type of screen for debris control), then impingement is not occurring. What would be occurring in this instance would be entrainment.

Relative to the 0.5 ft/sec through-screen velocity criteria, we refer EPA again to our technical comments on the proposed rule (EPRI 2011a, Report 1019858). Specifically, EPRI research (EPRI 2001) and studies by utilities and others have demonstrated that a 0.5 ft/sec through-screen velocity is extremely conservative. Our research, as noted by EPA in the NODA, the 2011 proposed Rule and the Phase I Rule (66 FR 65256, December 18, 2001, Section V.B.1.b.1), indicates an approach velocity of 0.5 ft/sec will protect 96 percent of fish tested. The margin of safety EPA adds by requiring a 0.5 ft/sec through-screen velocity reduces, on average, the approach velocity to 0.25 ft/sec. This lower approach velocity further increases the percentage of fish protected – significantly greater than the criteria EPA has proposed (or may re-calculate) for impingement survival of 12% annual and 31% monthly mortality. Facilities that can deploy a year-round barrier net with 3/8” mesh and a through-screen velocity of 0.5 ft/sec will incur annual costs ranging from several hundred thousand to several million dollars depending on net size, water depth and other site-specific conditions. Plants that cannot deploy nets, however, would have to re-design their CWIS doubling and even tripling the intake screen surface area. EPRI is working with many of our members to identify potential compliance approaches relative to the proposed Rule. Table 2-1 provides a representative estimate of the costs that would be incurred to re-design a CWIS to accommodate the 0.5 ft/sec through-screen velocity with dual-flow traveling water screens.

Table 2-1
Cost estimate summary for converting existing CWIS to accommodate Ristroph-modified dual flow screens with through-screen velocity of 0.5 ft/sec.

Cost Summary					
Plant	**Existing Screen Dimensions**			**New CWIS for 0.5 ft/sec – Modified-Ristroph Dual-flow Screens**	
ID#	**Number**	**Height (ft)**	**Width (ft)**	**Number**	**Cost**
MW Reservoir	8	22	10	17 (8 ft wide)	$36,144,000
MW Large River	8	51	8	17 (8 ft wide)	$53,863,000
Great Lakes	2	30	6	9 (8 ft wide)	$17,016,000
SE Small River	15	38.51	10	16 (10 ft wide)	$62,264,000
SE Reservoir	16	36	7	29 (10 ft wide)	$69,288,000
MW Small River	8	54	10	19 (10 ft wide)	$60,140,000
SE Small River	16	44.2	10	19 (10 ft wide)	$61,036,000
SE Reservoir	16	61	10	26 (10 ft wide)	$80,891,000
MW Large River	8	53	10	22 (10 ft wide)	$76,158,000
SE Reservoir	6	55	10	7 (10 ft wide)	$37,981,000
SE Estuary	3	33	10	8 (10 ft wide)	$18,718,000
SE Small River	3	43.5	10	17 (10 ft wide)	$43,408,000
Great Lakes	16	36	10	26 (10 ft wide)	$84,496,000
Great Lakes	4	29	5	11 (10 ft wide)	$21,469,000
				Average Cost	$51,633,714

For this subset of facilities the cost average is almost $52 million with a range from $17 to $84 million, the upper end of the range approaching the cost of a closed-cycle cooling system. Furthermore, these are costs for dual flow screens that maximize open area to attain 0.5 ft/sec through-screen. Use of dual flow traveling screens may not always be a practical option because of hydraulic issues they can create resulting in debris management concerns. If through-flow traveling water screens can only be used to expand the intake to meet the 0.5 ft/sec criterion then the number of screen bays required would increase along with the associated cost to build new cooling water intake structure to support those screens. This cost would be even higher if fish protection modifications and a fish return system were required to address entrapment as is required in the proposed Rule. The point of this analysis is that given the overly conservative nature of the 0.5 ft/sec through-screen velocity criteria EPA has proposed, unless a plant can deploy a barrier net for 24 hours/365 days/year (and many plants cannot because of icing and debris issues) or use cylindrical wedge wire screens with design slot velocity of 0.5 ft/sec (and many plants cannot because of insufficient water depth, sweeping flow, and navigation issues), few plants are likely to use this compliance approach because of the high cost.

These costs can also be put in the context of the monetized benefits to be attained. In 2011, EPRI completed an evaluation of the monetized benefits that would be attained from reducing impingement and entrainment commensurate with closed-cycle cooling for comparison to the cost of closed-cycle cooling retrofits (EPRI 2011d, Report 1023401). The average facility cost noted above for re-configuring CWIS to meet the 0.5 ft/sec through-screen velocity criteria exceeds by more than a factor of 3 the total estimated national benefit for reducing impingement and entrainment commensurate with what can be obtained with closed cycle cooling (i.e., $51 million average re-configuration cost versus and estimated total national benefit of $16 million for recreational and commercial fisheries). EPRI further notes that if a facility re-configures to meet the 0.5 ft/sec velocity criteria for impingement compliance, it will still have to conduct studies and possibly install BTA to reduce entrainment. We do note, however, that EPRI's 2011 national benefit estimate does not include non-use economic value, the subject of EPA's separate NODA on the data collected in their Stated Preference Survey. Non-use economic valuation remains a challenging and debated concept and EPRI's comments on this issue and EPA's survey are submitted in a separate report.

EPA also received comments suggesting that a direct velocity measurement posed technical challenges. Some of these comments suggested that EPA provide the flexibility to calculate velocity based on other direct measurements, such as water depth, pressure differential, and plant intake flow. Based on the comments and data received in response to the proposed rule, actual through-screen intake velocity can be measured directly. However, after further discussion with vendors, EPA is aware that some sites may have difficulty measuring through-screen velocity (DCN 11-6602).

A particular point of confusion in the NODA is the proposed location for monitoring for compliance with the velocity criterion. On the one hand the NODA recognizes that monitoring at the screens is problematic and allows for monitoring upstream of the screens. EPRI fully agrees with this point. On the other hand the NODA has text suggesting that the monitoring point is at the traveling water screens. Based on EPRI's analysis of the state-of-technology for measuring water velocity, through-screen (i.e., 3/8" or ½ x ¼") velocity cannot be measured directly. Even under the best of conditions in a laboratory using acoustic Doppler velocity meters (ADV) this would be extremely difficult. It is impractical to place an array of ADVs with millimeter precision required to accomplish such a measurement. A 4 mm by 4.5 mm sample cell would require an accuracy of placement of about 2 mm. The slightest vibrations (caused by water flow and the moving traveling screen) from the probe would move this cell over the screen mesh and compromise the readings. Even if it was possible, it would only be a measure of one cell mesh on the screen. Furthermore, the "array of meters" necessary would act as an obstruction and collection point for waterborne debris. The only way to estimate through-screen velocity is indirectly, either by measuring approach velocity and adjusting for open area in the screen to estimate through-screen velocity or theoretically based on pump volume and design open area.

EPA indicates in the NODA that it is re-considering the need for meeting criteria under "all flow conditions" and that there be no more than 15% blockage of the screens. EPRI continues to point out that we are not aware of any currently available method to detect at what point the 15% blockage criteria has been exceeded. EPRI also agrees with EPA that after storms or that in certain waterbodies, episodic debris problems such as floating leaves in the fall, seasonal break-off of aquatic and terrestrial vegetation and algae, natural fish kills, and jellyfish can exceed the capability of traveling water screens to not exceed a 15% blockage. While EPA suggests in the NODA that it may allow relief for such events for up to a day, EPRI notes that such events can last for several days or a week. EPA suggests that the margin of safety incorporated into the 0.5 ft/sec criterion is a potential basis for requiring the not-to-exceed 15% blockage provision and meeting the velocity criterion under all flow conditions. Relative to EPRI comments on the conservative nature of the criterion above, EPRI agrees excluding such requirements from a technical standpoint makes sense.

EPA may also wish to consider "approach velocity" as the monitoring target. Approach velocity is relatively easily monitored. Furthermore, use of approach velocity would standardize the target parameter for plants with screens versus plants without screens. For plants without screens and where the point of compliance is the CWIS opening as proposed by EPA, the approach velocity and "through-screen" velocity are one and the same. Plants with screens would have to meet a more stringent velocity criteria than those without as currently proposed by EPA.

Impingement Mortality Limitations

EPA requests comments on a number of issues related to the impingement mortality limitations. EPRI's comments follow each issue noted.

EPA solicits comment on recalculating the impingement mortality limits using the new studies that meet EPA's criteria as just described. EPA also solicits comment on whether such a single monthly and annual limit could be sufficiently protective for all facilities and also recognize site specific variations.

EPA's effort to expand the model data base for estimating traveling screen survival performance with the additional 80 data sets it has obtained is a valuable exercise toward understanding how the screens perform in various environments and for various species. The information obtained from this analysis may further support EPA's technical basis for identifying fish protection-modified traveling water screens as BTA. EPRI notes, however, that despite whatever new annual and monthly performance criteria EPA calculates, all the technical problems that make implementation problematic (EPRI 2011a, Report 1019858) remain. As

EPRI noted in our comments on the site-specific approach section, EPA is applying the regulatory model that was developed for control of chemical substances to biological organisms whose behavior is non-predictable and influenced by the internal and external physical and biological environment they interact with. Attainment of treatment performance criteria for chemical substances can be determined via analytical methods that have been independently verified and standardized, evaluated against controls and sample spikes, have robust documentation of analytical variability and the ability to repeat experimental analysis if sample contamination is suspected or determined. None of this is possible for assessing impingement survival. Specifically:

- Standardized methods for impingement survival do not exist. For example, it is not even known whether fish and shellfish should be held for 24 or 48 hours post-impingement to determine mortality.
- Experimental controls are problematic. While use of hatchery raised fish for testing is an option for many species of concern – subject to EPA, permit authority and resource agency approval – for others it is not and the process of collecting wild fish from the source waterbody can itself be a source of stress, especially for non-hardy species of concern.
- Impingement is highly episodic and zero catches are common. Zero catches dominated EPRI impingement survival studies at 15 power plants on the Ohio River, during our assessment of the rotary screen at Mirant's Potomac Station on the Potomac River, and at our evaluation of the Beaudrey vacuum screen at North Omaha Station on the Missouri River. This problem would be further compounded if EPA were to base performance criteria on a species specific basis as discussed in the NODA. Zero catches provide a statistical analysis problem in determining monthly and annual averages – are zero catches zero mortality or are they no data?
- Balancing low catch numbers between months is problematic. As noted above, the episodic nature of impingement results in many zero catches as well as catches of less than 10 organisms, and these 10 can be distributed among several species. This can be followed by a month of a 1,000 or more fish. EPA proposes no methodology for how this varying sample size is accommodated when calculating annual and monthly survival performance.
- Environmental factors outside the control of the applicant can confound experimental control. Storm events, water quality changes, extreme and rapid changes in air temperature are but a few of the parameters outside the control of the operator that can confound impingement survival results.
- Health of the impinged fish is also a factor that is not addressed. There is an increasing body of evidence that fish of poor health are the ones most commonly impinged. EPRI reported (EPRI 2011a, Report 1019858) in our comments on the proposed Rule on the body of evidence being developed by EPRI and Alabama Power on this issue.

EPRI has previously commented that violations of the impingement mortality performance criteria could be frequent at many facilities, depending on the species of concern, and recent results corroborate this point. EPRI is performing a collaborative R&D project with Alabama Power Company (APC) to assess the performance of newly installed state-of-the-art fish protection-modified traveling water screens at APC's Plant Gorgas Steam Station in Alabama. A latent impingement mortality (LIM) facility was constructed in the early 2012 and survival monitoring has been ongoing since March. The following are key results of the collaborative EPRI-APC R&D (see APC 2012 for details provided by APC in their comments on the EPA NODA):

- After 5 months of impingement monitoring, 50% of the 8-hour sampling events (total of 65) yielded less than 29 impinged shad and less than 5 fish of other species.
- 93% of the total impinged fish (including gizzard and threadfin shad) did not survive 48 hours. Excluding shad, which EPA in the proposed Rule considers "naturally moribund" and potentially exempt from "species of concern" monitoring, 33% did not survive. The running average exceeds the 12% annual average criteria EPA presented in the proposed Rule and none of the monthly results were less than the 31% monthly criteria.
- Approximately 21% of the total fish impinged during the study period were randomly sub-sampled and sent to Auburn University Fish Disease Laboratory for health assessment. 41% of the shad and 28% of the non-shad species were significantly infected with known fish pathogens that can impair swimming performance.
- A one day study with hatchery raised bluegills placed in the traveling screen fish buckets, transferred to the fish return system and ultimately held for 48 hours in the LIM facility found that 80% survived. While this is a significant improvement relative to survival of wild fish, it is still below the EPA proposed 12% annual mortality limit (or 88% survival).
- The labor for this survival and fish health monitoring, exclusive of facility construction, is 368 person-hours per week.

Despite these results, as EPRI has discussed in the previous section on the streamlined compliance approach for impingement control, laboratory data and limited field data using hatchery fish demonstrate that fish protection-modified traveling water screens and properly designed and maintained fish return systems provide a high level (>90% and exceeding the EPA proposed performance criteria) of survival for non-shad species including several commercially and recreationally important fish.

EPA has concluded that an alternative compliance option that would streamline the permitting process as well as provide for reduced monitoring requirements may be appropriate for facilities employing the model BTA technology. The BTA technology properly operated according to best management practices would then be deemed compliant with the IM standards. Under this approach, EPA might require the facility to provide site-specific performance data to identify the operational conditions that would ensure that the technology is being operated appropriately. EPA's current understanding suggests that two-years of data may be an appropriate amount to make this determination. Note the biological monitoring conducted as part of a performance study would not be used to demonstrate compliance with the limit, but rather would be *used to help set operational parameters for the facility. The performance data could consist of a two year study focused on the operational conditions that optimize the proper design, installation, operation and maintenance of modified traveling screens with fish return systems. A facility could use relevant data already collected as part of the study, or conduct a new two-year performance study. Once these operational conditions have been identified, EPA would expect the permit writer to incorporate these operational parameters as conditions of the permit. EPA solicits comment on providing this compliance flexibility and data on these assumptions.*

EPRI notes the following key points it will develop in the following discussion: (1) fish protection modified ("Ristroph") traveling water screens and a well designed fish return system perform as well if not better than the EPA proposed annual and monthly impingement criteria for many non-fragile fish and shellfish; (2) the two-year screen and fish return operation optimization studies under consideration by EPA will be a significant challenge for the industry to properly implement and obtain meaningful results; and (3) EPA's desired optimization can alternatively be obtained through design specifications and post-installation visual inspections of the screen and fish return system operation.

EPRI R&D indicates that "Ristroph-modified" (continuous screen rotation, smooth woven screen mesh, Fletcher-modified fish collection buckets to minimize turbulence, low pressure wash and flap seal) with a well designed fish return system provide high survival – equal to if not exceeding the EPA performance criteria in the proposed Rule – for several non-fragile species of fish and shellfish including those of recreational and commercial interest. This conclusion is based largely on laboratory results (EPRI 2006a, Report 1003238) where the performance of these screens has been assessed under controlled conditions using fish of known health quality. Some field observations further corroborate this conclusion (e.g., the high [95%] survival EPRI observed when the Beaudrey vacuum screen was evaluated at North Omaha Power Station on the Missouri River; see Bigbee et al. 2010); however, EPRI recognizes there is a disconnect between our laboratory results and field observations – field observations of post-impingement survival in general being lower than laboratory results. EPRI theorizes that this disconnect is because of the numerous uncontrollable variables that confound field R&D including but not limited to the following:

- Water quality as influenced by meteorology (runoff, water temperature, sediments and other pollutants)
- Mortality caused by the survival monitoring procedure
- Impingement process potentially "selecting" for fish of poor health condition (e.g., presence of disease, parasites, reduced condition factor)

Each of these factors can further interact with each other to additionally compromise post-impingement survival values. This interaction is not constant but changes by time of day, by week, by month/season and between years. The previous section noted the results currently being obtained in the collaborative EPRI-Alabama Power Company impingement survival research being conducted at Plant Gorgas (APC 2012). None of the monitoring to date has demonstrated survival that meets the EPA proposed monthly and annual limits. The poor survival results are partially explained by the fact that a high percentage of the impinged fish (41% of the shad and 28% of the non-shad) were significantly infected with known fish pathogens. A recent but limited test with hatchery fish placed directly in the LIM tanks also indicates that as much as 20% of the observed mortality may be due to the holding/experimental process.

The previous section also noted the episodic nature of impingement and the fact that zero and/or low impingement counts are common. Low impingement numbers will severely limit the conduct of screen and fish return optimization studies. The combination of confounding factors of the experimental process with the low sample sizes make it extremely difficult to determine if, for example, a given screen speed, spray wash pressure, and fish return water depth perform better than another. Extensive effort would be expended with little (and potentially incorrect) results. One method to address some of the problems is to use hatchery supplied fish. This reduces any issues of fish health, requisite sample size, and study timing – particularly the need for "two-years of data" EPA is considering for this alternative. Inter-annual variability is an issue associated with the fish community and not the operation of the screens. Hatchery supplied fish would preclude the need to address inter-annual differences in impingement survival with screen operation.

The engineering, operational and laboratory data indicates that the performance of fish protection modified traveling water screens and fish returns can be "optimized" through screen and fish return design specifications and post-installation visual inspection and reporting. Suggested fish-protection specifications include:

- Screen mesh – woven wire, drilled plastic or molded polymer. Each will minimize interaction with fish and shellfish external organs and mucous membranes to maximize survival (see next section regarding EPRI's discussion on performance of new screen designs such as the rotary, molded polymer and vacuum).
- Screen rotation – continuous screen rotation will reduce impingement duration. EPRI research indicates that fish are not even likely to impinge, but instead seek refuge in the fish buckets as subsequently discussed. Continuous screen rotation will insure that the collected fish are expeditiously transferred to a fish return system.
- Fish buckets – "Fletcher" modifications (Fletcher 1990), basically a higher front lip than back, minimize the turbulence in the buckets caused by the intake flow, providing a low stress environment to hold collected fish until they are transferred to the fish return system.
- Low pressure spray – the low pressure spray serves two purposes: (1) to reduce friction on the screen surface as the screen rotates over the top sprocket allowing fish to slide off the screen into the fish return system and (2) provide mild stimulation to fish on the screen to initiate a "C" reaction (i.e., muscle contraction for rapid change in direction as used to avoid predators or when frightened) causing them to flop down the screen surface.

The intent of the low pressure spray is not to physically wash the fish off the screen, therefore, testing of alternative spray pressures is really not needed. For a molded polymer screen, the low pressure wash is not required because gravity allows fish to drop into the fish return. For the rotary screen, the low pressure wash will also stimulate fish to move and reduce friction in the fish bucket.

- High pressure spray – this spray is designed to remove debris from the traveling water screen mesh. They are preferably located on the descending screen side, to remove the debris with gravity assist, after fish have been removed by the low pressure sprays. They can also be located on the ascending side but this is less common because of space constraints and lower effectiveness. On the descending side, the orientation and pressure of the high pressure spray is not a consequence to the fish transfer and overall survival performance. If the high pressure nozzles are on the ascending side of the screen, they should be oriented such that they do not spray high pressure water into the fish bucket, as this may cause turbulence or even dislodging fish from the bucket. This design/performance can be visually verified and optimized.
- Flap seal – this seal insures that fish are efficiently transferred to the fish return system and do not fall into the well behind the screen where they will be entrained into the cooling system. Its performance can be visually verified. Hatchery fish can be used to examine the effectiveness of the transfer from the screen, over the flap seal and into the fish return system rather than sticking on the screen, or falling onto the floor or into the intake well behind the screen.
- Fish return system – the American Society of Civil Engineers (ASCE) published guidelines in 1982 (ASCE 1982) on the proper design and operation of fish return systems. EPRI has also done recent research on the influence of fish return design, surface material, influence of debris, and discharge height (EPRI 2012 and 2010, Reports 1024999 and 1021372). Effective fish return design and operation is fairly intuitive and can be visually verified post-installation. Key design practices include: (1) smooth material to minimize fish abrasion during transport; (2) laminar flow with minimal turbulence; (3) sufficient depth to minimize interaction of fish with flume material and transport them as expeditiously as possible to the source water body yet not too deep as to allow the fish to swim in the return that can cause exhaustion or otherwise delay their return; (4) covered to prevent predation by birds and mammals; (5) discharge located as close as possible to the screens but distant enough or downstream to preclude re-impingement or discharge into the thermal effluent; (6) discharge pipe is best subsurface in the receiving water to minimize turbulence and disorientation of the organisms as occurs when discharged above the water surface; and (7) routine cleaning of the system to minimize biofouling growth and remove any debris accumulation. Nearly all of these factors can be addressed in the return system design, while others such as laminar flow, water depth, and cleaning frequency can be visually verified and adjustments made without the need for problematic biological monitoring studies.

Several of these and related factors are discussed in greater detail in Taft et al.'s (2007) paper "Fish and Cooling Water Intakes: Debunking the Myths." The myths addressed in this paper include: (1) Myth #1 – intakes are vacuum cleaners; (2) Myth #2 – fish are attracted to intake screens; (3) Myth #3 – high spraywash pressure kills fish; and (4) Myth #4 – fish return systems kill. The R&D information that "debunks" these myths is contained in EPRI (2006a, Report 1013238). EPA did not include the EPRI data from this R&D in its traveling screen performance criteria development because researchers "sometimes operate the technologies with the intention of increasing impingement and entrainment occurrences. As a consequence, data from these studies are not representative of the performance expected at the facilities." Although already provided in our comments on the proposed EPA Rule, EPRI reiterates the technical information because of its relevance to this issue. During EPRI's laboratory evaluation of Ristroph screens, fish were introduced into an enclosed area upstream of the screen. Fish were allowed to interact with the screen for up to 2 hours. Those fish still swimming upstream of the screen at the end of the 2 hour period were crowded toward the screen using a mechanical crowder[2]. Fish tended to remain upstream of the screen until crowding at lower velocities. Conversely, at higher velocities, the majority of fish tended to be impinged and collected during the first 15 minutes. Thus, for any given velocity, the majority of fish fell into only one collection category. Data analysis indicated that there were no significant differences in the mortality, injury, or scale loss between fish in each collection period. Therefore, crowding fish to increase impingement and entrainment occurrences should not necessarily exclude laboratory studies from consideration in developing a performance standard. As subsequently presented, laboratory studies provide significant insight into how traveling water screens perform.

EPRI performed the above studies on modified traveling water screens because they have advantages over many of the other impingement reducing options including: (1) they are commonly available at most U.S. facilities (as EPA has concluded); (2) they are relatively easy to retrofit at facilities that currently have un-modified screens; (3) they can be cleaned automatically; (4) they do not interfere with navigation; (5) they do not alter aesthetics; and (6) they will not generally require substantial civil/structural modifications or dredging, except for the addition or modification of a fish return line. In EPRI's laboratory studies on the performance of these screens, the survival, injury, and scale-loss rates of 10 species of freshwater fish impinged and recovered with a modified traveling screen were evaluated. Species tested included: golden shiner; fathead minnow; white sucker; bigmouth buffalo; channel catfish; hybrid striped bass; bluegill; largemouth bass; yellow perch; and freshwater drum. These fish were selected because they represent a broad spectrum of fish commonly impinged at power plants. Although limited to freshwater fish (flume use of salt water is problematic because of waste disposal as well as corrosion of laboratory equipment), there is

[2] A "crowder" is a screen that is moved in the direction of the traveling water test screen essentially forcing fish to impinge or be collected in the fish buckets. Crowders are used because many fish can avoid impingement and entrainment for very long periods of time, particularly under low velocity conditions.

no technical information available to suggest that survival of marine species would be different. Fish were impinged at 1, 2, or 3 ft/sec approach velocity. Survival rates exceeded 95% for all species and velocities tested. More specifically, the 48-hour survival rate was 98.1% with the 95% confidence interval ranging from 97.7–98.3%. *N*=9,753 (total number collected). This value was calculated as: (number alive at 48 hr / total number collected) x 100. The confidence interval was calculated using the normal approximation of the binomial distribution. The control survival for all species combined was 99.7% (95%CI – 99.4% - 99.9%; n=2,817). Duration of impingement (DI) for the velocity trials was up to 40 seconds (8 ft/min x 5 ft water depth), which is short. Based on data from 56 CWIS representing 39 power plants that EPRI has examined, the average calculated DI was 2.8 minutes SE = (± 0.26), with a median value of 2.1 minutes. The minimum and maximum durations of impingement were 0.5 and 12 minutes, respectively. In addition, for most species, rates of injury and scale-loss were low. EPRI could have held the screen to increase DI, but we observed differences in fish behavior interacting with a stationary screen and felt that continuous operation of the screens provided conditions more representative of field. Ultimately, EPRI used the lowest screen rotation practicable with the laboratory screen (8 ft/min).

Because of the relatively short duration of impingement, EPRI undertook a second set of tests with a subset of species at 3 ft/s approach velocity and durations of impingement up to 10 minutes. A total of 40 test and control replicates were run with channel catfish (12 replicates; n=446), golden shiner (12 replicates; n=262), and fathead minnow (16 replicates; n=332). EPRI published the following findings from the study:

- Post-impingement survival for fish collected with these screens exceeded the EPA annual and monthly mortality criteria
- Fish length plays a critical role in impingement survival
- Velocity is not a significant predictor of impingement survival in most species tested, and
- For some species, survival is reduced when durations of impingement increase, but that these longer durations of impingement can be avoided in the field given the average intake water depth.

Finally, these studies suggest that the prevailing assumptions about the sources and mechanisms of fish injury and mortality (velocity and duration of impingement, scale loss and injury) associated with fish impingement, and the behavior of fish prior to impingement (fish are attracted or "vacuumed" to screens) may not be correct. As previously noted, many of the myths associated with impingement are explored and "debunked" in Taft et al. (2007).

EPRI research on fish return systems with larval and juvenile fish has also found that when fish attain a length of approximately 12 mm, return survival for the hardy species tested ranged from 70-100% (EPRI 2010a, Report 1021372). In this study, flume length, water velocity and drop height did not impact survival across the range of each parameter examined that were representative of field conditions. These results are for entrainable life stages – survival for impingeable life stages because of increased scale, muscle and vertebral development is expected to be even higher. To verify this expectation, EPRI is now conducting fish return survival tests in a pilot facility (1000 and 200 feet in length) characteristic of actual fish returns at power plants. EPRI will also examine the influence of different types of debris (e.g., filamentous, woody, leaves) on fish return survival. EPRI R&D (EPRI 2012, Report 1024999) in a relatively short return flume found that flume material (smooth, stone, fiber) had a minor effect on survival (stone material did have lower survival for fragile golden shiner tested than other species) and that simulated debris (woody material, leaves, and fiber) did not reduce passage survival of the juvenile bluegills and channel catfish tested. EPRI's 2012 fish return R&D will be completed by early fall and if the opportunity exists, the final report will be provided to EPA to technically inform its final Rule development effort.

The key point relative to this information on fish protection modified traveling water screens and fish return systems is that when properly designed, installed and operated post-impingement survival of healthy and hardy fish can be high or approach and exceed the proposed EPA impingement mortality criteria. Optimization R&D proposed in EPA's "streamlined approach" could face numerous technical challenges that may compromise the results and the studies are not required to achieve optimal screen and fish return performance. Traveling water screen and fish return system design and operation specifications combined with visual verified post-installation can ensure an optimal level of fish protection.

New traveling water screen designs (rotary, molded polymer and vacuum): are they BTA for impingement control?

Although not an issue raised by EPA in the NODA, the issue is implicit in this discussion with regard to the pre-approved or streamlined technology approach: i.e., whether or not rotary, molded plastic or vacuum-based traveling water screens perform at an equivalent level to "Ristroph-modified" traveling water screens. There are approximately a dozen facilities in the U.S. that are now using rotary screens at their cooling water intake structures, several plants have installed molded polymer screens and many facilities are considering installing one of these screen options. While the installed screens are generally modified for debris management, they can be easily retrofit with Fletcher-type fish buckets and operated continuously for fish protection. While data on the performance of these screens is limited, EPRI believes, as subsequently discussed, that these screens are from an engineering and scientific point of view fundamentally the same as "Ristroph-modified" band screens and would demonstrate equal performance if the data base was robust.

Fish Bucket Hydraulics

Fletcher identified turbulence within the early modified screen fish buckets as a potential contributor to injury and mortality (Fletcher 1990). He and several other researchers (e.g., Ronafalvy et al. 2000) developed new designs that reduce or eliminate turbulent water flow in the fish bucket. Both the Geiger and Hydrolox screens have designed and laboratory tested modifications to their bucket designs to minimize turbulence, resulting in no substantial differences in the hydraulic conditions within the buckets of modified traveling screens. Therefore, while different in form, all three screening systems employ functionally equivalent buckets that should not result in any significant differential mortality.

Screening Material and Removal Mechanisms

One difference between the Geiger and Hydrolox screens and more traditional modified traveling screens is the mesh material. Injury associated with mesh is thought to be a result of mucous and scale-loss as organisms slide over the mesh. No immediate mortality is likely attributable to this process, but loss of mucous and scales could result in osmoregulatory stress and greater susceptibility to disease, which in turn could lead to higher latent mortality rates. Modified traveling screens typically use a flat-top woven wire mesh to minimize mucous and scale loss. Similarly, the Hydrolox screen uses a molded polymer plastic for the same result. The Geiger screen can be fitted with a flat-top woven wire mesh, but Passavant-Geiger's preference is the use of a drilled plastic mesh which, again, reduces potential injury.

With modified traveling screens, fish can flop and slide across the mesh during the transfer process to the fish return. That is, as the screen panel rotates over the head sprocket, the contents of the fish lifting bucket are poured back onto the screen mesh. As the screen panel continues to the back side of the screen, its orientation moves from vertical to horizontal. During this transition, fish slide across the screen mesh as a low-pressure spray helps remove the fish from the panel to the fish return trough. Hydrolox and Geiger screens both have features that limit or eliminate this sliding during the removal process. The top sprocket of the Hydrolox screen is offset from the bottom sprocket, such that screen panels rotate beyond horizontal and fish and debris drop under the force of gravity into the fish return without re-contacting the screen mesh. All fish collected during post-impingement survival studies at Barrett Station with the Hydrolox screen (ASA 2008) were collected in the fish trough and not exposed to the high-pressure debris removal system – a confirmation of the effectiveness of this gravity drop system to remove fish without re-contacting the screen mesh. With Geiger screens the fish are poured from the fish lifting buckets directly into a combined fish and debris return trough. There is no opportunity for fish collected to re-contact the screen mesh. Therefore, both the Hydrolox screen and Geiger screens have features that reduce the potential for mucous and scale loss that can occur with modified traveling screens during the transfer process. An additional benefit of Geiger screens is that there is very little fish or shellfish by-pass (under screen) or carry over that can occur with conventional Ristroph-modified traveling water band screens.

Field studies of screens with fish protection features do not typically assess scale loss. However, scale loss was evaluated in lab studies for both the modified traveling screen (EPRI 2006a, Report 1003238) and Hydrolox screen (Alden

2006). In both studies, fish were exposed to the screens at various approach velocities (1, 2, and 3 ft/sec with the modified traveling screen and 1 and 2 ft/sec with the Hydrolox screen). Following collection, live and injured fish were held for 48-hours. At the end of the 48-hour holding period the fish were euthanized and the injury and scale loss levels were assessed. The amount of scale loss was categorized into one of four categories: 1 = <3%; 2 = 3–20%; 3 = 20–40%; 4 = >40% based on methods similar to those reported by Neitzel et al. (2000) and Basham et al. (1982). Among the three species that were tested in both studies (golden shiner [*Notemigonus crysoleucas*], bluegill [*Lepomis macrochirus*], and bigmouth buffalo [*Ictiobus cyprinellus*]), the fish collected by the Hydrolox screen showed less scale loss than those collected by the modified traveling screen (Table 2-2).

Table 2-2
Percent of Fish Exhibiting > 3% Scale Loss Following Impingement on a Hydrolox Screen and a Modified Traveling Screen (Modified from Alden 2006, EPRI 2006a). Percent of Control Fish with > 3% Scale Loss Shown Parenthetically.

Species	Hydrolox	Modified Traveling Screen
Golden shiner	61.6% (46.1%)	81.9% (50.8%)
Bluegill	4.9% (1.3%)	12.3% (8.3%)
Bigmouth buffalo	28.7% (21.3%)	66.7% (51.5%)

Spray Wash Pressure and Spray Wash Systems

Spray wash pressures and spray wash mechanisms are most similar between the Hydrolox and modified traveling band screens. In both cases, internal and external low-pressure sprays can be used to assist transfer of organisms into a fish return. The Geiger screen has a slightly different mechanism, in that a single spray header is used for the fish and debris sprays. Geiger uses different nozzles which spray different volumes of water, such that the fish spray has a lower pressure at the screen face than the debris spray. Limited data using alewife (*Alosa pseudoharengus*) in the laboratory (PSEG 2002; Table 2-3) indicated that pressures up to 100 psi did not result in higher mortality. Given that spray wash pressure is not a major contributor to mortality (PSEG 2002) and the similarities between the Geiger, Hydrolox, and modified traveling screen spray wash systems, it is unlikely that the Hydrolox or Geiger screens have any disadvantage over modified traveling screens relative to spray wash systems.

Table 2-3
Results of Debris Spraywash Testing. Data from Replicate Trials are Pooled for Each Condition (PSEG 2002)

Test Condition	Number of Fish Released	Number of Fish Collected*	Total Mortalities After 48-Hours	Percent Mortality	Percent of Fish Recovered
Handling control	299	292	2	0.7	97.7**
0 psi					
(basket control)	300	284	3	1.1	94.7
20 psi	300	299	-	0.0	99.7
40 psi	300	300	-	0.0	100
60 psi	300	300	-	0.0	100
80 psi	300	300	-	0.0	100
100 psi	300	300	3	1.0	100

* Fish that passed by the debris trough flap seal were not included as mortalities.

** During a single replicate of the handling control, the net pen slipped partially off of the collection trough. Seven fish escaped into the test flume. If this trial is excluded from recovery calculations, the handling control recovery rate is 100%.

Flap Seals

The Geiger and modified traveling screens have a very similar flap seal design and there would likely be little difference in their impact on fish survival. The Hydrolox screen has a flap seal, however, because of the gravity assisted transfer of organisms, few organisms are likely to directly encounter the flap. Therefore, differences in the flap seal configurations between the three screen types are unlikely to result in differential mortality rates.

Vacuum Screen

Vacuum screens are currently limited to the Beaudrey WIP design. These screens do have significant engineering and operational differences compared to traditional band screens. Impinged fish and debris are removed by a vacuum system, pumped under pressure to the intake deck and then transported in a fish return system as would be employed for other traveling screens. Through-screen velocity for the vacuum screen is also slightly higher because of the reduced open area associated with the rotary disc of the system; however, duration of impingement is reduced and fish remain submerged in water from the time of collection to return to the source waterbody. Additionally there is no by-pass or carryover of fish or shellfish with these screens as can occur with conventional Ristroph-modified screens. During operation, the screen continuously rotates at two revolutions per minute for a maximum retention time of fish on the screen of 30 seconds. This is much shorter than the duration of impingement for traveling water screens which can be as much as 4 minutes and longer. In addition, this system also limits any exposure impinged fish would have to the atmosphere as they are returned to the water body. This will significantly aid in reducing injury and mortality and available data supports this. As EPRI has previously reported to EPA, a Beaudrey WIP screen was tested by EPRI at Omaha Public Power's North Omaha Station (Bigbee et al. 2010, EPRI 2009a, Report 1018490). Initial efforts focused on the collection of impinged fish from the Missouri River followed by a 48-hour impingement survival study. Low numbers of naturally impinged fish, however, led the EPRI team to introduce seine netted (after a holding period) and hatchery fish into the Beaudrey WIP screen bay. Collected fish were held for 48-hours to assess post-impingement survival. Screen performance was assessed during spring and mid-summer 2008. Results showed that fish impinged and recovered from the Beaudrey WIP screen exhibited high survival. In fact, survival rates of impinged fish were not significantly different from the hatchery fish that were exposed to the experimental process and used as control fish. Channel catfish and bluegill exhibited 48-hour survival rates greater than 90%; and fathead minnow and the native river fish group, comprised primarily of emerald shiner, had survival rates of 79 to nearly 85%. Statistical tests showed that there were no significant differences ($P<0.05$) in survival between the control and test groups, indicating that screen contact and collection added no additional mortality.

Conclusion

There are several design features that are different among traditional modified traveling band screens, Hydrolox, and Geiger screens. These differences are minor (relative to fish impingement and handling) and should not negatively impact post-impingement survival. In fact, in some cases (e.g., direct transfer of organisms to the fish return in the case of Geiger screens and gravity transfer of organisms in the case of Hydrolox screens) the Hydrolox and Geiger screens have small advantages over modified traveling band screens. Therefore, EPRI believes that Hydrolox and Geiger screens perform equally as well as traditional traveling water band screens to justify inclusion in the potential EPA streamlined approach. EPRI has also initiated a laboratory project to evaluate the post-impingement survival of up to six species of fish collected off a pilot-scale rotary screen. EPRI testing will follow the same methodology it used to evaluate "Ristroph-modified" band screens in 2006 (EPRI 2006a, Report 1013238). In that study, as discussed earlier herein and in EPRI's comments on the proposed Rule (EPRI 2011a, Report 1019858), survival exceeded 95% for all species and velocities tested. Results of the testing on the rotary screen will be available by September 2012 and submitted to EPA for its consideration. Finally, while the rotary vacuum screen does have engineering design and operational differences compared to the band, rotary, and polymer screens, the differences are not substantial and field testing indicates survival performance equal to the other designs.

Credit for Existing or Newly Installed Technologies

EPA solicits comment on whether [the approach presented] reasonably addresses commenter's request that EPA identify velocity caps to be a pre-approved BTA for IM by appropriately taking into account facilities' existing technologies in determining whether a facility meets the proposed IM requirements. … In the final rule, EPA may decide to include the equations for calculating IM and the alternative provision in the rule language to provide additional clarity. EPA solicits comment on how frequently a facility would need to calculate credit for existing technology after the initial demonstration.

EPA is considering a provision that would allow existing facilities to use data already collected as part of a site-specific analysis of calculation baseline to demonstrate compliance with the alternative provisions. EPA solicits comment on these data and possible changes to the rule language for providing credit in reductions in impingement calculations to demonstrate compliance with the annual average and monthly average IM limitations.

EPA is thus also considering identifying additional technologies (which could include velocity caps) as satisfying the IM performance standards without having to conduct the type of study and calculation discussed in this example. EPA requests comment on this approach, on what technologies could be deemed compliant under this approach, and on what requirements or demonstrations would be appropriate to establish the technology as a compliance alternative. EPA also requests comment on whether the final rule should allow permitting authorities to approve additional technologies as satisfying the

IM requirements, and if so, what specific demonstrations or procedures would be appropriate for permitting authorities to use in making such determinations.

EPRI submits comments on (1) the general computational approach; (2) specific data on performance of velocity caps in particular; and (3) EPA's request for comment on how frequently a facility would need to calculate credit for an existing technology(ies) after the initial demonstration.

Credit Computational Approach for Existing or Planned Impingement Mortality Reduction Technologies and/or Operational Measures:

EPRI provides comment on three technical points relative to EPA's proposed computational approach for providing credit for existing or planned fish protection technologies and/or operational measures:

1. The arithmetic average is not appropriate for averaging percentages unless sample sizes for the percentage estimates are equal or very large.
2. The adjustments for existing technology should be based on proportions rather than absolute numbers.
3. There should be some minimum number of fish collected per month, below which the monthly criterion is not enforced because of lack of sample precision and meaningful interpretation of results.

Each of these topics is discussed in more detail in the following sections.

Arithmetic Average

On page 32 the document states: *"At the end of the 12-month period, the facility calculates the annual average as the arithmetic average of the monthly averages during that period."* It is not clear if the EPA is offering the arithmetic average as an example of one way to compute and estimate of annual IM percent reduction or prescribing that it is the only acceptable method for estimating annual IM. There are potential technical issues associated with use of the arithmetic average, since in many cases it may be misleading. To illustrate, consider a simple case of only two months. In one month 100 fish are impinged and 1 dies to yield IM=1%. In the second month only one fish is impinged and it dies to yield IM=100%. The arithmetic average of 1% and 100% is 49.5% and yet only 2 of 101 fish have died. Consider a second example where in one month 1000 fish are impinged and 200 die yielding IM=20% and a second month one fish is impinged and it survives so that IM=0%. The arithmetic average of 0% and 20% is 10% which is below the performance criterion of 12% even though 19.98% of the impinged fish have died. It is clear from these examples that the arithmetic average can either overestimate or underestimate the magnitude of annual impingement. One solution is to estimate annual impingement using a weighted average approach where the monthly percentages are weighted by the number of fish impinged. A simpler approach which produces the same estimate is to simply sum the number of fish that die and sum the number of fish impinged and compute the ratio.

It should also be noted that methods proposed by the EPA are not internally consistent with respect to the correct method of averaging percentages. On page 34 an example is given where a monthly mean is computed as a weighted average of four observations made within one month.

The examples presented here are extreme and simple to clearly illustrate the point. One might argue that such extreme examples would not occur in reality or that over the course of 12 months these extremes would tend to average out. However, due to the seasonal nature of impingement it is likely that the arithmetic average would result in biased results, and EPRI experience suggests this would be a common problem. Here is one such example reported by an EPRI member from the Great Lakes region:

> An annual arithmetic average of monthly averages can be problematic in that each month's average is given equal weight even though the numbers of fish impinged in a given month can be vastly different. As an example, one of our facilities that has incorporated a number of measures to reduce fish impingement has exhibited a total annual reduction of nearly 97% when compared with an adjacent calculation baseline facility (CBF) of comparable size. However, the arithmetic average of the monthly average reductions results in a reduction of 54%. Looking at six possible species of concern (rainbow smelt, logperch, yellow perch, emerald shiner, smallmouth bass and rock bass) the differences between the calculations ranged from 7% to 26%. These discrepancies are primarily due to differences in the temporal distributions of impinged fish at the two facilities, with the largest reductions occurring during periods when the largest numbers of fish were impinged at the CBF and low reductions occurred when fish impingement was low at the CBF. This scenario indicates the need to have some flexibility in calculating impingement mortality because of the variability that can occur not only with temporal distributions of fish, but environmental conditions and plant operations.

The EPA may want to consider the implications of using an overly prescriptive statistical methods due to the variety of potential credit and site-specific circumstances. Consider a facility where observation shows that IM is strongly correlated with dissolved oxygen concentration (DO) in the forebay of the CWIS such that fish avoid the area and therefore IM during low DO periods. Using this correlation and continuous measurements of DO, a model based estimation procedure could be implemented to more accurately estimate annual IM. Providing flexibility to accommodate use of such a model could result in a more accurate estimate of IM than a fixed statistical method. This is especially the case since in many situations, the best method of estimation is not clear until the data have been collected and examined.

Adjustment for Existing IM Mitigation Technology

On page 33 of the NODA is the statement: *"Second, the calculations for each month would require a different set of adjustments that would create additional, unnecessary,* *complications for the facility and permit authority."* The EPA may want to consider that implementing technologies to reduce IM entails great expense and statistical methods may vary in there appropriateness to accurately assess the magnitude of IM. The NODA further states on page 33: "To simplify the adjustment procedures, a facility would estimate the monthly reduction using the total reduction divided by the number of months in the study." This statement is followed by an example that indicates the EPA considers the "total reduction" to be an absolute number.

Impingement mortality is the result of multiplicative processes. The number of fish impinged is a proportion of the population at risk. If more fish are at risk, more fish will be impinged. The number of fish that die as a result of the impingement experience is a proportion of the number impinged. It is not clear why the EPA proposes to make adjustments for existing technology in the form of absolute numbers rather than proportional adjustments, but it is clear that this choice can result in either over or under estimation of IM.

Consider an example where the large majority of impingement occurs in one month and use the adjustment proposed on page 34 of the document of 11% which for one year equates to 1100 fish. By prorating the adjustment as an absolute number equally across months (Table 2-4), the monthly estimated IM for months with low impingement is biased low because the denominator is inflated. For August where impingement is high, the change in IM because of the adjustment is small because the adjustment is small relative to the denominator. In months when impingement is low the change in IM is large because the adjustment is large compared to the denominator. When these biases are coupled with the arithmetic average, the result is a roughly 40% reduction in IM when only 11% of fish were saved. An example could be constructed that results in a overestimate of IM.

On the other hand by prorating the adjustment as a fixed percentage of the number impinged (Table 2-5), the reduction in IM becomes consistent from month to month and reduction in annual IM is consistent with the number of fished saved.

The proposal to treat adjustments for existing technology as fixed rather than relative also becomes an issue in cases where inter-annual variability is large (King et al. 2010; EPRI 2009b, Report 1018540). If the adjustment is estimated in a successful spawning year which consequently results in high impingement and then subsequently is applied in a year of low impingement the result will be an underestimate of IM. The converse scenario is equally plausible.

Table 2-4
Illustration of biased estimates of IM due to equally prorating adjustments for existing technology as an absolute number.

Month	Estimated Monthly Impingement	Estimated Fish Killed	IM % Without Adjustment	Absolute Adjustment	IM % With Adjustment
Jan	1000	120	12	1100	5.7
Feb	1100	150	13.6	1100	6.8
Mar	1050	95	9	1100	4.4
Apr	1020	97	9.5	1100	4.6
May	1150	105	9.1	1100	4.7
Jun	900	85	9.4	1100	4.2
Jul	2000	210	10.5	1100	6.8
Aug	100000	20000	20	1100	19.8
Sep	3000	250	8.3	1100	6.1
Oct	1200	100	8.3	1100	4.3
Nov	1400	110	7.9	1100	4.4
Dec	1100	95	8.6	1100	4.3
arithmetic mean			10.52		6.34
weighted mean			18.6		16.7

Table 2-5
Illustration of unbiased estimates of IM due to equally prorating adjustments for existing technology as a fixed percentage of impingement.

Month	Estimated Monthly Impingement	Estimated Fish Killed	IM % Without Adjustment	Relative Adjustment	IM % With Adjustment
Jan	1000	120	12	110	10.8
Feb	1100	150	13.6	121	12.3
Mar	1050	95	9	115.5	8.2
Apr	1020	97	9.5	112.2	8.6
May	1150	105	9.1	126.5	8.2
Jun	900	85	9.4	99	8.5
Jul	2000	210	10.5	220	9.5
Aug	100000	20000	20	11000	18
Sep	3000	250	8.3	330	7.5
Oct	1200	100	8.3	132	7.5
Nov	1400	110	7.9	154	7.1
Dec	1100	95	8.6	121	7.8
arithmetic mean			10.52		9.5
weighted mean			18.6		16.8

The example of adjusting for multiple technologies given by EPA is reformulated here to illustrate how to apply adjustment rates to give credit for existing technologies.

First the estimates for the offshore location (30,000) and the velocity cap (24,000) are used with an estimate of annual impingement (12*4000=48000) to compute a combined rate for adjustment for these two technologies. That is, the number of fish that would have been impinged without these technologies which will be called the counterfactual impingement is (30,000 + 24,000 + 48,000) = 102,000. The number of fish saved expressed as a percent of the counterfactual impingement is 100*(54,000/102,000) = 52.94%. From this percentage an adjustment factor is computed as: adjustment factor =1/(1-0.5294) = 2.125

This adjustment factor is applied to the denominator of the IM estimate to obtain the IM adjusted for these two technologies.

*IM(adjusted) = 1000 / (4000*2.125) = 11.76 %* *Equation 2-1*

To further adjust for the reduction in flow rate of 11%, another term must be added to the counterfactual impingement such that the reduction between the counterfactual impingement and the observed impingement is 11%. This difference is computed using the factor (1/(1-0.11) = 1.123596. Thus without flow reduction, 4000*1.123596=4494 would have been impinged and 494 is 11% of 4494.

The fractional part of this factor is applied to the number of fish impinged and added to the denominator to adjust for reduced flow.

IM(adjusted) = 100(1000 / (4000*2.125 + 4000*0.123596)) = 11.11 %*
Equation 2-2

EPA's proposal to compute 11% of near field fish density to estimate the number of fish saved by flow reduction assumes that fish behave as passive particles which is a flawed assumption. This flaw is clear because if 1100 represents 11% of the fish, then the remaining 89% would be 8900 which is far greater than the 4000 that were impinged. It is more realistic to adjust the number impinged based on an assumption that the rate of impingement per unit volume of water pumped is constant.

If these adjustments by rates were applied to a month with the same raw IM, where impingement was 2000 and 500 fish died, there resulting adjusted IM would be the same.

IM(adjusted) = 100(500 / (2000*2.125 + 2000*0.123596)) = 11.11 %*
Equation 2-3

Using the EPA's approach with absolute numbers the result would be much lower.

$$IM(adjusted) = 100*(500 / (2000+4500+ 1100)) = 6.58\ \%$$

Equation 2-4

Given an unadjusted IM of 25%, the rates approach to adjustment will yield consistent adjustments regardless of the monthly number impinged.

Low Monthly Impingement and False Positives

While the NODA discusses the possibility that annual impingement might be sufficiently low such that IM regulation is not necessary, there is no discussion of the issue that low monthly impingement might result in a high probability of exceeding the 31% monthly limit by chance even when the technology is performing at a level that is better than the monthly limit. Table 2-6 shows the number of fish to be sampled per month in order to achieve a low risk of exceeding the limit by chance for a range of true performance levels. The risk of exceeding the limit is computed using the binomial distribution where the probability of IM is given by the true performance level, the number of trials is the monthly number of fish collected, and the limit is set to the number of fish allowed to die without exceeding 31%. For each level of true performance, the point at which the risk of a false positive drops below 1 in 20 is reported. That is, when the true performance is 25% (row 1) and 158 fish are collected then the risk of having more than 48 fish die is 0.0515 or just over 1 in 20. In the next row of the table, if 159 fish are collected, the risk of having more than 49 fish die is 0.0395 or just under 1 in 20. Thus if it is acceptable to have one month where the true performance level is 25 percent, then 159 or more fish are required to insure the risk of a false positive is less than 1 in 20. Even if the technology were consistently performing at the annual limit of 12 percent, at least 10 fish per month would be required to insure a low risk of false positive response.

Table 2-6
Illustrations of numbers of fish required to achieve an acceptably low risk of false positive responses in IM monitoring.

True Performance	Monthly Number Collected	31% Limit	Risk of Exceeding Limit
0.25	158	48	0.0515
	159	49	0.0395
0.20[3]	45	13	0.0521
	46	14	0.0361
0.15	19	5	0.0537
	20	6	0.0219
0.12	9	2	0.0833
	10	3	0.0239

[3] In previous comments EPRI reported that 44 fish per month were required to maintain a risk of false positive of less than 1 in 20 when the true performance level is 0.20. These results are based on exact computations using the binomial distribution and differ slightly from the previous results which were computed using a normal approximation to the binomial.

Velocity Cap Performance

At the 2011 American Fisheries Society Annual Meeting in Seattle, WA, EPRI sponsored a two day symposium on 316(b) issues. One of the papers presented at the symposium focused on the topic of performance of offshore velocity caps in reducing impingement mortality. These studies were all focused on California facilities with offshore velocity caps that have the capability to reverse flow. By closing a gate valve, these facilities can use the offshore cooling water discharge pipe that has no velocity cap to withdraw water and discharge the water through the velocity cap. This procedure is used by the facilities to control biofouling in the offshore intake pipe by using the thermally heated water to kill any biofouling organisms that may be colonizing the intake tunnel. By reversing flow for controlled periods of time, data can also be collected to compare the number fish entering the offshore velocity cap that are impinged on the traveling water screen to the number entering the offshore discharge pipe (with no velocity cap) and impinged when it is used as the intake. Studies at four power plants have resulted in reductions as follows:

- El Segundo Units 1 and 2 (1956-1958 Study) – 95% reduction in IM
- Scattergood (1968-1975) - ~ 83% reduction in IM
- Ormond Beach Units 1 and 2 (1979/1980) - 61% - 87% reduction in IM
- Huntington Beach Units 1-4 (1979/1980) – 53% - 99% reduction in IM

The most recent of this study type was conducted at the Scattergood Generating Station in 2006/2007. In that study flow was reversed for two week periods to compare impingement with and without the velocity cap. The results of this study demonstrated a 97% reduction in impingement numbers, a 97.6% reduction in flow weighted impingement and a 95% reduction in biomass when the velocity cap was used. Some 94% of the impingement during this study was made up of the Pacific Sardine which had a 99.6% reduction with the velocity cap compared to a 91.7% reduction for topsmelt, a 77% to 78.8% reduction for jacksmelt, and highly variable reductions in queenfish impingement.

Frequency of Credit Calculations

EPA may want to consider the benefits of confirmatory fish protection technology testing in terms of the fish losses that will occur at some facilities as a result of such testing. This is a potential issue for any facility taking credit for technologies and/or operational measures that prevent fish from being impinged as a result of removal of the IM reduction deterrent to compare IM with and without the deterrent. Examples of such deterrents include behavioral devices, diversion systems, exclusion devices such as barrier nets that would not qualify for 0.5 ft/sec through-screen velocity reduction (e.g., Chalk Point Barrier Net).

Furthermore in some cases monitoring may not yield useful information. Note that the formulation of the percent impingement mortality calculation (section 1 on this topic above) makes it clear that in the EPA's example, the only thing that changes from month to month is the unadjusted mortality rate. Most facilities with velocity caps will use reductions in the total impingement rather the increased survival of fish that are impinged to meet the percent impingement mortality criteria. Many facilities may not have a fish return system, for example. Thus for these facilities, the unadjusted percent impingement mortality is constant (i.e. 100%) as are the adjustment factors. Therefore, in such circumstances, monitoring does not provide useful data related to compliance (or for fine tuning of technology performance) and need not be required.

Facilities with Low Impingement Rates

EPA solicits comment on the data and approaches under consideration for facilities that already have very low impingement rates. EPA also solicits comment on whether EPA should identify in the final rule a specific upper limit on what could be considered a very low level of impingement mortality, or if this should be left to the discretion of the permitting authority. In addition, as noted above, EPA is soliciting comment on recommendations it received following proposal that EPA consider a regulation under which impingement requirements (like entrainment requirements) would be established on a site-specific basis. If EPA adopted the approach proposed for entrainment, the permit writer could weigh site-specific costs and benefits, among the factors being assessed, in the decision whether to require further impingement controls. EPA also requests comment on a hybrid approach under which the permittee could choose among several compliance options that might include both meeting an IM performance standard or requesting a site-specific determination of BTA for both impingement and entrainment, if the benefits of meeting the performance standard did not justify the costs on a site-specific basis. This could be structured in a manner similar to the "cost-benefit variance" that was included as a compliance option in the final Phase II rule. EPA requests comment on all of these approaches.

Whether or not EPA allows an exclusion for facilities with a low or *de minimis* level of impingement is a policy decision. EPA's view relative to low impingement numbers *that these facilities are not likely having an adverse effect on aquatic life* is consistent, however, with EPRI's review of impacts of CWIS on aquatic life as subsequently discussed. EPRI also notes that, in addition to site-specific assessment of AEI, the value(s) of low level impingement could be identified using information from our recent national survey of impingement and entrainment, the cost-benefit test, or using statistical approaches to identify the requisite sample size required to ascertain that observed impingement mortality exceeds EPA's biological performance criteria as proposed or as it may be revised based on new data received. Each of these approaches are subsequently discussed.

In 2011, EPRI submitted to EPA our comprehensive examination of the technical literature on the occurrence of adverse environmental impact associated with CWIS operation. That analysis (EPRI 2011b, Report 1023094) found limited evidence for any CWIS caused impact on fish populations. In 2002, EPRI also reported (EPRI 2003a, Report 1005178) the results of a comprehensive examination of the influence of water withdrawal of any type on fish populations and also found no relationship between volume of water withdrawn (e.g., by CWIS, municipal water supply, irrigation) or lost (e.g., downstream flow through dams for hydropower or spillage) and the quality of the fish community in the source water body. This earlier study reported that all across the U.S. and around the world high quality fish communities exist in reservoirs and rivers despite consumptive and non-consumptive water use.

EPRI has previously commented on the episodic nature of impingement, that zero or very low daily impingement numbers are common, that annual numbers can be very low and that impingement numbers can vary significantly between years. Relative to the latter point on inter-annual impingement variability, in the impingement characterization study EPRI conducted on the Ohio River, impingement levels in year two of the study were an order-of-magnitude less than those observed during year one (King et al. 2010; EPRI 2009b, Report 1018540). In this same study (15 plants were monitored at least two times per month, 24 hours each sample day), during year one, there were a total of 20 sampling days where the catch was less than ten fish and 68 sampling days (30% of the total) during year two when less than ten fish were collected. For the EPRI Potomac River evaluation of the rotary screen (EPRI 2007, Report 1013065), 56 of the total 73 24-hour sampling days had catches of less than ten fish and of that total, 35 of the days were zero catches. Lastly, for the EPRI evaluation of the Beaudrey vacuum screen at the North Omaha Power Station on the Missouri River (Bigbee et al. 2011), 24-hour survival monitoring was abandoned after four months of zero fish catches.

EPRI previously provided comments to EPA on the data EPRI collected during our national survey of impingement and entrainment as monitored by the power industry in accordance with the 2004 final, though remanded, Phase II Clean Water Act §316(b) Rule for existing power plants. Results of the survey were published in 2011 (EPRI 2011e, Report 1019861) and provided to EPA in our comments on the proposed 2011 Rule. This report summarizes responses from 240 facilities. Because I&E varied geographically and by water body type, EPRI grouped plants within 12 geographic regions (six freshwater regions and six marine or estuarine regions) as a way to evaluate the existence of regional trends among the plant-specific results. In all six of the freshwater regions, gizzard shad (*Dorosoma cepedianum)* or threadfin shad (*D. pentenense)* dominated impingement. There was greater diversity among the marine and estuarine plants. In most of the regions, the mean annual impingement was much higher than the median value, indicating that the means were greatly influenced by one or two very high annual estimates. Nearly half of the plants had annual impingement that was estimated to be 50,000 or fewer fish and shellfish, and 83% of the plants had values estimated to be 500,000 or fewer fish and shellfish. Five percent of the plants had estimated annual values greater than or equal to five million fish and shellfish. Very few state or federal threatened or endangered species were impinged at any of the plants responding to the questionnaire.

In this national survey, EPRI found the impingement level percentile frequencies by water body type and U.S. region presented in Tables 2-7 through 2-9.

Table 2-7
Impingement level percentile frequency for power plants on marine and estuarine waterbodies by U.S. region (EPRI 2011e, Report 1019861).

	Percentile		**Facilities Within a Specified Percentile Range**	
Region	**%**	**Value**	**Range**	**Count**
West Coast	5%	5,800	0-5%	1
	10%	8,600	>5-10%	-
	25%	17,000	>10-25%	1
	50%	100,000	>25-50%	1
	75%	270,000	>50-75%	1
	90%	870,000	>75-90%	1
			>90%	1
Northeastern Coastal	5%	2,900	0-5%	1
	10%	5,400	>5-10%	1
	25%	9,200	>10-25%	2
	50%	20,000	>25-50%	4
	75%	140,000	>50-75%	4
	90%	6,300,000	>75-90%	2
			>90%	2
Mid-Atlantic Coastal	5%	4,000	0-5%	1
	10%	5,100	>5-10%	-
	25%	34,000	>10-25%	1
	50%	150,000	>25-50%	2
	75%	170,000	>50-75%	1
	90%	260,000	>75-90%	1
			>90%	1
Southern Coastal and Gulf	5%	7,000	0-5%	1
	10%	8,100	>5-10%	-
	25%	17,000	>10-25%	1
	50%	77,000	>25-50%	2
	75%	240,000	>50-75%	1
	90%	760,000	>75-90%	1
			>90%	1
All Coastal Facilities	5%	2,900	0-5%	3
	10%	3,100	>5-10%	2
	25%	8,900	>10-25%	6
	50%	26,000	>25-50%	10
	75%	180,000	>50-75%	9
	90%	590,000	>75-90%	5
			>90%	4

Table 2-8
Impingement level percentile frequency for power plants on freshwater water bodies by U.S. region (EPRI 2011e, Report 1019861).

	Percentile		Facilities Within a Specified Percentile Range	
Region	**%**	**Value**	**Range**	**Count**
Great Lakes	5%	1,800	0-5%	2
	10%	3,100	>5-10%	1
	25%	19,000	>10-25%	3
	50%	360,000	>25-50%	5
	75%	2,800,000	>50-75%	5
	90%	24,000,000	>75-90%	3
			>90%	3
Southeastern Reservoirs	5%	8,600	0-5%	1
	10%	9,200	>5-10%	-
	25%	27,000	>10-25%	1
	50%	53,000	>25-50%	2
	75%	180,000	>50-75%	1
	90%	190,000	>75-90%	1
			>90%	1
Midwestern Reservoirs	5%	660	0-5%	1
	10%	1,100	>5-10%	-
	25%	13,000	>10-25%	2
	50%	120,000	>25-50%	2
	75%	330,000	>50-75%	2
	90%	2,100,000	>75-90%	1
			>90%	1
Southwestern Cooling Lakes	5%	3,200	0-5%	1
	10%	5,200	>5-10%	-
	25%	10,000	>10-25%	2
	50%	42,000	>25-50%	2
	75%	220,000	>50-75%	2
	90%	320,000	>75-90%	2
			>90%	1
Large Rivers	5%	420	0-5%	3
	10%	1,200	>5-10%	2
	25%	6,100	>10-25%	8
	50%	52,000	>25-50%	12
	75%	170,000	>50-75%	12
	90%	860,000	>75-90%	7
			>90%	5

Table 2-8 (continued)
Impingement level percentile frequency for power plants on freshwater water bodies by U.S. region (EPRI 2011e, Report 1019861).

	Percentile		Facilities Within a Specified Percentile Range	
Region	**%**	**Value**	**Range**	**Count**
Small Rivers	5%	700	0-5%	2
	10%	990	>5-10%	1
	25%	4,500	>10-25%	5
	50%	42,000	>25-50%	7
	75%	290,000	>50-75%	7
	90%	1,100,000	>75-90%	4
			>90%	3
All Freshwater Facilities	5%	740	0-5%	7
	10%	1,300	>5-10%	6
	25%	7,300	>10-25%	19
	50%	56,000	>25-50%	31
	75%	280,000	>50-75%	31
	90%	1,800,000	>75-90%	19
			>90%	13

Table 2-9
Impingement level percentile frequency for all power plants (EPRI 2011e, Report 1019861).

	Percentile		Facilities Within a Specified Percentile Range	
Collection Type	**%**	**Value**	**Range**	**Count**
Impingement	5%	1,045	0-5%	10
	10%	1,772	>5-10%	8
	25%	8,079	>10-25%	25
	50%	59,318	>25-50%	41
	75%	262,602	>50-75%	40
	90%	1,622,137	>75-90%	24
	100%		>90%	17

It is possible for EPRI to provide additional analyses of this data set, subject to protecting the identity of the facilities that provided the data per confidentiality agreements established with EPRI as part of the survey, to EPA to support identifying criteria for low impingement level compliance exclusions.

EPA has also noted that a cost-benefit test could potentially be used for identifying low impingement levels. The tools and resources for performing cost-benefit analysis are readily available. EPRI (2006b, Report 1012539) reviewed the requisite information and tools consistent with those used in natural resource economics as well as by EPA for supporting the overall Clean Water Act §316(b) regulation development. EPRI further tested the methods on the impingement data set EPRI collected for 15 power plants on the Ohio River (King et al. 2010). That test (EPRI 2009c, Report 1018643) found that on an individual plant basis the estimated annual economic value of the impinged fish ranged from $2,500 to $213,000 in year one and from $140 to $84,000 in year two. Resource economic analysis is a relatively straightforward analytical process common in the fisheries profession. It is one way of placing the value of fish losses in perspective that is easily grasped by professionals and lay individuals.

Another option for identifying low levels of impingement is to use sample size analysis. This approach assumes EPA continues to use the proposed or revised annual and monthly impingement mortality performance criteria from the model traveling screen data base. These calculated performance criteria values can be further parameterized with confidence intervals reflecting the variability in the observed values. EPA can then query what the required sample size would be at some level of precision (e.g., 5% alpha level) to assure that the observed screen performance in biological testing statistically significantly exceeds the proposed monthly and annual criteria. EPRI performed an example calculation in its comments on the proposed EPA Rule (see EPRI 2011a, Report 1019858, Section 2, subsection 6 – Monthly and Annual Limits on Impingement Mortality). If a project cannot capture enough samples to determine if it is or is not in compliance, that sample size is by default a *de minimis* impingement level.

Species of Concern

EPA solicits comment on the data and approaches under consideration here that best address the variability in species and life stages of fish and shellfish. Alternatively, EPA takes comment on the suggested addition of defined species of concern, explicitly identifying those specific species that are not subject to the IM limitations.

This is an additional issue of importance to the site-specific nature of impingement and, though not a comment issue in this NODA, of entrainment. What are and are not species of concern for evaluating the performance of compliance technologies is fundamentally a policy issue. EPRI has previously noted, however, (as EPA has also noted in the proposed Rule) that there are numerous species of freshwater fish that are invasive and highly abundant (e.g., round goby, Asian carp, Great Lakes alewife) or highly abundant, fragile and experience episodic natural mortality events (e.g., gizzard and threadfin shad). EPRI has previously provided EPA with its R&D results on potential causes of natural mortality events and the frequency with which they occur (EPRI 2011f, 2008, Reports 1023101, 1014020). EPRI also notes that many state resource agencies have programs to deliberately reduce the abundance of highly fecund forage fish to improve recreational fisheries or to minimize the public nuisance magnitude of natural mortality events when they occur (e.g., Catalano and Allen 2011).

EPRI, to assist our members in recommending "species of concern" for performance monitoring if it is required in the final EPA Rule, has initiated a project to develop objective criteria for inclusion and exclusion of species of concern. The criteria will consider such issues as:

- Level of involvement with cooling water intake structures by waterbody type;
- Life history characteristics, such as population structure, distribution, age at maturity, fecundity, and natural mortality rates;
- Recreational and commercial value;
- Regulatory interest as possible sentimental species;
- The degree to which the species represents the greater suite of species involved with the facility;
- T&E species; and
- Invasive species

The criteria developed will be tested for several facilities on different waterbody types. Application results will be presented in the final report. This EPRI report will be completed by the end of 2012 and available for use when compliance activities begin. A copy of the final report will be provided to EPA.

Section 3: EPRI's Response on EPA's Stated Preference Survey Preliminary Results

Econometric Modeling

EPRI evaluated the models presented in the NODA and analyzed the survey data EPA provided. As part of this evaluation, EPRI reproduced the models presented in the NODA and also developed new models with more significant variables and greater overall model significance than the NODA models.[4] These new models imply lower WTP by survey respondents and also indicate the potential for survey induced bias in WTP estimates. This section describes the results of the models EPRI developed using the survey data presented in the NODA.

Given a set of preferences held by survey respondents, the experimental design, sampling, and econometric modeling approach of a choice experiment are used together to determine the magnitude and significance of the estimated preference coefficients. Econometric modeling is required to estimate survey respondents' willingness to pay because this value is not directly provided in the choice experiment and because respondents are a heterogeneous subset of the general population with specific characteristics and preferences which must be considered when generalizing the results.

The EPA's survey memo of June 5, 2012 describes work done to conduct such a choice experiment in order to identify the values (both use and nonuse) that survey respondents have for reducing cooling water intake structure impacts (USEPA 2012). As described in the NODA, following the Stated Preference Survey's administration, results from the study were modeled using mixed logit. The NODA presents the five best performing models and notes that they are preliminary and do not include all data. Results indicate that the value "fish saved" is significant in all five models, "commercial fish populations" in four of

[4] In replicating the NODA models, EPRI found minor differences between the coefficients in its replicated models and the ones presented in the NODA. These differences occurred mainly in variables with insignificant coefficients. Because the NODA notes that the models are preliminary, the minor differences in the replicated model coefficients are assumed to be related to additional survey data that may not have been made available at the time of the NODA's release.

the five models, "fish populations" is significant in three of the five models, and "aquatic ecological conditions" is statistically significant in two of the five models. The alternative specific constant (ASC) that represents the status quo (i.e., no new regulation) is not significant in any of the models presented in the NODA. In describing results EPA interprets statistically significant results on environmental attributes as indicating positive willingness to pay (WTP) for changes in those environmental attributes. Their research memo attributes insignificance on the alternative specific constants as respondents' unwillingness to pay a positive or negative amount for a regulation that has no effects on ecological attributes. EPA does not offer any interpretation of the derived standard deviations for parameters that are modeled as random. When discussing the significance of coefficient estimates, EPA notes that analogous outcomes are common in ecological choice literature where the substantial majority of choice attributes are statistically significant. EPA interprets the overall models as significant based on chi-squared and pseudo-r-squared results.

EPA does not discuss the lack of significance in the mixed logit standard deviation variables or that the only consistently significant environmental variable reflects "fish saved" from I&E.[5] For choice experiments such as this one, where the researcher has control over all aspects of the study including attribute ranges, experimental design, and sample size, the expectation is that all of the coefficients are statistically significant. When they are not, it is typically because of some combination of the data modeling technique, experimental design, or sampling (i.e., lack of large sample properties). In this case, the alternative determination is that what is verbalized in focus groups and generally thought of as important (here fish populations and aquatic conditions) is simply not important to people.

It is more likely that the approach described in the NODA has insufficient information due to some combination of modeling, experimental design, or small sample size. With a given set of data, the only one of these that can be directly addressed is econometric modeling. EPRI's ability to provide technical review of EPA's modeling is greatly enhanced because EPA provided the survey responses and experimental design. EPRI developed some mixed logit models with EPA data and specifications—i.e., same random variables and 300 Halton draws.[6] Although these results do not perfectly match the NODA results, they are very similar. In these models, the same 14 out of 20 environmental variables are significant. These are similar in magnitude to the NODA results. Like the NODA models, the coefficients specific to mixed logit (standard deviations) are only consistently significant on the standard deviation of the "fish saved" coefficient. Similar to the NODA models, the ASC coefficient representing the "status quo" variable is insignificant in all cases.

The mixed logit models in the NODA and the new models that EPRI developed, only have significant coefficients on the standard deviations of the

[5] EPA appropriately points out that a disparity in the ranges over which environmental impacts were evaluated (2% to 4% for populations and aquatic conditions versus 5% to 95% for I&E) may underlie this result.

[6] Halton draws refers to the randomization algorithm used in econometric modeling.

“fish saved” variable. Generally speaking, insignificant coefficients here means the mixed logit specification is not the correct specification (Train 2009). Also, ASC’s on “status quo” are more often significant than not and are often of a much higher magnitude than other coefficients (Scarpa et al. 2005).

EPRI developed new models with the survey data to determine if better-performing, mixed logit specifications are available. EPA’s description of its econometric modeling is limited. However, an important feature of the models EPRI developed in replicating EPA’s results is that the three responses provided by each surveyed individual were treated independently (i.e., cross sectionally). An implied assumption is that tastes vary across respondents in the same way that they vary for a particular respondent across those same choices. An alternative is to account specifically within the econometric modeling for the inter- and intra-personal nature of data associated with repeated choice experiments. With this approach, the objective function is specified so that the multiple choices are identified with each specific respondent (i.e., the integration across preference coefficient distributions is applied to each respondent’s sequence of choices rather than each choice independently). Conceptually, this approach uses more information relevant to mixed logit parameters. In particular, the ability to identify taste distributions is enhanced. Empirically, this approach has been shown to lead to improved fit (Hess and Rose 2009; Hess and Train 2011).

EPRI developed some new mixed logit models with EPA data and specifications—i.e., the same random variables and 300 Halton draws, but with the integration occurring over each sequence of choices rather than each choice. Model results are reported below in Tables 3-1 through 3-5.

Table 3-1
Northeast Results from Mixed Logit Model

Northeast mixed logit model		Number of obs	=	3381
		LR chi2(5)	=	505.32
Log likelihood	= -896.34839	Prob > chi2	=	0.0000

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Mean						
Cost	-.0267515	.0043242	-6.19	0.000	-.0352267	-.0182762
com_fish	.1081598	.0406006	2.66	0.008	.0285842	.1877354
fish_pop	.0075061	.0603582	0.12	0.901	-.1107939	.1258061
fish_saved	.0252922	.00358	7.06	0.000	.0182755	.032309
aq_cond	.1722583	.0616893	2.79	0.005	.0513496	.2931671
Nopolycon	-4.404175	.979319	-4.50	0.000	-6.323604	-2.484745
SD						
com_fish	.2133642	.095881	2.23	0.026	.0254409	.4012876
fish_pop	.2716865	.175747	1.55	0.122	-.0727713	.6161442
fish_saved	.0280164	.0052505	5.34	0.000	.0177256	.0383071
aq_cond	.3113528	.1310696	2.38	0.018	.0544612	.5682444
Nopolycon	8.860602	1.364075	6.50	0.000	6.187065	11.53414

Table 3-2
Southeast Results from Mixed Logit Model

Southeast mixed logit model	Number of obs	=	4167
	LR chi2(5)	=	673.82
Log likelihood = -1107.173	Prob > chi2	=	0.0000

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Mean						
Cost	-.0393682	.004596	-8.57	0.000	-.0483763	-.0303602
com_fish	.0854395	.0356008	2.40	0.016	.0156632	.1552157
fish_pop	.0323906	.0524259	0.62	0.537	-.0703624	.1351436
fish_saved	.0256318	.0037194	6.89	0.000	.0183418	.0329218
aq_cond	.1703836	.0568209	3.00	0.003	.0590166	.2817505
Nopolycon	-2.792884	.6466675	-4.32	0.000	-4.060329	-1.525439
SD						
com_fish	.2002899	.0898086	2.23	0.026	.0242682	.3763115
fish_pop	-.0134848	.3064272	-0.04	0.965	-.6140712	.5871015
fish_saved	.0373778	.0063086	5.92	0.000	.0250132	.0497424
aq_cond	.4138743	.1372707	3.02	0.003	.1448287	.6829198
Nopolycon	7.880412	1.103414	7.14	0.000	5.71776	10.04306

Table 3-3
Pacific Results from Mixed Logit Model

Pacific mixed logit model		Number of obs	=	2436
		LR chi2(5)	=	438.01
Log likelihood	= -566.6001	Prob > chi2	=	0.0000

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Mean						
Cost	-.039674	.0065119	-6.09	0.000	-.0524371	-.0269108
com_fish	.1227784	.0496346	2.47	0.013	.0254965	.2200604
fish_pop	.1737601	.0815061	2.13	0.033	.0140112	.333509
fish_saved	.040499	.0059821	6.77	0.000	.0287742	.0522238
aq_cond	.3313621	.0893806	3.71	0.000	.1561795	.5065448
Nopolycon	-6.548519	1.554477	-4.21	0.000	-9.595238	-3.501801
SD						
com_fish	-.0818793	.1321854	-0.62	0.536	-.3409578	.1771993
fish_pop	.0459179	.4277561	0.11	0.915	-.7924687	.8843045
fish_saved	.037635	.0068488	5.50	0.000	.0242116	.0510584
aq_cond	.4351818	.1865582	2.33	0.020	.0695345	.8008292
Nopolycon	-12.37356	2.78119	-4.45	0.000	-17.8246	-6.922531

Table 3-4
Inland Results from Mixed Logit Model

Inland mixed logit model	Number of obs	=	6540
	LR chi2(5)	=	1004.69
Log likelihood = -1810.306	Prob > chi2	=	0.0000

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Mean						
Cost	-.0310208	.0028097	-11.04	0.000	-.0365278	-.0255138
com_fish	.0623152	.0224425	2.78	0.005	.0183286	.1063017
fish_pop	-.0008125	.0357292	-0.02	0.982	-.0708404	.0692154
fish_saved	.0162811	.0034868	4.67	0.000	.0094472	.023115
aq_cond	.1651303	.037028	4.46	0.000	.0925567	.2377039
Nopolycon	-3.172588	.5288658	-6.00	0.000	-4.209146	-2.13603
SD						
com_fish	-.0016497	.127395	-0.01	0.990	-.2513394	.24804
fish_pop	-.0438515	.1022277	-0.43	0.668	-.2442141	.1565111
fish_saved	.0427479	.0055097	7.76	0.000	.031949	.0535467
aq_cond	.228239	.1137161	2.01	0.045	.0053595	.4511184
Nopolycon	7.052188	.7988269	8.83	0.000	5.486516	8.61786

Table 3-5
National Results from Mixed Logit Model

National mixed logit model		Number of obs	=	2367
		LR chi2(5)	=	376.03
Log likelihood = -635.15393		Prob > chi2	=	0.0000

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Mean						
Cost	-.0276496	.0048561	-5.69	0.000	-.0371674	-.0181318
com_fish	.0800296	.0399994	2.00	0.045	.0016321	.158427
fish_pop	.0812713	.06806	1.19	0.232	-.0521239	.2146665
fish_saved	.0244286	.0044539	5.48	0.000	.0156991	.033158
aq_cond	.0606736	.0690761	0.88	0.380	-.0747131	.1960603
Nopolycon	-4.052673	1.106476	-3.66	0.000	-6.221327	-1.88402
SD						
com_fish	.0587125	.1494473	0.39	0.694	-.2341987	.3516238
fish_pop	-.2900689	.2195004	-1.32	0.186	-.7202818	.1401439
fish_saved	-.0279005	.0058515	-4.77	0.000	-.0393693	-.0164317
aq_cond	-.3320315	.1604665	-2.07	0.039	-.6465401	-.0175229
Nopolycon	9.358682	1.731755	5.40	0.000	5.964504	12.75286

Several things are worth pointing out with these results. The first point is the significance levels on the environmental variables are somewhat similar, but not identical, to the model results presented in the NODA. The new mixed logit models isolate 15 out of 20 significant coefficients (at 95%) compared to 14 out of 20 for the NODA models. Results on this criterion are similar for the Northeast and Southeast with both models having insignificant coefficients on "fish populations." Significance diverges widely for the Pacific models, where all environmental variables are significant in the new version, but only "fish saved" is significant in the NODA version. For the Inland model, in the NODA approach, "aquatic conditions" is insignificant and "fish populations" is significant. In the NODA Inland model, this is reversed. In the NODA national model, only "fish populations" is insignificant. In the new, National model, both "fish populations" and "aquatic conditions" are insignificant.

Mixed logit modeling also allows identifying the significance of standard deviations for preference parameters. For the environmental variables in the NODA models, only the estimated standard deviation of "fish saved" has a significant coefficient at 95% and only for four of the regional models. By comparison, the standard deviations on the new models are significant in 12 out of 20 cases. Like the NODA models, the new models identify a significant standard deviation on fish saved. However, the new models also consistently identify a significant standard deviation on "aquatic impacts" and identify a significant standard deviation on “commercial fish populations” in one case. These results suggest that better-performing, mixed logit specifications of the survey data are available.

Cost coefficients across models are generally comparable, with a dramatic exception being the Pacific data, where the new model cost coefficient is nearly twice as low as the NODA model coefficient. Another notable case is the National model where the new model coefficient estimate is about 30% lower than the NODA one. Developing marginal values by combining cost and environmental variable coefficients is instructive because this brings together the coefficients used to assess values.[7] These values (for “fish saved”) are reported in Table 3-6.

Table 3-6
Comparison of Marginal Values for Fish Saved in NODA and New Models

Regional Model	NODA Model Marginal Value	New Model Marginal Value
Northeast	$1.12	$ 0.95
Southeast	$0.75	$0.65
Pacific	$2.52	$1.00
Inland	$0.78	$0.53
National	$1.13	$0.88

A final important difference between these models concerns the alternative specific constant (ASC). In the NODA models, the coefficient for the ASC that represents the status quo is never statistically significant. By comparison, the ASC’s for “status quo” in the new models are always very significant and of a magnitude similar to what is often observed in choice experiments.

With respect to coefficient significance, the NODA models have a total of 19 out of 30 (means) and four out of 20 (standard deviations) that are statistically significant for 23 out of 50 significant variables overall. The new models have 25 out of 30 (means) and 12 out of 20 (standard deviations) for 37 out of 50 significant variables overall. This difference carries through to overall model significance where all of the new models except the Inland model have a lower (improved) chi-square significance result. These are directly comparable across models because the new modeling with mixed logit estimates the same number of parameters. For these reasons the new specification is judged a better model fit, and EPRI encourages EPA to explore this approach.

An important result of applying the new approach is that the ASCs for “status quo,” which are not statistically significant in the NODA model, are statistically significant in the new model. Regarding the interpretation of ASCs, EPA

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[7] Values were calculated as the ratio of mean coefficient estimates as an expedient approximation to EPA’s more sophisticated uncertainty simulation approach.

appropriately notes that an ASC captures systematic but unobserved features of options that enter into a choice, but are unrelated to the set of choice attributes. EPA views insignificance of the ASC's as a desirable result and states that it indicates that "respondents are not willing to pay a positive or negative amount for a regulation that has no effects on ecological attributes." While EPRI does not necessarily agree with this interpretation, EPA has some rationale for not considering "status quo" effects because the variable that represents them is insignificant. However, in the new models, the ASC coefficients for "status quo" effects are significant, which implies that "status quo" effects must be considered.

The "status quo" effect is well-known in individual decisions and choice experiment modeling. Often, it refers to a bias toward the status quo. This is revealed in choice experiments where respondents often disproportionately select the status quo option. Reasons for this vary but include protesting the survey, environmental attitudes, and perceived complexity of the choice task (Meyerhoff and Liebe 2009).

In the new mixed logit models, the signs on ASC coefficients for "status quo" are always negative and statistically significant. This is a less common outcome for choice experiments, but also indicates the potential for "status quo" bias. Negative "status quo" effects have not been thoroughly studied in the context of choice experiments. However the effect has been interpreted as donation behavior and in the context of contingent valuation as "warm glow." In this case, the willingness to contribute comes from two sources; the first is the desire for more of the public good that is being studied. The second is due to some private benefit potentially related to social pressure and feelings of guilt or sympathy (Nunes and Schokkaert 2003). An important result is that WTP estimates do not reflect values solely attributable to the environmental improvement.

Sampling Weighting and Extrapolating

There is substantial evidence that awareness of I&E impacts is quite low among the general public, suggesting that the Stated Preference Survey's results are not applicable to the majority of United States residents. In addition, little effort has been undertaken in the NODA to identify demographic groups that are willing to pay to reduce I&E impacts. That information is required to extrapolate the survey results to the unsurveyed population.

To provide insights on this issue, EPRI developed models that combine the regional data provided by EPA. The results of these combined regional-data models indicate that there are demographic differences in both the WTP estimates and bias toward the survey's hypothetical I&E regulations. This section considers implications for the NODA sampling, weighting, and extrapolating approach in the context of these econometric models.

Sample size is always critical: larger sample sizes will improve the quality of any inferences drawn from research data sets, but larger sample sizes also increase the associated costs of the study. Sample size has critical ripple effects on the quality of ultimate population level results. First, sample size affects researchers' ability to identify demographic interactions. Second, weighting functions are derived from these identified demographic interactions. And, third, extrapolating survey results to the population level is based on the derived weighting functions. As described in this section, EPRI is not convinced that the EPA approach can properly account for these linked sample weighting issues and identify valid population-level, WTP estimates. In earlier comments, EPRI recommended that EPA conduct simulations to identify appropriate sample sizes as well as efficient sampling and modeling approaches (EPRI 2010b and 2011g). The NODA section describing the sample size cites Louviere in attributing to Bunch and Batsell (1989) that "6 to 12 completed responses are required for each profile in order to achieve large sample properties for choice experiments."

EPRI reviewed these documents. This review determined, first, that the Louviere book discusses the Bunch and Batsell (1989) paper only superficially. Second, the review of the paper by Bunch and Batsell (1989) indicates that it is not about sample sizes; instead, it is a test of various micro-econometric modeling techniques. Third, an electronic search of the paper for 6 and 12 (and six and twelve) indicated these numbers/words do not appear in the paper, so it is not possible to verify the statement mentioned in the preceding paragraph.

Based on this and other research, EPRI is unable to find evidence that any rule of thumb based on profile repetition is a useful way to determine sample size requirements for choice experiments. This is not unexpected because the statistical significance of coefficients in discrete choice models is not driven by the number of times profiles are seen. Rather, it is driven by intensity of preferences, degree of error, and number of samples. Repetition of a profile is perhaps a useful way to ensure the ability to model an ASC for a particular profile. However, it's not directly related to overall model significance. Although this topic has not been studied generally, an appropriate reference for studying sample size in mixed logit models is Hess and Train (2011), which indicates that the data requirements of mixed logit may be "more substantial than is commonly assumed."

In considering weights, EPA models interactions by college education (yes/no) and gender using mixed logit. Although there is some amount of statistical significance at the individual variable level, EPA determines that the group of interacted terms does not improve model fit due to a statistical rejection of joint influence. This leads to some ambivalence by EPA regarding the requirement of weighting models.

The results of this exercise are important both for establishing validity of WTP results and for extrapolation to the unsampled population. Certainly a WTP estimate that is not related to respondents' income or knowledge/concern (perhaps proxied by education) should lead an analyst to question study validity. We should expect the demand for nonuse goods to be quite sensitive to income.[8] However, this is not a real result. Rather, the lack of statistical significance

[8] By comparison, goods that are perceived as necessities are typically less sensitive to income levels.

observed here appears to be an artifact of not fully utilizing the panel nature of data and of the small sample size.

Bateman et al. (2002) is a well established guide to stated preference and economic valuation. In the sampling section, this reference notes that "Unfortunately there is no free lunch with respect to obtaining estimates for subgroups. The required sample size increases linearly to a first approximation with the number of subgroups for which separate parameter estimates are required." EPRI believes that population subgroups are important in this study and previously suggested a useful way to ensure capturing them by pretesting and using the estimated equation to develop an experimental design and calculate sample sizes. Although EPA did not use this approach, it is possible to isolate interactions in the data as indicated by the pooled model results presented in Table 3-7. In this model, data from all EPA regions is modeled jointly. The number of observations is the total number of choice experiment questions across all regions and respondents. Interactions are modeled continuously for income (in $1,000 per year) and for two levels of education and gender. The results for significant interaction terms can be interpreted as follows (for example) incfishsave = 0.0001064 implies that every $1,000 in income adds an additional $3 in WTP per percentage of fish saved (0.0001064/0.0315589 x $1,000) and femalefish~e = 0.0129843 implies females have an additional $0.41 (0.0129843/0.0315589) in WTP per percentage point of fish saved compared to men.

Table 3-7
Interacted Mixed Logit Model Results

Mixed logit model		Number of obs =	18891
		LR chi2(5) =	2851.46
Log likelihood =	5025.9267	Prob > chi2 =	0.0000

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Mean						
Cost	-0.0315589	0.001828	-17.26	0.0000	-0.0351417	-0.0279761
inccomfish	-0.0000255	0.0002236	-0.11	0.9090	-0.0004637	0.0004128
incfishpop	0.0006779	0.0003589	1.89	0.0590	-0.0000256	0.0013814
incfishsave	0.0001064	0.0000211	5.04	0.0000	0.000065	0.0001478
incaqcond	0.0006989	0.0003621	1.93	0.0540	-0.0000107	0.0014086
educomfish	0.0435525	0.028773	1.51	0.1300	-0.0128415	0.0999466
edufishpop	0.0238932	0.0457212	0.52	0.6010	-0.0657187	0.1135051
edufishsave	0.009101	0.0028078	3.24	0.0010	0.0035978	0.0146041
eduaqcond	0.0613972	0.0463114	1.33	0.1850	-0.0293714	0.1521659
femalecomf~h	0.0272579	0.0286356	0.95	0.3410	-0.0288668	0.0833827
femalefish~p	0.0938162	0.0454836	2.06	0.0390	0.00467	0.1829623
femalefish~e	0.0129843	0.0027949	4.65	0.0000	0.0075063	0.0184623
femaleaqcond	0.0637825	0.0460975	1.38	0.1660	-0.026567	0.1541319
com_fish	0.0467707	0.0264606	1.77	0.0770	-0.0050911	0.0986326
fish_pop	-0.0559539	0.0414786	-1.35	0.1770	-0.1372505	0.0253426
fish_saved	0.0071056	0.0025006	2.84	0.0040	0.0022045	0.0120068
aq_cond	0.0634517	0.0421981	1.5	0.1330	-0.019255	0.1461583
nopoliycon	-2.774331	0.2979115	-9.31	0.0000	-3.358227	-2.190435
SD						
com_fish	-0.1326205	0.042666	-3.11	0.0020	-0.2162444	-0.0489966
fish_pop	0.1160733	0.0738549	1.57	0.1160	-0.0286796	0.2608261
fish_saved	0.0304502	0.0028955	10.52	0.0000	0.0247752	0.0361252
aq_cond	0.3205517	0.0589366	5.44	0.0000	0.2050381	0.4360653
nopoliycon	7.215399	0.4348979	16.59	0.0000	6.363015	8.067783

As Table 3-7 data indicate, when sample size is increased, there are important interaction effects that can be determined. These interactions are particularly important because survey respondents' willingness to pay estimates are conditioned on the information provided by the survey. To develop regional and national benefit estimates, the survey estimates would presumably be extrapolated to some larger number of households represented by the survey's sample for each region or nationally. Because the sample responses are conditioned on the information in the survey, the relevant population to which the willingness to pay estimates can be extrapolated is the set of households that are aware of impingement and entrainment impacts.

EPRI raised the question of awareness of impacts in previous comments. EPA has not addressed this, and EPRI has not identified any sources that suggest that utility gains from nonuse values are available to individuals who are unaware of changes. Although it is a departure from the previous approach, this survey apparently captures both use and nonuse values. Revealed-preference-based evaluations and the importance of the "fish saved" variable indicate that the great majority of surveyed respondents' WTP is from nonuse values.

There is no utility theoretic foundation known to EPRI that allows unaware nonusers to experience welfare increases.[9] The results from the 2012 Environmental Impacts Awareness survey provide insight into the size of the aware population. The survey was administered to a representative sample of more than 2,000 United States' residents and asks them about their current awareness of environmental impacts, including impacts from power plants (Veritas Economics 2012). The results of the survey indicate that slightly over 13% of the United States population is aware of aquatic impacts from steam electric plants. These include impacts such as water pollution, thermal discharge, wastewater impacts, and impacts to fish. No respondents specifically mentioned impingement and entrainment, only one respondent was aware that fish could be impacted through cooling water intakes, and fewer than 5% of respondents are aware that fish can be affected by power plant operations (this includes respondents who are aware of fish impacts resulting from either steam electric or hydroelectric plants).

Extrapolating results from the NODA to the general population in a manner that is consistent with Kaldor-Hicks utility principles requires linking willingness-to-pay and awareness at the finest level possible. Although this cannot be reliably done for the Environmental Impacts Awareness survey because of extremely low awareness levels, it is possible to develop a model with these sorts of deep interactions using the pooled EPA data (Table 3-8).10 In these models, males with no degree and low income form an omitted category out of mutually exclusive bins that contain all other deep interactions for two categories

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[9] By comparison, recreational anglers who are unaware of improvements might nevertheless experience catch rate improvements resulting in improved welfare.

[10] Deep interactions refers to the combination of multiple factors to identify profiles that resemble people rather than group averages. Here only eight mutually exclusive groups are evaluated. Larger data sets allow increased precision (Gelman 2007).

each of gender, education, and income. The coefficient for "fdhfishsave" equaling 0.0226307 can be interpreted as females with a college degree and high income having a WTP for a percentage reduction in I&E that is $0.72 (0.0226307/0.0314043) higher than that of males with no college degree and low income.

Table 3-8
Deeply Interacted Mixed Logit Model Results

Mixed logit results	Number of obs = 18891 Number of cases = 6297
	Wald chi2(8) = 2838.52
Log likelihood = -5020.1176	Prob > chi2 = 0.0000

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Policy						
cost	-0.0314043	0.001859	-16.89	0	-0.0350475	-0.027761
inccomfish	0.0005039	0.000391	1.29	0.197	-0.0002615	0.0012693
incfishpop	0.0000241	0.000642	0.04	0.97	-0.0012349	0.001283
incfishsave	0.0001029	3.71E-05	2.78	0.006	0.0000302	0.0001756
incaqcond	0.0000802	0.000645	0.12	0.901	-0.0011844	0.0013448
fdhcomfish	-0.0149405	0.07547	-0.2	0.843	-0.1628597	0.1329787
fdhfishpop	0.2691313	0.129955	2.07	0.038	0.0144234	0.5238391
fdhfishsave	0.0226307	0.007571	2.99	0.003	0.0077928	0.0374685
fdhfishaqc~d	0.2285536	0.123262	1.85	0.064	-0.0130363	0.4701435
fdlcomfish	0.0564311	0.048834	1.16	0.248	-0.0392819	0.1521441
fdlfishpop	0.175279	0.078313	2.24	0.025	0.0217886	0.3287695
fdlfishsave	0.0213761	0.00483	4.43	0	0.0119102	0.030842
fdlfishaqc~d	0.1016563	0.079966	1.27	0.204	-0.0550749	0.2583874
fndhcomfish	-0.12027	0.098743	-1.22	0.223	-0.3138025	0.0732625
fndhfishpop	0.1174152	0.156612	0.75	0.453	-0.1895384	0.4243689
fndhfishsave	0.0060537	0.010669	0.57	0.57	-0.0148569	0.0269644
fndhfishaq~d	0.0386847	0.163226	0.24	0.813	-0.2812325	0.358602
fndlcomfish	0.0342152	0.042052	0.81	0.416	-0.0482041	0.1166346
fndlfishpop	0.1063517	0.065022	1.64	0.102	-0.0210887	0.2337921
fndlfishsave	0.0106223	0.004001	2.66	0.008	0.0027812	0.0184635
fndlfishaq~d	0.0365723	0.066291	0.55	0.581	-0.0933554	0.1664999
mdhcomfish	-0.028418	0.063078	-0.45	0.652	-0.1520477	0.0952117
mdhfishpop	0.1245568	0.103145	1.21	0.227	-0.0776038	0.3267173
mdhfishsave	0.006299	0.006127	1.03	0.304	-0.0057099	0.0183079

Table 3-8 (continued)
Deeply Interacted Mixed Logit Model Results

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
mdhfishaqc~d	0.1482783	0.104883	1.41	0.157	-0.0572883	0.3538448
mdlcomfish	0.0459683	0.047952	0.96	0.338	-0.0480162	0.1399528
mdlfishpop	0.0820929	0.075801	1.08	0.279	-0.0664742	0.2306599
mdlfishsave	0.0059993	0.004539	1.32	0.186	-0.0028966	0.0148953
mdlfishaqc~d	-0.0307984	0.076583	-0.4	0.688	-0.1808986	0.1193019
mndhcomfish	-0.1277079	0.072118	-1.77	0.077	-0.2690555	0.0136397
mndhfishpop	0.2145962	0.117295	1.83	0.067	-0.0152974	0.4444898
mndhfishsave	0.0014577	0.006728	0.22	0.828	-0.0117293	0.0146448
mndhfishaq~d	0.0114585	0.116131	0.1	0.921	-0.2161532	0.2390702
com_fish	0.0391582	0.029241	1.34	0.181	-0.0181525	0.0964688
fish_pop	-0.0607245	0.046824	-1.3	0.195	-0.1524984	0.0310494
fish_saved	0.0088934	0.002771	3.21	0.001	0.0034617	0.014325
aq_cond	0.1081251	0.0478	2.26	0.024	0.0144389	0.2018114
nopoliycon	-2.72842	0.302977	-9.01	0	-3.322244	-2.134596
SD						
com_fish	-0.1285789	0.044787	-2.87	0.004	-0.2163602	-0.0407976
fish_pop	0.1184747	0.07984	1.48	0.138	-0.0380081	0.2749576
fish_saved	0.0301547	0.003094	9.75	0	0.0240905	0.0362188
aq_cond	0.3146792	0.061858	5.09	0	0.1934408	0.4359176
nopoliycon	7.189365	0.447033	16.08	0	6.313196	8.065534

As Table 3-8 model results indicate, there are potentially important interaction effects occurring at subgroup levels. For appropriate extrapolation, WTP tied to deep interactions such as these should be identified by subgroup. Extrapolation of these subgroup-level WTPs should be tied to an appropriately estimated number of individuals in that subgroup who are aware of impingement and entrainment impacts.

Experimental Design and Survey Approach

More efficient experimental designs produce better parameter estimates. As described previously, EPRI believes that EPA modeling has not uncovered significant important interaction effects that should be modeled to validate willingness to pay estimates and for extrapolation purposes. One way to uncover these effects is through larger sample size, and another is through improved experimental design.

The experimental design that EPA employed offered three choices to each respondent. The experimental design development and criteria are not thoroughly described but were apparently developed using SAS software and based on maximizing D-efficiency for main effects designs. Dominated pairs (where one profile is better on every attribute) and non-credible pairs (e.g., one option offers both a greater reduction in fish losses and a smaller increase in fish populations) were removed.

Earlier in this document the requirement of increasing sample size to identify population subgroups was discussed. When data are only cross-sectional, the "no free lunch" admonishment of Bateman et al. (2002) applies – data requirements for identifying subgroup means increase linearly (e.g., if it takes 300 observations to identify the population mean coefficients, it takes 300 of each gender to identify means by gender). When data are collected as a panel, this is not the case. When panel data are being collected, another option is to increase the number of questions asked of each respondent. When estimating in a panel fashion, the improvement is not linear. It depends on a mixture of improved statistical efficiency at the individual level and the respondents' ability to answer questions.

To evaluate this option of increasing the number of times questions are asked for panel respondents in the current case, EPRI considered individual level D-error for optimal designs based on attributes and levels in the NODA's Northeast models. D-error was evaluated based on estimated parameters and following the approach of Bliemer and Rose (2005). Preliminary results indicate that there is a dramatic nonlinear improvement to be expected in D-error and, therefore, overall model error when increasing from four to five questions per respondent.

These D-error estimates are specified such that respondent error is constant over the number of choices. Variations in respondents' ability to answer questions over the sequence can impact the validity of this result in application. Generally, two possibilities include: (1) respondents improving their ability to accurately express their preferences as choice questions are posed and (2) respondents' diminishing ability to do this as fatigue sets in. This, like any survey, will reflect respondent-specific issues (e.g., observing that older respondents tend to exhibit more fatigue with increasing numbers of questions). Although this can vary with any given survey, modeling health-state-related discrete choice questions shows that respondents' capabilities to answer choice questions go beyond the point where substantial design-based efficiencies of panel models have been obtained (Johnson and Bingham 2001).

A final important consideration of the design concerns disentangling of effects. The EPA's design allows disentangling survey respondents' values for reducing I&E from their values for improving fish populations, improving commercial fish populations, and overall aquatic health. This is useful and important because it has proven difficult to directly relate relatively-easily-quantifiable, I&E reduction metrics to fish population and aquatic outcomes. However, the EPA is employing a main effects design with all non-zero outcomes for "fish saved" (the variable in the NODA models for reductions in I&E) and the other variables in the model. It is possible that some of the effect observed in "fish saved" as a main effect is actually an unidentified higher order effect. This is because every positive change in "fish saved" is associated with a certain, non-zero positive change in all other environmental variables. The implication is that WTP for changes in "fish saved" that are associated with zero, uncertain, or negative aquatic and population outcomes cannot be evaluated. This is because "fish saved" is completely aliased (i.e., correlated in an experimental design context) with positive outcomes for other environmental variables. Uncertain or zero changes are the expectation, and EPRI is aware of cases where NPDES permits recommend operating in a way to improve aquatic conditions.

Moreover, in this design it is impossible to identify additional negative effects that could come along with I&E remedies, particularly cooling towers. In the actual implementation of remedies that would achieve high I&E reductions (e.g., cooling towers) there can be significant site-specific negative environmental effects. These can be aquatic, as fresh water flow and warm water discharge are disrupted.[11] Cooling towers can also have viewshed, terrestrial impacts, and air impacts arising from energy efficiency reductions (EPRI 2011h). However, a person taking this survey sees outcomes that are uniformly good. For this reason, it's quite possible that some observed WTP and status quo bias arises in the context of all positive outcomes that aren't consistent with actual outcomes – however, this cannot be tested due to survey design limitations.

Structural Modeling and Validity of WTP Estimates

The modeling conducted by EPRI demonstrates that increasing sample size and/or improving experimental design would improve study capabilities. Such changes are likely to help substantially in identifying statistically significant ecological value coefficients that can be differentiated by demographic groups. A remaining question is whether values elicited in this survey truly represent WTP for the environmental commodity being considered.

EPRI believes that the results presented in the NODA fail to demonstrate a valid method for validating and aggregating WTP estimates. As the NODA describes, EPA is familiar with approaches for reducing hypothetical bias. Despite this, the value of the approaches employed is limited by the partial and unstructured nature of the EPA approach. To demonstrate validity, the EPA must impose some global structure that properly identifies where resources to pay for nonuse goods are coming from and simultaneously allows for competing goods of this nature when WTP is elicited.

The results from EPRI's modeling efforts support using a more-global, public surveying and modeling design. As described in EPRI's previous comments (EPRI 2010b and 2011g), such a design would force respondents to choose among multiple categories of goods based on their ability to pay (i.e., use

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[11] For one example among many, cooling water flow to the J.H. Campbell plant supports a high quality lake and marina (Pigeon Lake). The Fort Meyers plant is one of many whose discharge supports a manatee refuge or warm water fishery.

discretionary or re-allocated income for private or other public benefits such as health care, public safety, and education) and would not be overly focused on any single good such as reductions in I&E.

As the NODA describes, mixed logit is a state of the art microeconometric modeling technique that overcomes certain important limitations of less computationally intensive choice modeling techniques. However, mixed logit also relieves the researcher of the requirement to evaluate the decision-making process that generates choice experiment data.

Nested logit models provide a more structured environment to evaluate decision-making and preferences. In nested models, correlations between alternatives are dealt with by grouping alternatives that are specified into similar "nests."[12] In this way, the nested logit model provides insight into respondent decision-making process that underlies the data. Earlier mixed logit models indicate that interactions exist at a very important conceptual point in the model—where the respondent who has seen a particular description and status quo according to their regional survey exhibits a value through choosing either the status quo or a change. To better understand, the status quo effect, EPRI developed some nested logit models with the nesting structure of either accept status quo or change. One objective was to develop regional models. Because at the regional level there is no variation in status quo attributes, the status quo is modeled as a so-called "degenerate" nest (i.e., no choices in it) with the nesting structure presented in Figure 3-1.

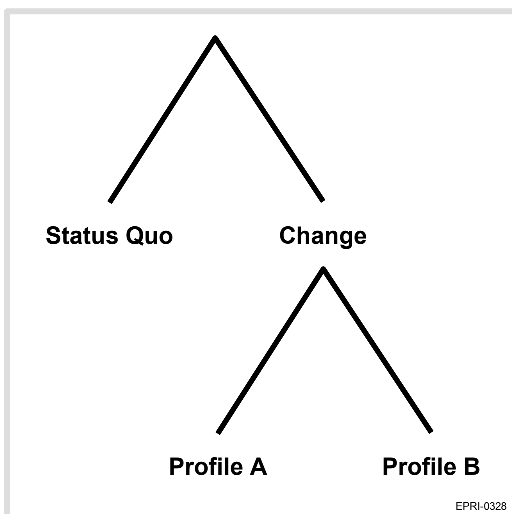

Figure 3-1
Nesting Structure of Status Quo

[12] For example, in the oft-repeated red-bus/ blue-bus example of iia violations in conditional logit, iia is re-established by forming nests in which the top level decision is mode (i.e., train or bus).

A reason for econometrically modeling this structure is that it produces coefficients that provide insight into respondent decision-making. Like mixed logit, this econometric modeling approach also generates coefficients for average values of variables. Unlike mixed logit, it does not produce coefficient estimates for standard deviations. However, with this approach, an inclusive value parameter is produced that indicates whether the nesting structure is appropriate. This indicates difference in error scales across nests which can be an important tool in understanding decision making processes. EPRI's modeling results using the nested structure are presented in Tables 3-9 through 3-13.

Table 3-9
Northeast Results from Status Quo Model

RUM-consistent nested logit regression Case variable: csid	Number of obs = 3381 Number of cases = 1127
Alternative variable: policy	Alts per case: min = 3 avg = 3.0 max = 3
	Wald chi2(8) = 231.27
Log likelihood = -1139.1605	Prob > chi2 = 0.0000
(1) [statusquo_tau]_cons = 1	

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Policy						
cost	-.0088339	.0018906	-4.67	0.000	-.0125394	-.0051285
com_fish	.0410907	.0139655	2.94	0.003	.0137187	.0684626
fish_pop	.0011585	.0215475	0.05	0.957	-.0410739	.0433909
fish_saved	.0086663	.0013104	6.61	0.000	.0060979	.0112348
aq_cond	.074522	.021842	3.41	0.001	.0317124	.1173316
Nest Equations						
Yespolicy						
inck	.001725	.0011519	1.50	0.134	-.0005326	.0039827
degree	.3175618	.1455355	2.18	0.029	.0323175	.6028061
employ	.110749	.1513383	0.73	0.464	-.1858686	.4073667
Dissimilarity Parameters						
Nest						
/statusquo~u	1					
/yespolicy~u	.5535752	.092899			.3714965	.7356539
LR test for IIA (tau = 1):			chi2(1) = chi2 =	13.65 0.0002		Prob >

Table 3-10
Southeast Results from Status Quo Model

RUM-consistent nested logit regression Case variable: csid	Number of obs = 4167 Number of cases = 1389
Alternative variable: policy	Alts per case: min = 3 avg = 3.0 max = 3
	Wald chi2(8) = 190.83
Log likelihood = -1422.4455	Prob > chi2 = 0.0000
(1) [statusquo_tau]_cons = 1	

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Policy						
cost	-.010886	.0021056	-5.17	0.000	-.0150128	-.0067592
com_fish	.0225266	.0102937	2.19	0.029	.0023513	.042702
fish_pop	.0120843	.0156568	0.77	0.440	-.0186025	.0427711
fish_saved	.0083357	.0013456	6.19	0.000	.0056984	.0109729
aq_cond	.0632805	.0175635	3.60	0.000	.0288567	.0977043
Nest Equations						
Yespolicy						
inck	.005017	.0010868	4.62	0.000	.0028869	.007147
degree	-.0641121	.1224988	-0.52	0.601	-.3042053	.1759811
employ	-.155562	.1211724	-1.28	0.199	-.3930555	.0819315
Dissimilarity Parameters						
Nest						
/statusquo~u	1					
/yespolicy~u	.4251866	.0761622			.2759113	.5744618
LR test for IIA (tau = 1):			chi2(1) = chi2 =		26.73 0.0000	Prob >

Table 3-11
Pacific Results from Status Quo Model

RUM-consistent nested logit regression Case variable: csid	Number of obs = 2436 Number of cases = 812
Alternative variable: policy	Alts per case: min = 3 avg = 3.0 max = 3
	Wald chi2(8) = 197.90
Log likelihood = -766.90447	Prob > chi2 = 0.0000
(1) [statusquo_tau]_cons = 1	

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Policy						
cost	-.0087288	.001952	-4.47	0.000	-.0125546	-.004903
com_fish	.0272074	.0123771	2.20	0.028	.0029488	.0514659
fish_pop	.0436538	.0194562	2.24	0.025	.0055204	.0817872
fish_saved	.008501	.0015635	5.44	0.000	.0054366	.0115654
aq_cond	.092422	.0225623	4.10	0.000	.0482006	.1366433
Nest Equations						
Yespolicy						
inck	.0003039	.0012762	0.24	0.812	-.0021974	.0028052
degree	.4504311	.1686379	2.67	0.008	.119907	.7809553
employ	.2235755	.1778762	1.26	0.209	-.1250554	.5722065
Dissimilarity Parameters						
Nest						
/statusquo~u	1					
/yespolicy~u	.3628004	.0708411			.2239544	.5016464
LR test for IIA (tau = 1):			chi2(1) = chi2 =		36.88 0.0000	Prob >

Table 3-12
Inland Results from Status Quo Model

RUM-consistent nested logit regression Case variable: csid	Number of obs = 6540 Number of cases = 2180
Alternative variable: policy	Alts per case: min = 3 avg = 3.0 max = 3
	Wald chi2(8) = 386.56
Log likelihood = -2261.3833	Prob > chi2 = 0.0000
(1) [statusquo_tau]_cons = 1	

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Policy						
cost	-.0050569	.0014256	-3.55	0.000	-.007851	- .0022627
com_fish	.0071232	.0043235	1.65	0.099	-.0013508	.0155971
fish_pop	-.0020719	.0063667	-0.33	0.745	-.0145505	.0104066
fish_saved	.0036466	.000948	3.85	0.000	.0017885	.0055046
aq_cond	.0302847	.0094065	3.22	0.000	.0118484	.0487211
Nest Equations						
Yespolicy						
inck	.0026244	.0009779	2.68	0.007	.0007078	.0045411
degree	.3208674	.1025162	3.13	0.002	.1199394	.5217955
employ	.5078725	.0992326	5.12	0.000	.3133801	.7023649
Dissimilarity Parameters						
Nest						
/statusquo~u	1					
/yespolicy~u	.2072381	.0574304			.0946766	.3197996
LR test for IIA (tau = 1):			chi2(1) = chi2 =		50.22 0.0000	Prob >

Table 3-13
National Results from Status Quo Model

RUM-consistent nested logit regression Case variable: csid	Number of obs = 2436 Number of cases = 812
Alternative variable: policy	Alts per case: min = 3 avg = 3.0 max = 3
	Wald chi2(8) = 197.90
Log likelihood = -766.90447	Prob > chi2 = 0.0000
(1) [statusquo_tau]_cons = 1	

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Policy						
cost	-.0087288	.001952	-4.47	0.000	-.0125546	-.004903
com_fish	.0272074	.0123771	2.20	0.028	.0029488	.0514659
fish_pop	.0436538	.0194562	2.24	0.025	.0055204	.0817872
fish_saved	.008501	.0015635	5.44	0.000	.0054366	.0115654
aq_cond	.092422	.0225623	4.10	0.000	.0482006	.1366433
Nest Equations						
Yespolicy						
inck	.0003039	.0012762	0.24	0.812	-.0021974	.0028052
degree	.4504311	.1686379	2.67	0.008	.119907	.7809553
employ	.2235755	.1778762	1.26	0.209	-.1250554	.5722065
Dissimilarity Parameters						
Nest						
/statusquo~u	1					
/yespolicy~u	.3628004	.0708411			.2239544	.5016464
LR test for IIA (tau = 1):			chi2(1) = chi2 =		36.88 0.0000	Prob >

The mean coefficient estimates for environmental variables in these nested models are significant for 17 out of 20 variables. By comparison, the mixed logit models produce 14 and 15 significant environmental variable coefficients for the NODA and new models, respectively. In the nested models, only the coefficient on the "fish populations" variable is insignificant for some of the models; in particular, this occurs in the Northeast, Southeast, and Inland models. These models do not have a variable for "status quo"; however, in nested models, the inclusive value parameter indicates the validity of the nesting structure. In these models, the inclusive value parameter is always significant. In addition to inclusive value parameters these models produce nest parameters. These nest parameters indicate the factors that influence choosing each nest. The nest parameters modeled include income, degree, and employment. These are significant as follows. Degree is significant in the Northeast, Pacific, and National models. Income is significant in the Southeast model. All three are significant in the Inland model.

To identify interactions, the regional data are pooled similar to the previous approach with deep interactions. The analysis (Table 3-14) includes all the variables from EPA's analysis, and also deep interaction terms of the demographic variables and policy-related variables.

Table 3-14
Highly Interacted Nested Logit Model Results

RUM-consistent nested logit regression Case variable: csid	Number of obs = 18891 Number of cases = 6297
Alternative variable: policy	Alts per case: min = 3 avg = 3.0 max = 3
	Wald chi2(8) = 1152.36
Log likelihood = -6372.5334	Prob > chi2 = 0.0000
(1) [statusquo_tau]_cons = 1	

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
Policy						
cost	-0.0091686	0.0010625	-8.63	0.0000	-0.011251	-0.0070862
com_fish	0.0192713	0.0086628	2.22	0.0260	0.0022926	0.03625
fish_pop	-0.0177718	0.0129654	-1.37	0.1700	-0.0431834	0.0076399
fish_saved	0.004896	0.0007933	6.17	0.0000	0.0033411	0.0064508
aq_cond	0.0374559	0.0135185	2.77	0.0060	0.0109601	0.0639516
fdhcomfish	0.0032706	0.0201104	0.16	0.8710	-0.0361451	0.0426864
fdhfishpop	0.0672157	0.0333534	2.02	0.0440	0.0018442	0.1325873
fdhfishsave	0.0088135	0.0016716	5.27	0.0000	0.0055372	0.0120897
fdhfishaqc~d	0.0882063	0.0300302	2.94	0.0030	0.0293483	0.1470643
fdlcomfish	0.0182591	0.0157654	1.16	0.2470	-0.0126406	0.0491587
fdlfishpop	0.0516502	0.025059	2.06	0.0390	0.0025356	0.1007649
fdlfishsave	0.0053231	0.0012491	4.26	0.0000	0.0028748	0.0077713
fdlfishaqc~d	0.0345239	0.0240762	1.43	0.1520	-0.0126646	0.0817124
fndhcomfish	-0.0229641	0.0278075	-0.83	0.4090	-0.0774657	0.0315375
fndhfishpop	0.0182903	0.0426335	0.43	0.6680	-0.0652697	0.1018504
fndhfishsave	0.0040321	0.0021857	1.84	0.0650	-0.0002517	0.0083159
fndhfishaq~d	0.010566	0.0424778	0.25	0.8040	-0.0726888	0.0938209

Table 3-14 (continued)
Highly Interacted Nested Logit Model Results

Choice	Coefficient	Standard Error	Z	P>|z|	95% Conf. Interval	
fndlcomfish	0.0056611	0.0130346	0.43	0.6640	-0.0198862	0.0312084
fndlfishpop	0.0344125	0.0203823	1.69	0.0910	-0.0055362	0.0743611
fndlfishsave	0.0023471	0.0009319	2.52	0.0120	0.0005206	0.0041737
fndlfishaq~d	0.0208576	0.0196061	1.06	0.2870	-0.0175697	0.0592849
mdhcomfish	-0.0018128	0.0132882	-0.14	0.8910	-0.0278573	0.0242317
mdhfishpop	0.0191621	0.021137	0.91	0.3650	-0.0222657	0.06059
mdhfishsave	0.0032442	0.0009957	3.26	0.0010	0.0012926	0.0051958
mdhfishaqc~d	0.0371707	0.0205784	1.81	0.0710	-0.0031621	0.0775036
mdlcomfish	0.0044771	0.01531	0.29	0.7700	-0.0255299	0.0344842
mdlfishpop	0.0076904	0.0237641	0.32	0.7460	-0.0388865	0.0542672
mdlfishsave	0.0018924	0.0011008	1.72	0.0860	-0.0002651	0.0040499
mdlfishaqc~d	-0.0135072	0.0232495	-0.58	0.5610	-0.0590754	0.032061
mndhcomfish	-0.0322671	0.0186506	-1.73	0.0840	-0.0688216	0.0042873
mndhfishpop	0.0709202	0.0300818	2.36	0.0180	0.0119609	0.1298794
mndhfishsave	0.0016841	0.0012605	1.34	0.1820	-0.0007865	0.0041547
mndhfishaq~d	-0.0132863	0.0292448	-0.45	0.6500	-0.0706051	0.0440325
Nest Equations						
Yespolicy						
inck	0.0017104	0.0006505	2.63	0.0090	0.0004354	0.0029853
degree	0.0023938	0.0867976	0.03	0.9780	-0.1677264	0.172514
employ	0.1521389	0.0623018	2.44	0.0150	0.0300296	0.2742482
region1	0.4584234	0.1065325	4.3	0.0000	0.2496236	0.6672232
region2	0.1147408	0.1000013	1.15	0.2510	-0.0812581	0.3107397
region3	0.0722184	0.1020127	0.71	0.4790	-0.1277227	0.2721596
region4	0.4714538	0.1184673	3.98	0.0000	0.2392621	0.7036455
region5	0.2393062	0.1164455	2.06	0.0400	0.0110771	0.4675353
Dissimilarity Parameters						
Nest	1					
/statusquo~u	.4071863	.0469471			.3151716	.499201
/yespolicy~u						
LR test for IIA (tau = 1):	chi2(1) =	89.98	Prob	>	chi2 =	0.0000

All the policy-related variables except “fish population” are statistically significant. In addition, many, though not all, of the demographic variables are significant, which suggests that they affect peoples’ willingness to pay for environmental policies. The inclusive value parameter is statistically significant; indicating that the nested structure is justified by differences in errors across the status quo and change cases. Not only are people selecting away from the status quo as indicated by the significance of income and degree in the nest coefficients, they are thinking differently about the attributes across status quo and change. This model includes a parameter representing each survey version in the nest equation. The Northeast, Pacific, and National regions all lead to higher likelihoods of choosing a policy option. This is a relatively large effect for example with the effect of having seen the Northeast status quo having three times the effect of being employed.[13]

The current approach relies on the non-mathematical imposition of the budget constraint by using survey techniques such as budget reminders. EPRI’s previous comments (EPRI 2010b and 2011g) outlined a sequential nested approach, noting that sequential models are not new to choice experiments (Bateman et al. 2006). Imposing this structure supports the idea of employing a more global structural approach for eliciting WTP from survey respondents. A global approach would allow trade-offs among more categories as depicted in Figure 3-2.

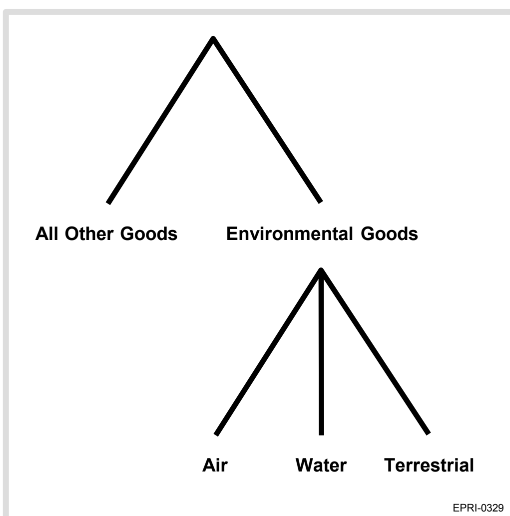

Figure 3-2
Nesting Structure

The concept of inducing constraints and optimizing behavior via sequential nested decision-making is important because a potential implication of the models developed is that total WTP includes some component of altruistic

[13] These factors are aliased with the survey version and region a person is from. The first is of interest for diagnostics and the second seems less relevant. The correlation here could also be offset by introducing other location controls such as state of residence down to market segment.

donations. These values have been shown to be subject to rapidly declining marginal utility. (Nunes and Schokkaert 2003) "Warm glow" effects diminish as additional hypothetical situations are faced. An important question regarding validity relates to the degree to which these can be controlled by external admonishments. Completely developing a structured approach might lead to a global, utility-theoretic model of preference with inclusion of nonuse values.

Section 4: References

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Section 5: EPRI Technical Reports

In addition to EPRI's technical comments presented herein, EPRI submits the following technical reports that have been completed since the comment period on the proposed Rule closed in August 2011. These Technical Reports along with a brief review on their content include:

Fish Life History Parameter Values for Equivalent Adult and Production Foregone Models: Comprehensive Update. Technical Report 1023103, April 2012.

A previous EPRI report (1008471) provided guidance on the use of two types of extrapolation models used in economic benefits analyses related to entrainment and impingement at power plant intake structures: equivalent adult (EA) models and production foregone (PF) models. To facilitate applications of these models by EPRI members, a follow-on report (1008832) provided estimates of species-specific mortality and growth rate parameters for 25 fish and macroinvertebrate species that are commonly entrained and impinged at U.S. power plants. This report synthesizes the two previous reports, updates the parameter values for all of the previously evaluated species, and provides estimates of mortality and growth rate parameters for 24 additional marine and freshwater fish species. The values provided in this report are intended to be "default" values that can be used in the absence of site-specific data. Where well-designed field studies provide site-specific estimates of growth and mortality rates of susceptible species, the site-specific values should generally take precedence. The final list includes 27 predominantly marine or estuarine species and 22 predominantly freshwater species.

Effects of Fouling and Debris on Larval Fish within a Fish Return System. EPRI Technical Update 1024999, April 2012.

EPRI has funded laboratory studies on the biological efficacy of fish return systems for larval and early juvenile fish survival removed from fine-mesh traveling water screens. This report presents results of additional testing that investigated the effects of fish return biofouling and debris on their survival. This project is generating additional data necessary to determine the overall biological efficacy of fish collection and return systems used with cooling water intake structures (CWIS). Over 8500 larval and early-stage juvenile fish were tested in July and August 2011. A summary of the results is as follows:

- For three of the four species tested (common carp, bluegill, and channel catfish), the survival exceeded 96% for all substrates (stone, fiber, smooth) tested. Higher mortality was observed with golden shiner. Treatment survival ranged from 75% for fiber to 94% for stone, while the control fish exhibited 100% survival.
- When comparing across species, the fiber treatment (simulating biofouling) showed a relatively consistent lower survival rate than the controls. These results suggest that biofouling can reduce the transport survival of larvae and juveniles and that facilities should consider routine maintenance to remove biofouling.
- Debris testing was conducted with bluegill and channel catfish. There was no statistical difference between the debris treatments and the controls (without debris), indicating that the addition of debris did not increase mortality.
- Testing was limited to a few species that were readily available as larvae and juveniles. The tested organisms, by their nature, are hardier than pelagic species, such as clupeids and bay anchovy, which can dominate actual CWIS entrainment.

Results are from ideal laboratory testing conditions. Field conditions that could lower post-collection survival include the presence of uncontrolled amounts of debris, suspended sediments, elevated temperatures, and variable water quality.

Field Evaluation of Debris Handling and Sediment Clogging of 2.0 mm Fine-mesh Traveling Water Screen at the Hawthorn Power Plant, Missouri River, Kansas City, MO. EPRI Technical Report 1024697, February 2012.

This report reviews results of an effort that evaluated the field performance of a fine-mesh (2.0 mm) traveling water screen in a debris and sediment-laden river. Fine-mesh overlay panels were installed on one intake screen at Kansas City Power & Light's Hawthorn Generating Station on the Missouri River, Kansas City, MO. Its operation relative to an adjoining coarse-mesh (9.5 mm) screen was evaluated over a nearly 22 month period from December 2009 through August 2011. No loss of cooling flow occurred due to screen blockage with either sediment or debris during the evaluation. On a few occasions, head loss due to blockage approached levels of concern; however, the loss was comparable to that observed for the coarse-mesh screen and not, therefore, attributable to the finer mesh. River flows during the study period reflected the typical pattern of flows that annually occur on the Missouri River; however, the monthly average flow throughout the study period exceeded the historical flows. The fine mesh screen was exposed to suspended sediment, terrestrial debris including leaf litter and woody material, agricultural debris including corn shucks and other crop waste, floating and frazil ice and human litter from urban and suburban runoff and combined sewer overflow. Results are applicable to facilities with similar operating conditions to Hawthorn Station. Overlay of fine-mesh screen panels on an existing coarse-mesh system was demonstrated to be, with some engineering modifications, a viable retrofit approach.

Full-Time/Seasonal Closed-cycle Cooling: Cost and Performance Comparisons. EPRI Technical Report 1023100, January 2012.

This report reviews the results of analyses that examined the issues, practicality, and cost associated with the use of cooling towers for fish protection on a seasonal basis—specifically during the season when entrainable life stages (that is, eggs, larvae, and juvenile fish and shellfish) are present in the source water body. The key results for both performance effects and retrofit costs for seasonal cooling towers include:

- Both full-time and seasonal closed-cycle cooling systems incurred a significant operating penalty in comparison to once-through cooling.
- The total reduction in plant output, expressed as a percentage of annual output with once-through cooling ranges from 1% to 3.5% for full-time closed-cycle operation and from 0.25% to 1.8% with seasonal operation.
- The difference in operational financial impacts between full-time closed cycle and seasonal operation ranges from $7.74 million to $130 thousand per year.

Seasonal Patterns of Fish Entrainment for Regional U.S. Electric Generating Facilities. EPRI Technical Report 1023102, December 2011.

This report addresses the predictability of the seasonal entrainment of fish eggs, larvae, and early juveniles at cooling water intakes on the basis of geography and fish community composition. Entrainment reductions required by a revised Clean Water Act (CWA) §316(b) rule in some cases might be met using seasonal rather than year-round operation of compliance measures and, therefore, would depend on the duration of the entrainment season and the requirements of the final regulations. Data from a sample of 111 existing U.S. generating facilities were analyzed to determine the timing and duration of occurrence of the majority of entrainment regionally. Regional patterns in the monthly timing of entrainment were found, with some regional entrainment seasons being either earlier or more prolonged than others. It was apparent that facilities located on freshwater would require shorter periods to encompass the majority or entirety of entrainment, while facilities located on estuaries or marine systems might require a considerably longer period. Because of the relative consistency in the timing and duration of the entrainment season within regions and among some regions, it might be possible to predict the period when temporary or seasonal implementation of entrainment reduction measures would be most effective.

Analysis of the relationship between entrainment and water temperature also suggested the possible use of a "threshold temperature," above which entrainment levels might be expected to be elevated. In planning the temporary use of entrainment reduction measures, whether involving calendar months or water temperatures, a "safety factor" of an additional few weeks or more could ensure that the desired entrainment reduction is achieved and might compensate for annual variations in species composition (dominance), water temperature, or other controlling environmental variables.

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com