United States
Environmental
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Agency

Survey Support Document

In Support of Section 316(b) Stated Preference Survey Notice of Data Availability

June 2012

Contents

I. Introduction

On April 20, 2011, EPA published proposed standards for cooling water intake structures at all existing power generating, manufacturing, and industrial facilities as part of EPA's implementation of its responsibilities under section 316(b) of the Clean Water Act (CWA), at 76 FR 22174. EPA received voluminous comments and data submissions during the 90-day public comment period. After many commenters requested additional time to review the proposal, on July 20, 2011, EPA extended the comment period by an additional 30 days (76 FR 43230).

As part of the proposal, EPA indicated it was in the process of developing a stated preference survey to estimate total willingness to pay (WTP) for improvements to fishery resources affected by impingement and entrainment (I&E) mortality from in-scope 316(b) facilities. EPA acknowledged it did not have sufficient time to fully develop and implement this survey for the proposed regulation (76 FR 22174). EPA indicated its intent to issue a Notice of Data Availability (NODA) pending survey implementation and data analysis. This support document provides additional detail to the NODA that was signed on June 1, 2012, for publication in the *Federal Register*.

In this NODA survey support document, EPA is providing additional preliminary data that may be relevant to the benefits of the rule, based on the results of a stated preference survey. Stated preference surveys are an attempt to determine the economic value of goods or services outside of the context of the marketplace. Simply described, a stated preference survey attempts to gauge the value of an item through questions designed to mimic consumer decision-making in actual markets. A stated preference survey, in this case, was used to measure values associated with ecosystem improvements. The stated preference survey estimates the value held by the public for ecosystem improvements based on the choices the surveyed members of the public make between hypothetical policy options and current conditions. In the proposal published in April 2011, EPA's estimated benefits were partial estimates only. Specifically, the proposal included only a partial estimate of non-use values, or those values people may hold for an environmental improvement that are not associated with use of the resource (e.g., recreation). When there is no behavioral trail (Larson, 1993), that is, no observable behaviors (such as recreational trips) that can be analyzed to infer value, stated preference methods are the only way to measure values, especially non-use values (U.S. EPA 2010 Guidelines for Preparing Economic Analyses).

Section II presents this new data and preliminary analysis for the Northeast, Southeast, Inland, and Pacific regions as well as the national survey. EPA presents a set of unweighted models that do not account for possible systematic variations between the populations of individuals that responded and did not respond to the surveys. The survey non-response assessment work has been completed for only the Northeast region; therefore EPA presents a weighted model which statistically adjusts for the differences among populations for that region. EPA has not yet completed the non-response assessments for the Pacific, Southeast, and Inland regions and the national survey. The remainder of this section provides an overview of this Survey Support Document. The first step in developing a stated preference survey is to specify the question format. Question design is usually developed using focus groups to test wording and attribute selection and ensure that respondents understand and are not cognitively burdened by the question format. Attributes should also link directly to the policy to be analyzed. Choice experiments are designed to mimic consumer decision–making in actual markets where goods comprise a bundle of attributes and consumers make tradeoffs among those attributes when selecting bundles for purchase. Once the question format is developed, the experimental design, which is the plan for varying attribute levels across questions within a survey and across survey versions, must be specified. Following recommendations in the stated preference literature, these attribute levels vary according to realistic ecological and policy expectations (see Section II.A for more details).

The next steps are to determine the mode of survey delivery (e.g., mail, phone, or web-based), and develop the associated sample frame. The sample frame is the population from which potential respondents are selected, in this case, at random (see Section II.B for more details). EPA chose to conduct a mail survey, and used a list of all postal addresses as the sample frame. The address sample was drawn from database which covers 97% of residences in the United States. The mail survey approach avoids potential sampling biases associated with incomplete coverage of landline and cellphone databases. Upon return of surveys, EPA entered responses into a database (see Section II.C for more details). EPA has completed fielding the main versions of the four regional and the national surveys, by virtue of achieving the target response rate of 30%.

EPA has also estimated preliminary regional and national models based on data from respondents. In general, EPA expected to observe variations in surveyed individuals' responses across the regions, due in part to differences in tastes and preferences of respondents, and to aspects of the experimental design (e.g., baseline levels of the attributes vary across the regions). Although EPA has not yet conducted scope and validity testing, certain expected patterns have been observed (e.g., there is variation across the regions in the importance respondents place on the different attributes).

Once regional and national models have been appropriately estimated and subject to validity testing and peer review, EPA may then use the reduced fish mortality from cooling water intake structures to predict average household willingness-to-pay associated with each of the regions. At the time this supporting document was prepared, EPA had produced preliminary estimates of average willingness-to-pay per household per percentage point improvement in each of the attributes, based on unweighted models (see Section II.E for more details). For example, the average dollar value per household per percentage point of reduced fish mortality at cooling water intake structures ranges from $0.75 and $0.78 in the Southeast and Inland regions, respectively, to $1.12 and $1.13 in the Northeast and national versions, respectively, to $2.52 in the Pacific region. These preliminary results suggest that respondents are responding rationally, given that fish mortality in the Inland region is generally lower than the coastal regions, and that the national average is within the range of the regional results, based on responses from different respondents.

EPA is also conducting a non-response study for each version of the survey, to account for the possibility that respondents are fundamentally different from non-respondents. EPA would use the non-response study results to develop weights that correct for any differences, reducing the weight placed on overrepresented respondent groups, while increasing the weight placed on any underrepresented respondent groups.

See Section II.G for details on the non-response study for the Northeast region of the survey (the only region for which the non-response study has been completed to date). EPA currently is still fielding the non-response studies for the other three regional and national versions of the survey. EPA intends to complete weighted models for the remaining regions and the national surveys. After completing the non-response studies for all regions, reviewing public comment, and conducting additional scope and validity testing, EPA will present a more complete set of stated preference survey materials for an external peer review. EPA will then determine what role, if any, the monetized benefits based on the stated preference survey should play in EPA's assessment of benefits for the final rule, and will include the complete results in its assessment as appropriate.

II. Willingness to Pay Survey

In this supporting material, EPA is documenting the availability of data collected from a stated preference survey designed to facilitate the estimation of households' willingness to pay to reduce the number of fish impinged or entrained in cooling water intake structures. Stated preference methods provide a non-market approach to quantifying values associated with ecosystem improvements, such as increased protection of aquatic species or the restoration of habitats with specific attributes. These methods rely on an analysis of responses to survey questions through which individuals state information about their values. In contrast, EPA's estimated benefits at proposal were partial estimates only. Specifically, the proposal included only a partial estimate of non-use values, that is, values individuals may hold for an environmental improvement that are not tied to use of the resource (e.g., recreation).

Estimation of monetized non-use benefits is challenging, since market proxies are generally not available, and in the absence of such proxies, they can only be estimated by using either stated preference methods or benefits transfer based on prior stated preference results. For this reason, non-use benefits are often discussed qualitatively instead of attaching monetized values to them. Today's notice presents data collected from a stated preference study (EPA ICR # 2402.01) that EPA conducted regarding total (use plus non-use) benefits from reductions in fish mortality at cooling water intake structures. EPA's peer-reviewed guidelines for benefits analysis (U.S. EPA 2010, pp. 7-41, DCN 11-4712) recognize "advantages of [stated preference] methods includ[ing] their ability to estimate non-use values and to incorporate hypothetical scenarios that closely correspond to a policy case."

The results presented in this document are estimated based on a choice experiment. Choice experiments, also called choice models, are a stated preference technique in which individuals' values are estimated based on their choices over a set of hypothetical but realistic policy options.

Stated preference methods have "… been tested and validated through years of research and are widely accepted by … government agencies and the U.S. courts as reliable techniques for estimating non-market values" (Bergstrom and Ready 2009, p. 26). EPA's own peer-reviewed Guidelines for Preparing Economic Analysis (US EPA 2010, DCN 11-4712) indicate that the use of stated preference study data, when the study is conducted properly in accord with best current practices, is the only potential method for monetizing non-use values. Likewise, OMB's Circular A-4 notes that stated preference results "have also been widely used in regulatory analyses by Federal agencies" (p. 22), and that "there is no mechanical formula that can be used to determine whether a particular study is of sufficient quality to justify use in regulatory analysis" (p. 23). OMB also cautions that "a number based on a poor quality study is not necessarily superior to no number at all" (p. 24).

EPA recognizes that several issues have been raised regarding the estimation of welfare values from stated preference surveys. For example, the stated preference study discussed in this document creates a hypothetical market where respondents are asked to reveal their values for increases in "fish saved" in conjunction with increases in fish populations (total and commercial) and aquatic conditions by voting for or against alternative hypothetical policies that would regulate cooling water intake structures and that would impose increases in annual household cost of living. The issue of whether respondents are capable of respecting hypothetical budget constraints knowing that their responses to the survey would not compel them to incur any costs is a concern that has been cited as a reason to question t the results of stated preference studies. The hypothetical nature of the market has raised questions as to whether this type of elicitation accurately reveals and elicits WTP associated with the good being considered.

Substantial research has been conducted over the past two decades on hypothetical bias in stated preference surveys. While many studies have found evidence of hypothetical bias (List and Gallet 2001), a recent meta-analysis indicates that "hypothetical bias in SP studies may not be as important" as some have argued previously (Murphy et al. 2005). This mirrors similar findings in prior studies that compare hypothetical and actual referenda (see discussion in Johnston 2006). EPA used all available means for mitigating hypothetical bias in designing and conducting the survey. Stated preference surveys also require the provision of information to enable respondents to comprehend the potential implications of their hypothetical choices. For example, in this case, respondents may not be aware that cooling water intake structures can potentially kill large numbers of fish, eggs, and larvae, or that the vast majority of those organisms are species that provide no consumptive use (e.g., commercial or recreational fishing) to humans. Even if they are aware of this issue in a general way, it is unlikely that most respondents will have previously considered what preserving those species is worth to them. In order to elicit informed responses, it is necessary to provide information to respondents about the general context and scope of the issue. Following standard practice, EPA pretested the information provided to respondents in focus groups and cognitive interviews to determine what quantity and types of information were required by respondents in order to feel confident and well-informed in their responses (DCN 11-4710). For example, in the introductory materials accompanying the four regional and national stated preference surveys, EPA presents the number of "young adult fish" (also called "age-one-equivalents") that are lost in coastal and fresh waters due to cooling water use, and that these losses include eggs and larvae. Without this educational material, respondents to the survey might not otherwise realize that reported effects on "fish saved per year" in the valuation questions partially result from reduced mortality of eggs and larvae. The presentation of this type of background information, if not properly vetted in the survey instrument development process, could result in focusing respondent attention on particular environmental amenities to the exclusion of other market and non-market goods that may also be important to some respondents' decision making with regard to the choice questions.

Consistent with established best practices for stated preference surveys, EPA has sought to minimize possible biases by careful and thorough construction and testing of the survey instrument. The Agency recognizes that potential biases may still remain and may influence the results of the study. While in EPA's view, the study incorporates current best professional practice in the conduct of stated preference studies, EPA acknowledges that the results of any empirical study depend on the methodology applied. EPA has not yet completed its statistical analyses of these survey data and therefore has not determined the role that the monetized benefits assessed through the stated preference survey will play in the analysis of benefits for the final rule.

At the time this supporting material was prepared, EPA had finished fielding all five versions of the main mail survey (four regional and one national). EPA undertook the Northeast version in advance of the other versions as a pilot study to inform potential changes to other survey versions, as described in the ICR for the 316(b) stated preference survey (EPA ICR # 2402.01) and as recommended in published guidance for stated preference survey design (Arrow et al. 1993; Bateman et al. 2002). EPA notes that the stated preference survey regions differ from the benefits regions used in the Environmental and Economic Benefits Assessment (EEBA) document for the proposed rule.[1] This section describes the methods used by EPA to develop and implement the 316(b) stated preference survey and presents preliminary benefits estimates for each survey version (Northeast, Southeast, Pacific, Inland, and National). EPA uses a statistical model estimated based on the survey results to estimate benefits to households for ecological improvements. EPA emphasizes that benefits estimates presented here are

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[1] See Exhibit II-3 for a list of the states included in each survey region.

preliminary. Results are presented separately by survey version. If EPA includes the quantified benefits derived from the stated preference survey in the final benefits analysis, the Agency will perform additional analysis comparing the results of the regional survey versions to the results of the national survey version. This additional analysis will allow EPA to look at the impacts of program size (regional vs. national) on willingness to pay and to consider the implications of any differences for the validity of results. For the final benefits analysis, EPA may present a range for the total national benefit estimates produced by the stated preference research for the final rule. Alternatively, EPA may decide to consider non-use benefits qualitatively and/or by using benefits transfer, as was done for the proposed rule.

A. Survey Format and Experimental Design

Stated preference surveys, in general, ask questions that elicit individuals' stated values for carefully specified changes in an environmental amenity (Freeman 2003). This value is typically estimated in terms of willingness to pay (WTP), defined as the maximum amount of money (or some other commodity) that an individual or household would be willing to give up in exchange for a specified environmental change, rather than go without that change. Various question formats have been used in the stated preference literature to elicit stated WTP. Some types of stated preference surveys ask respondents to express their WTP using open-ended questions, payment cards, or bidding games. Increasingly, however, these original types of stated preference surveys have been replaced in the literature by methods grounded in random utility models (Hanemann 1984), in which respondents express their WTP through choices over alternative policy options. Advantages of these choice-based methods include similarity to familiar referenda or market choice contexts, in which individuals choose among alternative bundles of attributes or commodities at different costs (Freeman 2003). These methods are intended to reduce the hypothetical choice bias that might result from asking survey questions versus assessing willingness to pay through market transactions or referenda.

For the 316(b) stated preference survey, EPA followed well-established choice experiment methodology (Adamowicz et al. 1998; Louviere et al. 2000; Bennett and Blamey 2001; Bateman et al. 2002). Under the choice experiment (or choice modeling) format, respondents are presented with a set of multi-attribute alternatives and asked to select their preferred alternative, much as one might choose a preferred option in a public referendum. Choice experiments have been applied to assess WTP for ecological resource improvements of a type similar to those at issue in the 316(b) policy case (e.g., Bennett and Blamey 2001; Hanley et al. 2006a, b; Hoehn et al. 2004; Johnston et al. 2002, 2011a, b; Milon and Scrogin 2006; Morrison and Bennett 2004; Morrison et al. 2002; and Opaluch et al. 1999). Choice experiments allow survey respondents to express WTP for a wide range of different potential outcomes, differentiated by their attributes. This enables EPA to isolate the marginal effects of different potential policy outcomes on stated choices and hence, on estimated WTP. EPA can thereby estimate benefits for a wider range of potential policy outcomes. This is a primary factor distinguishing choice experiments from older forms of stated preference analysis, in which stated WTP is typically contingent upon a single specification of ecological effects.

Following well-established methods, respondents in the choice experiment are presented with two alternative hypothetical policy options and asked to choose (or vote for) the policy that they would prefer. Respondents may also choose to reject both policies and retain the status quo. The underpinning theoretical model is adapted from a standard random utility specification in which household *h* chooses among three choice options (*j=A,B,N*), including two multi-attribute policy options (*A, B*) and a fixed "no policy" status quo (*N*) that includes no policy changes and zero cost to the household. Each choice option reflects a hypothetical but feasible outcome under various 316(b) regulatory alternatives. The effects of the policy options are described in terms of a household cost and four environmental endpoints, or attributes: (a) commercial fish populations, (b) fish populations (all fish), (c) fish saved per year, and (d) condition of aquatic ecosystems. The definition of each attribute is presented in Exhibit II-5. Values are reflected in the survey by individuals' willingness to "vote" for policies that would increase their cost of living, in exchange for specified changes in the four environmental attributes. Other questions in the survey elicit information including whether the respondent is a user of the affected aquatic resources, household income, and other respondent demographics.[2]

Following established practices, EPA used an experimental design to generate multiple unique combinations of policy options for different respondents to compare. Respondents were presented with three separate policy questions in the survey, each with a specific combination of policy options. The experimental design specifies how attribute levels were "mixed and matched" within choice questions, thereby developing an

[2] The four environmental attributes were designed based on the Johnston et al. (2011a,b; 2012) Bioindicator-Based Stated Preference Valuation (BSPV) method which was developed to promote ecological clarity and closer integration of ecological and economic information within SP studies. This methodology was developed in part to address the EPA Science Advisory Board's call, in its May 2009 report, *Valuing the Protection of Ecological Systems and Services: A Report of the EPA Science Advisory Board*, for improved quantitative linkages between ecological services and economic valuation of those services.

empirical data framework with appropriate statistical properties to allow for analysis of respondent's choices (Louviere et al. 2000). EPA applied a fractional factorial experimental design representing a subset of all possible combinations of environmental attributes and household cost. This allows efficient estimation of particular effects of interest (Louviere et al. 2000) and reduces the cognitive burden faced by respondents (Holmes and Adamowicz 2003).

The fractional factorial experimental design was generated using a D-efficiency criterion for main effects estimation (Kuhfeld 2010; Kuhfeld and Tobias 2005). This more efficient design enables model coefficients, and hence, estimated willingness–to-pay, to be estimated with greater precision; i.e., lower standard errors or variability, for any given number of observations. It also minimizes correlation between attributes across survey questions (i.e., attributes do not "move together" across different survey questions), so that the unique effect of each attribute on respondents' choices, and ultimately, values, can be isolated.[3]

Exhibit II-1 presents the set of attribute levels that are used across the option pairs. The resulting experimental design is characterized by 72 unique Option A vs. Option B pairs, each corresponding to a choice question defined by an orthogonal (independent) array of attribute levels for the two policy options. Following guidance from the literature, EPA designed the attribute levels to illustrate realistic policy scenarios that "span the range over which we expect respondents to have preferences, and/or are practically achievable" (Bateman et al. 2002, p. 259). Choice scenarios

[3] EPA removed dominated pairs where one option is superior to the other in all attributes. Focus groups showed that respondents react negatively and often protest when offered dominated pairs. Given that such choices provide negligible statistical information compared to choices involving non- dominated pairs, they are typically avoided in choice experiment statistical designs.

represent each ecological attribute in relative terms with regard to upper and lower reference conditions; i.e., best and worst possible in the attribute, as defined in survey informational materials. The surveys also present the cardinal basis for relative scores where applicable (e.g., respondents were asked to evaluate changes in fish saved per year as a percentage of current estimated mortality, but those changes were also illustrated in terms of numbers of age-one equivalent fish).[4] Relative scores represent percent progress towards the upper reference condition (100%), starting from the lower reference condition (0%). In interpreting the results, it is useful to keep in mind that while three of the attributes spanned a relatively narrow range of percentage values reflecting realistic ecological expectations (e.g., commercial fish populations differing by no more than six percentage points from the baseline), the "fish saved per year" attribute, which was ultimately used to estimate household WTP for the policy options, was presented in a way that spanned a much larger range (e.g., up to 95 percentage points). Again, this reflects the expected range of potential reductions based on available technology performance. Allowing the range of variables to vary according to realistic ecological and technological expectations, is recommended practice in stated preference design (Bateman et al. 2002).

[4] Age-one equivalents, in addition to providing a way to standardize losses so that losses could be compared among species, years, facilities, and regions, is a convenient way to express losses of all life stages, including fish eggs and larvae, as numbers of individual fish.

Exhibit II-1—Attribute Levels Assigned Across Policy Options and Survey Versions

Attribute	Baseline (Status Quo)[a]	Max Change Assigned	Attribute Levels Assigned to Option A vs. Option B Pairs					
			1	2	3	4	5	6
Commercial Fish Populations *(Score showing the overall health of commercial and recreational fish populations)*								
Northeast	42%	6%	43%	45%	48%	-	-	-
Southeast	39%	6%	40%	42%	45%	-	-	-
Pacific	56%	6%	57%	59%	62%	-	-	-
Inland	39%	6%	40%	42%	45%	-	-	-
National	51%	6%	52%	54%	57%	-	-	-
Fish Populations (all fish) *(Score showing the estimated size of all fish populations compared to natural levels without human influence)*								
Northeast	26%	4%	27%	28%	30%	-	-	-
Southeast	24%	4%	25%	26%	28%	-	-	-
Pacific	32%	4%	33%	34%	36%	-	-	-
Inland	33%	4%	34%	35%	37%	-	-	-
National	30%	4%	31%	32%	34%	-	-	-
Fish Saved per Year *(Score showing the reduction in young fish lost compared to current levels)*								
Northeast	0%	95%	5%	50%	95%	-	-	-
Southeast	0%	90%	25%	55%	90%	-	-	-
Pacific	0%	95%	2%	50%	95%	-	-	-
Inland	0%	95%	55%	75%	95%	-	-	-
National	0%	95%	25%	55%	95%	-	-	-
Aquatic Ecosystem Condition *(Score showing the ecological condition of affected areas, compared to the most natural waters in the region)*								
Northeast	50%	4%	51%	52%	54%	-	-	-
Southeast	68%	4%	69%	70%	72%	-	-	-
Pacific	51%	4%	52%	53%	55%	-	-	-
Inland	42%	4%	43%	44%	46%	-	-	-
National	53%	4%	54%	55%	57%	-	-	-
Household Costs *(The increase in annual household cost, in unavoidable price increases)*								
Northeast	$0	$72	$12	$24	$36	$48	$60	$72
Southeast	$0	$72	$12	$24	$36	$48	$60	$72
Pacific	$0	$72	$12	$24	$36	$48	$60	$72
Inland	$0	$72	$12	$24	$36	$48	$60	$72
National	$0	$72	$12	$24	$36	$48	$60	$72

[a] Each question includes a "no policy" option, characterized by the baseline levels for each attribute and a household cost of $0.

The estimates of "fish saved" in the valuation questions are based on EPA's estimate of age-one-equivalent (A1E) losses due to cooling water intake structures at baseline; a metric used by EPA to convert all I&E mortality losses into equivalent numbers of one-year-old fish. This conversion allows losses to be compared among species, years, facilities, and regions. Exhibit II-2 shows the composition of estimated national A1E losses at cooling water intakes at baseline in terms of the various life stages. The introductory materials describe the age classes impacted due to cooling water intakes and the "fish saved" metric as "young fish lost compared to current levels." The A1E terminology is not used specifically within the valuation questions themselves, although pre-testing during focus groups and cognitive interviews suggested that participants understood the "fish saved" attribute and the concept of "young fish" as reflecting initial losses of eggs and other juvenile life stages. Page three of the survey booklet includes introductory materials that specify the proportion of "fish saved" that are and are not commercial or recreational species.

Exhibit II-2—Composition of Baseline National CWIS Fish Losses [a]

Fish Group	Organisms Lost Count (in millions)	Organisms Lost %	A1E Losses Count (in millions)	A1E Losses %
By Life Stage				
Egg	387,199.2	73.2%	28.6	1.3%
Larvae	138,740.3	26.2%	557.5	25.5%
Juvenile[b]	2,225.7	0.4%	491.6	22.5%
Adult	731.8	0.1%	1,110.9	50.8%
Total	528,897.0	100.0%	2,188.6	100.0%
By Use Category				
Forage	360,651.0	68.2%	1,654.5	75.6%
Commercial & Recreational	168,245.9	31.8%	534.1	24.4%
Total	528,897.0	100.0%	2,188.6	100.0%

[a] Totals are based on the sum of losses within all survey regions.

[b] The juvenile stage begins after fish larva undergo metamorphosis following absorption of the yolk sac. The metamorphosis is complete when all fin rays are present and the process of squamation (growth of fish scales) has begun. In our model, juvenile stages end at age 1.

It is standard practice to include more than one choice question in each survey, thus increasing the information obtained from each respondent (Poe et al. 1997; Layton 2000). EPA randomly assigned the 72 option pairs to 24 distinct versions for each of the four regional surveys and the national survey, with three option pairs (i.e., choice questions) per survey booklet. See the ICR supporting statement (EPA ICR # 2402.01) for additional detail on the experimental design.

Following recommended methods for stated preference survey design (cf. Arrow et al. 1993; Bateman et al. 2002; Bennett and Blamey 2001; Kaplowicz et al. 2004), the survey instrument was pre-tested extensively in six focus groups, with eight to ten participants each, and a set of eight one-on-one cognitive interviews (EPA ICR # 2090-0028). Each cognitive interview included only one participant. This allowed in-depth exploration of the cognitive processes used by respondents to answer survey questions, without the potential for interpersonal dynamics to sway respondents' comments (Kaplowicz et al. 2004). Focus groups and cognitive interviews also included questions following the verbal protocols suggested by Schkade and Payne (1994), in which respondents were asked to talk through the process they used to answer choice questions. Within the focus group and cognitive interview format, the moderator first asked the participants to complete a draft survey questionnaire. The moderator then led a general conversation which took the group/individual through a series of debriefing questions. During debriefing, the moderator asked focus group and cognitive interview participants about their reactions to the survey format and content, whether the survey questions were clear, whether the background information presented in the survey or introductory materials was sufficient and how participants interpreted it, what went through participants' minds when they read survey questions, and what their motivations were for responding the way they did to the survey.

The participants comments and feedback provided important information on such concerns as (1) whether questions and survey information were readily understood, (2) whether respondents were interpreting questions similarly to how EPA interprets them, (3) whether responses or survey interpretations showed any evidence of heuristics or survey biases including hypothetical bias, (4) whether respondents were addressing choice questions in a manner commensurate with utility maximization and neoclassical WTP estimation, and (5) whether respondents were following instructions provided in the survey instrument and responding to questions accordingly. Focus group participants' responses to the survey choice questions could not be included in model estimation because the draft surveys completed during pre-testing differ somewhat from the final survey. EPA modified the survey several times based on the results of these pre-tests, to help minimize potential biases, and to help ensure shared and accurate interpretation of survey language by the respondents. The amount of pre-testing conducted for stated preference surveys varies within the literature and tends to be related to the complexity of the survey instrument. EPA believes that the amount of time and number of focus groups the Agency applied in survey design compares quite favorably to stated preference analyses in the peer reviewed literature.

B. Sampling Frame

EPA designed the 316(b) stated preference study as a household mail survey. The mail survey approach allowed EPA to draw the survey sample from a nearly comprehensive database of residences in the U.S. and avoid potential sampling biases associated with the incomplete coverage of landline and cellphone databases. EPA stratified households based on the geographic boundaries of four regions: Northeast, Southeast, Inland, and Pacific. As noted previously, these regions differ from the 316(b) benefits regions used in the EEBA for the proposed rule. EPA developed target sample sizes for each region to provide statistically robust results while minimizing the cost and burden of the survey to individual respondents.[5] The target sample sizes refer to *completed* mail surveys. A larger number of households must be mailed surveys because, as is the case for all mail surveys, only a portion of households that receive a survey will return a completed mail survey.

EPA selected a total target sample of 2,000 completed surveys across all four regional surveys to provide estimates of population percentages with a margin of error ranging from 3.6 to 5.8 percentage points at the 95% confidence level. These 2,000 surveys were allocated across the four regions based on the number of households in each region relative to the total number of household in the continental U.S. In addition, a minimum number of completed surveys were required for each region. Monte Carlo experiments indicate that approximately 6 to 12 completed responses are required for each profile (unique set of choice options) in order to achieve large sample statistical properties for choice experiments (Louviere et al. 2000, p. 104, citing Bunch and Batsell 1989). As described previously, the experimental design includes 72 option profiles. Following this guidance, the experiment design will require 12 completed surveys for each of the 72 profiles, for a total of 864 profile responses per region ($72 \times 12 = 864$). A

[5] EPA included three choice questions within each survey, to increase information obtained from each respondent. It is standard practice within choice experiment and dichotomous choice contingent valuation surveys to include more than one choice question in each survey (Poe et al. 1997; Layton 2000). Including more than three choice questions may have negatively affected the response rate by increasing burden on respondents and including fewer would have increased survey costs by requiring additional households.

minimum of 288 completed surveys are required for each region because each survey version includes 3 profiles (864÷3=288).

The allocation of the 2,000 completed surveys across the four regions resulted in target sample sizes of 417 for the Northeast version, 562 for the Southeast version, 289 for the Pacific version, and 732 for the Inland version. EPA also conducted a national version of the mail survey with a target sample size of 288 completed surveys. EPA mailed the survey to 7,840 households in total, anticipating a response rate of 30 percent. Exhibit II-3 presents the states included in each region, the total number of households in each region, the target number of completed surveys, and the number of surveyed households for each survey version.

Exhibit II-3—Target Sample Sizes and Number of Mailed Surveys by Survey Region

Survey Region	State Included	Number of Households	Target Sample Size [a,b]	Number of Surveyed Households[c]
Northeast	CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT	23,281,296	417	1,440
Southeast	AL, FL, GA, LA, MS, NC, SC, TX, VA	31,378,122	562	1,920
Pacific	CA, OR, WA	40,852,983	289	1,040
Inland	AR, AZ, CO, ID, IA, IL, IN, KS, KY, MI, MN, MO, MT, ND, NE, NM,NV, OH,OK,SD,TN, UT, WI, WV, WY	16,158,206	732	2,480
Total for Regional Survey Versions	U.S. (excluding AK and HI)	111,670,607	2,000	6,880
National Survey Version	U.S. (excluding AK and HI)	111,670,607	288	960

[a] Target sample sizes presented here refer to completed mail surveys.
[b] The sample is allocated to each region in proportion to the total number of households in that region, with at least 288 completed surveys in each region, the number required to estimate the main effects and interactions under an experimental design model.
[c] The number of intended completed questionnaires for each survey region was rounded up so that the same number of households received each of the 24 survey versions.

EPA used multiple preview and reminder mailings to promote a high response rate and minimize the potential for non-response bias. This approach follows Dillman et al. (2009), which is among the most definitive sources for survey logistics management.

Households were selected from the U.S. Postal Service Digital Sequence File (DSF) of residences which, in total, covers 97% of residences in the United States. EPA is also conducting a follow-up study of households that did not return a completed mail survey. The purpose of the non-response follow-up study is to identify whether survey non-respondents are fundamentally different than survey respondents by asking them a few demographic and attitudinal questions. Refer to Section II.G below and the ICR (EPA ICR # 2402.01) for additional details regarding the non-response study and sampling design.

C. Mail Survey Responses

At the time this supporting material was prepared, EPA had received a total of 2,313 completed mail surveys across all versions. Exhibit II-4 summarizes the number of completed surveys received and the response rate (minus undeliverable surveys across the survey versions. The average response rate across all versions was 33 percent. This response rate is comparable to various other recent mail surveys in the stated preference literature (e.g., Hanley et al. 2006; Johnston and Duke 2009; Johnston and Bergstrom 2011; Boyle and Ozdemir, 2009).

Exhibit II-4—Completed Surveys Received and Response Rates by Survey Version

Survey Version	Households Surveyed	Completed Surveys Received	Response Rate[a]
Northeast	1,440	421	31%
Southeast	1,920	506	30%
Pacific	1,040	311	32%
Inland	2,480	787	36%
National Survey Version	960	288	34%

[a] The number of undeliverable surveys was subtracted from surveys mailed when calculating the response rate for each survey region. Undeliverable surveys are those surveys that were returned to sender.

Analysis of the survey data across all four regions and the national survey indicates that respondents appear to have been evaluating trade-offs between costs and benefits of policy options presented to them, and that WTP is responsive to scope (i.e., the quantity of environmental improvements across different attributes). Responses also reveal, as suggested in the focus groups, that respondents appeared to understand and distinguish between different types of outcomes from 316(b) regulation. About 90 percent of respondents answered the choice experiment questions (questions 4, 5, and 6 of the survey). Question 8 of the survey asked respondents to rate their understanding of the survey material, with only 14 percent disagreeing when asked whether the survey material was easy to understand. They were also confident in their responses to the survey questions. Seventy-one percent of respondents strongly agreed or agreed when asked if they were confident in their responses to the survey questions. The vast majority indicated that they would answer the same way if parallel questions were asked in a binding referendum with less than two percent of respondents indicating otherwise.

About 75 percent of mail survey respondents were under age 65 and the majority of those completing the survey (63 percent) were male. About 87 percent of respondents selected "white" for racial category. For additional information on the demographic characteristics of respondents see EPA's memorandum to the 316(b) rulemaking record (DCN-4524).

D. Random Utility Model

EPA's analysis of the 316(b) stated preference survey data is grounded in the random utility model of Hanemann (1984) and McConnell (1990). The use of the random utility model is standard in the stated preference literature for attribute-based experiments such as choice experiments (Bennett and Blamey 2001; Bateman et al. 2002). Under the random utility model, "utility is the sum of systematic [or observed] and random [or unobserved] components" (Holmes and Adamowicz 2003, p. 189). The individual choices are systematic (i.e., deterministic) while the random component reflects researcher uncertainty about preferences, among other things (Holmes and Adamowicz 2003). It is applied extensively within stated preference research, and allows well-defined welfare measures (i.e., WTP) to be derived from choice experiment models (Bennett and Blamey 2001; Louviere et al. 2000).

The random utility models for all four regions and the national survey were estimated using maximum likelihood mixed logit. The mixed logit model is an approach for modeling preference heterogeneity based on the assumption that people's preferences are randomly distributed and that heterogeneity in population preferences can be captured by estimating the mean and variance of the random parameter distribution (Holmes and Adamowicz 2003). As described by Henscher and Greene (2003), "the mixed logit model offers an extended framework within which to capture a greater amount of behavioral choice making. Broadly speaking, the mixed logit model aligns itself much more closely with reality than most discrete choice models. This is because every individual has their own inter-related systematic and random components for each alternative in their perceptual choice set(s)" (p. 170). It is a highly flexible model that "obviates the three limitations of standard logit by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time" (Train 2009, p.134).

The mixed logit model allows for the possibility of preference heterogeneity but cannot attach specific parameter values to particular individuals. That is, the mixed logit (ML) model relaxes the assumption of respondents being identical (required for multinomial logit estimation), replacing it with a less restrictive assumption that respondents follow a predetermined distributional form. The theory and methods of mixed logit modeling are well-established (Train 2009), and it has now become standard practice in many areas of research (Hensher and Greene 2003). These models allow for coefficients on attributes to be distributed across sampled individuals according to a set of estimated coefficients and researcher-imposed restrictions. The model is evaluated numerically using random draws because choice probabilities take the form of an integral over a mixing distribution which does not have a closed form (Train 2009). The likelihood simulation for the models used 300 Halton (random) draws.

Economic theory provides guidance regarding some, but not all, aspects of model specification for mixed logit models within stated preference choice experiments. For example, the parameter on program cost is expected to have a negative sign, reflecting a positive marginal utility of income. To allow for this, preliminary models included specifications in which the coefficient on cost was modeled as (1) fixed, (2) lognormal, and (3) bounded triangular. Comparison of model output suggest that superior overall model fit and greatest robustness of results is achieved when cost is modeled as fixed within the mixing distribution. Coefficients on all variables except that on program cost (*cost*) are specified as random with a normal distribution. Similar results and WTP estimates are generated by all preliminary model specifications. However, the illustrated model leads to somewhat more conservative WTP estimates than other model variants.

Mixed logit model statistics suggest good statistical fit across the survey versions. Across the models, the χ^2 values ranged from 389.97 to 989.68 (all with d.f. = 21, $p<0.0001$) and pseudo R^2 ranged from 0.22 to 0.29. See Exhibits II-5 to II-9 for detail on the significance of the model estimated for each survey version. Direct comparisons of statistical fit measures across different choice experiments in the literature can be misleading and should be viewed with extreme caution. Many measures of model fit are not directly comparable across different datasets or models. Nonetheless, the overall statistical fit of the model appears broadly similar to choice experiments found in the published literature addressing environmental improvements both worldwide and in the United States Johnston et al. (2011a,b), in a similar survey of ecological improvements, report a χ^2 of 533.62 (d.f. = 12, $p<0.0001$) and a pseudo R^2 of 0.30. By way of comparison using a commonly reported measure of model fit (pseudo or McFadden R^2), Campbell et al. (2009) report a pseudo R^2 of 0.20; Carlsson et al. (2003) report pseudo R^2 values between 0.12 and 0.27; Do and Bennett (2009) report pseudo R^2 between 0.07 and 0.18; and Colombo and Hanley (2008) report values between 0.16 and 0.36. Other measures of fit are also similar, although again, caution must be exercised when drawing conclusions from any such comparisons across models.

Model results for all five surveys are presented in Exhibits II-5 to II-9. The variable for fish saved (*fish_sav*) is significant in all five models, commercial fish populations (*com_fish*) is significant in four of the five models, fish populations (all fish) (*fish_pop*) is significant in three of the five models, and aquatic ecological condition (*aquatic*) is statistically significant in two of the five models. The significance of these attributes suggests positive implicit prices, that is, positive WTP for changes in individual attributes. Analogous outcomes are common in choice experiments across the literature addressing aquatic ecological improvements, with the substantial majority of choice attributes found to have statistically significant impacts (e.g., Johnston et al. 2011a,b; Carlsson et al. 2003; Do and Bennett 2009). The alternative specific constant (ASC) (*constant*) is a fixed coefficient estimated within choice experiments, which is designed to capture "systematic but unobserved information about why respondents chose a particular option; that is, unrelated to choice set attributes" (Bennett, Rolfe and Morrison 2001). The ASC was not significant in any of the five models, which should be viewed as a desirable result. ASCs become statistically significant in choice experiment models only when elements other than the independent variables, or choice attributes, in the model influence respondents' choices (Kerr and Sharp 2006). At the time this supporting material was prepared, EPA had not completed the non-response studies for the Southeast, Pacific, Inland and National survey versions. The models summarized in Exhibits II-5 to II-9 do not include any weighting based on non-response studies.

As noted above, all variables, except cost, represent percent progress towards the upper ecological reference condition (100%). Hence, these coefficients may be directly interpreted as the relative marginal utility derived from a one percentage point change in each ecological attribute. In the estimated Northeast model, for example, marginal utility is greatest (per percentage point change) for increases in aquatic ecological condition (*aquatic*), with lower, but still statistically significant. impacts associated with changes in commercial fish populations (*fish_pop*) and the number of fish saved (*fish_sav*). As noted above, the percentage differences across the options presented were much larger for the number of fish saved (*fish_sav*) than for the other variables. Following recommended practice in stated preference valuation, these variations correspond with realistic ecological and policy expectations for regulatory outcomes (Bateman et al. 2002).

EPA notes that these model results are preliminary. EPA intends to complete the non-response studies for the other regions to estimate weighted models that correct for non-response bias. EPA also intends to apply a number of validity tests to examine the robustness and theoretical consistency of estimated WTP equations after the non-response studies have been completed for all versions. When these efforts are completed, EPA intends to post these findings on its website,[6] and subject the complete survey results and analysis, including scope and validity testing, to external peer review. EPA is asking for public comments on the survey and results, and their use in estimating environmental benefits under regulatory options.

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[6] http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/

Exhibit II-5—Model Results for the Northeast Region [a]

Variable	Variable Definition	Coefficient [b]	Standard Error	P-value
Random parameters in utility functions				
CONSTANT	ASC associated with the status quo, or choice of neither plan.	-0.08269	0.36139	0.8190
COM_FISH	Score showing the overall health of commercial and recreational fish populations.	0.20338	0.05351	0.0001
FISH_POP	Score showing the estimated size of all fish populations compared to natural levels without human influence.	0.07493	0.08347	0.3693
FISH_SAV	Score showing the reduction in young fish lost compared to current levels.	0.03044	0.00519	0.0000
AQUATIC	Score showing the ecological condition of affected areas, compared to the most natural waters in the Northeast.	0.20973	0.08991	0.0197
Nonrandom parameters in utility functions				
COST	The increase in annual household cost, in unavoidable price increases for products and services, including electricity and common household products.	-0.02792	0.00447	0.0000
Derived standard deviations for parameter distributions				
sdCONSTANT	-	0.03823	1.05647	0.9711
sdCOM_FISH	-	0.17539	0.28451	0.5376
sdFISH_POP	-	0.17880	0.31559	0.5710
sdFISH_SAV	-	0.05615	0.01159	0.0000
sdAQUATIC	-	0.26680	0.33937	0.4318

[a] The mixed logit results have a χ^2 of 518.40 (d.f. = 21, $p<0.0001$) and a pseudo R^2 of 0.22.

[b] For random parameters in utility functions, coefficients represent the estimated means of random parameter distributions.

Exhibit II-6—Model Results for the Southeast Region [a]

Variable	Variable Definition	Coefficient [b]	Standard Error	P-value
Random parameters in utility functions				
CONSTANT	ASC associated with the status quo, or choice of neither plan.	0.08004	0.34193	0.8149
COM_FISH	Score showing the overall health of commercial and recreational fish populations.	0.12104	0.04574	0.0081
FISH_POP	Score showing the estimated size of all fish populations compared to natural levels without human influence.	0.12531	0.07138	0.0791
FISH_SAV	Score showing the reduction in young fish lost compared to current levels.	0.02568	0.00536	0.0000
AQUATIC	Score showing the ecological condition of affected areas, compared to the most natural waters in the Southeast.	0.23161	0.07885	0.0033
Non-random parameters in utility functions				
COST	The increase in annual household cost, in unavoidable price increases for products and services, including electricity and common household products.	-0.03487	0.00351	0.0000
Derived standard deviations for parameter distributions				
sdCONSTANT	-	0.02489	1.16784	0.9830
sdCOM_FISH	-	0.09525	0.16377	0.5608
sdFISH_POP	-	0.09301	0.13918	0.5040
sdFISH_SAV	-	0.06804	0.00952	0.0000
sdAQUATIC	-	0.12186	0.12918	0.3455

[a] The mixed logit results have a χ^2 of 683.29 (d.f. = 21, p<0.0001) and a pseudo R^2 of 0.24.

[b] For random parameters in utility functions, coefficients represent the estimated means of random parameter distributions.

Exhibit II-7—Model Results for the Pacific Region [a]

Variable	Variable Definition	Coefficient [b]	Standard Error	P-value
Random parameters in utility functions				
CONSTANT	ASC associated with the status quo, or choice of neither plan.	0.24593	0.54100	0.6494
COM_FISH	Score showing the overall health of commercial and recreational fish populations.	0.10278	0.10424	0.3241
FISH_POP	Score showing the estimated size of all fish populations compared to natural levels without human influence.	0.14215	0.15130	0.3475
FISH_SAV	Score showing the reduction in young fish lost compared to current levels.	0.05323	0.01141	0.0000
AQUATIC	Score showing the ecological condition of affected areas, compared to the most natural waters in the Pacific.	0.20853	0.16636	0.2100
Non-random parameters in utility functions				
COST	The increase in annual household cost, in unavoidable price increases for products and services, including electricity and common household products.	-0.02226	0.00483	0.0000
Derived standard deviations for parameter distributions				
sdCONSTANT	-	0.02585	1.92718	0.9893
sdCOM_FISH	-	0.20354	0.15901	0.2005
sdFISH_POP	-	0.14019	0.36490	0.7008
sdFISH_SAV	-	0.13881	0.05278	0.0085
sdAQUATIC	-	0.18715	0.50826	0.7127

[a] The mixed logit results have a χ^2 of 455.32 (d.f. = 21, $p<0.0001$) and a pseudo R^2 of 0.29.

[b] For random parameters in utility functions, coefficients represent the estimated means of random parameter distributions.

Exhibit II-8—Model Results for the Inland Region [a]

Variable	Variable Definition	Coefficient [b]	Standard Error	P-value
Random parameters in utility functions				
CONSTANT	ASC associated with the status quo, or choice of neither plan.	-0.25032	0.35323	0.4785
COM_FISH	Score showing the overall health of commercial and recreational fish populations.	0.09898	0.03205	0.0020
FISH_POP	Score showing the estimated size of all fish populations compared to natural levels without human influence.	0.11198	0.05370	0.0370
FISH_SAV	Score showing the reduction in young fish lost compared to current levels.	0.02470	0.00427	0.0000
AQUATIC	Score showing the ecological condition of affected areas, compared to the most natural waters in the Inland region.	0.08669	0.06599	0.1890
Non-random parameters in utility functions				
COST	The increase in annual household cost, in unavoidable price increases for products and services, including electricity and common household products.	-0.03186	0.00272	0.0000
Derived standard deviations for parameter distributions				
sdCONSTANT	-	0.02650	2.01575	0.9895
sdCOM_FISH	-	0.07322	0.16944	0.6656
sdFISH_POP	-	0.06925	0.20775	0.7389
sdFISH_SAV	-	0.05182	0.00773	0.0000
sdAQUATIC	-	0.52674	0.40309	0.1913

[a] The mixed logit results have a χ^2 of 989.68 (d.f. = 21, p<0.0001) and a pseudo R^2 of 0.22.
[b] For random parameters in utility functions, coefficients represent the estimated means of random parameter distributions.

Exhibit II-9—Model Results for the National Survey [a]

Variable	Variable Definition	Coefficient [b]	Standard Error	P-value
Random parameters in utility functions				
CONSTANT	ASC associated with the status quo, or choice of neither plan.	-0.06065	0.60390	0.9200
COM_FISH	Score showing the overall health of commercial and recreational fish populations.	0.17407	0.06579	0.0082
FISH_POP	Score showing the estimated size of all fish populations compared to natural levels without human influence.	0.25141	0.12384	0.0423
FISH_SAV	Score showing the reduction in young fish lost compared to current levels.	0.03938	0.01084	0.0003
AQUATIC	Score showing the ecological condition of affected areas, compared to the most natural waters in the U.S.	0.14043	0.13630	0.3029
Non-random parameters in utility functions				
COST	The increase in annual household cost, in unavoidable price increases for products and services, including electricity and common household products.	-0.03539	0.00461	0.0000
Derived standard deviations for parameter distributions				
sdCONSTANT	-	0.02280	1.82792	0.9900
sdCOM_FISH	-	0.13724	0.52054	0.7921
sdFISH_POP	-	0.11719	0.56426	0.8355
sdFISH_SAV	-	0.10766	0.05600	0.0545
sdAQUATIC	-	0.16083	1.21828	0.8950

[a] The mixed logit results have a χ^2 of 389.97 (d.f. = 21, p<0.0001) and a pseudo R^2 of 0.24.
[b] For random parameters in utility functions, coefficients represent the estimated means of random parameter distributions.

E. Estimation of Willingness-to-Pay

EPA used the results of the random utility models presented in Exhibits II-5 through II-9 to estimate the marginal annual WTP (or implicit price) for a one percentage point change in each of the four environmental attributes within each survey region. This represents WTP per household, per year, for a one percentage point change in the corresponding choice model attribute. If utility is modeled as a linear function of attributes, implicit prices may be calculated as $IP_a = \beta_a / \beta_n$, where β_a is the estimated coefficient on an environmental attribute (e.g., change in fish saved), and β_n is the coefficient on program cost. Assuming a linear preference function as estimated above, compensating surplus (or household WTP) for any given policy option may be calculated as:[7]

$$\text{WTP} = (IP_{com\_fish} * \Delta com\_fish) + (IP_{fish\_pop} * \Delta fish\_pop) + (IP_{fish\_sav} * \Delta fish\_sav) + (IP_{aquatic} * \Delta aquatic),$$

where the delta (Δ) represents a change in the attribute in question. That is, total WTP for a policy change is calculated as the sum of the product of implicit prices and corresponding attribute changes.

EPA notes that ecological systems are typically characterized by correlation among many processes and outcomes. In the context of impingement and entrainment losses, for example, a reduction in age-one-equivalent losses (*fish_sav*) may be correlated with changes in fish populations (*fish_pop*), aquatic ecosystem condition (*aquatic*), and commercial fish populations (*com_fish*). Were the stated preference survey scenarios to incorporate the same correlations, it would have been difficult to determine which attribute(s) caused respondents to choose one scenario over another. For example, if it were the case that large reductions in I&E losses always accompany large positive effects on fish populations and large positive effects on ecosystem condition and these correlations were embedded within survey scenarios, it would be difficult to estimate the relative influence of each attribute on respondents' choices.

The experimental design used in the stated preference survey breaks this correlation, allowing different survey attributes to vary independently. This enables different respondents to view many different possible policy outcomes, each with different combinations of *fish_sav*, *fish_pop*, *aquatic* and *com_fish*. While some of the

[7] EPA excluded the ASC when estimating the benefits of regulatory options because there is no clear theoretical reason for inclusion.

resulting scenarios might be unlikely in actual aquatic systems, they are not ecologically impossible. For example, the experimental design allows respondents to consider scenarios in which large reductions in fish losses accompany small changes in fish populations and aquatic condition (positive changes in *fish_sav* in some questions are also paired with no change in the population or aquatic condition metrics). Because attributes vary independently across the 72 different choice questions presented to respondents in each survey region, it is possible to estimate the unique effects of each attribute on individuals' choices and therefore, values. By breaking the correlation between these attributes present in ecosystems, the choice experiment design allows estimation of the independent effect of each attribute on choices and willingness to pay.

These attributes have almost zero correlation in the resulting experimental design. It is thus possible to obtain precise (i.e., efficient) estimates of each effect, without concerns that these estimates are confounded by correlations among the ecological outcomes in the survey. This allows willingness to pay for each ecological effect to be estimated, independent from all other effects. [8]

Because the mixed logit model includes random coefficients, EPA estimates implicit prices using the welfare simulation approach of Johnston and Duke (2007; 2009) following the framework outlined by Hensher and Greene (2003). The procedure begins with a parameter simulation following the parametric bootstrap of Krinsky and Robb (1986), with R=1,000 draws taken from the mean parameter vector and associated covariance matrix. For each draw, the resulting parameters are used to characterize

[8] The experimental design utilized in EPA's survey ameliorates the problem of correlation between estimated model attributes. The actual correlation among the ecological attributes, such as fish saved and aquatic condition, would be accounted for in the predicted attribute changes used (in conjunction with the estimated model coefficients) for model prediction of willingness to pay.

asymptotically normal empirical densities for fixed and random coefficients. For each of these R draws, a coefficient simulation is then conducted for each random coefficient, with S=1,000 draws taken from simulated empirical densities. WTP measures are calculated for each draw, resulting in a combined empirical distribution of $R \times S$ observations from which summary statistics are derived. All implicit prices are modeled as the WTP for a one percentage point change in the ecological attribute, all else being constant. Exhibit II-10 presents the implicit price and standard deviation for a one percentage point increase in each attribute. The 90 percent confidence intervals for each variable, based on the 5th and 95th percentiles of its empirical distribution, are also presented. As shown in Exhibit II-10, the estimated implicit prices are uniformly larger for commercial fish populations, fish populations (all fish), and aquatic ecosystem condition than fish saved. In the Northeast for example, households value a one percentage point increase in commercial fish populations or aquatic ecosystem condition about seven times more than a one percentage point increase in fish saved. Although the discussion in this section refers to willingness-to-pay for a percentage point increase in fish saved, it is important to note that this variable represents a one percentage point reduction relative to the baseline mortality (e.g., the Northeast survey booklet indicated a baseline loss of 1.1 billion fish). This relationship between the percentage point reduction and cardinal fish losses was specified clearly in survey questions, and the same relationship was maintained throughout each survey version. Again, using the Northeast survey as an example, EPA is presenting the willingness to pay for a percentage point reduction of mortality which is associated with a specific absolute quantity of fish out of 1.1 billion fish, rather than a general relative reduction of one percent from an unspecified level of I&E mortality. The regional and national survey versions have different baseline fish losses. EPA expected survey responses to vary across the regions, both because residents might have different values, and because baseline losses differ. The implicit prices reflect this expected variation. EPA plans to explore whether respondents are more sensitive to the representation of fish saved in percentage terms, or in absolute numbers.

Exhibit II-10— Estimated Implicit Prices for a One Percentage Point Change in Each Attribute , WTP per Household, per Year (2011$)

Region/Attribute	Implicit Price [a]	Standard Deviation	90% Confidence Interval	
			5th	95th
Northeast				
Commercial Fish Populations (*COM_FISH*)	$7.35	$2.15	$4.14	$11.14
Fish Populations (all fish) (*FISH_POP*)	$2.66	$3.13	-$2.32	$7.71
Fish Saved (*FISH_SAV*)	$1.12	$0.22	$0.76	$1.50
Aquatic Ecosystem condition (*AQUATIC*)	$7.66	$3.40	$2.35	$13.45
Southeast				
Commercial Fish Populations (*COM_FISH*)	$3.49	$1.42	$1.30	$5.89
Fish Populations (all fish) (*FISH_POP*)	$3.57	$2.08	$0.27	$6.98
Fish Saved (*FISH_SAV*)	$0.75	$0.18	$0.46	$1.04
Aquatic Ecosystem condition (*AQUATIC*)	$6.61	$2.12	$3.00	$10.00
Pacific				
Commercial Fish Populations (*COM_FISH*)	$4.67	$5.26	-$3.16	$13.35
Fish Populations (all fish) (*FISH_POP*)	$6.43	$7.32	-$5.12	$17.61
Fish Saved (*FISH_SAV*)	$2.52	$0.80	$1.39	$3.90
Aquatic Ecosystem condition (*AQUATIC*)	$9.50	$7.67	-$3.03	$22.38
Inland				
Commercial Fish Populations (*COM_FISH*)	$3.10	$1.07	$1.43	$4.83
Fish Populations (all fish) (*FISH_POP*)	$3.48	$1.72	$0.75	$6.30
Fish Saved (*FISH_SAV*)	$0.78	$0.14	$0.55	$1.01
Aquatic Ecosystem condition (*AQUATIC*)	$2.70	$2.11	-$0.84	$6.16
National				
Commercial Fish Populations (*COM_FISH*)	$4.93	$2.03	$1.84	$8.34
Fish Populations (all fish) (*FISH_POP*)	$7.04	$3.56	$1.35	$12.78
Fish Saved (*FISH_SAV*)	$1.13	$0.32	$0.59	$1.68
Aquatic Ecosystem condition (*AQUATIC*)	$3.94	$4.00	-$2.72	10.56

[a] The implicit prices are per percentage point increase from the specified baseline (reference) levels for each survey version. See Exhibit II-1for baseline values.

F. Method for Estimating Regional and National Benefits

The implicit prices presented in Exhibit II-10 could be used to estimate annual monetized benefits for the survey regions and total U.S. households under regulatory options. Annual WTP per household for a regulatory option can be calculated by multiplying changes in environmental attributes due to the regulation (fish saved, commercial fish populations, fish populations (all fish), and aquatic ecosystem condition) by their respective implicit prices, or WTP per percentage point change. The models use a linear approximation for utility, so the implicit price of each attribute is constant.

The annual household WTP under each regulatory option could be estimated solely based on changes in fish saved (*fish_sav*) by multiplying its implicit price by the percentage change in fish saved. EPA has calculated the marginal change in fish saved (%) under each regulatory option in the proposed rule, based on the percentage reduction in A1E losses relative to baseline A1E losses within the survey region. The resulting estimates of A1E reductions and percentage fish saved for each survey region and the United States are presented in Exhibit II-11. Changes in commercial fish populations, fish populations (all fish), and aquatic ecosystem condition could also factor into the calculation of household WTP, however, EPA has not modeled changes in these drivers of WTP. Within the context of the model, using only changes in fish saved would result in conservative estimates of benefits, in that it assumes zero impacts on all other choice model attributes. EPA notes that while monetized benefits based solely on fish saved would be conservative within the framework of the survey results and model, there are other reasons why the WTP estimates might be biased, as discussed previously.

As described previously, the regions for the stated preference survey differ from the benefits regions used for the analysis of the proposed rule.[9] EPA estimated the A1E reductions in Exhibit II-11 by applying state-level data for facility actual intake flow (AIF) to regional A1E reductions from the proposed rule. EPA believes that the use of flow to extrapolate A1E reductions is appropriate for this regional and national level analysis, but it is important to note that the generalized relationship between flow and A1E described, as well as any resulting estimates of WTP for percent of fish saved, which are based on specific regional levels of baseline losses, may not hold at specific sites around the country.

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[9] See Exhibit II-3 for the list of states included within each survey region.

Exhibit II-11—Reduction in A1E Losses and Percent Fish Saved by Regulatory Option

Survey Version and Regulatory Option	Reduction in A1E Losses	Fish Saved (%)
Northeast		
Eliminating Baseline I&E Mortality Losses [a]	964.87	100.00
Option 1	78.31	8.12
Option 2	880.70	91.28
Option 3	893.73	92.63
Option 4	77.29	8.01
Southeast		
Eliminating Baseline I&E Mortality Losses	722.97	100.00
Option 1	271.41	37.54
Option 2	642.28	88.84
Option 3	651.70	90.14
Option 4	265.86	36.77
Pacific [b]		
Eliminating Baseline I&E Mortality Losses	385.99	100.00
Option 1	1.78	0.46
Option 2	33.28	8.62
Option 3	34.74	9.00
Option 4	1.73	0.45
Inland		
Eliminating Baseline I&E Mortality Losses	462.29	100.00
Option 1	263.48	56.99
Option 2	425.29	92.00
Option 3	433.38	93.75
Option 4	257.54	55.71
National Version		
Eliminating Baseline I&E Mortality Losses	2536.13	100.00
Option 1	614.97	24.25
Option 2	1981.55	78.13
Option 3	2013.55	79.39
Option 4	602.42	23.75

[a] This hypothetical scenario reflects the benefits that would be achieved if all I&E mortality losses were eliminated. EPA includes it to allow comparison of regulatory option benefits to total baseline I&E mortality losses. This scenario was listed as "Baseline I&E Losses" in the EEBA for the proposed rule.
[b] The calculation of Fish Saved (%) for the Pacific survey region includes reductions in A1E losses at Hawaii facilities. This approach is consistent with the EEBA which included Hawaii facilities in the California region. Regulatory Scenarios: Option 1 = IM limitations based on modified traveling screens for all facilities with flow greater than 2 million gallons per day (MGD); Option 2 = Intake flow commensurate with closed-cycle cooling for facilities that have a design intake flow of greater than 125 MGD and IM limitations based on modified traveling screens for all facilities with flow greater than 2 MGD; Option 3 = Intake flow commensurate with closed-cycle cooling for all facilities and IM limitations based on modified traveling screens for all facilities with flow greater than 2 MGD; Option 4 = IM limitations based on modified traveling screens for all facilities with flow greater than 50 million gallons per day (MGD).

If the results of the stated preference survey are to be used for the final rule, EPA would calculate the total annual WTP within each of the survey regions under each regulatory option by multiplying the annual household WTP by the number of households in the survey region. See Exhibit II-3 for the number of households in each survey region. Total annual WTP within the survey region would then be discounted based on the regulatory compliance schedule. The compliance schedule is a time profile that reflects when benefits from each facility will be realized. Refer to Appendix D of the EEBA of the proposed rule for additional description of the compliance schedule. Since the compliance schedule moves the reductions in A1E into the future, this step would reduce the present value of the total benefits accrued to households, decreasing annualized benefits estimates.

Annualized national benefits can potentially be calculated as the sum of regional benefits or based on the national survey version. EPA will conduct additional analysis to compare the results and evaluate the validity of these two approaches for estimating benefits to U.S. households.

As described previously, the model estimates a constant marginal WTP (or implicit price) per percentage point reduction in baseline mortality, regardless of how much progress has already been made in reducing I&E mortality. EPA notes that this simplification, while common in many types of benefit analysis, does not allow one to quantify or test theoretically-expected effects such as diminishing marginal WTP, i.e., that the more of a good an individual has, the less she is willing to pay for an additional unit. Relative to a diminishing marginal utility form, the linear functional form likely produces lower estimates of WTP at low percentages of fish saved, and higher estimates of WTP at high percentages of fish saved. This fact could affect the relative attractiveness of regulatory options from a cost-benefit viewpoint; therefore, EPA will also investigate alternative non-linear functional forms that relax the assumption of constant utility.

At the time this supporting material was prepared, EPA had not yet completed fielding the non-response studies and analyzing the non-response data for the Southeast, Pacific, Inland, and national versions. If EPA includes quantified benefits from the stated preference survey in the analysis for the final rule, EPA would update its models for the final rule based on the results of the non-response studies that are being conducted. EPA will post these results on the Agency's website once they become available.[10] The Northeast non-response study has been completed and a weighted model based on its results is discussed in the next section. EPA will also make adjustments to the estimation methodology that may be necessary to address issues of representativeness that arise as a result of the Agency's continuing efforts at scope and validity testing, public comments, and comments from the planned external peer review. As already noted, EPA will carefully consider those comments and results before determining what role, if any, the quantified benefits based on this stated preference survey should play in the benefits analysis for the final rule.

EPA notes that benefits estimated based on the stated preference survey would not be viewed as additive to those benefit values estimated at proposal. Values estimated using the stated preference survey would represent both use and non-use willingness-to-pay. As a result, if EPA includes the quantified benefits derived from the stated preference survey in the final benefits analysis, those benefits would supplant the previous benefit estimates.

[10] http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/

G. Northeast Non-Response Study, Weighted Model Results, and Sensitivity to Scope

As described earlier, EPA conducted the Northeast mail survey and non-response study in advance of the other three regional and national surveys. At the time this supporting material was prepared, EPA had not finished collecting and analyzing the non-response data for the Inland, Southeast, Pacific, and national surveys. EPA obtained a total of 111 completed responses for the Northeast non-response survey and has statistically tested the set of demographic characteristics across both the main stated preference survey and the non-response survey for the Northeast. Education and gender values were found to be statistically different. As a next step in the assessment process, EPA estimated regressions which included interaction variables designed to indicate whether both education and gender had a statistically significant impact on the estimated implicit prices. Based on the above results, EPA developed weights that adjust for the difference between the education and gender attributes across the two Northeast survey samples and their potential influence on the estimated implicit prices. The results of the weighted model are presented in Exhibit II-12.

EPA used the results of the weighted Northeast random utility model to estimate the marginal annual WTP (or implicit price) for a one percentage change in each of the four environmental attributes within the Northeast U.S. The resulting implicit prices are presented in Exhibit II-13. For the Northeast region, the implicit prices are higher when using the weighted results. This increase is the net result of increases and decreases from weighting to decrease the impact of overrepresented groups and increase the impact of underrepresented groups. For additional information on the non-response survey assessment, see EPA's memorandum to the 316(b) rulemaking record (DCN-4524. EPA will analyze the non-response data for Southeast, Pacific, Inland, and national surveys using an approach consistent with that of the Northeast non-response data, and notes that the relationship between unweighted and weighted results in the Northeast region may not apply to the other survey versions. The implicit prices presented in Exhibit II-13 could be used to calculate annual WTP for Northeast households under regulatory options following the approach described in the Section F.

Exhibit II-12—Weighted Model Results for the Northeast Region [a]

Variable	Variable Definition	Coefficient[b]	Standard Error	P-value
Random parameters in utility functions				
CONSTANT	ASC associated with the status quo, or choice of neither plan.	-0.19167	0.34295	0.5762
COM_FISH	Score showing the overall health of commercial and recreational fish populations.	0.14850	0.04921	0.0025
FISH_POP	Score showing the estimated size of all fish populations compared to natural levels without human influence.	0.09356	0.07931	0.2381
FISH_SAV	Score showing the reduction in young fish lost compared to current levels.	0.02712	0.00548	0.0000
AQUATIC	Score showing the ecological condition of affected areas, compared to the most natural waters in the Northeast.	0.18299	0.09398	0.0515
Non-random parameters in utility functions				
COST	The increase in household cost, in unavoidable price increases for products and services, including electricity and common household products.	-0.02017	0.00393	0.0000
Derived standard deviations for parameter distributions				
sdCONSTANT	-	0.03763	0.93582	0.9679
sdCOM_FISH	-	0.17587	0.14002	0.2091
sdFISH_POP	-	0.18098	0.21738	0.4051
sdFISH_SAV	-	0.05255	0.01532	0.0006
sdAQUATIC	-	0.24411	0.43106	0.5712

[a] The mixed logit results have a χ^2 of 478.67 (d.f. = 21, p<0.0001) and a pseudo R^2 of 0.22.
[b] For random parameters in utility functions, coefficients represent the estimated means of random parameter distributions.

Exhibit II-13— Estimated Implicit Prices for a One Percentage Point Change in Each Attribute in the Northeast, WTP per Household, per Year based on the Weighted Model (2011$)

Attribute	Implicit Price [a]	Standard Deviation	90% Confidence Interval	
			5th	95th
Commercial Fish Populations (*COM_FISH*)	$7.55	$3.01	$3.37	$12.76
Fish Populations (all fish) (*FISH_POP*)	$4.75	$4.32	-$1.84	$11.62
Fish Saved (*FISH_SAV*)	$1.40	$0.38	$0.85	$2.08
Aquatic Ecosystem condition (*AQUATIC*)	$9.34	$5.03	$1.35	$18.14

[a] The implicit prices are per percentage point increase from the specified baseline (reference) levels for each survey version. See Exhibit II-1 for baseline values.

The role of external scope tests within choice modeling has been given relatively little attention in the literature (cf., Heberlein et al. 2005). Unlike open-ended contingent valuation questions, choice experiments provide a direct mechanism for respondents to react to the scope and scale of resource changes, by enabling respondents to compare policy options with different levels for each attribute. Hence, as noted by Bennett and Blamey (2001, p. 231), "internal scope tests are automatically available from the results of a [choice modeling] exercise." Within a choice modeling context, external scope tests may also be confounded by differences in the implied choice frame (Bennett and Blamey 2001). These caveats aside, an external scope test can provide some insight into response patterns, and many view these tests as a "stronger" form of validation than internal scope tests. Hence EPA implemented some preliminary external scope tests to evaluate this form of validity using the Northeast survey data.

EPA performed a split-sample external validity test for the Northeast mail survey data based on the concept that, if all else is orthogonal (effectively equal), a choice option with a greater number of fish saved should be chosen more often than a choice option with a lesser number of fish saved. To distinguish this from the "internal" scope tests automatically performed by choice experiments, it is implemented using a split sample of choice options viewed in isolation. To implement the test, we first create a dataset *only* of observations on Option A for all survey responses, along with the dummy (0-1) variable *choice*, indicating whether that option was chosen. We then further split this sample into three sub-samples: (1) observations on Option A when *fish_sav* = 95%, (2) observations on Option A when *fish_sav* = 50%, and (3) observations on Option A when *fish_sav* =5%. Because of the near orthogonal nature of the experimental design, all other attribute levels should be approximately equal across each of these three sub-samples. Given this split sample, we would expect to observe the greatest proportion of respondents choosing Option A in sub-sample (1), followed by sub-sample (2) and then (3). This order would establish external sensitivity to scope. We then repeated the same test for Option B.

EPA found that the proportion of respondents choosing Option A (*choice*) declines from 0.45 to 0.42 to 0.25 as the percentage of fish saved (*fish_sav*) declines from 95% to 50% to 5%. Option B exhibits a similar decline in *choice* with *fish_sav*. This external scope tests for split samples of both Options A and B demonstrate scope sensitivity, as indicated by economic theory. For additional information on this external scope test see EPA's memorandum to the 316(b) rulemaking record (DCN-4524).