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Summary

Although popular with the environmental community for quite a while, the designation of the 362 thousand km^2 Northwest Hawaiian Islands Marine National Monument in 2007 by President George W. Bush symbolizes the political ascension of Marine Protected Areas (MPAs) in the United States. MPAs are not panaceas for resource allocation, though (Degnbol et al. in press). The benefits of fishery reserves, in particular, are arguable. There is general agreement, however, that no-take ecological reserves are the most effective way to enhance and preserve the ecological diversity of marine species and their habitats on the sea floor.

Scientific research indicates that 10%-40% of an ecosystem is required to preserve all species and their habitats. To insure against catastrophic events would require considerably more. But policy-makers must ask whether complete protection is too costly when compared to the opportunity costs of displaced activities. The zoning plans of MPAs generally exclude or substantially restrict many activities that are important to the economy and consumers, including commercial and recreational fishing, oil and natural gas production, sand and gravel mining, and clean renewable energy from windmills that require being attached to the sea floor.

Debate over non-fungible objectives such as environmental protection and opportunity costs can be informed by adding the public's valuation of ecological diversity. A person might value ecological reserves as a bequest to younger generations, or they might simply get personal satisfaction from knowing that a part of the environment exists in a natural state.

Bequest value and existence value are a class of economic benefits not revealed by markets. Instead economists use surveys that describe hypothetical market-like situations to elicit valuations of an environmental good, service, or asset. The contingent choice class of non-market methods is ideally suited to collecting data on the non-use value of multi-attribute resources such as marine ecological reserves.

This research presents estimates of non-market values of marine protected areas in the Northeast Region of the US. A random sample of over 1300 households in the Northeast Region was presented with sets of hypothetical alternatives which differed in terms of reserve size (5%-40%), compatible uses (No-Take, Science and Education, passive forms of Leisure and Tourism, pelagic Fishing), and personal costs ($10-$150) and asked to choose the bundle that they preferred. Answers from the 77% of responders were analyzed with a latent class specification of the random-utility-model (RUM) to objectively test for heterogeneous preferences.

Three distinct latent classes were identified in the sample. Roughly half of the responders (48%) saw reserve size as a normal economic good with positive, but diminishing marginal utility. Compensating variation was maximized at $133 per-household per-year for this group when total reserve size was 27% of the EEZ and the areas could only be used for scientific and educational purposes. Another class was characterized by

negative utility from MPAs (28%), and the final class (24%) had an incongruous positive response to personal cost, i.e. paying more for reserve size the more costly it became, possibly due to hypothetical bias in the questionnaire or non-conforming preferences.

The model was applied to estimate the publics' valuation of the Habitat Areas of Particular Concern (HAPC) being considered by the New England Fishery Management Council for an amendment to its Essential Fish Habitat Omnibus Plan. Together, the seamounts, canyons, and diverse areas of the shelf comprise 5.2% of the EEZ in the region. Allowing scientific and educational uses doubled estimates of compensating variation by Class 1 (positive utility) responders from more than $50 to almost $110 depending on the status quo. In contrast, compensating variation for Class 3 (disutility) averaged -$40 for the No-Take alternative and increased to -$9 as more uses were allowed. The positive parameter on cost for Class 2 is intractable in this model.

In addition to presenting the methodology and results in detail, the report addresses the need to control for heterogeneous preferences in contingent choice research, a benefit-cost analysis framework that accounts for non-use value, and the effect of operating and opportunity costs on scientists' estimates of optimum reserve size.

Introduction

In the first assessment of the state of the oceans in 35 years, the US Commission on Ocean Policy (2004) reported continued threats to resource sustainability, degradation of marine ecosystems, and unproductive competition for ocean space by traditional and new stakeholders. These persistent problems can be traced to defective governance and property rights arrangements that fail to allocate resources effectively. However, even a "perfect" institutional arrangement (whatever that might be) would be compromised by the dearth of information on the value of things not exchanged in markets. The NRC *Panel on Integrated Environmental and Economic Accounting* (NRC 1999) warned that ignorance of the size of the "non-market" economy biases measures of aggregate welfare in favor of markets, such as National Income and Product Accounts. Perhaps least known (and understood) are the "non-use" values – i.e., the personal satisfaction that people get from protecting the environment for the benefit of others, particularly subsequent generations or wildlife itself.

Marine Protected Areas (MPAs) – especially ecological reserves -- are the leading vehicle for promoting "non-use" values in the ocean. In 2000 when President Clinton signed *Executive Order 13158 Marine Protected Areas* to "help protect the significant natural and cultural resources within the marine environment for the benefit of present and future generations" (EO 13158, 2000), less than 1% of U.S. territorial waters was part of an MPA (Kelleher 1999). However, pressure from environmental organizations worldwide has begun to take effect. For example, in the United States in 2007, President Bush created the largest MPA in the world – the 362 thousand km^2 Northwest Hawaiian Islands Marine National Monument which takes up a third of the Insular-Pacific Hawaiian Large Marine Ecosystem, and is bigger than the combination of all the states in the Northeast Region.

MPAs are used for three general purposes – fisheries management, protection of cultural resources, and preservation of species and habitat diversity. There is scientific evidence that closing an area to extractive uses can rebuild fish stocks inside the area (Palumbi 2002; Halpern 2003; Roberts 2005), but scientists (Hilborn et al. 2004) and conservationists (Agardy 2005) are less sanguine about the overall benefit of fishery reserves. Similarly, economists point out that even fishery reserves that are successful from a biological standpoint could still fail on economic grounds if there is sufficient excess capacity to dissipate resource rents (Hannesson 1999). In large measure, the economic value of fishery reserves depends primarily on whether any net gains in the fishery from the migration of fish from inside the protected area is greater than the opportunity costs of closing the area (Sanchirico 2004).

While the utility of fishery reserves is in doubt, there appears to be a consensus among scientists that MPAs are the only viable way to protect habitat and conserve biodiversity (Hilborn et al. 2004, Lubchenco et al. 2003; NRC 2001; Lauck et al. 1998; Scientific Consensus Statement on Marine Reserves and Marine Protected Areas 2001). The main objective of the MPA Federal Advisory Committee (Anonymous 2005; p. 4) is "conserving, enhancing, and/or restoring marine biodiversity … [and] … representative

examples of the nation's marine habitats, as well as unique biophysical and geological features". However, the committee also highlights the objective of "[p]roviding both appropriate access to and use of marine resources within MPAs consistent with the goals and objectives of the MPA" (p. 4).

Scientists estimate that 10%-40% of a marine ecosystem (depending on its characteristics) would have to be set aside to preserve all ecological diversity (NRC 2001). The percentage can increase substantially to insure against the risk of catastrophe from oil spills, fishing gear, storms, and introduced species (Allison et al. 2003; Halpern 2003). From a policy standpoint, however, the question is not so much "how much is enough?" (Lubchenco et al. 2003), but "how much is too much?". There are costs associated with displaced activities, such as the value of forgone energy and seafood.

MPAs could not possibly be designed without scientific data, but E.O. 13158 is a public policy imbued with subjectivity about humans place in marine ecosystems, not an experiment. It is therefore legitimate to inquire about the public's valuation of ecological reserves and the appropriate mix of protected areas and exploited areas. Even if someone does not expect to ever experience the sea floor first-hand, (s)he might value ecological reserves as a bequest to younger generations (bequest value) or for the knowledge that a part of the environment exists in a natural state (existence value). Together, these values are called non-use values.

The contingent choice class of non-market methods is ideally suited to researching the non-use value of ecological reserves. Non-use values are, by definition, neither directly nor indirectly revealed in market data or by household production behavior (e.g., travel costs used as the price of a fishing trip); therefore, data can only be collected from a survey. In addition, the contingent choice method is designed to collect data on the attributes of a multi-characteristic commodity, such as ecological reserves.

Data were collected from a survey of households in the Northeast Region of the US (for this research the Northeast Region refers to the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia) to test the hypothesis that individuals have preferences not only for the size of an ecological reserve, but also for different types of uses of the reserve. Model results and estimates of non-use value are presented and discussed in the main text. Appendices present the questionnaire, summarize the survey data, and report test results for sampling and selection biases.

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Related Research

The economics literature on the non-market benefits of MPAs is meager, says virtually nothing about non-use values, and cannot address questions about reserve size or allowable uses. Most of the literature reports estimates of the use-value of marine recreation, such as diving and snorkeling. In a contingent valuation study, Wielgus et al. (2003) found that divers were willing to pay US$2.60 per dive for a marginal improvement in coral and fish diversity at Eilat coral reefs in Israel. Using a similar methodology, divers at the Turks and Caicos Islands reportedly valued large increases in the size and abundance of Nassau grouper at US$50 (Rudd, Gore, and Tupper 2000). Other studies found that international tourists in the Seychelles were willing to pay about US$12 on average to prevent coral reef degradation in Seychelles' marine parks (Mathieu et al. 2003). Arin and Kramer (2002) found that protecting coral reefs in the Philippines for local and international divers could generate revenues ranging from several thousand dollars a year up to one million, depending on the location of the coral reef being protected. Leeworthy (1991) reported estimates of divers' willingness-to-pay ranging between $356 and $533 for trips to coral reefs in the Florida Keys National Marine Sanctuary. For comparison, Bhat (2003) estimates that, under the current quality conditions, trip values for diving, snorkeling, and glass-bottom boating also in the Florida Keys are about $463. The same study suggests that with significant improvements in fish abundance, visibility, and coral quality, the per-trip value would increase by 69%.

Estimates of non-use values for MPAs are rare, but what exist are not applicable to US policy either because they are site-specific and carried out overseas, responders were visitors and local residents instead of the general public, or they are outdated (Davis 2003). Of the studies that do exist, Bennett (1984) reported that in 1979 local visitors to the coastal Nadgee Nature Reserve in New South Wales, Australia, were willing to pay an average of US$3 a year in perpetuity to preserve the park's existence. Spash et al. (2000) reported that locals and tourists surveyed during 1998 were willing to pay US$1.17 and US$4.26 annually for five years for the uncertain proposition that money in a trust fund would support ways to improve marine biodiversity by 25% on coral reefs in Montego Bay, Jamaica.

There are also a limited number of studies in the field of environmental and natural resource economics that have used the latent class estimator to test for heterogeneous preferences. The contingent valuation study of endangered species by Aldrich et al. (2007) is noteworthy because our results are qualitatively similar. In addition to improving model fit, they identified three classes of responders with very strong preferences for preservation, moderate preferences, or disutility. Conventional practice would combine these groups with structurally different preferences, which could lead to incorrect inferences, or address the differences through a priori specifications of the demand function or through the use of random parameters models (Morey 1993; Layton 1996).

Our study extends the literature in several ways. First, it is one of the first studies of the non-use value of preserving species and habitat diversities in a large marine ecosystem.

Second, we are unaware of any other study that has estimated the economic value of an MPA as a function of the policy-relevant attributes, size and allowable uses. Finally, as just mentioned, our research contributes to the limited though growing use of latent class models for the valuation of environmental goods and services, and underscores the benefits, particularly for policy questions, of more flexible models (see Boxall and Adamowicz 2002).

Survey Design

Questionnaire development: The questionnaire was developed during January to September 2005 when three focus groups, three sets of cognitive interviews, and two pilot tests were conducted. Three challenges cropped up during these meetings. First, it became clear from the first focus group that managing the information effects in the survey would be a critical issue, as most participants had heard of the term marine protected area but had quite different views and understandings of what they are and why they are established. Further, many participants in focus groups associated coral reefs or other warm water habitats with MPAs. Thus one of the first challenges in survey design was to clearly communicate to responders what the primary purpose of the MPAs discussed in the survey would be. We stressed at several different points in the survey that the benefits of the MPAs would include (1) the protection of habitat and marine life diversity on the sea floor in the Northeast Region, and (2) the prevention of industrial development, such as drilling for oil or gas, within the MPA boundaries. Any other benefits would be incidental at best (e.g., protection of migratory species).

A second challenge was to convey in clear and concise text the findings from the scientific literature about reserve size. This was difficult, as many of the findings do not enjoy consensus among all scientists, and even when they do they are often case or site-specific. Ultimately we relied on wordsmithing the NRC (2001) report which summarized the views of thirteen marine scientists on the relationship between reserve size and preservation of ecological diversity.

A third challenge was ensuring that we presented balanced information on both the potential benefits and costs of MPAs. This was particularly important since MPAs are a relatively contentious in the northeastern US, due in part to strong ties to fishing and other marine related industries. Not surprisingly, all three focus groups contained participants who, prior to the focus group, either strongly supported or opposed MPAs, and thus it was important that the information in the survey was presented neutrally. We felt that the benefits were aptly described by communicating the purpose of the MPAs, e.g. protecting habitat and diversity on the sea floor, and the relationship between reserve size and diversity summarized by the NRC. To balance that information we developed a section of the survey that described the costs associated with MPAs such as establishment and monitoring costs as well as opportunity costs of displaced production, the potential loss of jobs, and increased regulation of activities within MPA boundaries.

The qualitative research was also used to refine the list of potential attributes for the choice experiment and determine the range of attribute levels. At the onset of the

research we had several loosely defined attributes that were of policy interest, including the size of an MPA, the types of use that would be allowed, different types of marine habitat that may be included within the MPA boundaries, the proportions of each habitat type, and an individuals willingness to pay for an MPA. During the qualitative research period we learned that some of these attributes were either not meaningful to responders or the set of attributes was too complex for making the types of trade-offs required in a choice experiment survey. Ultimately the attribute set was refined to include three attributes: size, use, and cost. Size was defined as the percent of water within the northeastern EEZ that would be part of a network of integrated protected areas. Use refers to the types of activities that would be allowed within the boundaries of the network which would be compatible with the objective to promote ecological diversity. Cost was the cost to the responder of choosing a particular scenario.

Two pretests were conducted prior to the final survey implementation. As the final survey was implemented as a web-based survey, both pretests were also implemented online, using subsets of a web-enabled panel. The first pretest was administered to a random sample of 200 households, and a total of 117 responders completed the survey. The pretest assessed responders' comprehension of the survey instrument, obtained an estimate of survey time (about 20 minutes), and examined the validity of the experimental design, discussed below. The second pretest investigated a slightly different experimental design with smaller levels for the size attribute. A total of 68 out of 100 panelists completed this pretest. After completing both pretests slight modifications were made to the instrument and a final experimental design was developed.

Final questionnaire: The final questionnaire, entitled *Marine Protected Areas in the Northeast United States*, consisted of 19 pages and 48 questions divided among eight sections (Appendix A). Sections 1-6 and 8 described below contained 2 – 6 attitudinal or informational questions that supported the section topic, including a total of 21 questions requiring responses on the Likert scale. Section 7 was the choice experiment.

- Section 1 showed the federal waters in the Northeast Region on a map and informed households that MPAs are in a discussion stage.
- Section 2 provided background information on the state of the ocean and the use of MPAs as a tool for marine management, drawn largely from the *U.S. Commission on Ocean Policy* (2004).
- Section 3 described the potential benefits and costs of MPAs, specific to the types of MPAs discussed in the survey.
- Section 4 addressed the relationship between MPA size and ecological diversity, drawn largely from the NRC (2001) report.
- Section 5 described the current status of MPAs in Northeast region (only Stellwagen Bank National Marine Sanctuary, i.e. the "Current Situation" in the choice task), and the presence of other, non-permanent closed areas used for fisheries management.
- Section 6 described four possible use levels of the MPA network, including No-Take, Scientific Research and Education, passive Recreation and Tourism, and compatible Limited Fishing. The last level allows for fishing in the water column

with gear that does not contact the sea floor (e.g., herring purse seine and swordfish harpoons). The levels were essentially ordinal, ranging from least to most intrusive.

- Section 7 was the choice experiment. Each household in the sample faced five choice tasks, with each task containing two alternatives plus the Stellwagen Bank status quo (SQ) option. A sample choice task is shown in Figure 1.
- Section 8 consisted of Likert-scale questions concerning a more general environmental ethic, and gave responders the opportunity to comment on the survey.

If desired, responders could connect to previous information or additional information about a topic using hyperlinks throughout the survey.

Experimental Design Plan

An experimental design plan was used to create the alternative MPA scenarios that varied in size, use, and cost. The attributes size and cost each took one of five levels, and use took one of four levels that were cumulative (e.g., Limited Fishing includes all other uses; Table 1). The design plan was computed using the SAS experimental design and choice modeling macros (Kuhfeld 2005). The final design plan allowed for variable interactions, second order effects, and restrictions that eliminated unrealistic designs. For example, a design that produced a scenario where one large, more restrictive MPA costs less than a smaller, less restrictive MPA would be considered unrealistic given that the cost attribute was used to offset losses to industry. The final design plan consisted of 200 alternative scenarios which were then paired and blocked into groups of five using the SAS choice efficiency and blocking macros, ultimately resulting in 20 survey versions. The versions were randomly distributed among 1342 sample households from the web-enabled panel. Each version was allocated approximately 67 times.

The payment vehicle was specified as an annual contribution to an environmental organization. Responders were told that contributions would be used in negotiations with the federal government to lease, monitor, and enforce the MPA network, and to offset costs to industries and other parties who are impacted by the closures. Despite the potential for "free-riding", this vehicle was clearly preferred by focus groups over donations via federal tax returns because there is a direction connection between one's choice and the outcome, and because of latent distrust of government actions. Furthermore, this construction is similar to a real-life mechanism used recently by The Nature Conservancy and Environment Defense to preserve marine life and habitats in large areas of the Pacific Ocean (Marsh, Beck, and Reisewiitz, 2002).

Implementation and Weighting Corrections

The survey was administered to a random sample of households from a web-enabled panel maintained by Knowledge Networks, Inc. On October 5, 2005, the questionnaire was sent to a random sample of 1342 households on the panel who lived in the Northeast region (Maine, Vermont, New Hampshire, Massachusetts, Rode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Washington D.C., Pennsylvania, Virginia,

West Virginia, and North Carolina). Up to two reminders were made if necessary. The first reminder was e-mailed a few days after the initial electronic mailing, and the second reminder was a telephone call on week after the initial mailing. The survey was taken offline on October 19, 2005 after achieving a 77% response from 1037 households. Only four responders were removed due to high item non-response (> 33%).

Data weighting was necessary to correct for known deviations from the equal-probability design which are an inherent part of the sampling process. These deviations result from several sources, including partial sub-sampling of telephone numbers without matched addresses, RDD sampling rates being proportional to the number of phone lines in a house, double-sampling in the four largest states, under-sampling households not serviced by Microsoft TV, over-sampling of minority households (Black and Hispanic), over-sampling of households with personal computer and internet access, and selection of one adult per household. Post-stratification of survey weights reduces sampling error for characteristics that are highly correlated with reliable demographic and geographic totals. For this study, the most recent Census data on gender, age, race, education, state, household internet access, and residence in a metro or non-metro area were used to weight a household records individually. Weights averaged 1.0 but ranged from 0.0994 to 3.7308.

Self-selection and non-response bias may also exist in survey data, because cooperation from some people will be determined by their opportunity costs of time as well as intensity of interest. Because Knowledge Networks maintains a data profile of common demographic, social, and economic characteristics of each panelist, we were able to examine self-selection and sample bias by comparing responders and non-responders to each other and to the Census data using the following characteristics: (a) distribution of total population by state in the region; (b) distribution of the population of persons 18 years-old or older by state in the region; (c) distribution of the population between coastal counties and inland areas across the region; (d) total number of households in the region by state; (e) distribution of households in coastal counties and inland areas by state; (f) average household size in the region; (g) race and ethnicity in the region; and (h) mean household income in the region.

Discrete ratio data (i.e., counts) were tested for goodness of fit to a theoretical distribution using the chi-square statistic:

$$\chi^2 = \sum_{i=1}^{k} \frac{(f_i - F_i)^2}{F_i}$$

where f_i is the sample count in class i, F_i is the expectation in class i (i.e., percent of population in class i times the sample total), and k is the number of classes. When $k=2$ and there is only one degree of freedom (i.e., $\nu=k-1$), the Yates Correction for Continuity is required:

$$\chi_c^2 = \sum_{i=1}^{2} \frac{(|fi - Fi| - 0.5)^2}{F_i}.$$

In contrast, continuous data on mean income and household size ($\overline{X}$)were simply compared to the Census values (μ) using the t-test:

$$t = \frac{(X - \mu)}{s_{\overline{X}}}$$

where $s_{\overline{X}}$ is the standard error of the mean.

Self-selection bias in the discrete characteristics was tested by comparing responders and non-responders with the log-likelihood ratio for contingency tables. Twice the value of the log-likelihood ratio (G) approximates the Chi-square distribution:

$$G = 2\Big[\sum_i \sum_j f_{ij} \ln(f_{ij}) - \sum_i R_i \ln(R_i) - \sum_j C_j \ln(C_j) + n \ln(n) \Big]$$

where R_i and C_j are the individual i row and j column totals, and n is the sum of all values.

Finally, self-selection bias in the two continuous variables for income and household size was tested for the difference between the two means and the t-test:

$$t = \frac{\overline{X_1} - \overline{X_2}}{s_{\overline{X_1} - \overline{X_2}}}$$

where $s_{\overline{X_1} - \overline{X_2}}$ is the pooled standard error.

Test results can be found in Appendix B. Tests for sample bias (Table B-1) suggest that the weighted data improved all fits, but not always by enough to accept the null hypothesis that sample data were selected from the population described by the Census. Total 18+-year population, total households, average household size, and race/ethnicity were not significantly different from the Census. However, the null hypotheses concerning total population, the distribution of people and households between coastal counties and inland areas, and average income population were rejected with high levels of confidence. Specifically, the sample had (a) too many people from Delaware, Maine, and Pennsylvania and too few people from Maryland and Rhode Island; (b) too few people and households in coastal counties; and (c) relatively low income. While these results are not a clear rejection of sample bias, the survey's interest in households (vs. population) lessens concerns about sample bias.

Self-selection bias (Table B-2) was examined by comparing responders and non-responders. The tests suggest a significant difference in the population data, but the vast majority of the variance is actually due to difference between states instead of between the responder and non-responder factors. Likewise, the household measures were not

significantly different, and mean incomes were also similar. The only potential source of self-selection bias would be due to relative differences in race and ethnicity.

Econometric Model

Random utility theory provides the modeling framework for this research. The theory specifies that utility (U) for a good consists of a systematic, known component (V) and a random component (ε). In this case, the good in question is an MPA network, and the utility that individual *i* receives from MPA alternative *a* can be expressed as

(1) $$U_{ia} = V_{ia} + \varepsilon_{ia}$$

where U_{ia} is the unobservable utility that *i* associates with *a*, V_{ia} is the quantifiable, known portion of utility, and ε_{ia} is the random, unobservable effects associated with *a* for individual *i*. Alternative *a* can be decomposed into its specific attributes of size, use, and cost, and the systematic component of utility V_{ia} is then

(2) $$V_{ia} = \beta X_{ia}$$

where X_{ia} is a vector of attributes and the associated levels for MPA alternative *a* and β are the attribute coefficients. Substituting the expression for V_{ia}, the utility function can be expressed as

(3) $$U_{ia} = \beta X_{ia} + \varepsilon_{ia}$$

Under the assumption that individuals are utility maximizers, the probability that an individual *i* will choose MPA alternative *a* from a set of C alternatives is equal to the probability that the utility derived from *a* is greater than the utility derived from any other alternative in the choice set C, expressed as

$$\begin{aligned} \Pr(i \text{ chooses } a \text{ from } C) &= \Pr(U_{ia} > U_{ij}) && \forall j \in C \\ &= \Pr(V_{ia} + \varepsilon_{ia} > V_{ij} + \varepsilon_{ij}) && \forall j \in C \\ &= \Pr(\beta X_{ia} + \varepsilon_{ia} > \beta X_{ij} + \varepsilon_{ij}) && \forall j \in C. \end{aligned} \quad (4)$$

Assuming a type I extreme value distribution for the error component (a common assumption for discrete choice models; Louviere, Hensher, and Swait 2000), (4) is operationalized as

(5) $$\Pr(i \text{ chooses } a) = \exp(\beta X_{ia}) / \sum_{j=1}^{J} \exp(\beta X_{ij})$$

If choice observations are ordered so that the first n_1 individuals chose alternative *a*, the next n_2 individuals chose alternative *b*, and so on for all *j* elements of the choice set C, the likelihood function for (5) can be written as

$$L = \prod_{i=1}^{n_1} P_{1i} \prod_{i=n_{1+1}}^{n_1+n_2} P_2 i ..... \prod_{i=I-n_{j+1}}^{I} P_{Ji}$$

which simplifies to

$$L = \prod_{i=1}^{I} \prod_{j=1}^{J} \ln P_{ij}^{f_{ij}}. \quad (6)$$

Defining a dummy variable f_{ij}, where $f_{ij} = 1$ when alternative j is chosen and $f_{ij} = 0$ otherwise, the function can be can be written as

$$L^* = \sum_{i=1}^{I} \sum_{j=1}^{J} f_{ij} \ln P_{ij}. \quad (7)$$

By replacing the term P_{ij} with (5), the only unknown parameters are the elements of β, which are estimated through maximum likelihood techniques.

The multinomial logit model above is a popular choice for modeling discrete choice data, and when data are rich and disaggregate the model is often robust (in terms of prediction success) to the implicit behavioral assumptions arising from the chosen error distribution (Louviere, Hensher, and Swait 2000), notably, the assumption of independence from irrelevant alternatives (IIA). This assumption, however, has motivated much of the research on extensions to the basic model, including the nested logit, mixed logit, and latent class specifications (Greene and Hensher 2002). We apply the latent class extension as a way to accommodate taste parameter heterogeneity, a situation that was clearly evidenced during qualitative research.

The underlying theory of the latent class model is that choice depends on attributes that are observable, e.g. the attributes in the choice scenarios, and on latent heterogeneity that varies with factors that are not observable by the researcher (Greene and Hensher 2002). In the latent class model individuals are sorted into *k* classes, and given class assignment, parameters are the same for all individuals in that class but may vary between classes. The latent class model is the same as equation (5) except that an individual's choice is now conditional on belonging to class *k*

$$\Pr(i \text{ chooses } j \mid k) = \exp(\beta_k X_j) / \sum_{j=1}^{J} \exp(\beta_k X_j). \quad (8)$$

Following Greene and Hensher (2002), the probability of individual *i* belonging to class *k* is denoted H_{ik} and itself determined by the conditional logit model

$$H_{ik} = \exp(\delta_k s_i) / \sum_{k=1}^{K} \exp(\delta_k s_i) \quad (9)$$

where s_i is a set of individual characteristics that enter the model for class membership. Error distributions for (9) are assumed to be type I, as in the multinomial logit. The choice likelihood of an individual is then expressed as the joint probability of (8) and (9),

$$P_i = \sum_{k=1}^{K} H_{ik} P_{i|k} \tag{10}$$

Again using the dummy variable f_{ij}, where $f_{ij} = 1$ when alternative j is chosen and $f_{ij} = 0$ otherwise, the log-likelihood function can be can be written as

$$L = \sum_{i=1}^{I} \ln P_i = \sum_{i=1}^{I} \ln\left[\sum_{k=1}^{K} H_{ik}\left(\prod_{j=1}^{J} P_{ij|k}\right)\right] = \sum_{i=1}^{I} \ln\left[\sum_{k=1}^{K} H_{ik} \sum_{j=1}^{J} f_{ij} P_{ij|k}\right]. \tag{11}$$

Replacing $P_{ij|k}$ and H_{ik} with (8) and (9), respectively, the unknown parameters β_k and δ_k can be estimated using maximum likelihood techniques.

Latent Class Construction

We relied on qualitative and quantitative criteria to determine the number and specification of the latent classes. During the focus groups we noted that three types of preferences usually emerged – a "pro-MPA" stance from individuals who strongly supported MPAs of most sizes, a "moderate-MPA" stance from individuals who supported MPAs but seemed to consider things like size and use when expressing their opinions, and individuals who were against MPAs in principle, often because of maritime industry interests or anti-state sentiments. Although anecdotal, this assessment was fairly intuitive and represented what seemed to be a logical continuum of preferences for MPAs. Based on this we considered a latent class models with two, three, and four classes.

To specify the latent class itself we conducted a factor analysis on the attitudinal and socio-economic survey variables. A varimax rotated solution extracted three factors with eigenvalues greater than 1.00 (3.87, 3.21, and 1.77). Because we preferred a parsimonious specification for (9), we chose to retain only one of the three factor scores to include in s_i. The retained factor (eigenvalue = 3.21) had strong factor loadings (> 0.65) for variables concerning employment ties to the ocean (e.g. someone in family fishes commercially, operates a charter fishing boat, etc…) and variables asking for general attitudes toward environmental conservation and economic growth.

Information criterion measures were used to test models with two, three, and four classes (Roeder, Lynch, and Nagin 1999; Lee et al. 2003). We calculated Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) following Lee et al. (2003) as

$$BIC = -2 \cdot \{LL(\beta)\} + \rho \cdot \log(N)$$

$$AIC = -2 \cdot \{LL(\beta) - \rho\}$$

where ρ is the number of model parameters, and N is the number of observations in the sample. Results (Table 2) show that the three class model minimizes both the AIC and BIC measure, and since earlier qualitative work with focus groups also supported a three class model it was selected as the "best" model for welfare analysis.

Results

Responses to attitudinal questions that focused on general views of MPAs and the marine environment are summarized in Appendix C. Public opinion supports the creation of a network of MPAs in the Northeast Region, although not unequivocally. Nearly three-quarters of responders believed that MPAs could be used to balance environmental protection and extractive uses of the ocean, such as fishing and oil and gas production, and there was about 80% agreement with the statement "I like knowing that part of the ocean in the Northeast Region is protected even if I never see or use it." Further, about two-thirds of the responders favored a reduction in their material standard of living if it meant that the environment could be protected for its own sake or for the benefit of their children and future generations.

These results certainly bolster the relevance of marine reserves in public policy. However, public support of MPAs was not blind to practical considerations, including the requirement that "their rules and boundaries can be enforced" and whether MPAs needed to be "… large enough to protect every type of plant and animal regardless of costs." Support for MPAs dropped to 47% when responders were asked if they "would be willing to pay higher prices for products such as seafood and energy to preserve areas of the ocean." This finding appears to be in conflict with the support just mentioned, but attitudinal questions are imprecise and probably induce conservative responses on personal costs. That is, households need to be asked about specific amounts and payment mechanisms.

Consistent with results from the qualitative research, the majority of responders were able to choose among the three alternatives with a moderate degree of confidence. Non-response to the total number of choice scenarios (1033 x 5=5165) was only 0.7%. One of the two MPA alternatives was selected in about 76% of choice tasks. There is also evidence that many responders compared alternatives and did not choose arbitrarily. For example, 85% of responders varied their choices among the 5 choice tasks, and 20% switched between the SQ and one of the MPA alternatives. Only 3.8% of responders consistently chose either MPA Alternative 1 or Alternative 2. In contrast, the SQ was always chosen by 11% of responders. Choice-certainty was requested after each choice task with the following question: "Inexperience with a commodity such as Marine Protected Areas can sometimes cause uncertainty. How certain do you feel about your choice?" Over 60% of the responders were either *very certain* or *somewhat certain* about their choices each time, and 75% of them never chose *somewhat uncertain* or *not certain at all* after the choice task.

Choice model results are presented in Table 3. We focus primarily on the results of the latent class specification; however, the base multinomial logit model is presented for comparative purposes, underscoring the need for more flexible models. Independent variables in the model included the choice experiment attributes size, use, and cost. Size-squared was specified because focus group information suggested that there is diminishing marginal utility for increasing the size. Size and cost attributes were treated as continuous variables. Effects-coding (Fx) was used for the use level attribute because it is ordinal but not linear (Table 4). Effects-coding creates dummy variables for all N-1 use levels, leaving one level - in this case the SQ - as a base case (coded as -1).

Results of the multinomial logit model confirmed diminishing marginal utility for size. Use had a negative influence on value in the strict no-take case, but became positive once access for scientific research and education were allowed. The other uses diminished the value of MPAs, but it was still positive. The cost parameter in the multinomial logit model has the expected negative sign and is significant. Though the pseudo R^2 value is small, this model seems generally intuitive and not out of line with any opinions expressed during the focus groups and cognitive interviews.

The multinomial logit model conceals important differences among responders that can lead to results that are not always consistent with economic theory. The latent class estimator identified three classes of responders with distinctly different preferences that are homogenized by the multinomial logit model. Segregating the data into three groups significantly improved the fit (the pseudo R^2 tripled).

The multinomial and Class1 models are qualitatively similar, although parameter estimates are quite different due the mixing of different preferences. We describe Class 1 (59% likelihood being in the class) as having relatively moderate preferences because they get positive utility from reserves but this is augmented by allowing compatible uses.

There was a 24% likelihood that responders received disutility from MPAs judging from the sign on the size attribute and fell into Class 3. If there are reserves, Class 3 prefers that they be used to the maximum extent.

Class 2 (17% likelihood that responder fell into this class) appears to have the strongest preferences for ecological reserves in the region (compare parameters on size; Table 3), and it was the only group of responders who valued fully-protected areas without any type of use positively and fishing negatively. What is peculiar though is the positive parameter on the cost variable. This result precludes including responders in Class 2 in any welfare analyses, as discussed below.

Analysis of the Latent Classes

To help understand the differences among the three classes, we sorted responders by class based on their individual-specific class probabilities, and then examined class responses to other questions in survey. For all variables in the survey that were ordinal, such as the

Likert-scale questions, education, and income categories, we used a Mann-Whitney U test to determine differences between a class pair. For continuous variables such as the distance of a household from the coast (Table 5) and age we used a t-test to examine differences between class pairs. Results of these analyses (Table 6) suggest that there are significant differences between classes for the socio-economic variables education level and distance from coast (based on respondent zip code information), and for several of the Likert scale questions, including:

- We should allow exploration and drilling for oil and natural gas in the Northeast region to help create a stable supply and lower prices
- MPAs can be an effective way to balance environmental protection and activities such as fishing and oil exploration
- People can live with less economic growth in order to preserve and protect the environment
- MPAs are not needed in Northeast Region because marine life and ocean habitat in the region are in good health

Tests for significant differences between these variables are presented in Table 6 and Figures 2a-e. In general, Class 2 is the most highly educated and lives farthest from the coast, while Class 3 has the least education and lives closest to the coast. Class 1 falls in the middle on both variables, and was not significantly different in most comparisons of distance and education.

Class 1 appears to consist of "middle of the road" individuals, whose preferences and attitudes about MPAs and the environment in general lie somewhere between those of the other two classes. Individuals in Class 2 are those who most strongy support MPA networks, even when the use level is completely restricted, i.e. a no-take network. They also disagree with the other two classes on drilling and oil exploration, as well as their opinions about the ecological health of the Northeast Region. Finally, while the model results suggested that individuals who fall into Class 3 receive disutility from protecting any additional area of the northeast waters in an MPA, a closer examination of this class suggests that these individuals are not necessarily anti-environmentalists, but may in fact simply not favor the use of MPAs as a means of protection. Results of the Mann-Whitney U test suggest that Class 3 responses only differed from Class 1 responses on one Likert scale question about whether MPAs are an effective way to balance environmental protection with other activities such as fishing and oil exploration. In addition, Class 3 only differed from Class 2 on three Likert scale questions. These results represent the largest number of differences between any class pair. In short, the two classes who were the most different in terms of their model output only differed on three of the 21 Likert scale questions examining attitudes toward MPAs and the environment. Thus, an appropriate depiction of Class 3 may be "anti-MPA" rather than "anti-environment."

It is worth noting the counterintuitive insignificant difference between Classes 2 and 3 on the variable 'MPAs can be an effective way to balance environmental protection and other activities' in Table 6. As the difference between Class 1 and three was significant for this variable, we would expect the difference between Class 2 and three to also be significant. We suggest that, for this variable, Class 2 has an unusually high proportion of

"I am unsure" responses (relative to their unsure responses on other questions) because the wording of the question implies that other activites such as fishing, oil exploration and drilling, etc… would be coexisting with MPAs, when in fact individuals in Class 2 may not want these other activities to exist at all. If this were true, the best answer option for them would be "I am unsure." When the unsure responses are removed from the data the difference between Class 2 and Class 3 becomes significant for this variable.

While we might not know why Class 2 individuals had a positive cost response, the latent class specification allows us to determine who they are in the dataset, and to calculate their individual choice probabilities. In the empirical application below, we are then able to exclude these choice probabilities when calculating the compensating variation of different policy scenarios.

Benefit Estimation

Hanemann (1982) derived the expression for compensating variation associated with a logit-type model under the assumption of no income effect:

$$CV_i = \left(\frac{1}{\beta_k} \left[\ln\left(\sum_{j \in C} \exp \beta_k X_j^0 \right) - \ln\left(\sum_{j \in C} \exp \beta_k X_j^1 \right) \right] \right) \quad (12)$$

where X^0 represents the SQ and X^1 the policy change. Boxall and Adamowicz (2002) modified equation (12) to accommodate classes of tastes in the sample with the weights, H_{ik}:

$$CV_i = \sum_{k=1}^{K} H_{ik} \left(\frac{1}{\beta_k} \left[\ln\left(\sum_{j \in C} \exp \beta_k X_j^0 \right) - \ln\left(\sum_{j \in C} \exp \beta_k X_j^1 \right) \right] \right). \quad (13)$$

That is, the total average compensating variation is the sum of the K individual class values. As noted earlier, however, we do not allow CV for Class 2 to enter the equation, essentially excluding this segment from the analysis.

Welfare estimates for the range of the size and use attributes are reported in Table 7 and graphed on Figures 3a-d. For comparative purposes, we also present calculations from the multinomial logit. Because the use attribute was effects-coded, we calculate a SQ coefficient by summing the four use level coefficients and multiplying by -1 (Louviere et al. 2000). We are then able to calculate welfare changes from SQ scenarios.

The compensating variations for Class 1 are positive for various combinations of size and use (Figure 3a). Science and education was most highly valued by Class 1 at $134, followed closely by leisure and tourism and then pelagic fishing with maxima at about $123 and $130, respectively. Whether the latter three sets of value are significantly different is unknown. The no-take valuation is clearly lower than the other scenarios.

Class 3 had negative valuations of each size-use combination, which is consistent with the disutility these responders receive from ecological reserves, particularly the no-take

type (Figure 3b). In other words, Class 3 responders would require compensation to by indifferent to a network of ecological reserves.

The combination of Class 1 and Class 3 results are simply a weighted average of the separate results. The mixture of distinctly different preferences results in an unconventional total value surface (Figure 3d). This is one example of how mixing people with structurally different preferences can yield results contrary to theory. The multinomial logit model is an amalgam of all responders, including Class 2. Estimates are qualitatively similar to those from Class 1 of the latent class model (Figure 3c).

The marginal value curves for Class 1, Class 3, and multinomial logit are plotted in Figure 4. Curves for the four use levels of the same model are identical because the slopes of the total value curves are equal. Compensating variation for Class 1 is maximized at a 27% size regardless of the use level. The multinomial logit welfare is maximized at 26% size. In contrast, Class 3 is worse off when size is about 33%.

Empirical Application – Valuation of Habitat Areas of Particular Concern (HAPC)

In 2004 the New England Fishery Management Council requested formal proposals for HAPCs from the general public. Some of the qualifying criteria concerned fisheries management, but several were related to environmental protection: (1) the importance of historical or current ecological functions of the area; (2) the sensitivity of the area to anthropogenic stress; (3) the extent of current or future development stress faced by the area; and (4) rare habitat within the area.

Nearly all proposals were submitted by environmental organizations interested in setting aside exclusive areas dedicated to protecting species and their habitats Three seamounts in the U.S. chain, 16 deep sea canyons throughout the shelf edge in New England and the Mid-Atlantic, several areas in the Gulf of Maine and Georges Bank described as having unique characteristics in the region, and an extensive area around the Great South Channel were nominated for HAPC protections.

At its June, 2007, meeting the New England Council accepted all of the canyon areas and two of the seamounts. However, it tabled the Great South Channel area for further development and replaced nominations on the shelf with several existing EFH Habitat Closure Areas. The current areas proposed by the council for HAPCs are listed in Table 8 and mapped on Figure 5.

Selecting a SQ for estimation of compensating variation has become problematical since the survey was completed because the proposed and many of the current HAPCs and EFH Habitat Closure Areas share some of the characteristics of ecological reserves. As mentioned above, the Stellwagen Bank National Marine Sanctuary (which occupies about 0.56% of federal waters; Figure 6) is the only official MPA in federal waters in the Northeast Region, but it does not regulate fisheries, including dredges and bottom trawls. Alternatively, some of the fishery management areas also provide incidental diversity benefits, particularly the juvenile cod HAPC on Georges Bank, the monkfish closures in

two canyons, and the groundfish and sea scallop EFH Habitat Closure Areas created by Amendments 13 and 10 (Figure 6). However, these managed areas were not designed as a network to promote general ecological diversity, and they are not indefinite because they could be erased by fishery managers at any time if they are not promoting stock recovery.

Thus, neither candidate for SQ was ideal, so both were used in the analysis to test the sensitivity of compensating variation estimates for Classes 1 and 3 (Table 9). The proposed HAPCs (Table 8) were grouped into two bundles: seamounts and canyons (2.2% of the EEZ), and all proposed HAPCs (5.1%). Double-counting was avoided by using ArcGIS 9.1 to erase areas of the HAPCs that overlapped each other or the SQ (see Figure 6).

Valuation of the two HAPC combinations by Class 1 responders ranged from $52-$59 per-household annually for the no-take use-level, depending on the SQ (Table 9). Estimates of average compensating variation doubled to $107-$114 when scientific research and education were allowed. The other use-levels were $3-$10 less than for Science and Education. Although more clearly seen at larger sizes, estimates of compensating variation were smaller for the larger SQ due to an endowment effect and diminishing marginal utility. That is, the value of a particular combination of HAPCs decreases when your initial holdings increase.

Class 3 estimates of the average household valuation of the proposed HAPCs ranged from -$40 to -$28 for No-take status and increased with use-level and became positive in some cases (Table 9).

Discussion

Importance of latent class estimator: It was not surprising to learn that the general public has heterogeneous preferences for ecological reserves. However, the latent class results demonstrate the importance of using an estimator that can differentiate structural preferences in a sample. Responders with normal, positive preferences for ecological reserves were combined with responders who would experience dis-utility. Mixing preference this way can result in peculiar economic relationships, such as the convex total value curve graphed in Figure 3d.

Perhaps more troubling with the usual practice of combining data from all responders in one equation is inclusion of incongruous responses to costs. Taken at face value, the Class 2 model suggests that nearly a fifth of the responders would ignore their budget constraint and pay for more reserve size the more costly it became. This result might be an artifact of the survey design (see below), but the modeling results otherwise made sense. Class 2 responders valued size more than any other group and they were the only ones who had positive value for fully-protected no-take areas and who gave fishing a negative valuation.

There are several possible explanations for the positive estimates on the Class 2 cost parameter: (1) high income response; (2) careless answers to choice questions; (3)

hypothetical bias; (4) an experimental design that induced a high degree of collinearity between size and cost attributes; and (5) non-conforming preference structures. The idea that these households had much higher incomes than the other classes and annual costs of up $150 (the highest value for cost used in our study) would be negligible was rejected because the classes' income distributions were indistinguishable.

Hypothetical bias is a strong possibility. It exists when the hypothetical nature of the survey causes the responder to ignore the price constraint and, in our case, choose alternatives on the basis of size and use attributes alone. A growing literature examines this issue, and while many studies find evidence of discrepancies between stated and actual behavior (List and Gallett 2001; Johannesson 1997) some research suggests that hypothetical bias may not be universal (Johnston 2006) or "may not be as significant a problem in stated preference analyses as is often thought" (Murphy et al. 2005). If a responder who was vulnerable to hypothetical bias favored larger, more restrictive MPAs, a positive cost parameter is likely. It is also conceivable that some responders inferred or associated something about the scenarios with higher costs that was not described in the survey. For example, responders may have inferred that programs with higher prices would be more successful, or would stand a better chance of being instituted, and thus they may have strategically chosen higher-cost programs.

A confounding factor to hypothetical bias is the experimental design that was used to generate the choice task questions. In order to exclude what responders would likely consider unrealistic scenarios (i.e., a larger MPA costing less than a smaller MPA that had the same allowable uses), constraints were placed on the experimental design. In effect, the constraint introduced a degree of collinearity between MPA size and cost, and ultimately may have forced responders who preferred larger MPAs to ignore the price constraint. Although this collinearity is undesirable, our focus groups and previous experience suggested that cognitively unacceptable choice scenarios would likely be a larger problem for the majority of responders, thus we chose to include the experimental design constraints.

Notwithstanding the possibility that Class 2 responders ignored the cost constraint, the above discussion of the consistency of the Class 2 model results suggests that these responders answered thoughtfully. This raises the possibility that Class 2 exhibits a preference structure that is incommensurable with the conventional neoclassical assumption of indifference (Clark et all. 2000; Edwards 1986; Rekola 2003, Stevens et al. 1993). The environmental economics literature on incommensurable preferences is sparse, but reports of up to nearly 80% lexicographic responses to contingent valuation questions about wildlife have been published (Stevens et al. 1991).

Rekola (2003) examines the question rigorously beginning with a theoretical model. He finds evidence of L*-ordering in his and others' empirical work, but the frequency in a population depends on a number of factors, including endowments and how narrowly the environmental good or service is defined. The incidence of lexicographic preferences should be considerably lower when the environmental good is narrowly-defined as a particular resource and paired with income in specific circumstances (e.g., preservation of

species and habitat diversities in federal waters of the Northeast Region versus preservation of global biodiversity in the world's oceans). After reviewing several empirical studies, Rekola (2003) reported that the percent of responders demonstrating non-compensatory behavior and attitudes was not as high as reported, but ranged from 0% to 48% with a 15% mean.

Although interesting, the question about why Class 2 responded positively to costs can not be easily resolved with data from our survey. To explore the topic more fully ex-post interviews would be required, which are beyond the scope of this research.

Reserve size: Our results are germane to the scientific and public policy debate about the size of ecological reserves. Here, too, it is important to separate the analysis by latent class due to qualitative differences in preferences. The preference of the disutility class of households for no reserves is antithetical to the objectives of the environmental community in the northeast (and elsewhere) which is seeking at least 20% protection of the ecosystem, including the New England seamounts, submerged canyons, cold water corals, and rare habitats (CLF 2006). Class 1's optimal size of 27% comports with the regional environmental community's goal (CLF 2006) and falls well inside the range of 10%-40% that scientists say is needed to preserve ecological diversity at its maximum level (NRC 2001). Class 2 might prefer an amount greater than 27%, but the optimum for the disutility Class 3 is 0%

We do not know the size requirements for complete protection of the species and habitat diversities of the Northeast Continental Shelf Large Marine Ecosystem and the deeper waters of the EEZ. However, responders who had an opinion were evenly split (a third each) on the statement "MPAs should be large enough to protect every type of plant and animal, regardless of cost" (question 6_1, Appendix). Unlike scientific research which does not consider opportunity costs, households look at a wide range of needs and wants competing for their dollars. Optimum size for Class 1 will be less than 27% once costs (and comparisons at the margin) are factored in (discussed next).

Comparing reserve benefits and costs: A benefit-cost analysis of ecological reserves is beyond the scope of this project. Although the New England Fishery Management Council has selected HAPCs for evaluation, alternative bundles of areas and regulations of fishing and other activities have not been developed. Nevertheless, a few comments about where non-use value fits in would be useful. To simplify matters, we ignored any potential sampling and selection biases when extrapolating valuations to the region. We also restricted the inquiry to the Science and Education use and the Stellwagen SQ. In these circumstances, estimates of compensating variation for Class 1 was $108 for the seamounts and canyons HAPCs (2.83% of the EEZ,) to $114 for all HAPCs (7.83%) (Table 9). For Class 3 the respective values were -$22 and -$33.

A simple extrapolation of Class 1 (48% of responders) to the region's 22 million households in the region equals about 11 million households. Therefore the total annual value of the two bundles of HAPCs is approximately $1.2 billion. However, the 28% of responders in Class 3, which extrapolates to more than 6 million households, had

negative valuations amounting to -$0.14 billion and -$0.20 billion for the two HAPC scenarios. On net, the regional annual valuation of proposed HAPCs is about $1 billion.

This huge number needs context before anyone concludes that ecological reserves are the highest valued use of the ocean. First, a calculation of the total value of any popular good, service, or asset would yield eye-popping results. For instance, consider the total gross value of product landed by only one fishery. The sea scallop fishery landed 59 million pounds of sea scallop meats in 2006 with an estimated total gross value of about $0.5 billion (assuming a linear demand between the $6.54 dockside price and a $12 choke price).

A second point to make is that use has at least as much influence on value as does size (Table 7; Figure 3). Further, most value associated with size is gained in the first 5% - e.g., 85% for Class 1 and the Science and Education use (Figure 3a). Therefore, the marginal value of an increase in reserve size beyond 5% appears to be rather small.

Finally, costs will have a strong effect on efficient size. There are three categories. One category is the transaction costs of developing a viable network over several years of research, debate, lobbying, consulting, contracting, and planning to get a consensus on reserve location, size, allowable uses, and rules and regulations (Helvey 2004). These activities expend a lot of productive resources and, in general, probably are the most costly part of the process of MPA formation.

A second category of costs which is incurred each year after reserves are established is operating costs, including research, management, maintenance, monitoring, and enforcement (Balmford et al. 2004). Operating costs are the most tangible costs, but they probably are the least expensive of the three categories.

The third category of costs is also incurred annually. The opportunity costs of forgone production by activities that have been excluded or restricted from a reserve area (net of gains elsewhere, if at all, and reduced by spillover costs) could be quite high in some places. Commercial and recreational fishing (Figure 7), oil and gas exploration and production, sand and gravel mining, and, potentially, aquaculture and renewable energy from windmills (etc.) contribute valuable products for the economy and consumers.

The final remark about context concerns how costs affect the efficient size. One way to envision this is through a benefit-cost analysis framework which combines the value and costs of a network of ecological reserves:

$$NPV = \left[-\sum_{t=-k}^{t=0} C_t^R(S,L) + \sum_{t=0}^{t=n} V_t^I(S,L) - \sum_{t=0}^{t=n} C_t^P(S,L) - \sum_{t=0}^{t=n} C_t^O(S,L) \right] \Big/ (1+r)^t$$

where NPV is net present value, S is reserve size, L is use-level, C^R are transaction costs of reserve development, V^I is reserve value for Class 1, C^P is reserve operating costs, C^O

is reserve opportunity costs, t is time period, and r is the discount rate. C^R are incurred before a network is implemented (hence the negative value on t). This simple formula belies many difficulties in data collection, extrapolation of value data to the population, and estimation of the opportunity costs of excluded current and sometimes future activities (commercial, recreational, and industrial).

Heterogeneous preferences for reserves would also have to be factored in. Class 3's dis-utility is incorporated by augmenting the value term to be $[V^I (S,L) + V^{III} (S,L)]$. The positive preference for reserves expressed by Class 2 does not fit into this equation, but it needs to be counted by decision-makers.

The theoretical point of efficient size is illustrated in Figure 8 for Class 1 and the Science and Education use. Household demand, or marginal value, was derived by estimating a quadratic regression of compensating variation on reserve size and differentiating with respect to size. Being a public good with non-use characteristics, many people can enjoy knowing about ecological diversity at the same time without causing any negative spillovers either to the resource or on each other. As a result, the marginal valuations for individuals in Class 1 are concatenated vertically (instead of horizontally as for consumers' demand for sea scallops). Household demand was expanded by 11 million households (i.e., 48% of responders in Class 1 times 22 million households in the region).

The two marginal cost curves on the graph represent hypothetical low cost and high cost situations. The most efficient allocation is found where marginal benefit is equal to (intersects) marginal cost. In an unrealistic no-cost situation - which is tacit in the requests of the environmental community – efficient resource allocation is where marginal benefits equal zero (27% for Class 1). Adding costs shifts the efficient choice to lower levels of protection, but how far depends primarily on the opportunity costs of excluded production and other activities and on operating costs. (At this point in the MPA process, transaction costs would be considered sunk costs.) Adding the negative valuation of Class 3 responders would lower aggregate demand and further shift the efficient solution to a smaller size.

Conclusions

Coastal states worldwide have begun to designate MPAs that occupy 25% or more of a Large Marine Ecosystem. This scale comports with scientific estimates of needs for ecosystem protection. However, boundaries are set without information about the general public's valuation of MPAs, or the costs to industries and the economy of displaced activities. Our research is one of the first empirical analyses of a general public's valuation of the non-market benefits of important attributes in the design of ecological reserves - total size and different levels of low impact uses by others. No study found in the literature provides comparables to validate our estimates because of differences in the type of benefits studied (e.g., personal use of an MPA for sport diving versus non-use) and our choice of the latent class model.

Although our data support a public policy that protects ecological diversity in the ocean, strict no-take, no-use reserves were the least valuable type of design for 76% of the responders (Classes 1 and 2). For these responders ecological reserves that allowed access for scientific research and education were the most highly valued. Beyond that, leisure and tourism and limited fishing diminished value. In contrast, valuations by the 28% of responders in Class 3 who are identifiable by their disutility for reserves became less negative as access became more liberal.

Over 80% of the responders said that they supported having ecological reserves in federal waters of the Northeast Region. This claim is supported by the choice experiments where about three-quarters of the responders selected alternatives with costs ranging from $10 to $150 per year indefinitely. It also matches the findings of a telephone survey sponsored by environmental organizations which asked households in New England and the Canadian Maritimes about their attitudes towards fully-protected marine areas (Edge Research 2002). Our results do not, however, endorse unconstrained sizes, and in fact suggest that smaller reserves with liberal uses may provide considerably more value than larger no-take reserves.

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Table 1
Attributes and Levels of Experimental Design

Attribute	Level
MPA Network Size as a percent of the total federal waters of the northeast region	5% (5 million acres) 10% (11 million acres) 20% (22 million acres) 30% (32 million acres) 40% (43 million acres)
Allowable Uses within the MPA Network	Level 1 – No-take Level 2 – Science and Education Level 3 – Recreation and Tourism Level 4 – Limited Fishing
Cost	$10 per year $25 per year $50 per year $100 per year $150 per year

Table 2
Information Criterion Measures

Number of Latent Classes	AIC	BIC
Two	9330	9346
Three	9250	9274
Four	9254	9286

Table 3
Parameter Estimates for Choice Models

Attribute	Base MNL	Latent Class		
		Latent Class 1	*Latent Class 2*	*Latent Class 3*
Size	0.0207**	0.0537**	0.0604**	-0.1239**
$Size^2$	-0.0004*	-0.0010**	-0.0006*	0.0019**
No-take	-0.3811**	-0.4736**	0.3158**	-0.5144**
Science and Education	0.3391**	0.7952**	0.5224**	-0.2853**
Recreation and Tourism	0.2936**	0.5524**	0.2908**	0.3611**
Limited Fishing	0.2753**	0.7154**	-0.2901**	0.4048**
Cost	-0.0063**	-0.0127**	0.0026**	-0.0071**
Latent class probs.	na	0.59	0.17	0.24
Pseudo R-squared	0.0638		0.1877	

** significant at $p < .01$
* significant at $p < .05$

Table 4
Effects Coding of Use Attribute

Use Level	Fx1	Fx2	Fx3	Fx4
No-take	1	0	0	0
Science and Education	0	1	0	0
Recreation and Tourism	0	0	1	0
Limited Fishing	0	0	0	1
Status Quo	-1	-1	-1	-1

Table 5
Average Distance from Shore (miles)

Class	Distance
1	7.11
2	5.67
3	7.16

Table 6
Significant Differences Between Classes

		Distance	Education	Allow gas exploration	Balance protection and other activities	Live with less growth to protect environment	Region in good health, MPAs not needed
Class	Mann-Whitney U (p-value)		0.06	0.07	ns	ns	ns
1 & 2	t-test (p-value)	0.00					
Class	Mann-Whitney U (p-value)		0.09	ns	0.08	ns	ns
1 & 3	t-test (p-value)	ns					
Class	Mann-Whitney U (p-value)		0.01	0.06	ns	0.09	0.09
2 & 3	t-test (p-value)	0.03					

Table 7

Estimates of Compensating Variation Corresponding to Survey Attribute Levels Other than Costs. Values are annual changes in the total welfare of households in the Northeast Region due an increase in the size of MPAs in federal waters from current levels of the Stellwagen Bank National Marine Sanctuary (0.6%). Class 2 can not be analyzed because of the theoretically incongruous estimate of the positive cost parameter. Estimates from the multinomial logit model are presented for comparison.

Use Level	Model	Size							
		5%	10%	15%	20%	25%	30%	35%	40%
No-Take	Class 1	58	66	72	76	78	78	75	71
	Class 3	-38	-54	-67	-76	-83	-86	-86	-83
	Classes 1 & 3	22	15	8	3	-2	-6	-8	-10
	Multinomial logit	20	26	31	34	35	35	32	28
Science and Education	Class 1	113	121	127	131	133	133	131	126
	Class 3	-30	-46	-59	-69	-75	-78	-78	-75
	Classes 1 & 3	85	78	71	65	61	57	55	53
	Multinomial logit	83	89	94	97	98	98	95	91
Leisure (passive)	Class 1	102	111	117	121	123	123	120	115
	Class 3	-8	-24	-37	-47	-53	-56	-57	-53
	Classes 1 & 3	96	89	82	77	72	68	66	64
	Multinomial logit	79	85	90	93	94	94	91	87
Fishing (pelagic)	Class 1	109	118	124	128	130	130	127	123
	Class 3	-7	-23	-36	-45	-52	-55	-55	-52
	Classes 1 & 3	105	97	91	85	81	77	74	73
	Multinomial logit	77	84	88	91	93	92	90	86

Table 8
Areas Proposed for Habitat Areas of Particular Concern

Size Category	Area	Size (% of EEZ waters)
Seamounts and Canyons (1.8%)	Bear & Retriever seamounts	0.310
	Heezen canyon	0.032
	North assemblage (Lydonia, Gilbert, Oceanographer)	0.744
	Hydrographer canyon	0.068
	Veatch canyon	0.062
	Alvin and Atlantis canyon	0.312
	Hudson canyon	0.211
	South assemblage (Toms, Hendrickson, & inter-areas)	0.296
	Wilmington canyon	0.093
	Baltimore canyon	0.062
	Washington canyon	0.036
	Norfolk canyon	0.042
Shelf areas (2.6%)	Cashes Ledge Habitat Closure Area	0.114
	Western Gulf of Maine Habitat Closure Area	0.583
	Gulf of Maine inshore cod (20 m line)	1.970
Total HAPC		4.6

Table 9

Estimates of Compensating Variation Associated with HAPCs Proposed for EFH Omnibus Amendment #2.Two status quo (SQ) conditions are used (a) Stellwagen Bank National Marine Sanctuary (SBNMS) and the combination of SBNMS and pre-existing HAPCs (Georges Bank cod, closures in monkfish plan) and EFH habitat closures in the groundfish and sea scallop plans. HAPCs are grouped in two bundles: (a) seamounts and canyons and (b) all proposed HAPCs. Use-level is Science and Education. Values are average annual valuation per household in Classes 1 and 3. HAPC percentages include the SQ.

Class	Use Level	SQ 1: SBNMS (0.56%)		SQ 2: SBNMS, PRE-EXISTING HAPCs, AND ALL EFH HABITAT CLOSURES (5.56%)	
		Seamounts and Canyons (2.83% with SQ)	All HAPCs (5.71% with SQ)	Seamounts and Canyons (7.83% with SQ)	All HAPCs (10.71% with SQ)
1	No-take	$53	$59	$52	$57
	Science	$108	$114	$107	$112
	Leisure	$98	$104	$97	$101
	Fishing	$105	$111	$104	$109
3	No-take	-$30	-$40	-$28	-$37
	Science	-$22	-$33	-$21	-$29
	Leisure	$0	-$11	$1	-$8
	Fishing	$1	-$9	$3	-$6

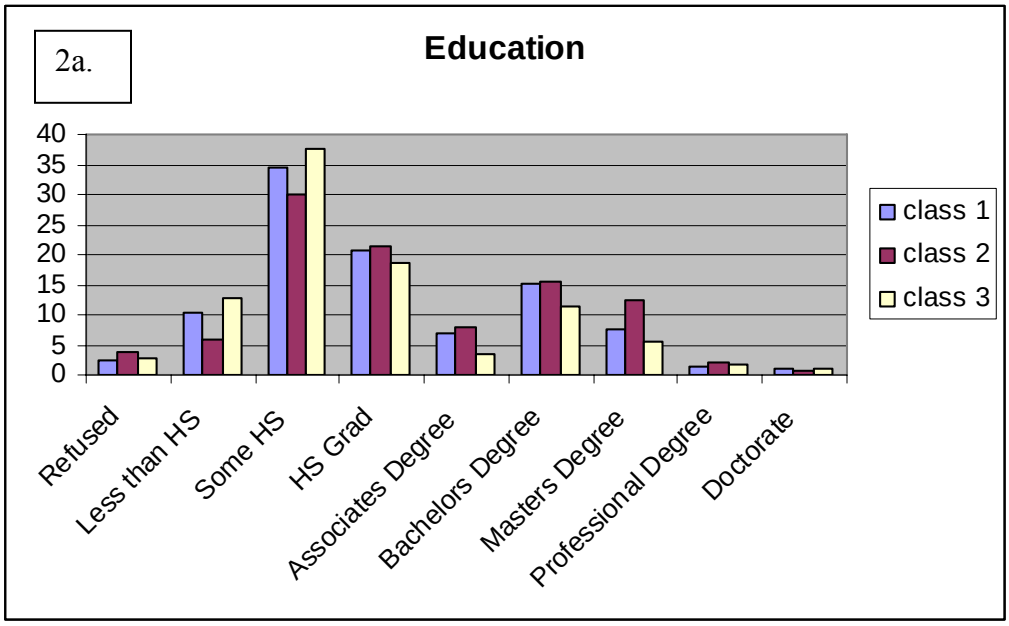
Figure 1
Sample Choice Task

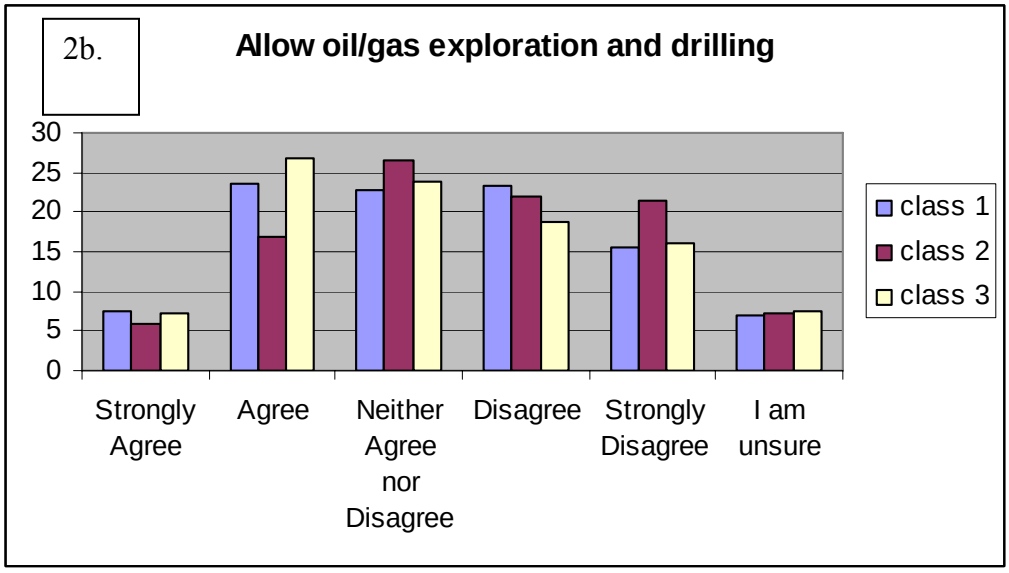
Please compare the Alternatives below and choose the one Alternative you would most prefer for the Northeast Region.

	Alternative A	**Alternative B**	**Current Situation**
What is the combined *Size* of all of the MPA areas in the network?	2% (2 million acres)	2% (2 million acres)	Click here to see the current situation again <hyperlinked to Section 5>
What are the *Allowable Uses* within the MPA network?	Level 4 Limited Fishing	Level 2 Science and Education	
What is the *Cost* to you each year if you voluntarily support an MPA network?	$25	$150	
Which do you most prefer for the Federal Waters of the Northeast Region?	❒ I prefer Alternative A	❒ I prefer Alternative B	❒ I prefer the Current Situation

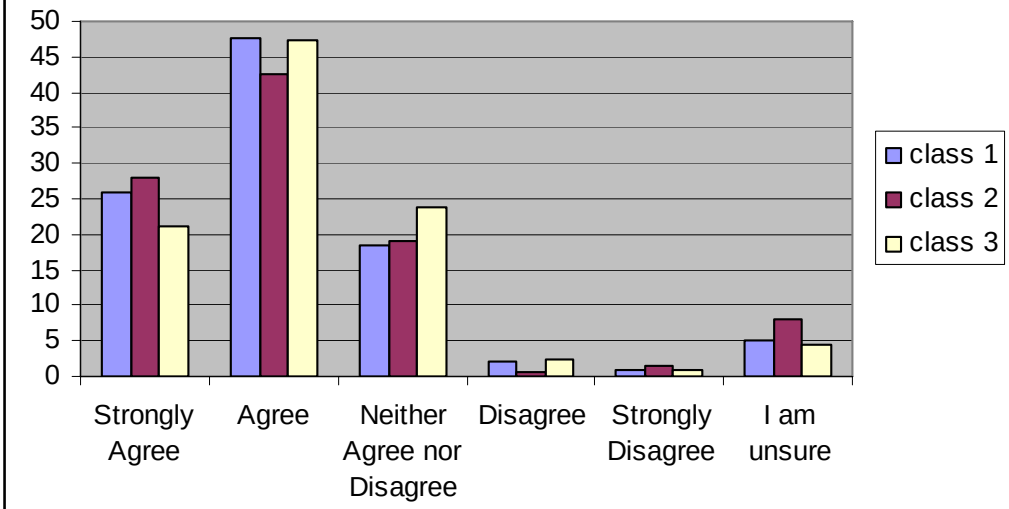
Figure 2

Demographic and responses to Likert-scale attitudinal questions that were significantly different between at least two latent classes.

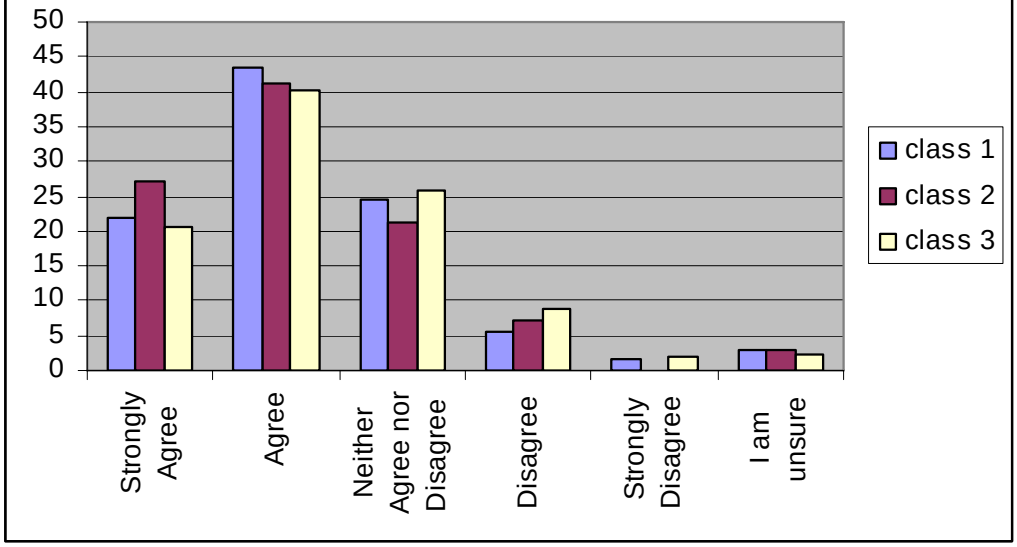




2c. **MPAs effective for balancing competing activities**



2d. **Live with less growth to protect environment**



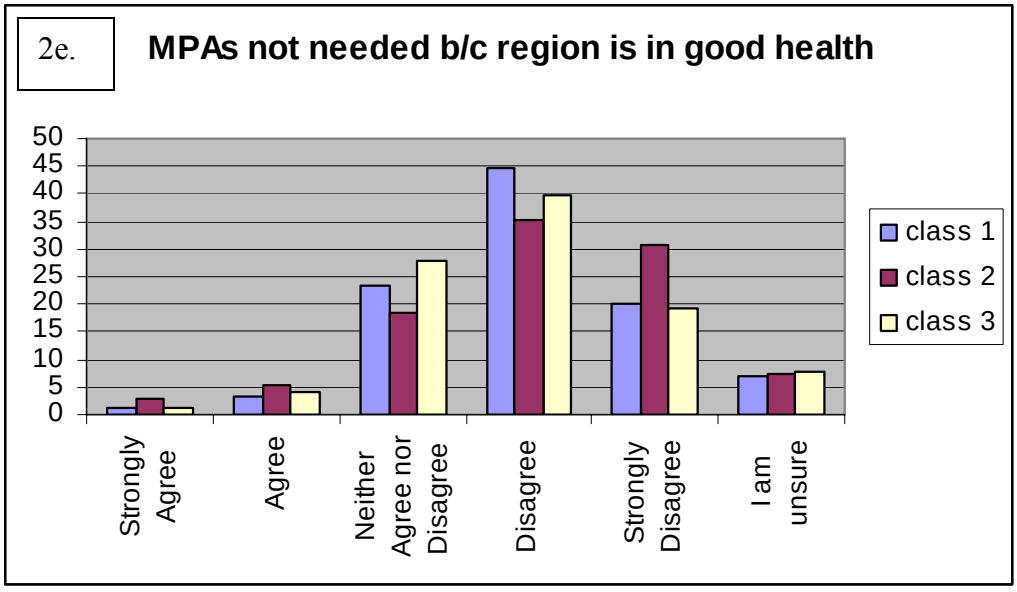
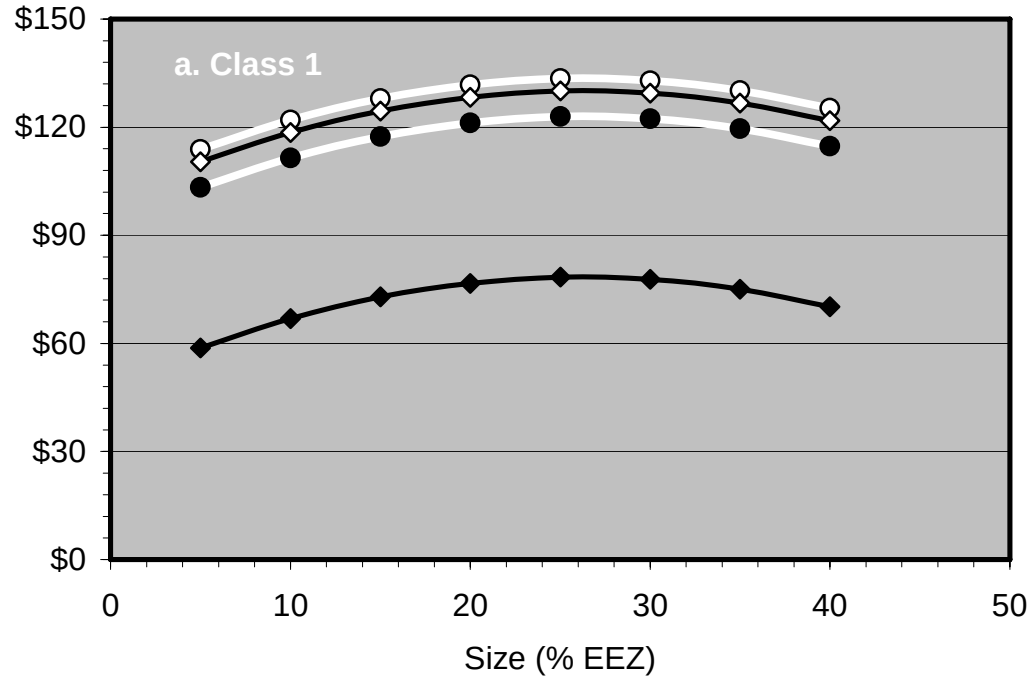
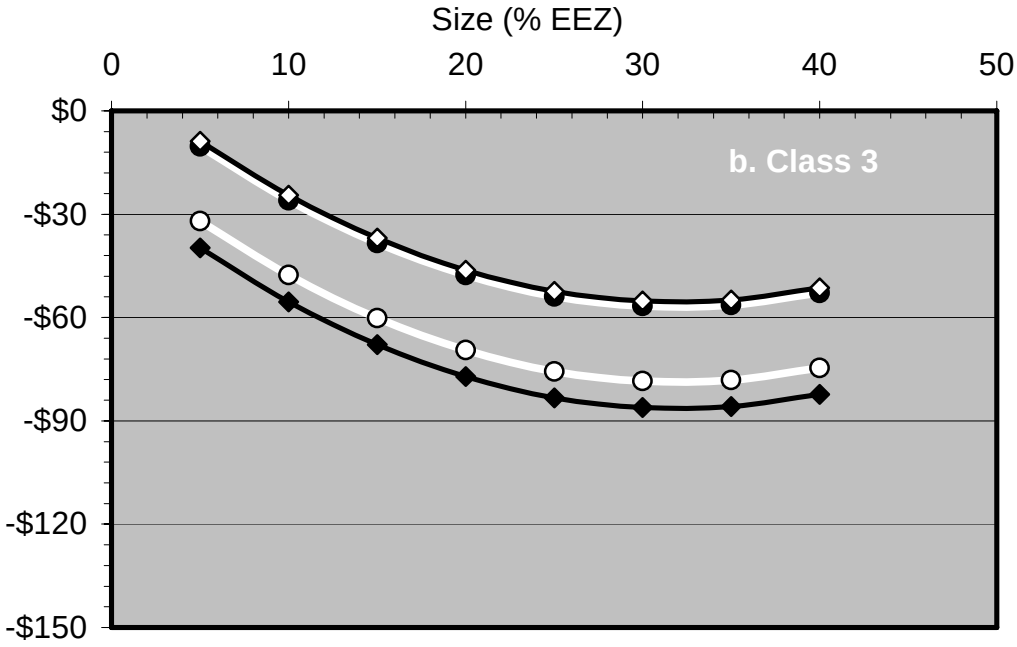
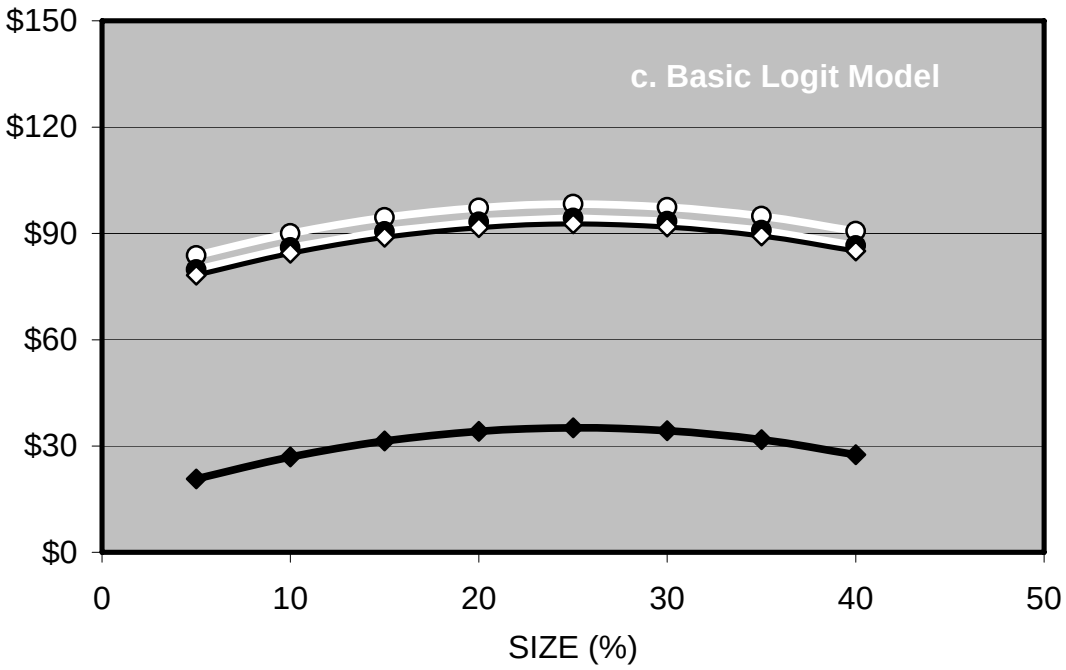

2e.
MPAs not needed b/c region is in good health
50
45
40
35
30
25
20
15
10
5
0
Strongly Agree
Agree
Neither Agree nor Disagree
Disagree
Strongly Disagree
I am unsure
class 1
class 2
class 3

Figure 3

Household average annual valuations (compensating variation) of the Size and Use Level attributes, by latent class. No-take is black diamond; Science and Education is white circle; Leisure and Tourism is black circle; Fishing is white diamond.






c. Basic Logit Model
$150
$120
$90
$60
$30
$0
0
10
20
30
40
50
SIZE (%)

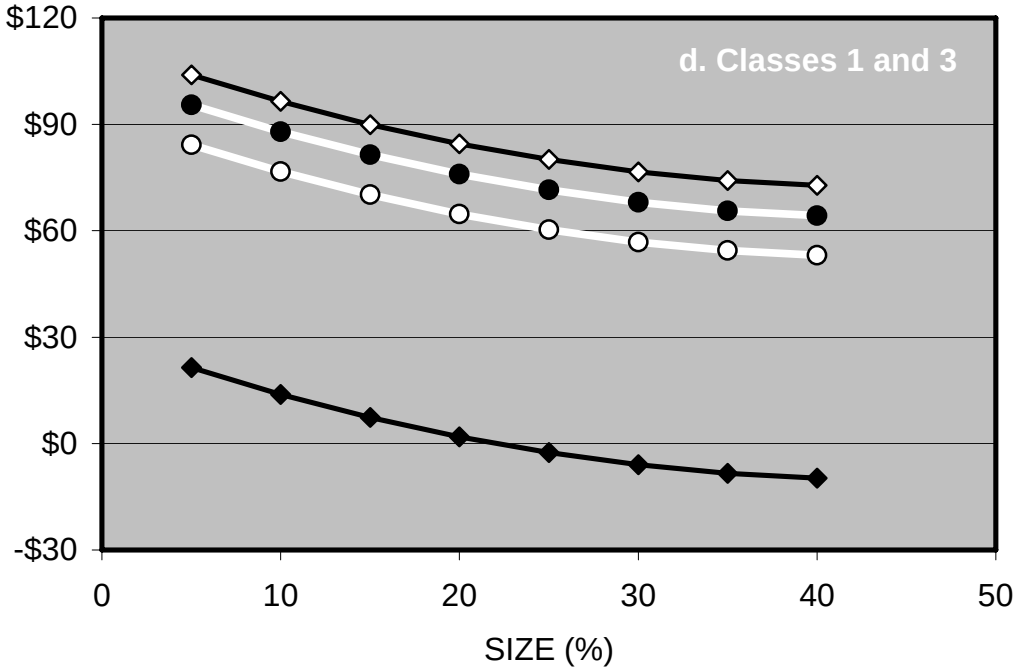

d. Classes 1 and 3
$120
$90
$60
$30
$0
-$30
0
10
20
30
40
50
SIZE (%)

Figure 4
Marginal Value of Size and Optimal Allocation when Costs are Zero

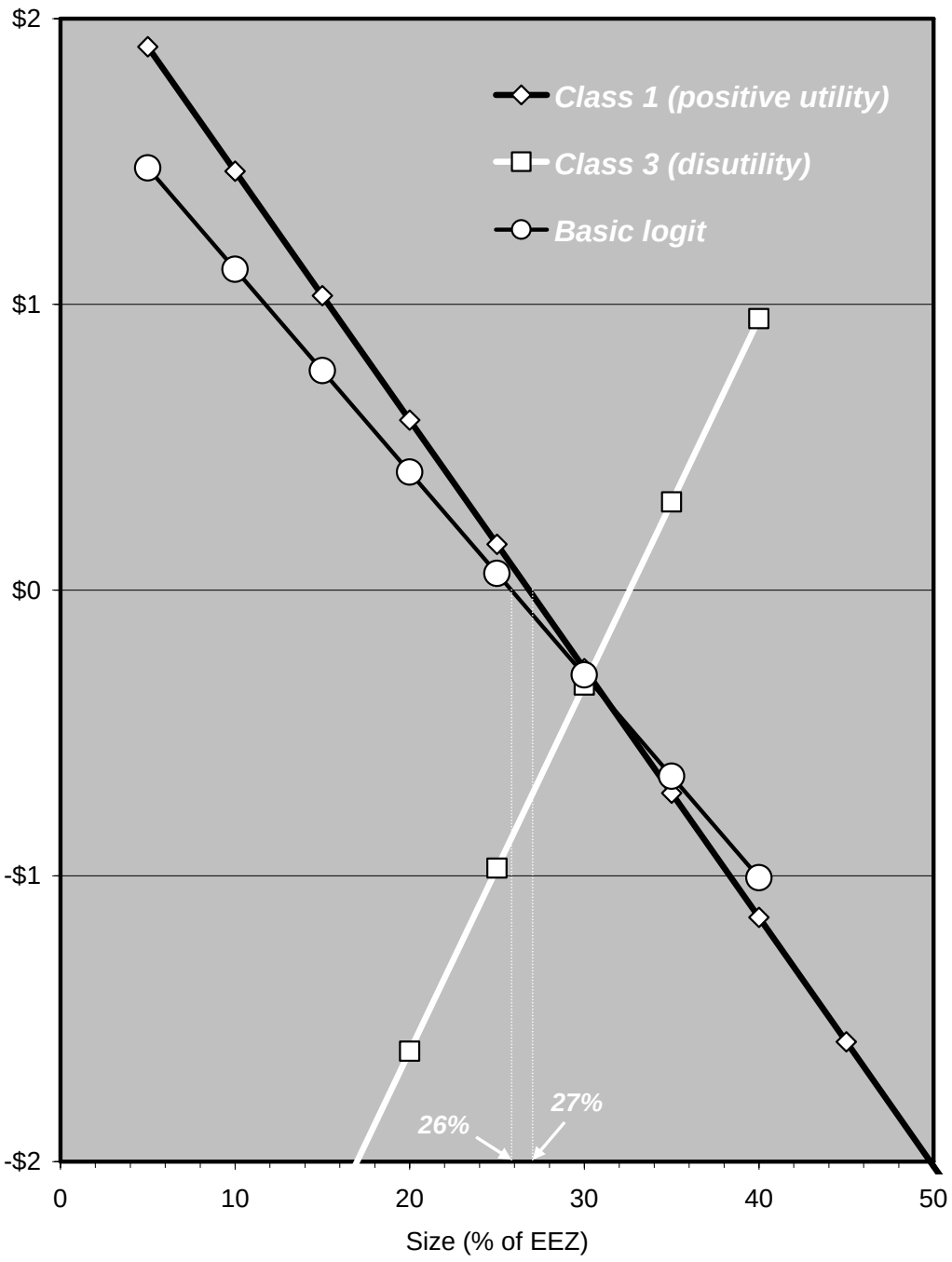


Figure 5
HAPCs Proposed by the New England Fishery Management Council for EFH Omnibus Amendment # 2.

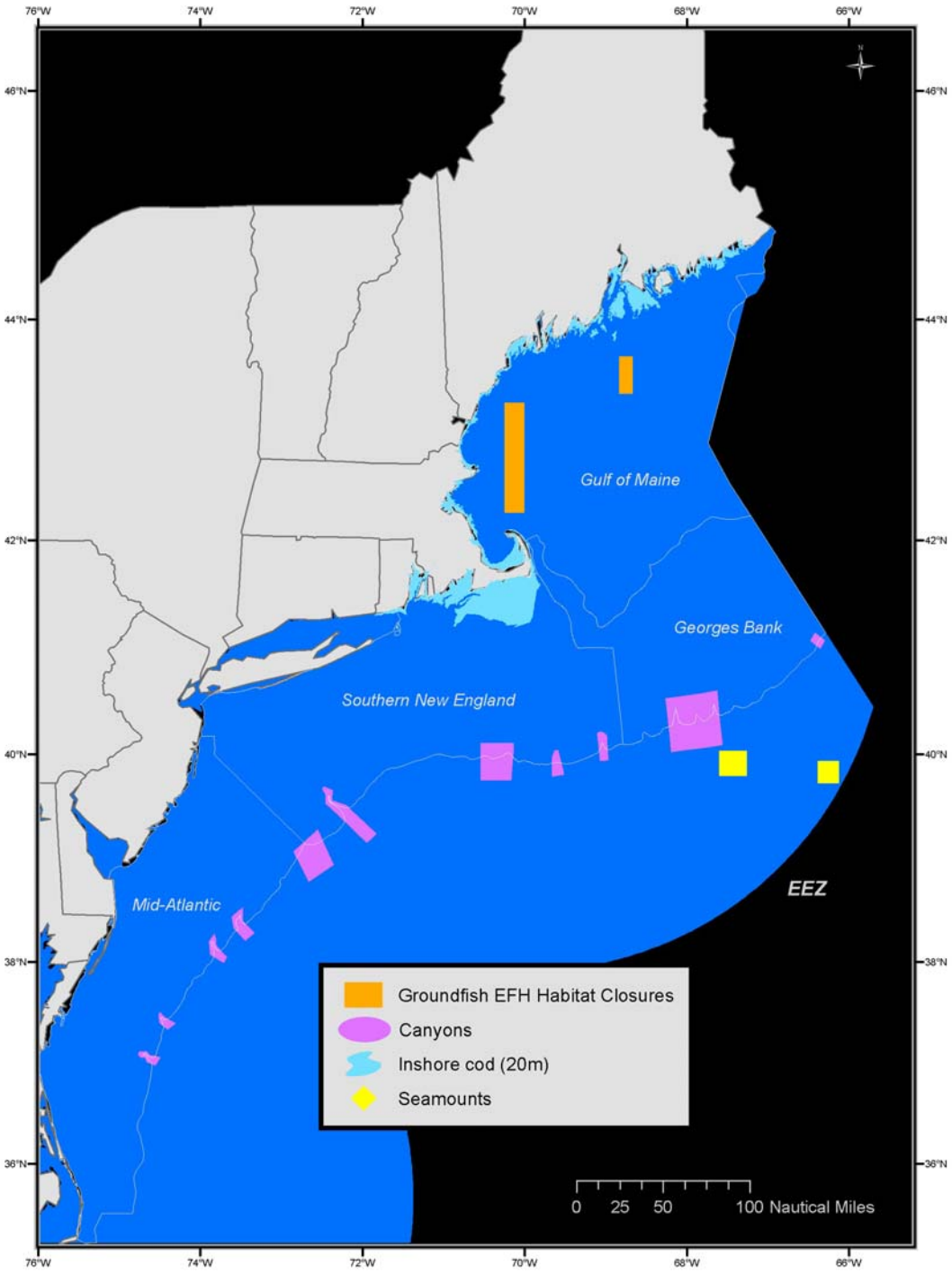


Figure 6
Overlap of Areas in Status Quo Scenarios with Proposed HAPCs

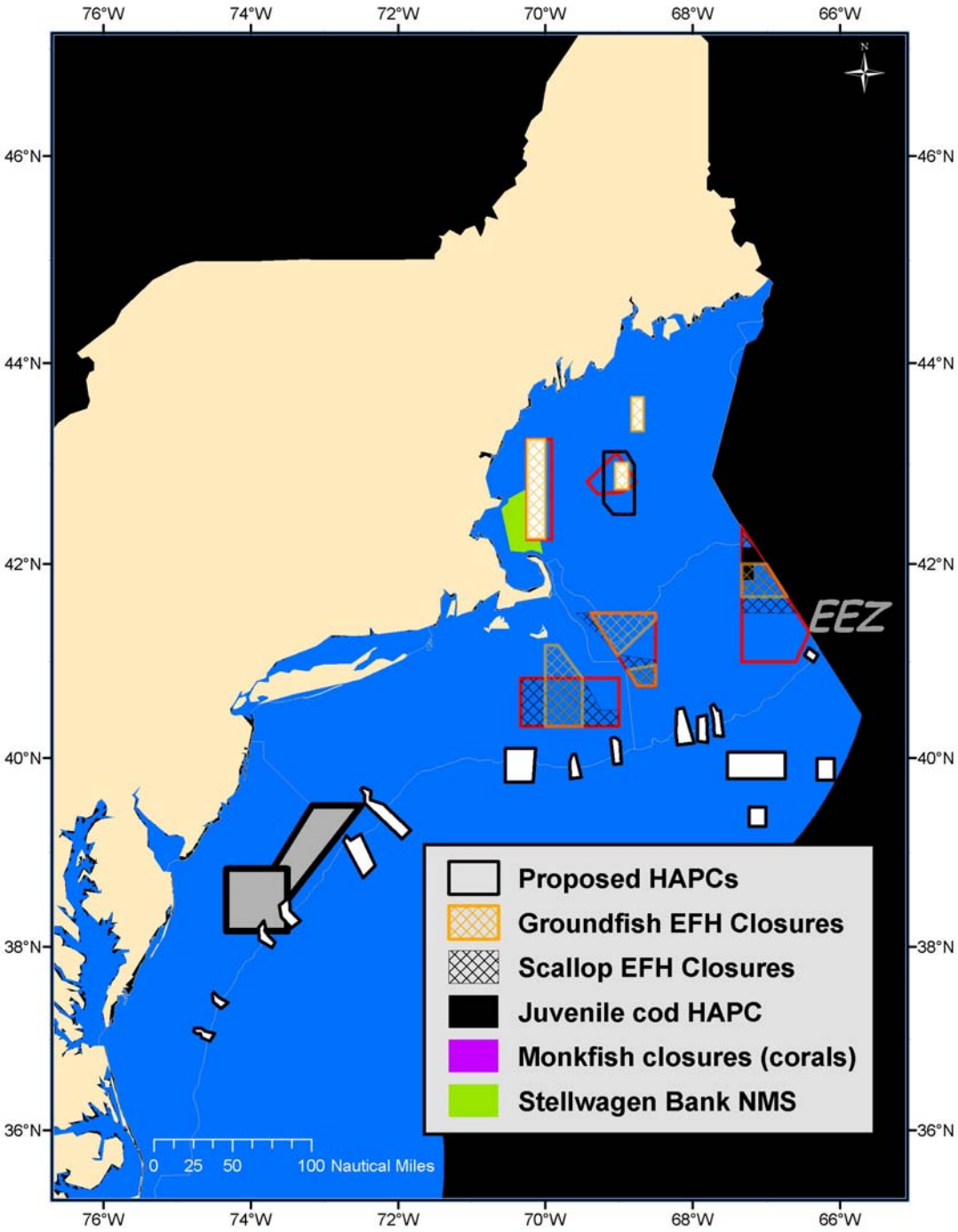


Figure 7
2005 Commercial and For-Hire (recreational) Fishing Trips that Fell Within the Boundary Lines of the Nominated HAPCs

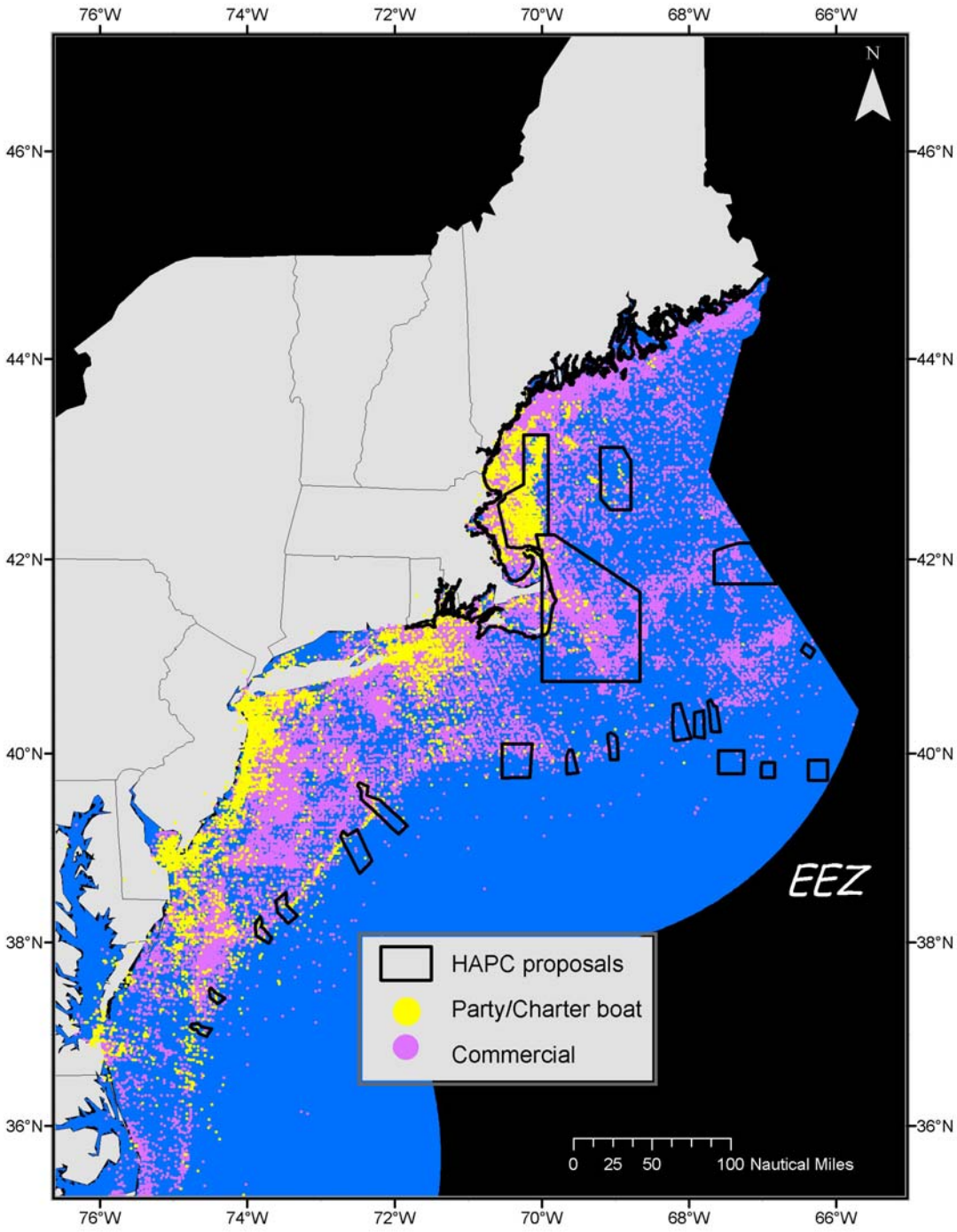
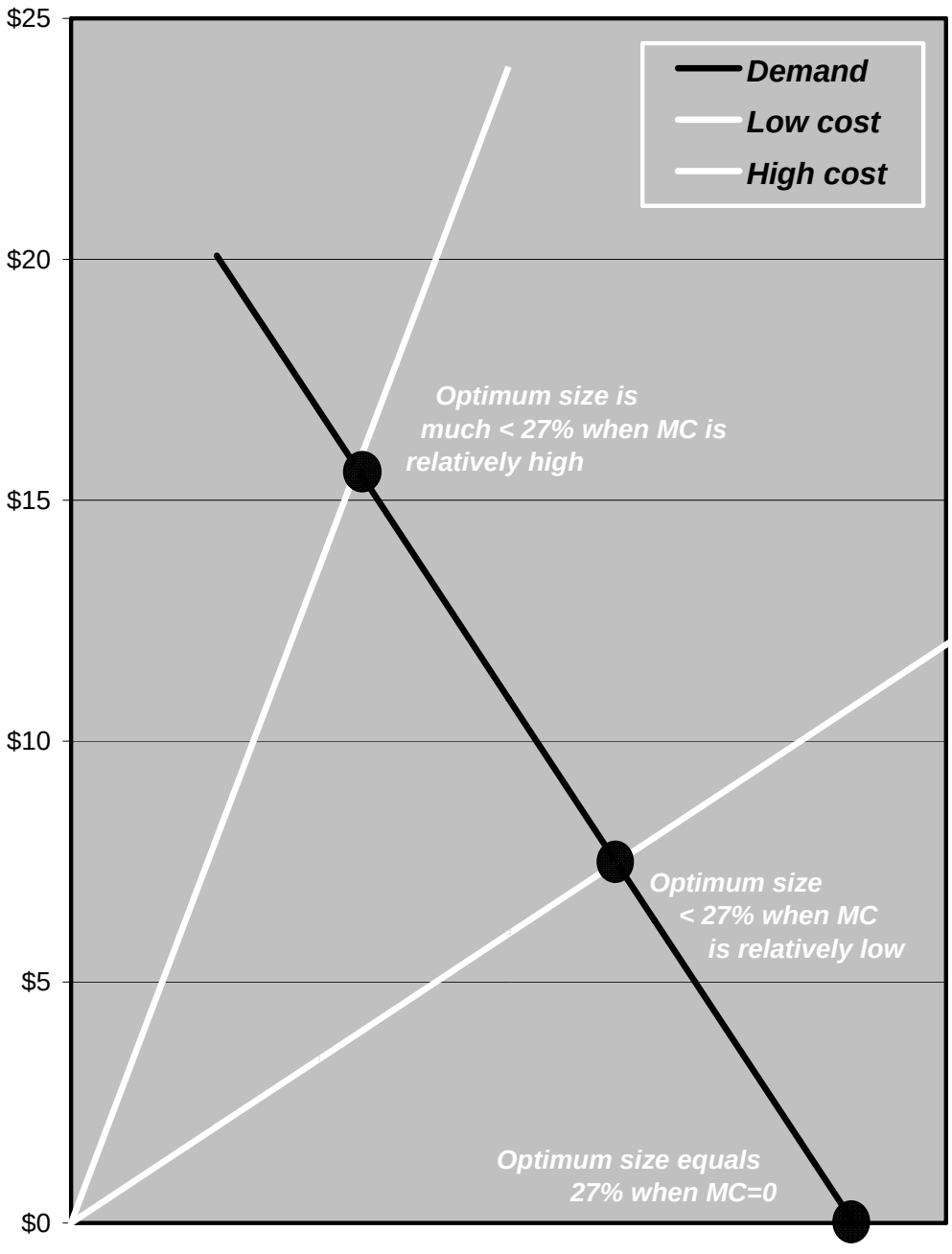


Figure 8

Regional Demand for Marine Ecological Diversity by Class 1 (approximately 13 million households). Individual marginal valuations were concatenated vertically because ecological diversity is a public good. Marginal costs are hypothetical. Size is allocated efficiently where marginal cost crosses demand. Values are $million annually.



Appendices to:

"Estimating Non-market Values for Marine Protected Areas: A Latent Class Modeling Approach"

Appendix A: The web-based questionnaire

Appendix B: Sampling and self-selection biases

Appendix C: Responses to attitudinal and opinion questions

Appendix A
Web-based Questionnaire

[display]

Marine Protected Areas

NOAA Fisheries is sponsoring a survey to understand opinions and support for Marine Protected Areas in the Northeast Region of the United States. The survey is being given to a select group of households from coastal states between North Carolina and Maine.

YOUR OPINIONS ARE IMPORTANT! The only way for managers to understand the variety of viewpoints people have about Marine Protected Areas is for everyone who is contacted to fill out the questionnaire completely, even if you have not heard about Marine Protected Area before.

The survey should take about 20 minutes to complete. All answers are confidential and anonymous. You will receive 7,500 bonus points for completing this survey.

In the survey, you can click on any <in yellow>yellow text</in yellow> to see a map or more information on the highlighted subject.

Thank you very much for your participation.

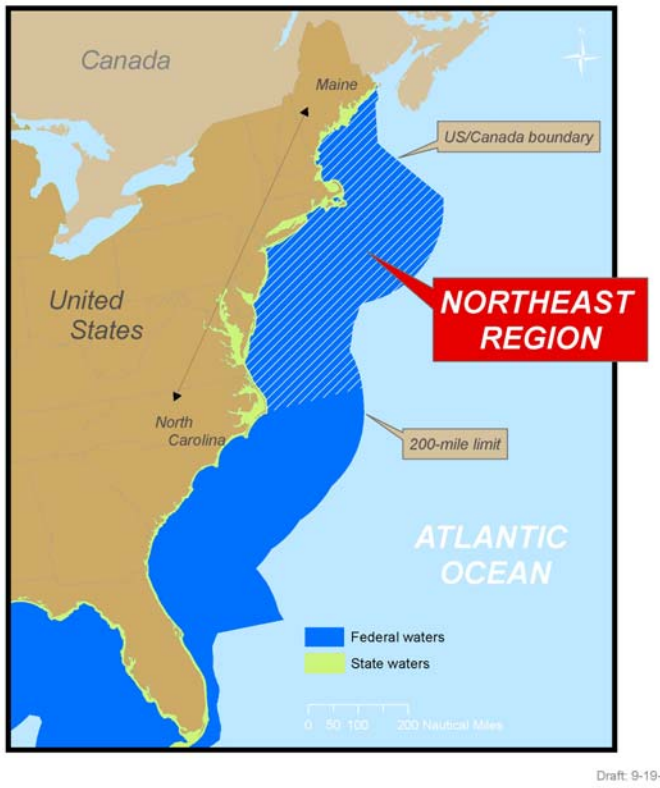
[display (show section numbers and titles in programmed survey)]

Section 1. Marine Protected Areas in the Northeast Region

This survey asks for your views on having Marine Protected Areas in the Northeast Region of the United States, to protect a variety of marine life and sea floor habitats.

Marine Protected Areas could be located in the federal waters of the Northeast Region. Federal waters lie between state waters and the 200-mile limit of the U.S. government's jurisdiction. <u>This survey is not about Marine Protected Areas in state waters along the coast</u>.

U.S. Federal Waters in the Northeast Region between Maine and North Carolina (dark blue area with white stripes)



Currently there are no proposals to create Marine Protected Areas in the Northeast Region that are designed primarily to preserve all kinds of marine life on the seafloor, but the possibility is being discussed. In theory, this type of Marine Protected Areas could be placed anywhere in federal waters that are acceptable on economic, social, and scientific grounds.

[radio]

Q1. Before receiving this survey, had you heard or read about MPAs (Marine Protected Areas)?

- ❒ Yes
- ❒ No

Q2. Have you ever visited a MPA anywhere in the United States?

- ❒ Yes
- ❒ No

[DISPLAY]

Section 2. Background Information About the Ocean and Marine Protected Areas

In 2000, the U.S. Congress created an independent *Commission on Ocean Policy* to review the condition of the oceans and to recommend ways to improve resource management. The 16 members of the *Commission* came from local, state, and federal governments, private industry, and academic and research institutions.

[DISPLAY]

The *Commission* found that:

- fishing, shipping, tourism, and other commercial, industrial, and recreational uses of the ocean are vital to the economies of coastal areas and for leisure
- new industries, such as offshore aquaculture and renewable energy from winds and tides, can also be beneficial
- the ocean environment and marine life are being degraded

[prompt if any row skipped]

Q2b – Q2f. Please answer each question by checking the appropriate box.

	Yes	No
Do you go saltwater fishing for fun or food in the Northeast Region?	❒	❒
Is your job directly tied to the ocean (fishing, defense, shipping, marina, etc.)	❒	❒
Do you or does anyone in your family fish commercially in the Northeast Region?	❒	❒
Do you or does anyone in your family work for a charter boat or party boat fishing company?	❒	❒
Are you currently a member of any type of organization involved with marine-based activities?	❒	❒

[TEXT BOX]
[IF Q2F=YES]

Q2a. What is the name of the organization you belong to?

_____

[DISPLAY]

Balancing economic growth with environmental protection is sometimes complicated. For example, ocean-based industries provide important jobs, income, and goods and services for the economy in the Northeast Region. At the same time, these industries can sometimes pollute the water, damage large areas of habitat, or harvest too many fish..

As one strategy to resolve the conflicts, the *Commission* recommended setting aside Marine Protected Areas, or MPAs, where most types of industrial and commercial activities are prohibited or strictly regulated.

Q3a. Please check the <u>one</u> box that most closely represents your opinion. There are not any right or wrong answers – your opinion is what's important.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	I am unsure
MPAs can be an effective way to balance environmental protection and activities such as fishing and oil extraction	❒	❒	❒	❒	❒	❒

[DISPLAY]

Section 3. Benefits and Costs of Marine Protected Areas

BENEFITS

Marine Protected Areas can be designed for many purposes. This survey is about a Marine Protected Area network that is designed to <u>preserve ecological diversity on the sea floor</u>.

- A network means that instead of one large reserve there may be several smaller reserves placed throughout the Northeast Region.
- Within the boundaries of the MPA network, human uses would be limited and regulated.

[display]

The primary benefits of the Marine Protected Area network are:

- Preservation of the variety of marine life in the Northeast Region (fish, shellfish, plants) in their natural habitats on the bottom of the ocean - regardless of their commercial or recreational importance.

- Preventing future industrial uses within the MPA network boundaries.

There might also be incidental benefits associated with the MPA network, but these are uncertain. Incidental benefits might include increased catches by fisheries outside of the boundaries of the MPA network, a temporary sanctuary for animals that migrate into and out of the region (such as herring and tuna), and possible medical or pharmaceutical discoveries from species that were preserved.

[GRID]
[SHOW HEADER ON TOP AND BOTTOM OF SCREEN]

Q3. For each statement below, please check the one box that most closely represents your opinion. There are not any right or wrong answers – your opinion is what's important.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	I am unsure
MPAs are not needed in the Northeast Region because marine life and ocean habitats are in good shape	❒	❒	❒	❒	❒	❒
I like knowing that part of the ocean in the Northeast Region is protected even if I never see or use it	❒	❒	❒	❒	❒	❒
MPAs should not be established unless their rules and boundaries can be completely enforced	❒	❒	❒	❒	❒	❒

[DISPLAY]

COSTS

There are also costs associated with Marine Protected Areas. The primary costs are:

- Higher production costs for industries that are affected by MPAs.
- Higher costs to producers could mean higher prices for consumers.
- Increased regulation of recreationists, scientists, and businesses who are allowed to use the MPAs.
- Financial expenses associated with MPA management, administration, and negotiation with stakeholders, possibly leasing sites from the government, monitoring, and enforcement.

[GRID]
[SHOW HEADER ON TOP AND BOTTOM OF SCREEN]

Q4. For each statement below, please check the <u>one</u> box that most closely represents your opinion..

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	I am unsure
I would be willing to pay higher prices for products such as seafood and energy to preserve areas of the ocean in the Northeast Region	❒	❒	❒	❒	❒	❒
Businesses and employees should be compensated for any lost income as a result of MPAs	❒	❒	❒	❒	❒	❒
The costs of establishing MPAs in the Northeast Region most likely outweigh the benefits	❒	❒	❒	❒	❒	❒

[DISPLAY]

Section 4. The Size of Marine Protected Areas

The appropriate size of a network of Marine Protected Areas is a difficult and controversial question for policy makers. Economic, social, and political considerations become as important as scientific relationship when final decisions are made.

We are concerned here with the *scientific relationships* between the size of Marine Protected Areas and the variety of fish, shellfish, and plants that can be preserved in their natural habitat on the sea floor. In other words, how much ecological diversity can be protected in Marine Protected Area networks of different sizes?

[DISPLAY]

In 2001, the *National Academy of Sciences* assembled a group of 13 marine scientists from universities around the world to summarize what was known about the design of Marine Protected Areas in Florida, California, and other countries. The group reported that no two places are alike, but in general:

- Between 10% and 40% of a regional ocean ecosystem might be needed to preserve all of the species of marine life in their natural habitats
    - Even so, Marine Protected Areas that cover relatively small areas still protect at least part of the ecological diversity.

This brief summary of the scientific research on Marine Protected Areas serves as a rough guideline for the Northeast Region, although no one knows the exact size that would be needed to protect all types of marine life and habitats on the sea floor in the Northeast Region.

[GRID]
[SHOW HEADER ON TOP AND BOTTOM OF SCREEN]

Q6. For each statement below, please check the <u>one</u> box that most closely represents your opinion.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	I am unsure
MPAs should be large enough to protect every type of plant and animal regardless of costs	❒	❒	❒	❒	❒	❒
The federal government has a duty to protect marine life and habitats in a natural state	❒	❒	❒	❒	❒	❒

[DISPLAY]

Section 5. What's the Current Situation in the Northeast Region?

The MPA network discussed so far in this survey would be designed to provide lasting protection for ecological diversity on the sea floor. Currently, there are no Marine Protected Areas in the Northeast Region that are designed specifically for this purpose.

Currently there is one official MPA in the Northeast Region - the Stellwagen Bank National Marine Sanctuary near Massachusetts, which covers less than one percent of the federal waters. In addition, other marine managed areas have been set up by federal fishery managers to help rebuild fish stocks and to protect marine mammals from fishing gear. These areas:

- Allow types of fishing that can damage seafloor habitats and catch all types of fish on the sea floor, including fish that will be discarded
- Are designed to protect only a select few number of species of marine life or their habitat
- Can be canceled at any time once the fishery objectives are met (protections is not necessarily lasting)
- Prohibit most industrial activities, such as oil exploration, waste disposal, and sand and gravel mining

Fishery managers are currently deciding which of these marine managed areas qualify as an MPA. In addition, managers are discussing policies to protect habitat of commercially and recreationally important fish.

[GRID]
[SHOW HEADER ON TOP AND BOTTOM OF SCREEN]

Q5. For each statement below, please check the one box that most closely represents your opinion.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	I am unsure
Fishing gear that sits on the seafloor and does not damage habitat should be allowed in the MPAs even if it catches fish and shellfish living on the sea floor	❒	❒	❒	❒	❒	❒
The areas now used by fishery managers probably provide enough protection for marine life in the Northeast Region	❒	❒	❒	❒	❒	❒
MPAs in federal waters should be placed as far away from the coast as possible	❒	❒	❒	❒	❒	❒

[DISPLAY]

Section 6. Uses of Marine Protected Areas

Some types of human uses may be compatible with preservation of marine life and habitat on the sea floor. On the next screen, we will show you four use levels. The four use levels below describe activities that would not have long-term impacts or interfere with the preservation goals of the MPA network for the Northeast Region. Assume that:

- The MPA network is located to avoid problems with shipping, transportation, and national defense.
- All other industrial uses not described, such as oil and gas production, sand and gravel mining, waste disposal, and dumping, would not be allowed in the network, because these activities damage the sea floor.

[DISPLAY]

USE LEVEL

Least Use

Level 1: NO-TAKE

All uses are prohibited inside the network of Marine Protected Areas. The areas are only monitored to determine their effectiveness at preservation

Level 2: SCIENTIFIC RESEARCH AND EDUCATION

Uses involving scientific research or education are allowed, and a limited amount of resources can be extracted for these purposes. These activities are regulated.

Level 3: TOURISM AND LEISURE

Tourism and leisure activities that do not remove anything, such as SCUBA, boating, or sightseeing, are allowed, plus all Level 2 uses. These activities are regulated.

Level 4: LIMITED FISHING

Commercial and recreational fishing in designated areas with fishing gear that does not touch the sea floor is allowed, plus all Level 2 and 3 uses. These activities are regulated.

Most Use

Q6a. Please check the one box that most closely represents your opinion.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	I am unsure
The marine environment is a public resource and none of it should be restricted	❒	❒	❒	❒	❒	❒
We should allow exploration and drilling for oil and natural gas in the Northeast Region to help create a stable supply and lower prices	❒	❒	❒	❒	❒	❒
Fishing with gear that sits on the seafloor and does not damage habitat should be allowed in the MPAs	❒	❒	❒	❒	❒	❒

[DISPLAY]

Section 7. Public Input into the Network Design

The next several questions ask you to assume that you are part of a Citizens Advisory Panel (CAP). CAP's are often used when policy-makers need public input on specific topics. CAP's are intended to be representative of a community, and consist of citizens from a wide variety of occupations. Most CAP members do not have in-depth scientific or technical knowledge of the specific topic.

You, as a member of the CAP, are being asked about your opinions of alternative Marine Protected Area networks for the Northeast Region. The alternatives are different in their size, the uses they allow, and their cost.

[radio]

Q6b. Have you ever been a participant on a Citizens Advisory Panel before?

Yes

No

[text box]

[Q6b=yes]

Q6c. What was the topic of the Panel?

[DISPLAY]

ON THE NEXT SCREEN, YOU WILL FIND A BRIEF DESCRIPTION OF WHAT WE MEAN BY SIZE, ALLOWABLE USES, AND COST.

[DISPLAY]

Size	The percentage of the sea floor in the federal waters of the Northeast Region that will be protected by the MPA network. Remember that coastal waters are not part of this study.
Allowable Uses	The types of uses that will be allowed within the MPA network which are compatible with preserving sea floor habitats and marine life, ranging from Level 1 to Level 4
Cost	One viable mechanism to pay for the economic and financial costs of Marine Protected Areas is for households to make a voluntary contribution <u>each year</u> to an environmental organization: ▪ the environmental organization works with the federal government to negotiate, lease, monitor, and enforce the Marine Protected Areas in the network ▪ monies received by the government could be used to offset costs to industries and other parties restricted or excluded from the areas

[display]

On the next several screens, you will see several pairs of Alternative A and Alternative B. For each pair, please review the information carefully and choose the alternative you would prefer. You may also select the current situation as your preference.

[RADIO]
[REPEAT THIS QUESTION FIVE TIMES]
[
USE THE DESIGN PROVIDED IN THE EXCEL SHEET]

Q8-Q12. Please compare the Alternatives below and choose the <u>one</u> Alternative you would most prefer for the Northeast Region. Remember you can click on Size, Allowable Use, and Cost links to be reminded of important information.

	Alternative A	**Alternative B**	**Current Situation**
What is the combined *Size* of all of the MPA areas in the network?			Click here to see the current situation again <hyperlinked to Section 5>
What are the *Allowable Uses* within the MPA network?			
What is the *Cost* to you <u>each year</u> if you voluntarily support an MPA network?			
Which do you most prefer for the Federal Waters of the Northeast Region?	❒ I prefer Alternative A	❒ I prefer Alternative B	❒ I prefer the Current Situation

[RADIO]

Q8A-Q12AInexperience with a commodity such as Marine Protected Areas can cause uncertainty. How certain do you feel about your choice? (Please check <u>only one</u> box)

Very certain	Somewhat certain	Neither certain nor uncertain	Somewhat uncertain	Very uncertain
❒	❒	❒	❒	❒

[check box]

[IF Q8=Q12: CURRENT SITUATION]

Q8b-Q12b. Why did you choose the Current Situation? (Please check all responses that apply)

- ❒ The annual costs of Alternatives A and B are too expensive
- ❒ The costs of Marine Protected Areas for the economy are too high
- ❒ Alternatives A and B restrict too many uses
- ❒ No part of the ocean should be closed to the public
- ❒ I don't trust the government to be part of the program
- ❒ I distrust environmental organizations being part of the program
- ❒ Too much of the federal waters in the region is already restricted
- ❒ I need more information to make a choice
- ❒ I am too unsure about how I feel about Marine Protected Areas
- ❒ Other(please explain) _____

[GRID]

[SHOW HEADER ON TOP AND BOTTOM OF SCREEN]

Section 8. General Views about the Environment

In the last section we would like to ask you a few questions about some general environment views.

[prompt if any row skipped]

Q13. For each statement below, please check the one box that most closely represents your opinion.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	I am unsure
We should protect the environment for our children and future generations, even if it means reducing our own standard of living	❒	❒	❒	❒	❒	❒
Plants and animals exist primarily to be used by humans	❒	❒	❒	❒	❒	❒
I enjoy being outdoors to experience the beauty of nature	❒	❒	❒	❒	❒	❒
People can live with less economic growth in order to preserve and protect the environment	❒	❒	❒	❒	❒	❒
We can rely on new technology to fix environmental problems	❒	❒	❒	❒	❒	❒
Government regulations and planning are always too costly and ineffective to benefit the environment	❒	❒	❒	❒	❒	❒

[RADIO]

Q14. How familiar were you with Marine Protected Areas before taking this survey?

❒ Very familiar ❒ Somewhat familiar ❒ Unfamiliar

[RADIO]

Q15. How familiar are you now with Marine Protected Areas?

❒ Very familiar ❒ Somewhat familiar ❒ Unfamiliar

[TEXT BOX]

Thank you for taking the time to complete this survey. Please provide any additional comments you have about the survey in the box below.

Appendix B
Sampling and Self-selection Biases

Sampling Bias

Table B-1. Test results for sample: comparison of full sample (responders and non-responders) to Census.

Characteristic		Test	Results					
			Un-weighted data			Weighted data		
General	Specific		Statistic	df	P (H_o: true)	Statistic	df	P (H_o: true)
Population[a]	Total by state	Chi-square	115.427	14	<0.001	30.919	14	<0.005
	18-years or older by state		86.150	14	<0.001	19.610	14	<0.25
	Total by coastal counties and inland areas[e]		101.170	1	<0.001	19.878	1	<0.001
Households[b]	Total by state	Chi-square	16.399	14	<0.50	11.454	14	<0.75
	Total by coastal counties and inland areas[e]		26.076	1	<0.001	6.085	1	<0.025
	Average size in region	t-test[f]	1.720	1341	<0.10	0.049	1341	>0.50
Race/ethnicity in region[c]		Chi-square	29.557	3	<0.001	5.829	3	<0.25
Mean household income in region[d]		t-test[f]	-15.216	1341	<0.001	-9.913	1341	<0.001

[a]Survey population was estimated as the responder plus the value of the PPHHSIZE variable provided by KN.
[b]Each record was interpreted as a single household.
[c]We assumed that everyone in the household had the same race/ethnicity as the responder.
[d]KN information on total household income was provided as intervals (e.g., $40,000 to $50,000). We used the median value of the intervals and the upper value of $200,000 .
[e]When there is only one degree of freedom, the Yates Correction for Continuity is required.
[f]t-tests are two-sided.

Self-selection bias

Table B-2. Self-selection bias: comparison of responders and non-responders.

Characteristic		Test	Results					
			Un-weighted data			Weighted data		
General	Specific		Statistic	df	P (H_o: true)	Statistic	df	P (H_o: true)
Population[a]	Total by state	Chi-square[d]	43.754	14	<0.001	34.162	14	<0.005
	18-years or older by state		34.931	14	<0.005	31.832	14	<0.005
	Total by coastal counties and inland areas[e]		0.763	1	<0.25	6.579	1	<0.01
Households[b]	Total by state	Chi-square[d]	12.610	14	<0.75	16.750	14	<0.25
	Total by coastal counties and inland areas[e]		0.138	1	<0.75	1.047	1	<0.25
	Average size in region	t-test[f]	-4.566	1340	<0.001	-2.401	1340	<0.02
Race/ethnicity in region[c]		Chi-square	51.992	3	<0.001	97.925	3	<0.001
Mean household income in region[d]		t-test[f]	0.619	1340	>0.50	0.774	1340	>0.50

[a]Survey population was estimated as the responder plus the value of the PPHHSIZE variable provided by Knowledge Networks.
[b]Each record was interpreted as a single household.
[c]We assumed that everyone in the household had the same race/ethnicity as the responder.
[d]Twice the value of the log-likelihood ratio for contingency tables has a Chi-square distribution.

Appendix C
Summary of Responses to Attitudinal and Opinion Questions

Q1. Before receiving this survey, had you heard or read about MPAs (Marine Protected Areas)?

REFUSED	1
Yes	203
No	833

Q2. Have you ever visited a MPA anywhere in the United States?

REFUSED	3
Yes	106
No	928

Q2B_1. Do you go saltwater fishing for fun or food in the Northeast Region?

Yes	173
No	864

Q2B_2. Is your job directly tied to the ocean (fishing, defense, shipping, marina, etc.)

Yes	9
No	1028

Q2B_3. Do you or does anyone in your family fish commercially in the Northeast Region?

Yes	37
No	1000

Q2B_4. Do you or does anyone in your family work for a charter boat or party boat fishing company?

Yes	11
No	1026

Q2B_5. Are you currently a member of any type of organization involved with marine-based activities?

Yes	29
No	1008

Q3A_1. MPAs can be an effective way to balance environmental protection and activities such as fishing and oil ext

REFUSED	2
Strongly Agree	259
Agree	485
Neither Agree nor Disagree	207
Disagree	20
Strongly Disagree	9
I am unsure	55

3_1. MPAs are not needed in the Northeast Region because marine life and ocean habitat

REFUSED	4
Strongly Agree	14
Agree	38
Neither Agree nor Disagree	248
Disagree	437
Strongly Disagree	221
I am unsure	75

Q3_2. I like knowing that part of the ocean in the Northeast Region is protected even i

REFUSED	6
Strongly Agree	315
Agree	521
Neither Agree nor Disagree	120
Disagree	28
Strongly Disagree	16
I am unsure	31

Q3_3. MPAs should not be established unless their rules and boundaries can be complete

REFUSED	6
Strongly Agree	98
Agree	424
Neither Agree nor Disagree	272
Disagree	145
Strongly Disagree	45
I am unsure	47

Q4_1. I would be willing to pay higher prices for products such as seafood and energy to preserve areas of the ocean in the Northeast Region

REFUSED	4
Strongly Agree	110
Agree	374
Neither Agree nor Disagree	260
Disagree	176
Strongly Disagree	58
I am unsure	55

Q4_2. Businesses and employees should be compensated for any lost income as a result of MPAs

REFUSED	5
Strongly Agree	41
Agree	252
Neither Agree nor Disagree	383
Disagree	241
Strongly Disagree	53
I am unsure	62

Q4_3. The costs of establishing MPAs in the Northeast Region most likely outweigh the benefits

REFUSED	4
Strongly Agree	43
Agree	197
Neither Agree nor Disagree	359
Disagree	234
Strongly Disagree	115
I am unsure	85

Q6_1. MPAs should be large enough to protect every type of plant and animal regardless of costs]

REFUSED	5
Strongly Agree	86
Agree	253
Neither Agree nor Disagree	286
Disagree	295
Strongly Disagree	56
I am unsure	56

Q6_2. The federal government has a duty to protect marine life and habitats in a natural state]

REFUSED	7
Strongly Agree	199
Agree	511
Neither Agree nor Disagree	214
Disagree	57
Strongly Disagree	18
I am unsure	31

Q5_1. Fishing gear that sits on the seafloor and does not damage habitat should be allowed in the MPAs even if it catches fish and shellfish living on the sea floor

REFUSED	6
Strongly Agree	29
Agree	293
Neither Agree nor Disagree	287
Disagree	257
Strongly Disagree	80
I am unsure	85

Q5_2. The areas now used by fishery managers probably provide enough protection for marine life in the Northeast Region

REFUSED	8
Strongly Agree	14
Agree	132
Neither Agree nor Disagree	342
Disagree	316
Strongly Disagree	99
I am unsure	126

Q5_3. MPAs in federal waters should be placed as far away from the coast as possible

REFUSED	10
Strongly Agree	39
Agree	235
Neither Agree nor Disagree	411
Disagree	191
Strongly Disagree	45
I am unsure	106

Q6A_1. The marine environment is a public resource and none of it should be restricted]

REFUSED	7
Strongly Agree	29
Agree	92
Neither Agree nor Disagree	200
Disagree	495
Strongly Disagree	168
I am unsure	46

Q6A_2. We should allow exploration and drilling for oil and natural gas in the Northeast Region to help create a stable supply and lower prices

REFUSED	4
Strongly Agree	75
Agree	242
Neither Agree nor Disagree	245
Disagree	228
Strongly Disagree	169
I am unsure	74

Q6B. Have you ever been a participant on a Citizens Advisory Panel before?

Yes	21
No	1016

Q13_1. We should protect the environment for our children and future generations, even if it means reducing our own standard of living

REFUSED	2
Strongly Agree	247
Agree	464
Neither Agree nor Disagree	219
Disagree	71
Strongly Disagree	8
I am unsure	26

Q13_2. Plants and animals exist primarily to be used by humans

REFUSED	3
Strongly Agree	54
Agree	182
Neither Agree nor Disagree	281
Disagree	327
Strongly Disagree	161
I am unsure	29

Q13_3. I enjoy being outdoors to experience the beauty of nature

REFUSED	2
Strongly Agree	439
Agree	454
Neither Agree nor Disagree	105
Disagree	13
Strongly Disagree	3
I am unsure	21

Q13_4. People can live with less economic growth in order to preserve and protect the environment

REFUSED	2
Strongly Agree	230
Agree	440
Neither Agree nor Disagree	254
Disagree	68
Strongly Disagree	15
I am unsure	28

Q13_5. We can rely on new technology to fix environmental problems

REFUSED	2
Strongly Agree	56
Agree	208
Neither Agree nor Disagree	342
Disagree	268
Strongly Disagree	114
I am unsure	47

Q13_6. Government regulations and planning are always too costly and ineffective to benefit the environment

REFUSED	2
Strongly Agree	96
Agree	234
Neither Agree nor Disagree	390
Disagree	194
Strongly Disagree	74
I am unsure	47

Q14. How familiar were you with Marine Protected Areas before taking this survey?

REFUSED	5
Very familiar	7
Somewhat familiar	180
Unfamiliar	845

Q15. How familiar are you now with Marine Protected Areas?

REFUSED	4
Very familiar	133
Somewhat familiar	793
Unfamiliar	107