MARINE RESOURCE ECONOMICS

Volume 21 Number 4 2006

Published by the MRE Foundation, Inc.
in association with the North American Association of Fisheries Economists (NAAFE) and the International Institute of Fisheries Economics & Trade (IIFET)

Marine Resource Economics, Volume 25, pp. 133-154
Printed in the U.S.A. All rights reserved.
0738-1360/00 $3.00 + .00

Valuing Enhancements to Endangered Species Protection under Alternative Baseline Futures: The Case of the Steller Sea Lion

DANIEL K. LEW
Alaska Fisheries Science Center, NMFS, NOAA and
University of California, Davis

DAVID F. LAYTON
University of Washington

ROBERT D. ROWE
Stratus Consulting

Abstract *This article presents results from a stated preference survey of U.S. households intended to value the public's preferences for enhancements to the protection of the western stock of Steller sea lions, which is listed as endangered under the Endangered Species Act. To account for the uncertainty of future populations under current programs without additional protection efforts, three survey versions were implemented that each present different, yet plausible, baseline futures for Steller sea lions. Stated preference choice experiment data from each survey are analyzed using repeated, rank ordered random parameters logit models, and welfare estimates are calculated and compared for each baseline for a variety of possible improvements. The willingness to pay (WTP) results reflect positive, but diminishing, marginal utility for improvements in the western stock population, regardless of baseline future: WTP increases for population improvements until the population greatly exceeds the current population, at which point the WTP for additional improvements levels off. Similarly, as would be expected, WTP for improvements to the western stock population decreases as the future baseline population forecast improves.*

Key words Choice experiments, threatened and endangered species, stated preference, non-market valuation, Steller sea lion.

JEL Classification Code Q51.

Daniel K. Lew is an economist, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, and a visiting scholar, Department of Environmental Science and Policy, University of California, Davis, One Shields Ave., Davis, CA 95616 (email: Dan.Lew@noaa.gov). David F. Layton is a professor, Daniel J. Evans School of Public Affairs, University of Washington, PO Box 353055, Seattle, WA 98195-3055 (email: dflayton@u.washington.edu). Robert D. Rowe is the chairman of the board, Stratus Consulting, PO Box 4059, Boulder, CO 80306 (email: browe@stratusconsulting.com).

The views and opinions expressed herein are the authors' own and do not necessarily reflect those of the National Oceanic and Atmospheric Administration or the U.S. Department of Commerce.

The authors thank Lowell Fritz, Ron Felthoven, Pat Livingston, Doug DeMaster, Rich Ferrero, Alan Haynie, and others at the Alaska Fisheries Science Center; Todd Lee at the Northwest Fisheries Science Center; and Dave Colpo at the Pacific States Marine Fisheries Commission for their support of this research. We also thank Vic Adamowic, Rich Bishop, Gardner Brown, Roger Tourangeau, Edward Morey, and two anonymous reviewers, as well as seminar participants at UC Davis, the 2008 W–1133 Western Regional Research Conference, and the 2009 NAAFE Forum for useful suggestions that have improved this research. Of course, all remaining errors are the authors.

Introduction

This article describes research to study the economic benefits of providing enhanced protection to the endangered western stock of Steller sea lions using a stated preference choice experiment (CE) approach. As is the case for many threatened and endangered species, the benefits of protecting Steller sea lions are primarily the result of the non-consumptive values that individuals attribute to such protection, such as active use values associated with viewing them, passive use values from reading or seeing films about them, or from existence values. Resource managers and policy-makers need information about these benefits to assist them in evaluating the merits of alternative management measures or policies that may affect Steller sea lions.

An important feature of this research is the treatment of the uncertainty of the future population and status of Steller sea lions. Several population viability analyses have been developed to assess the likely future status of Steller sea lions (Winship and Trites 2006; Gerber and VanBlaricom 2001; National Marine Fisheries Service 2008). These models, however, are sensitive to assumptions that drive them, and as a result, projections of future populations vary considerably (National Marine Fisheries Service 2008). Given that the outcomes of present species protection plans can never be known with certainty, policymakers, and in turn researchers, need to make judgments about how to incorporate this uncertainty.

One route is to attempt to explain the uncertainties to respondents and perhaps include their own subjective probabilities of outcomes in estimated values. This is the general approach followed by numerous non-market valuation studies that focus on estimating the value of the supply uncertainty; *i.e.*, the option price associated with an environmental change (*e.g.*, Desvousges, Smith, and Fisher [1987], Edwards [1988]). In the context of endangered species valuation, Whitehead (1992) employed a referendum-based contingent valuation approach to estimate willingness to pay (WTP) for protecting loggerhead sea turtles in the presence of an uncertain future state for the species by including subjective probabilities directly in the utility specification. While Whitehead's empirical model included each individual's subjective expectations of the future supply of sea turtles, Cameron (2005) employed a specification that accounted for the expectation and dispersion of subjective supply uncertainty in an application to climate change valuation. In both Whitehead and Cameron, information on supply uncertainty was based on self-reported information and thus was dependent upon the individual's background knowledge and perceptions of the information provided in the survey. In contrast, Roberts, Boyer, and Lusk (2008) included supply uncertainty explicitly as an attribute in a stated preference CE to value lake water quality and found that WTP estimates can be greatly affected in the presence of this type of uncertainty.

An alternative approach is to construct scenarios that reflect beliefs about likely outcomes. This approach might be especially apt when the uncertainties in underlying population models are quite large, and even population biologists have difficulty assigning probabilities about future outcomes, perhaps due to studies yet to be completed. This latter case characterizes the route we follow here well. In this article, three survey versions were implemented that each present different, yet plausible, baseline futures for Steller sea lions. In this manner, it is possible to bound the likely range of WTP associated with different future outcomes of protection actions on Steller sea lions. A key advantage of the approach over explicit incorporation of supply uncertainty is that it allows policy-makers to develop an expected value function using supply uncertainty weights to each state of nature without being dependent upon subjective respondent probabilities. As such, it provides great flexibility to decision-makers, enabling them to adjust program evaluation as information on expected future baselines change, which is particularly useful given the often large time gap between development, implementation, and analysis of stated preference-based surveys and use of the analytic results for policy analysis. Another advantage is the reduced burden on respondents, who need only consider one certain future baseline, as opposed to multiple futures or probabilistic ones, thereby reducing a principal source of uncertainty, which can otherwise impact the reliability of WTP. Still, few, if any, other studies have been conducted that provide estimates of welfare changes under alternative views of future supply.

A key question we ask is whether WTP will vary across the differing baselines. Using the method of convolutions approach to analyze differences between estimated mean WTP under different baselines (Poe, Giraud, and Loomis 2005), we find that WTP is indeed sensitive to the baseline future outcome for smaller enhancements in protection, though differences become insignificant for relatively larger enhancements.

To date, almost all economic benefit estimates for protection of threatened and endangered species have been based on stated preference contingent valuation methods (CVM) (Boyle and Bishop 1987; Jakobsson and Dragun 2001; among others).[1] A study by Giraud *et al*. (2002) used CVM to estimate the public's WTP for protecting Steller sea lions. In their study, respondents are asked for their WTP for a single proposed protection program, which is typical of many CVM-based species valuation studies. In contrast, the approach followed here allows us to estimate the public's values for a variety of possible policies or programs. This is particularly useful given researchers lack the resources to collect data and estimate WTP for all possible management alternatives, and the set of management alternatives considered by decision-makers often changes over time.

To this end, we depart from previous threatened and endangered species valuation studies and employ an alternative stated preference approach, the stated preference CE, or stated choice, approach for eliciting economic values for the Steller sea lion (Adamowicz, Louviere, and Williams 1994; Adamowicz *et al*. 1998; Alpizar, Carlsson, and Martinsson 2001; Hanley, Wright, and Adamowicz 1998).[2] In the CE approach, respondents are asked to choose between two or more alternatives that differ in one or more attributes, including cost. Choice experiments offer a useful alternative to CVM for estimating a wider range of economic values by decomposing environmental goods, in the form of choice alternatives (*e.g.*, species protection programs), into measurable attributes (*e.g.*, specific outcomes of protection such as population size under each protection program) whose value can be estimated from an analysis of choices between different alternatives. Since choice alternatives are described by their attributes, and the effects of these attributes on choice are estimated in the model, it is possible to estimate WTP for alternatives not originally included in the CE questions seen by respondents.

The remainder of the article is organized as follows. A national mail-telephone survey is described and used to illustrate the application of CE stated preference methods to the valuation of an endangered species. Second, details about the survey implementation and data are delineated. This is followed by a section that describes how the CE responses from each survey version (baseline future for Steller sea lions) are analyzed using random utility maximization-based (RUM) choice models. Repeated and rank-ordered random parameters logit models that account for preference heterogeneity are estimated. Then welfare estimates for several policy scenarios are calculated and compared across baseline survey versions. The results suggest WTP is sensitive to projected future baselines and that people are generally willing to pay for small-scale enhanced species protection programs, but do not appear to get additional utility from larger-scale improvements. Additional discussion concludes the article.

---

[1] See Loomis and White (1996) for a useful synthesis of the literature through the early 1990s and Richardson and Loomis (2009) for a recent update.

[2] To our knowledge, few previous studies have been conducted to value threatened and endangered species protection using CE methods. Layton and Levine (2005) conducted a Bayesian analysis of CE data collected in the mid-1990s on alternative programs to protect the northern spotted owl. Additionally, two recent studies conducted in Canada provide economic values for threatened or endangered species derived from stated preference choice experiment analyses. Rudd (2009) utilized the CE approach to value the protection of several endangered Canadian marine species on the Atlantic coast, while Olar *et al*. (2007) used CE to value some Canadian aquatic species in the St. Lawrence Estuary.

The Steller Sea Lion Economic Survey

Steller sea lions (*Eumetopias jubatus*) live in the North Pacific Ocean and consist of two distinct populations, the western stock and eastern stock. Steller sea lions are the largest sea lions, and can grow to 11 feet (3.4 m) long and 2,400 pounds (1,088 kg). As a result of large declines in the populations since at least the early 1970s, in April 1990 the Steller sea lion was listed as threatened throughout its range under the U.S. Endangered Species Act (ESA). Due to continued declines, the western stock was declared endangered in 1997, while the eastern stock remained listed as threatened (National Oceanic and Atmospheric Administration 1997).

The western stock is found mainly in the Gulf of Alaska and Aleutian Islands (see figure 1). One reason the western stock is believed to have declined in recent years is competition with commercial fisheries, which target many of the same fish species that make up Steller sea lions' diet (*e.g.*, pollock, Pacific cod, and Atka mackerel). Since 1990, the U.S. government has implemented a number of restrictions to conserve Steller sea lions and manage commercial fishing activities, including prohibiting shootings of Steller sea lions (with certain well-defined exceptions), setting up a Steller sea lion conservation area, and limiting fishing in and around key rookeries and haulouts where Steller sea lions mate, raise their young, and rest. These restrictions appear to have slowed, and perhaps even stopped, the decline. Through the 1990s, the annual rate of decline fell to about 4%, down from 15% observed during the 1980s. The rate of decline is higher in areas like the western Aleutian Islands. The most recent evidence suggests the western stock population as a whole may be stabilizing or perhaps even increasing slightly overall (National Marine Fisheries Service 2008).

The following analysis is based on data from a survey conducted on a sample of U.S. households in the winter and spring of 2007. The survey collects information on attitudes toward threatened and endangered species, seals and sea lions, and Steller sea lions, preferences for protecting Steller sea lions, and demographics. It was developed and tested with the aid of a series of focus groups (six in total) and cognitive interview sessions (four in total) conducted in Seattle, Denver, Sacramento, Rockville (Maryland), and Anchorage, as well as input from several Steller sea lion biologists and experts in stated preference techniques and survey design and methodologies. A pretest implementation (sent to 424 households) preceded the full survey.

The survey itself is divided into several sections. The first section sets the broader stage of threatened and endangered species by describing the ESA, how and what it protects, definitions for "threatened species" and "endangered species," and reasons why people may be interested in protecting threatened and endangered species (*i.e.*, benefits of protection) or not protecting them (*i.e.*, costs of protection). This section also lists the number of species by type (*e.g.*, mammals, reptiles, birds, etc.) protected by the ESA. The second section identifies other seal and sea lion species that may be similar or related (taxonomically and in appearance) to Steller sea lions, and provides information on population sizes and trends of these species. Presentation of this information is critical to respondents who may view other seals and sea lions, or other threatened and endangered species, as substitutes (or even complements) in their preferences for protecting Steller sea lions. It also serves as a reminder to all respondents that other species may need protection while answering questions about paying for additional Steller sea lion protection. In this fashion, this information acts as another budget constraint reminder.

The subsequent section presents information on Steller sea lions specifically, including their size and appearance, what they eat, where the two stocks of the species are found, and a description of the population declines over time. This section also describes causes behind the observed declines and measures taken to protect Steller sea lions, both historically and presently, and the outlook for the two stocks if current protection and population trends continue. The next section discusses the possibility of additional protection measures being undertaken and the potential positive and negative effects of these actions on the eastern and western stocks of Steller sea lions, fishing interests, and U.S. households. This provides the set-up for the CE questions, which are asked in the next section following instructions on answering the questions and a budget reminder. In the choice questions, respondents are asked to choose among three alternatives that differ in the level of protection provided to Steller sea lions and in their costs. Three choice questions are asked in each survey. The survey concludes with questions about the respondent and the respondent's household.

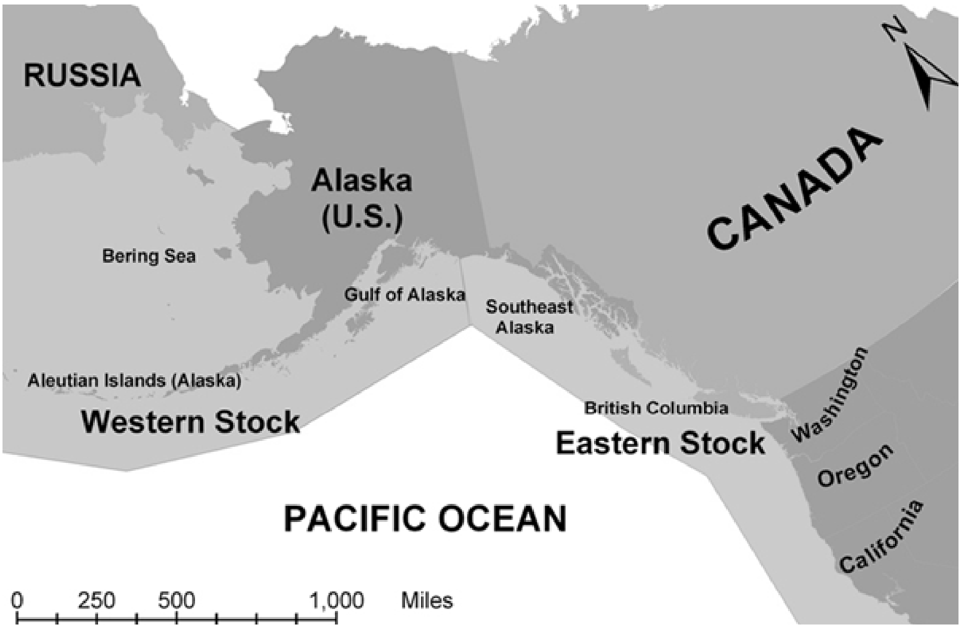

Figure 1. Map of the Ranges of the Western and Eastern Stocks of Steller Sea Lions

Dealing with Western Stock Population Uncertainty

To deal with the uncertainty of the future western stock population trend (*i.e.*, whether it will in fact stabilize, increase, or even decrease with current protection actions), three main survey versions were developed to cover the range of plausible future populations. The choice questions are framed in terms of results in 60 years. The Decreasing Version assumes the western stock population will decrease in the future from its current population of 45,000 to 26,000 and remain endangered during this time period. The Stable Version assumes the western stock population will stabilize over time but will likewise remain endangered. The Increasing Version assumes an increasing western stock population in the future, from 45,000 to 60,000, but with a relisting as threatened.[3] Table 1

[3] The final Steller sea lion recovery plan (National Marine Fisheries Service 2008) was published *after* the completion of the survey described herein and delineates the conditions that must be met for relisting to an improved status. The criteria include an increasing population over a specified time period and achievement of specific population size targets.

summarizes the attribute levels for the status quo (no additional protection) in each survey version. In all versions, the eastern stock of Steller sea lions is assumed to be "recovered" (taken off the endangered species list) in 60 years, which appears to be the consensus among biologists and is consistent with the Steller Sea Lion Recovery Plan and recent population trends in the stock. Projected populations of the eastern and western stocks under each alternative baseline are displayed in figure 2.

The experimental design of each survey version (Decreasing Version, Stable Version, and Increasing Version) differs. The experimental design for each main survey version was chosen based on a main effects design that maximizes D-optimality and accounts for limited parameter uncertainty (Sandor and Wedel 2001) while also considering level balance (Bunch, Louviere, and Anderson 1996).[4] To generate each version's experimental design, we employed an algorithm (programmed in GAUSS) to determine the best main effects choice designs that maximize Db-efficiency, a criterion that takes into consideration the fact that utility parameters are not known with certainty in the design stage (Sandor and Wedel 2001). The 150 most efficient experimental designs are determined from testing 10,000 candidate designs that conform to a set of design rules that rule out infeasible combinations (*e.g.*, better alternatives cannot cost less) and ensure internal consistency of the attributes each individual respondent will see in a survey. These efficient designs are then evaluated with respect to the level balance, the statistical design property that seeks to minimize differences in the frequency of occurrence of each attribute level in the design. The most balanced and efficient design for each survey version was selected based on an equal weighting of the balance and efficiency criteria.

Alternatives B and C in each choice question were assumed to provide better overall results, but for higher costs, compared to the status quo (current program) alternative. Consequently, the eastern stock is assumed to be recovered in all Alternatives B and C, since inferior eastern stock results are not considered possible and the status quo suggests the eastern stock will be recovered in 60 years. There are 10 Decreasing Version surveys and 8 each of the Stable and Increasing survey versions.

In each choice question, respondents are confronted with a choice between three Steller sea lion protection alternatives—the current Steller sea lion protection program (Alternative A), which is the status quo alternative (that differs between the three survey versions as illustrated in table 1), and two other alternatives that do more to protect Steller sea lions but cost more (Alternatives B and C) (see figure 3). Alternatives are described by their expected results on the ESA listing status of both the western stock (endangered, threatened, or recovered) and eastern stocks (recovered only), the population sizes of each stock (nine population levels for the western stock; two for the eastern stock), and the annual household cost of each alternative (14 costs ranging from $0 to $200). The range of costs was determined using input from qualitative pretesting activities and formal pretest results. The cost of the program would be borne by each household as a combination of taxes and increased costs associated with protection (*e.g.*, higher prices for seafood). The attributes and attribute levels in the experimental designs for each version are presented in table 2.

---

[4] Also, see Huber and Zwerina (1996), Lusk and Norwood (2005), and Ferrini and Scarpa (2007) for useful discussions of experimental design construction issues in choice experiments. A number of restrictions were placed on the candidate set of alternatives used in the selection of the experimental design to impose feasibility constraints on the choice alternatives respondents would see. Imposition of rules that significantly diminishes the size of the candidate choice alternatives reduces the overall efficiency of the design, but was needed to ensure respondents would not be faced with unrealistic choices that could lead to item or unit non-response. For example, within each survey version, clearly dominant choice alternatives were required to be more expensive than less effective alternatives. Level balance and statistical efficiency were given equal weight in the determination of an optimal design.

Table 1
Alternative A by Survey Version, Results in 60 Years under Status Quo Level of Protection

Attribute	Decreasing Version	Stable Version	Increasing Version
W. stock status (Wstat)	Endangered	Endangered	Threatened
E. stock population status	Recovered	Recovered	Recovered
E. stock population (Epop), thousands	60	60	60
W. stock population (Wpop), thousands	26	45	60
Added cost ($) (Cost)	0	0	0

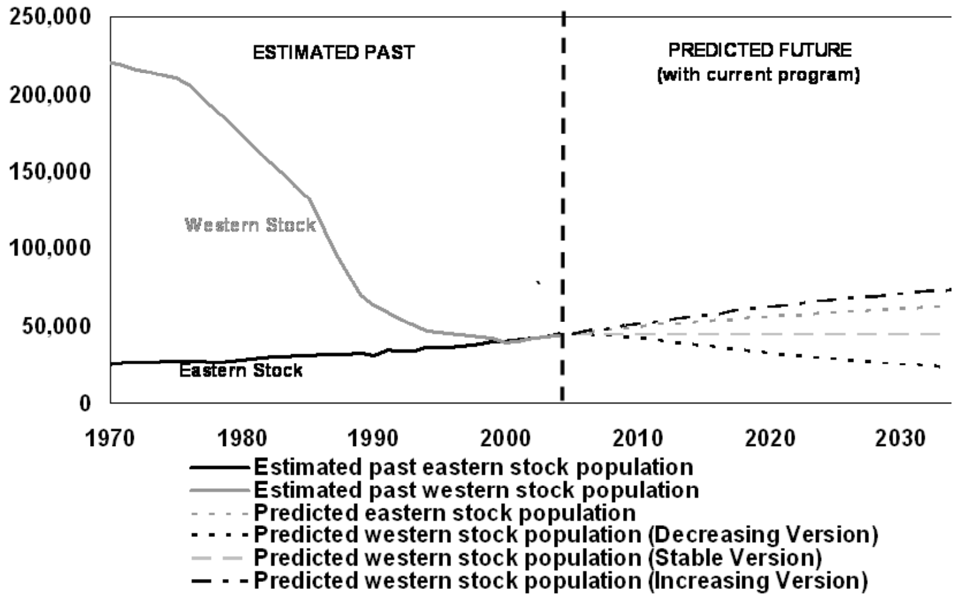

Figure 2. Estimated Past and Predicted Future Steller Sea Lion Populations Under Alternative Survey Versions

Note: Each respondent was presented only one of the three western stock predicted future baselines, consistent with their survey version.

Below the table, indicate which of these three alternatives you most prefer and which you least prefer.

	Results in 60 Years for Each Alternative		
	Alternative A Current Program	**Alternative B**	**Alternative C**
Western Stock			
Population status……………. (Endangered now)	Endangered	Endangered	Threatened
Population size……………… (45,000 now)	26,000	30,000	75,000
Eastern Stock			
Population status……………. (Threatened now)	Recovered	Recovered	Recovered
Population size……………… (45,000 now)	60,000	80,000	60,000
Added cost to your household………… each year for 20 years	$0	$20	$40

	<u>Alternative A</u>	**<u>Alternative B</u>**	**<u>Alternative C</u>**
Which alternative do you <u>prefer the most</u>? *Check one box------>*	☐	☐	☐
Which alternative do you <u>prefer the least</u>? *Check one box------>*	☐	☐	☐

Figure 3. Example of Choice Experiment Question from Decreasing Version

Table 2
Experimental Design Attribute Levels by Survey Version, Results in 60 Years under Status Quo Level of Protection

Attribute	Decreasing Version	Stable Version	Increasing Version
E. stock population (Epop), thousands	60, 80	60, 80	60, 80
W. stock status (Wstat)	Endangered (E) Threatened (T) Recovered (R)	Endangered (E) Threatened (T) Recovered (R)	Threatened (T) Recovered (R)
W. stock population (Wpop), thousands	26, 45, 50, 60, 75, 90	45, 50, 60, 75, 90, 100	60, 75, 90, 100, 120
Added cost ($) (Cost)	5, 10, 25, 50, 75, 100, 150, 250, 350	Same as Decreasing Version	Same as Decreasing Version

Survey Implementation and Data

The survey was implemented using a modified Dillman mail-telephone approach (Dillman 2000). The implementation included an advance letter, an initial mailing with a monetary incentive (US$10),[5] a reminder postcard, a follow-up telephone call, and a second mailing conducted by USPS certified mail for individuals who had not responded after the phone follow-up. The mail survey was initially sent to a stratified random sample of 4,200 U.S. (heads of) households.[6] The implementation achieved response rates, excluding undeliverables, of 60% across each of the three main survey versions.[7]

The datasets used in model and welfare estimation consist of 717 Decreasing Version respondents, 648 Stable Version respondents, and 587 Increasing Version respondents. These samples exclude individuals who indicated their most preferred and least preferred choices were the same choice alternative, thus indicating confusion over how to respond to the choice questions or a lack of well-defined preferences, and individuals who indicated they were not at all confident in their responses to the choice questions. Table 3 provides descriptive statistics of key demographic characteristics of the sample. Compared to the Census population estimates, the samples of respondents overall tended to be better educated, older, live in households with fewer residents, consist of more males, have a higher percentage of whites, and be more affluent. T-tests and chi-square tests support the assertion that there are differences between the Census population numbers and each sample, but do not support such differences between the samples themselves for these characteristics.[8]

Estimation Models

CE data are analyzed using RUM-based discrete choice econometric models. In the RUM approach, the conditional indirect utility of the *j*th choice alternative (U_j) is assumed to be composed of an observable deterministic component (V_j) and a stochastic component (ε_j) that is known to the individual, but not the researcher. For any choice question, individuals choose the alternative that yields the highest utility from among the *J* choices in the

---

[5] Inclusion of an incentive acts as a sign of goodwill on the part of the study sponsors and encourages reciprocity of that goodwill by the respondent. In the review of this survey by the U.S. Office of Management and Budget (OMB), we tested several different incentive amounts in a formal pretest at OMB's request. Results from the pretest implementation indicated that a $10 incentive led to a statistically higher response rate compared to $2 and $5 treatments at the 1% and 10% levels, respectively, and was thus the incentive used in the survey.

[6] The population frame for the samples used in this analysis is all U.S. households except Alaskans. Given Alaskans represent only about 0.23% of the U.S. population, their exclusion from the sample is not expected to lead to any appreciable bias. The random sample of households was obtained from Survey Sampling, International.

[7] Response rates varied only slightly over the main survey versions. They ranged from 59% (Decreasing Version) to 64% (Stable Version). Stable and Increasing Version surveys were sent to 1,292 households each. To accommodate the larger experimental design, 1,616 received the Decreasing Version. Response rates are based on 739, 801, and 918 completes from the Decreasing, Stable, and Increasing Versions, respectively, and exclude undeliverables (131 total) and deceased individuals (23 total). The 60% response rate achieved here is quite good relative to other recent stated preference mail surveys of general populations. Giraud *et al*. (2002), for instance, report a 51% response rate for their U.S. sample.

[8] Certain demographic differences between the heads of households making up respondents and the U.S. population estimates should be viewed cautiously because the comparison is not exact. That is, the comparison is not heads of household for the sample compared to heads of household U.S. Census numbers since head of household Census information was not available for several variables. Thus, the large difference in gender composition is somewhat misleading because the Census estimate is for the general population while the respondents are only heads of households. Likewise, age, race and ethnicity, and education may also differ because they are demographic characteristics about individuals that may be systematically different for heads of households relative to the general population. Additional modeling investigation suggests little effect due to the differences between sample and population values for these variables on the mean WTP presented herein (and on the population aggregate WTP).

Table 3
Head of Household Sample Versus Population Characteristics

Descriptive Statistics	Decreasing N=717	Stable N=648	Increasing N=587	U.S.
Median age	54	54	53	36.4
Male (%)	61.5	59.6	57.8	49
Household size	1.83	2.06	1.89	2.61
White/Caucasian (%)	86.6	85.3	87.2	73.9
Education				
Less than HS diploma (%)	4.0	4.0	3.2	15.8
High school or equivalent (%)	20.4	22.4	25.6	29.6
Some college or associate's degree (%)	30.4	30.7	30.2	27.5
College graduate or higher (%)	42.8	41.7	38.5	27.2
Income				
Median income category ($)	50,000 to 59,999	50,000 to 59,999	50,000 to 59,999	48,201

Note: U.S. characteristics are from the U.S. Census Bureau (2007) for all adults aged 18 and older (not just heads of households).

choice set. Letting $J = 3$ with corresponding choice alternatives A, B, and C, we model the probability that the individual chooses the jth alternative as Pr[choose j] = $\Pr[V_j \geq \max\{V_A, V_B, V_C\}]$. A common assumption in analyzing CE data is to assume ε_j is an independent and identically distributed Type I Extreme Value (TEV), or Gumbel. This leads to the familiar logit model and probabilities of the form:

$$\Pr[\text{choose } j] = \exp(V_j)/[\exp(V_A) + \exp(V_B) + \exp(V_C)] \qquad j = A, B, C. \tag{1}$$

In the survey, respondents are asked to identify their "most preferred" and "least preferred" from among three alternatives. This provides a full rank ordering of alternatives and therefore more information about the individual's preferences. Following Beggs, Cardell, and Hausman (1981) and Chapman and Staelin (1982), under the assumption of TEV errors, we can extend the model in equation (1) to allow for the full ranking. In our case, this requires a sequence of two probability terms. For example, the probability of observing an individual choosing Alternative A as most preferred and Alternative C as least preferred implies a ranking of A > B > C. The probability of observing this rank ordering is the product of the probability of choosing A from A, B, and C and the probability of choosing B from B and C:

$$\Pr[A > B > C] = \Pr[A \mid A, B, C]\cdot\Pr[B \mid B, C], \tag{2}$$

where: $\Pr[A \mid A, B, C] = \exp(V_A)/[\exp(V_A) + \exp(V_B) + \exp(V_C)]$ and $\Pr[B \mid B, C] = \exp(V_B)/[\exp(V_B) + \exp(V_C)]$.

To incorporate the additional information about each respondent's preferences due to the fact that each survey contains three choice questions, we model the joint probability of observing the sequence of choices an individual makes as the product of individual choice probabilities (*e.g.*, Morey, Rowe, and Watson 1993).

It is widely recognized that the logit probabilities in equations (1) and (2) exhibit the Independence from Irrelevant Alternatives (IIA) property, which restricts the substitution patterns. One model that relaxes this property is the mixed, or random parameters, logit (RPL) model (Train 2003). Layton (2000) used this approach to analyze rankings data, and we extend that approach here to accommodate a sequence of repeated rankings. Like the conditional logit model, the unobserved component of conditional indirect utility is assumed to be distributed as a TEV error term in the RPL model. However, unlike the conditional logit model, which assumes fixed parameters, this model assumes utility parameters are distributed continuously over the population. Consequently, the probabilities in an unordered RPL model must be evaluated over the parameter distributions:

$$\Pr[\text{choose } j] = \pi_j = \int \{\exp(V_j(\boldsymbol{\beta}))/\Sigma_i \exp(V_i(\boldsymbol{\beta}))\} f(\boldsymbol{\beta})\mathrm{d}\boldsymbol{\beta}, \tag{3}$$

for all j and where $f(\boldsymbol{\beta})$ is the probability distribution of the utility parameters $\boldsymbol{\beta}$. To operationalize the model, the probabilities (3) are approximated through simulation. R draws of $\boldsymbol{\beta}$ are taken from $f(\boldsymbol{\beta})$, and the conditional choice probabilities are evaluated at each draw. The simulated probability of choosing the jth alternative is the mean over the R draws:

$$\pi_j^s = (R^{-1})\cdot \sum_{r=1}^{R} \frac{\exp(V_j(\boldsymbol{\beta}^r))}{\sum_k \exp(V_k(\boldsymbol{\beta}^r))}, \tag{4}$$

where $\boldsymbol{\beta}^r$ is the rth coefficient vector draw from the mixing distribution, $f(\boldsymbol{\beta})$. For our sequence of rankings, the individual's simulated likelihood function to be maximized in estimation for our random parameters panel ranking model is:

$$L^s = (R^{-1}) \cdot \Sigma_r \left[\Pi_c \, \Pi_j \, (\pi_{cj}^{\,r})^{d_{cj}}\right], \tag{5}$$

where $\pi_{cj}^{\,r}$ is the simulated probability of observing the jth rank order in the cth choice that takes the form of (2) for the rth random parameter vector draw, the jth rank order is from the set {A>B>C, A>C>B, B>A>C, B>C>A, C>B>A, C>A>B}, and $d_{cj} = 1$ if the individual chooses the jth rank order in the cth choice question and zero otherwise. In this application, we assume the random parameters follow a multivariate normal distribution that allows for correlation between random parameters.

Modeling Preferences for Steller Sea Lion Protection

The choice models assume that preferences for providing additional protection to the western and eastern stocks depend upon the results of the protection on the population sizes and ESA statuses of the stocks. The model acknowledges there are two correlated (though not perfectly correlated) dimensions of resulting protection for each stock, its population size, and ESA status, and therefore simple specifications of the main effects or interaction effects of these attributes are insufficient to adequately describe the data and people's valuations. Instead, the conditional indirect utility of a choice alternative is assumed to be a linear function of the western stock population sizes above the minimum needed to achieve a given ESA status; that is, we assume it is the population "residual" above the minimum required to achieve a given ESA status that yields utility, in addition to the utility associated with achieving an improved ESA status. Note that these minimum thresholds are not explicitly defined for each respondent; rather, they are implicit in the choice alternatives they face in the survey. For instance, an individual respondent may have several choice alternatives in the survey they see that achieves a threatened status for the western stock. It stands to reason that, given that it was not possible to provide information about official threshold levels necessary to change ESA status levels since none had been determined at the time the survey was designed and implemented, the respondent likely assumes that the minimum population threshold for achieving a threatened status is equal to the lowest population size of the threatened choice alternatives they see in the survey.[9]

For a given individual, there are up to three possible "residual" western stock population variables, one for each ESA status: the western population residual associated with an endangered status (EndPop), the residual associated with a threatened status (ThrPop), and the residual associated with a recovered status (RecPop). Since the status quo baseline in the Increasing Version is that the western stock is threatened with a population of 60,000, there are only two residual populations (ThrPop and RecPop). In addition to these residual western stock population variables, utility was assumed to be a function of several dummy variables associated with the western stock ESA statuses (Wstat2 = threatened dummy and Wstat3 = recovered dummy), a larger than expected eastern stock population size (Epop = dummy variable for a population of 80,000 as opposed to 60,000), and income minus the cost of the alternative, which is equivalent to modeling the alternative's

[9] Alternatively, they may assume it is some population size between the largest population size of any choice alternative with an endangered western stock status and the lowest population size of the set of threatened choice alternatives. The minimum threshold level to achieve an endangered status for the western stock is assumed to be the status quo population level in the Decreasing and Stable Versions (26,000 and 45,000, respectively).

cost alone when assuming linear income effects.[10] In the empirical specifications, all parameters except the income minus cost term are allowed to be randomly distributed over the population.[11]

Estimation Results

Using the conditional utility specifications described above, repeated rank-ordered random parameters logit versions of the Decreasing, Stable, and Increasing models were estimated using simulated maximum likelihood methods in GAUSS.[12] Quasi-random numbers are used in lieu of pseudo-random numbers to generate draws from the normal distribution in constructing simulated probabilities. Recent research has shown that using quasi-random number sequences like Halton sequences instead of draws from a pseudo-random number generator can lead to more accurate and precise simulated probabilities with fewer iterations (Bhat 2001, 2003; Train 2000). In this application, the simulation of probabilities in the RPL models is based on 150 randomized Halton draws. Proposed by Bhat (2003) and based on work by Tuffin (1996), randomized Halton draws are Halton draws with random numbers added to them, which introduces randomness into the otherwise deterministic sequence.[13]

Estimation results for the Decreasing, Stable, and Increasing models are presented in table 4. Each model fit the respective choice data reasonably well. Likelihood ratio indices, which are often used as measures of goodness-of-fit in discrete choice models, are 0.295, 0.268, and 0.288, respectively, for the Decreasing, Stable, and Increasing Versions. The sign and significance of the model parameters suggest a context-specific effect in each model based on the expected future baseline (*i.e.*, what ESA status and population size the western stock will achieve in 60 years under current protection). Respondents appear to hold values for programs that improve conditions to the next one or two levels from the status quo future baseline ESA status level, but exhibit an apparent "wait and see" attitude towards spending for multiple status level improvements. For example, in the Decreasing Version there is value to increasing the western stock population if the status remains endangered (positive EndPop parameter) and to improving conditions to reach a threatened status level (positive Wstat2 parameter). However, there is diminished marginal value to a program that increases populations once at a threatened status level or to the recovered status level (since the magnitudes of WStat3 and ThrPop are less than WSstat2 and EndPop, respectively). Similarly, for the Stable Version there is value to increasing the western stock population size while in an endangered status and to undertaking improvements that result in achieving a threatened status or recovered status level. However, there is little or no value, at present, for increases in stocks within the improved status levels. For the Increasing Version, further improvements to the western stock while at the threatened level and improving to a recovered status, adds value, but improving stocks beyond the minimum level required to reach the recovered status adds little or no additional value.

---

[10] We investigated the role of income effects on preferences and welfare estimates, but did not find statistically significant non-linear income effects.

[11] Restricting the income minus cost term to be a fixed parameter in a linear income effects specification implies the welfare measures have a closed form and a more straightforward interpretation than if it were randomly distributed. Alternative specifications that account for non-linear income effects and demographic-based heterogeneity of income effects were estimated, but do not lead to significantly different results.

[12] Pooled data models were estimated, but pooling was rejected.

[13] A randomized Halton sequence is constructed as follows. For each Halton sequence consisting of numbers between 0 and 1, we add a random number between 0 and 1. If any number in the new sequence is greater than 1, we subtract one to get a number in [0,1].

Also note that the model results suggest that preferences for initial improvements to the western stock population size and status vary over the population, as indicated by large and significant estimated standard deviations on the random parameters associated with these improvements. For example, the standard deviation on the WSTAT2 random parameter is larger in magnitude than the mean parameter estimate in both the Decreasing and Stable Version models. This result indicates the presence of individuals who have strong preferences for protecting Steller sea lions, as well as those with strong preferences for not providing additional protection to the species.

Table 4
Estimation Results

Random Parameter Mean Random Parameter Std. Dev.	Decreasing Version		Stable Version		Increasing Version	
	Estimate	Asy. T-value	Estimate	Asy. T-value	Estimate	Asy. T-value
Western stock is threatened dummy variable (WSTAT2)	2.47817 4.56234	10.76573 13.1196	1.94421 2.9824	11.65638 14.50215	–	–
Western stock is recovered dummy variable (WSTAT3)	2.30689 1.17599	4.83404 1.39657	2.52087 -1.97212	8.45649 -4.3139	1.96102 2.72787	7.09831 6.74361
W. stock population residual for endangered status (ENDPOP)	0.08119 0.02505	12.16974 2.55294	0.10383 -0.05528	6.90103 –2.36026	–	–
W. stock population residual for threatened status (THRPOP)	0.01714 –0.0019	3.07845 –0.12868	–0.01667 0.0007	–3.48593 0.05268	0.08709 0.09676	9.36422 8.38644
W. stock population residual for recovered status (RECPOP)	0.00147 –0.01254	0.13689 –0.93137	–0.01789 –0.00827	–2.45925 –0.56322	0.00884 0.0118	1.26077 0.94282
Eastern stock has population of 80,000 dummy variable (EPOP)	0.35287 –0.04929	3.30729 –0.14362	0.68995 –0.02351	5.90479 –0.05867	0.67988 –0.22552	5.56024 –0.61935
Annual household cost (COST)	–0.01756	–14.8616	–0.01448	–18.3324	–0.02500	–13.2796
Sample size	717		648		587	
Maximized log-likelihood value	–2,719.93		–2,552.91		–2,249.47	
AICc	6,623.58		5,964.68		5,087.85	
BIC	5,623.95		5,287.09		4,594.57	

Notes: Estimates of the off-diagonal elements of the Choleski decomposition of the estimated random parameters covariance matrix are excluded from the table but are available upon request from the first author. AICc is the Akaike Information Criterion with a second-order correction for sample size. BIC is the Bayes Information Criterion.

Economic Benefits of Additional Protection for Steller Sea Lions Under Alternative Baseline Futures

The WTP results presented here are for a representative sample of U.S. households and thus are appropriate WTP estimates for a national valuation of public preferences toward additional protection of Steller sea lions. The welfare measures represent a U.S. household's annual WTP for the incremental change in the ESA listing status and population size of the western stock and the population size of the eastern stock from the status quo. When the marginal utility of money is constant and the compensating variation (CV) of a change from the status quo to an alternative state of the world is desired, the expected WTP is measured by $CV = (-1/\gamma)\cdot(V^1 - V^0)$. In this equation, V^0 is the conditional indirect utility evaluated at the original (status quo) levels, and V^1 is the conditional indirect utility under the alternative (improved) state of the world.

Table 5 displays mean annual household WTP estimates and associated 95% confidence intervals calculated for four hypothetical policy scenarios related to the western stock, which were selected as a reasonable subset of possible policy scenarios of interest.[14] Scenario 1 corresponds to the case where the western stock remains at its current level (45,000) and status (endangered). In Scenario 2, a population of 50,000 western stock sea lions results in 60 years, but the status remains endangered. In Scenario 3, the western stock population increases to 70,000, a level assumed to be beyond the minimum population needed to achieve a threatened status. The final scenario (Scenario 4) represents the case where the western stock reaches a population size of 90,000, a level assumed to be above the level needed to be removed from the ESA list of threatened and endangered species (*i.e.*, the western stock recovers). Under each scenario, WTP is calculated assuming the eastern stock is recovered, but alternatively with a (a) 60,000 or (b) 80,000 population size. Note that the first two scenarios cannot be valued using the Increasing Version results since the baseline in that version assumes a threatened status for the western stock and only improvements are being valued; likewise, the Stable model cannot be used to calculate WTP for Scenario 1(a) since that is its baseline scenario (and hence has a value of $0).

For the Decreasing Version welfare estimates, and for a given eastern stock population, the mean annual household WTP for maintaining the western stock at its present-day population size and an endangered level (Scenario 1) is lower than the mean WTP for achieving a higher population (Scenario 2), which reflects that individuals value more endangered sea lions to fewer. The mean WTP estimates for the endangered scenarios are likewise lower than the mean WTP for achieving a threatened status (Scenario 3), which is also consistent with our expectations. The mean WTP for a recovered status (Scenario 4), however, is lower than that for a threatened status. Importantly, the WTP of Scenarios 3 and 4 are not statistically different, suggesting that there may be leveling off of WTP in this range. Across all scenarios in the Decreasing Version, respondents were willing to pay about $20 more, on average, for a situation where the eastern stock has an increased population of 20,000 more sea lions than under the baseline (suggesting an additional 1,000 eastern stock sea lions is worth about $1 to the average household when the western stock is expected to decline).

The Stable Version welfare estimates follow a similar pattern. The mean annual household WTP for Scenario 1(b) is lower than for Scenario 2(b), again reflecting that individuals value programs that lead to more sea lions when in the endangered status. The mean WTP estimates for the endangered scenarios are also less than the mean WTP for achieving a threatened status (Scenario 3). In contrast to the Decreasing Version,

[14] The estimated conditional utility functions can be used to evaluate numerous possible improvements to the western stock status and population, so long as the population sizes and status levels are within the range estimated in the model (*i.e.*, the levels are within the experimental design).

however, the WTP for a recovered western stock is larger than the WTP for a threatened western stock. This may not be surprising given the fact that the Stable Version has as its baseline a larger western stock population size, so, in principle, programs that lead to a recovered status do not have as far to go as in the Decreasing Version. This is mitigated, to an extent, by the fact that the WTP for Scenarios 3 and 4 are not statistically different, which again suggests that respondents are willing to pay for small to modest improvements, but are less likely to pay even more for larger programs that promise dramatic changes. In this version, respondents were willing to pay about $48 more for situations that would lead to the eastern stock having a larger population size at the end of 60 years. In addition, the $48 premium for the higher eastern stock population suggests that when the western stock is stable, eastern stock sea lions are worth more (about $2.40 per 1,000 sea lions), suggesting respondents felt it is of increased importance to protect the eastern stock while the western stock is endangered but stable.

Only Scenarios 3 and 4 can be valued for the Increasing Version. Mean WTP estimates are generally much lower than the mean WTP calculated from the Decreasing and Stable Versions, which reflects the fact that the Increasing Version has a status quo baseline that assumes the western stock will reach 60,000 and a threatened status, and as a result, the population and status changes in nominal terms are less than under either the Decreasing or Stable Versions. Additionally, respondents were willing to pay about $27 more for programs that lead to 20,000 more eastern stock sea lions than under the baseline at the end of 60 years (about $1.35 per 1,000 sea lions). This is lower than the WTP for the eastern stock in the Stable Version, but higher than the WTP for the eastern stock in the Decreasing Version.

Formal Testing of WTP Differences

One may be tempted to evaluate significant differences between the WTP estimates from the survey versions by looking at whether the 95% confidence bounds on mean WTP do not overlap. However, as Poe, Severance-Lossin, and Welsh (1994) have discussed, non-overlapping confidence intervals are biased indicators of the significance of differences in estimated means. To formally test for WTP differences between baseline versions, we use the approach suggested by Poe, Giraud, and Loomis (2005) to develop precise confidence bounds for the difference between the mean WTP estimates for the three baseline surveys. We use a complete combinatorial convolution approach that involves empirically estimating the confidence interval around the difference of the mean WTP values. This is accomplished by computing every possible difference between WTP values in each iteration of the Krinsky-Robb simulation used to empirically simulate the welfare measures. This is a computationally intensive, but precise, method for estimating the difference between two (independent) WTP distributions.[15]

These results, shown in table 6, support the argument that different assumed baseline futures for Steller sea lions affect WTP for protection. Significant differences, as indicated by confidence intervals for the difference in mean WTP estimates that do not contain $0, were found for small improvements to Steller sea lion protection between the Decreasing and Stable Versions, between the Decreasing and Increasing Versions, and between the Stable and Increasing Versions. Significant positive differences in WTP were not found for larger improvements to Steller sea lions. For instance, positive and significant differences between the Decreasing and Stable Versions were found for Scenarios 1 and 2, but not 3 or 4. In fact, in the case of Scenario 4, the difference is significantly negative, indicating the mean WTP for the scenario is larger in the Stable Version compared to the Decreasing Version. A similar pattern of significance is found for differences between the Decreasing and Increasing Versions.

---

[15] On a 2.6 Ghz Pentium-based PC, the calculation of the confidence interval around the difference in means between survey versions took a little over two hours to run.

Table 5
Mean Annual Household WTP for Several Hypothetical Policy Scenarios Representing Improvements to Steller Sea Lions

Scenario in 60 Years	Decreasing Version Western Stock Declines to 26,000 and Remains Endangered	Stable Version Western Stock Remains at 45,000 and Remains Endangered	Increasing Version Western Stock Increases to 60,000 and is Threatened
Scenario 1. Maintain western stock population at 45,000 and endangered			
(a) Assuming eastern stock is 60,000	**$87.89** ($72.55, $105.55)	**$0**	n/a
(b) Assuming eastern stock is 80,000	**$108.22** ($88.32, $128.00)	**$47.55** ($32.88, $62.87)	n/a
Scenario 2. Western stock population increases to 50,000 and is endangered			
(a) Assuming eastern stock is 60,000	**$111.12** ($91.95, $131.65)	**$35.81** ($26.33, $45.48)	n/a
(b) Assuming eastern stock is 80,000	**$131.10** ($108.57, $156.02)	**$83.79** ($65.98, $101.01)	n/a
Scenario 3. Western stock increases to 70,000 and is threatened			
(a) Assuming eastern stock is 60,000	**$151.13** ($128.02, $175.48)	**$123.02** ($101.96, $144.63)	**$34.94** ($29.03, $41.16)
(b) Assuming eastern stock is 80,000	**$170.99** ($142.87, $199.76)	**$170.50** ($140.00, $201.07)	**$62.17** ($50.30, $74.53)
Scenario 4. Western stock increases to 90,000 and is recovered			
(a) Assuming eastern stock is 60,000	**$132.11** ($93.40, $168.65)	**$155.16** ($126.28, $182.61)	**$83.80** ($66.73, $100.94)
(b) Assuming eastern stock is 80,000	**$153.95** ($105.50, $199.37)	**$204.24** ($165.46, $239.48)	**$111.53** ($91.83, $131.74)

Notes: 95% confidence intervals are calculated using the simulation method of Krinsky and Robb (1986) using 1,000 draws. Welfare calculations associated with Scenarios 3 and 4 assume the minimum threshold population sizes of a threatened status for the western stock is 60,000, and 75,000 for a recovered status.

Table 6
95% Confidence Intervals for Differences in Mean WTP

Scenario in 60 Years	Decreasing vs. Stable $E[WTP^d]–E[WTP^s]$	Decreasing vs. Increasing $E[WTP^d]–E[WTP^i]$	Stable vs. Increasing $E[WTP^s]–E[WTP^i]$
Scenario 1. Maintain western stock population at 45,000 and endangered			
(a) Assuming eastern stock is 60,000	($75.06, $114.48)*	n/a	n/a
(b) Assuming eastern stock is 80,000	($26.50, $97.99)*	n/a	n/a
Scenario 2. Western stock population increases to 50,000 and is endangered			
(a) Assuming eastern stock is 60,000	($49.32, $102.36)*	n/a	n/a
(b) Assuming eastern stock is 80,000	($9.24, $79.14)*	n/a	n/a
Scenario 3. Western stock increases to 70,000 and is threatened			
(a) Assuming eastern stock is 60,000	(–$12.25, $76.40)	($92.79, $157.29)*	($60.17, $125.53)*
(b) Assuming eastern stock is 80,000	(-$43.77, $45.62)	($81.57, $151.11)*	($82.22, $147.72)*
Scenario 4. Western stock increases to 90,000 and is recovered			
(a) Assuming eastern stock is 60,000	(–$192.41, –$16.60)	(–$115.35, $36.16)	($7.19, $123.25)*
(b) Assuming eastern stock is 80,000	(–$217.33, –$55.04)	(–$119.22, $20.43)	($32.84, $139.82)*

Notes: Confidence intervals are calculated using the full combinatorial version of the method of convolutions approach of Poe, Giraud, and Loomis (2005). * Denotes significant differences in means, such that zero is not contained in the confidence interval.

Discussion

In this study, different survey versions were developed and implemented to enable calculation of WTP under different, but distinct, futures for the Steller sea lion. Since the future population and overall health of a species are unknown when policy decisions are made, it is important to understand how future supply uncertainty affects economic values for species protection. To this end, we bound the effects of supply uncertainty by generating estimates of WTP in the context of supply certainty for multiple states of nature, which differs from much of the empirical literature that addresses supply uncertainty in welfare measures of changes to non-market goods (Cameron 2005; Roberts, Boyer, and Lusk 2008; Whitehead 1992).

The results here suggest preferences for enhanced protection of the western and eastern stocks of Steller sea lions depend upon the predicted future state of the western stock, as mean WTP values for additional Steller sea lion protection calculated using the Increasing Version model are significantly less than the mean WTP values for the Stable Version for achieving the same level of improvements. Moreover, Decreasing and Stable Version welfare measures, as well as Decreasing and Increasing Version welfare measures, were statistically different for small improvements, with the Decreasing values being larger, but appear to converge to values that are statistically indistinguishable for larger improvements, which is suggestive of a finite limit on households' WTP for additional Steller sea lion protection under both baseline futures. For the Decreasing and Stable Versions, this limit is in the $150 per household per year range when the eastern stock population is 60,000 and about $200 per household when the eastern stock has a population of 80,000. The difference between the Decreasing and Stable Versions in this regard appears to be at what improvement level WTP levels off. For the Decreasing Version, WTP appears to level off earlier, when the western stock is improved to a Threatened status, while in the Stable Version WTP appears to level off when the stock is recovered.

While the focus of this article is on whether there is WTP sensitivity to different baseline futures, the comparison can be interpreted as a type of scope test (Carson and Mitchell 1995; Carson 1997). This is important since scope tests are rarely done in the context of choice experiments (see Lew and Wallmo [2010]). Since the versions differ only in the assumed future population size and status of the western stock under the status quo level of protection (and the differences are ordinal), one could interpret the examination of welfare estimates associated with scenarios leading to the same population and ESA status as between-sample, or "external," tests of scope. Viewed in this light, scope sensitivity is present in the 10 comparisons where there are positive and significant differences in WTP (table 6). The remaining comparisons, which do not support scope sensitivity, reflect comparisons for large improvements where the WTP function appears to flatten out. As such, we do not consider these cases failures of scope sensitivity, but rather a reflection of diminishing marginal utility for population increases well above current levels.

These results generally support the idea that people are willing to pay for incremental improvements (small- to modest-scale enhanced species protection programs), but appear to get diminished utility from large-scale improvements, perhaps as a result of the greater uncertainty that such large, wholesale improvements can be feasibly implemented.[16] The diminishing utility associated with larger improvements is consistent with convex preferences for protection (see Rollins and Lyke [1998] for a useful discussion) and suggests sensitivity to internal scope effects in the results. Another possible explanation is that given the long time horizon (60 years in the survey), respondents may only wish to get the species back on track in the near-term, as opposed to "fixing" the whole problem all

[16] Uncertainty related to the success of the protection programs was not included in the survey—program results were presented as certain. The extent to which respondents introduced uncertainty into the provision of the program results remains an open question and a topic for future research.

at once. Yet another possibility is a "wait and see" mentality—people may wish to make small changes, then wait to see how the changes work out before spending more money on improvements. As a whole, these observations point to the fact that respondents likely have more complex and nuanced preferences that incorporate dynamic processes and elements of uncertainty than can be fully understood in this study. Future research to better understand the structure of these preferences seems clearly warranted.

Another key point to emphasize is that welfare values for numerous potential improvements to the Steller sea lion can be determined from the estimated valuation functions. The welfare estimates in table 5 are just a few of the possible scenarios that can be valued. This is an appealing feature of the CE approach and, together with the fact that there are different valuation functions associated with different possible baseline futures for Steller sea lions, provides considerable flexibility in generating estimates of public values for enhanced Steller sea lion protection. To properly aggregate these welfare estimates, one needs to carefully consider the influence of sampling and response rates, sample representativeness, the geographic extent of the market, and the potential influence of factors such as physical distance from the good being valued on WTP values, issues that are beyond the scope of this research, and consequently, aggregation is left for subsequent work.

This study characterizes the results of enhanced protection of Steller sea lions in terms of population sizes and statuses achieved, but another possible dimension to measure the improvements to the species is by reductions in the probabilities, or risks, of extinction. Changes in extinction risks are obviously correlated with population and status levels, and their use as an attribute in the CE introduces uncertainty into the valuation exercise itself, which adds its own challenges both in measurement and interpretation terms. Nevertheless, given that it is possible respondents implicitly view changes in population sizes and status as changes in the risks of extinction, it may be worthwhile to explore in the future how these changes in risk affect preferences and whether there is added value to risk as an attribute compared to the approach followed here.

References

Adamowicz, W., P. Boxall, M. Williams, and J. Louviere. 1998. Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. *American Journal of Agricultural Economics* 80:64–75.

Adamowicz, W., J. Louviere, and M. Williams. 1994. Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities. *American Journal of Agricultural Economics* 26:271–92.

Alpizar, F., F. Carlsson, and P. Martinsson. 2003. Using Choice Experiments for Non-Market Valuation. *Economic Issues* 8(1):83–110.

Beggs, S., S. Cardell, and J. Hausman. 1981. Assessing the Potential Demand for Electric Cars. *Journal of Econometrics* 16:1–19.

Bhat, C.R. 2001. Quasi-Random Maximum Simulated Likelihood Estimation of the Mixed Multinomial Logit Model. *Transportation Research Part B* 35(7):677–93.

_____. 2003. Simulation Estimation of Mixed Discrete Choice Models Using Randomized and Scrambled Halton Sequences. *Transportation Research Part B* 37(9):837–55.

Boyle, K.J., and R.C. Bishop. 1987. Valuing Wildlife in Benefit-cost Analyses: A Case Study Involving Endangered Species. *Water Resources Research* 23(5):943–50.

Bunch, D.S., J.J. Louviere, and D. Anderson. 1996. A Comparison of Experimental Design Strategies for Multinomial Logit Models: The Case of Generic Attributes. University of California, Davis, Graduate School of Management Working Paper #11–96.

Cameron, T.A. 2005. Individual Option Prices for Climate Change Mitigation. *Journal of Public Economics* 89:283–301.

Carson, R.T. 1997. Contingent Valuation Surveys and Tests of Insensitivity to Scope. *Determining the Value of Non-Marketed Goods: Economic, Psychological, and Policy Relevant Aspects of Contingent Valuation Methods,* R.J. Kopp, W. Pommerhene, and N. Schwartz, eds. Boston, MA: Kluwer.

Carson, R.T., and R.C. Mitchell. 1995. Sequencing and Nesting in Contingent Valuation Surveys. *Journal of Environmental Economics and Management* 28:155–73.

Chapman, R.G., and R. Staelin. 1982. Exploiting Rank Ordered Choice Set Data within the Stochastic Utility Model. *Journal of Marketing Research* 19(3):288–301.

Desvousges, W.H., V.K. Smith, and A. Fisher. 1987. Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River. *Journal of Environmental Economics and Management* 14:248–67.

Dillman, D.A. 2007. *Mail and Internet Surveys: The Tailored Design Method.* 2nd ed. New York: John Wiley & Sons.

Edwards, S.F. 1988. Option Prices for Groundwater Protection. *Journal of Environmental Economics and Management.* 15:475–87.

Ferrini, S., and R. Scarpa. 2007. Designs with *A Priori* Information for Nonmarket Valuation with Choice Experiments: A Monte Carlo Study. *Journal of Environmental Economics and Management*. 53:342–63.

Gerber, L.R., and G.R. VanBlaricom. 2001. Implications of Three Viability Models for the Conservation Status of the Western Population of Steller Sea Lions (*Eumetopias jubatus*). *Biological Conservation* 102:261–69.

Giraud, K., B. Turcin, J. Loomis, and J. Cooper. 2002. Economic Benefits of the Protection Program for the Steller Sea Lion. *Marine Policy* 26(6):451–58.

Hanley, N., R.E. Wright, and W. Adamowicz. 1998. Using Choice Experiments to Value the Environment: Design Issues, Current Experience, and Future Prospects. *Environmental and Resource Economics* 11(3-4):413-28.

Huber, J., and K. Zwerina. 1996. The Importance of Utility Balance in Efficient Choice Designs. *Journal of Marketing Research* 33:307–17.

Jakobsson, K.M., and A.K. Dragun. 2001. The Worth of a Possum: Valuing Species with the Contingent Valuation Method. *Environmental and Resource Economics* 19:211–27.

Krinsky, I., and A.L. Robb. 1986. On Approximating the Statistical Properties of Elasticities. *Review of Economics and Statistics* 68:715–19.

Layton, D.F. 2000. Random Coefficient Models for Stated Preference Surveys. *Journal of Environmental Economics and Management* 40:21–36.

Layton, D.F., and R.A. Levine. 2005. Bayesian Approaches to Modeling Stated Preference Data. *Applications of Simulation Methods in Environmental and Resource Economics*, R. Scarpa and A. Alberini, eds. Dordrecht, The Netherlands: Springer.

Lew, D.K., and K. Wallmo. 2010. External Tests of Scope and Embedding in Stated Preference Choice Experiments: An Application to Endangered Species Valuation. Working paper, National Marine Fisheries Service.

Loomis, J.B., and D.S. White. 1996. Economic Benefits of Rare and Endangered Species: Summary and Meta-analysis. *Ecological Economics* 18:197-206.

Lusk, J.L., and F.B. Norwood. 2005. Effect of Experimental Design on Choice-Based Conjoint Valuation Estimates. *American Journal of Agricultural Economics* 87(3):771-85.

Morey, E.R., R.D. Rowe, and M. Watson. 1993. A Repeated Nested Logit Model of Atlantic Salmon Fishing. *American Journal of Agricultural Economics* 75(3):578–92.

National Marine Fisheries Service. 2008. *Recovery Plan for the Steller Sea Lion* (Eumetopias jubatus), *Revision*. National Marine Fisheries Service, Silver Spring, MD.

National Oceanic and Atmospheric Administration. 1997. Threatened Fish and Wildlife: Change in Listing Status of Steller Sea Lions under the Endangered Species Act. *Federal Register* 62(86):24345–55.

Olar, M., W. Adamowicz, P. Boxall, and G.E. West. 2007. Estimation of the Economic Benefits of Marine Mammal Recovery in the St. Lawrence Estuary. Report to the Policy and Economics Branch, Fisheries and Oceans Canada, Regional Branch, Quebec.

Poe, G.L., K.L. Giraud, and J.B. Loomis. 2005. Computational Methods for Measuring the Difference of Empirical Distributions. *American Journal of Agricultural Economics* 87(2):353–65.

Poe, G.L., E.K. Severance-Lossin, and M.P. Welsh. 1994. Measuring the Difference (X-Y) of Simulated Distributions: A Convolutions Approach. *American Journal of Agricultural Economics* 76(4):904–15.

Richardson, L. and J. Loomis. 2009. The Total Economic Value of Threatened, Endangered and Rare Species: An Updated Meta-Analysis. *Ecological Economics* 68:1535–48.

Roberts, D.C., T.A. Boyer, and J.L. Lusk. 2008. Preferences for Environmental Quality under Preference Uncertainty. *Ecological Economics* 66(4):584–93.

Rollins, K., and A. Lyke. 1998. The Case for Diminishing Marginal Existence Values. *Journal of Environmental Economics and Management* 36:324–44.

Rudd, M. 2009. National Values for Regional Aquatic Species at Risk in Canada. *Endangered Species Research* 6:239–49.

Sandor, Z., and M. Wedel. 2001. Designing Conjoint Choice Experiments Using Managers' Prior Beliefs. *Journal of Marketing Research* 38:430–44.

Train, K.E. 2000. Halton Sequences for Mixed Logit. Working paper #E00-278, Department of Economics, University of California, Berkeley.

_____. 2003. *Discrete Choice Methods with Simulation*. New York, NY: Cambridge University Press.

Tuffin, B. 1996. On the Use of Low-frequency Sequences in Monte Carlo Methods. *Monte Carlo Methods and Applications* 2:295–320.

Whitehead, J.C. 1992. *Ex Ante* Willingness to Pay with Supply and Demand Uncertainty: Implications for Valuing a Sea Turtle Protection Programme. *Applied Economics* 24:981–88.

Winship, A.J., and A.W. Trites. 2006. Risk of Extirpation of Steller Sea Lions in the Gulf of Alaska and Aleutian Islands: A Population Viability Analysis Based on Alternative Hypotheses for Why Sea Lions Declined in Western Alaska. *Marine Mammal Science* 22(1):124–55.