Contributed Paper

Public Willingness to Pay for Recovering and Downlisting Threatened and Endangered Marine Species

KRISTY WALLMO* AND DANIEL K. LEW†

*Office of Science and Technology, SSMC III, F/ST5 Economics and Social Analysis Division, 1315 East West Highway, Silver Spring, MD 20910, U.S.A., email kristy.wallmo@noaa.gov

†Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Building 4, Seattle, WA 98115, U.S.A., and Department of Agricultural and Resource Economics, University of California, Davis, CA 95616, U.S.A.

Abstract: *Nonmarket valuation research has produced economic value estimates for a variety of threatened, endangered, and rare species around the world. Although over 40 value estimates exist, it is often difficult to compare values from different studies due to variations in study design, implementation, and modeling specifications. We conducted a stated-preference choice experiment to estimate the value of recovering or downlisting 8 threatened and endangered marine species in the United States: loggerhead sea turtle (Caretta caretta), leatherback sea turtle (Dermochelys coriacea), North Atlantic right whale (Eubalaena glacialis), North Pacific right whale (Eubalaena japonica), upper Willamette River Chinook salmon (Oncorhynchus tshawytscha), Puget Sound Chinook salmon (Oncorhynchus tshawytscha), Hawaiian monk seals (Monachus schauinslandi), and smalltooth sawfish (Pristis pectinata). In May 2009, we surveyed a random sample of U.S. households. We collected data from 8476 households and estimated willingness to pay for recovering and downlisting the 8 species from these data. Respondents were willing to pay for recovering and downlisting threatened and endangered marine taxa. Willingness-to-pay values ranged from $40/household for recovering Puget Sound Chinook salmon to $73/household for recovering the North Pacific right whale. Statistical comparisons among willingness-to-pay values suggest that some taxa are more economically valuable than others, which suggests that the U.S. public's willingness to pay for recovery may vary by species.*

Keywords: choice experiment, economics, marine mammals, nonmarket valuation, threatened species, willingness to pay

Disponibilidad del Público para Pagar por la Recuperación y Reclasificación de Especies Marinas Amenazadas y en Peligro

Resumen: *La valoración extra mercado ha producido estimaciones del valor económico de una variedad de especies amenazadas, en peligro de extinción y raras en todo el mundo. Aunque existen más de 40 estimaciones de valor, a menudo es difícil comparar los valores de diferentes estudios debido a variaciones en el diseño, implementación y especificaciones del modelo del estudio. Realizamos un experimento de selección de opciones declarada para estimar el valor de la recuperación o reclasificación de 8 especies marinas amenazadas y en peligro de extinción en los Estados Unidos: Caretta caretta, Dermochelys coriacea, Eubalaena glacialis, Eubalaena japonica, Oncorhynchus tshawytscha, Monachus schauinslandi y Pristis pectinata. En mayo 2009 realizamos un muestreo aleatorio de hogares en E.U.A. Recolectamos datos de 8746 hogares y estimamos la disponibilidad para pagar por la recuperación y reclasificación de 8 especies. Los encuestados estaban dispuestos a pagar por la recuperación y reclasificación de taxa marinos amenazados y en peligro de extinción.*

Paper submitted September 7, 2011; revised manuscript accepted March 15, 2012.

Conservation Biology, Volume 26, No. 5, 830–839

DOI: 10.1111/j.1523-1739.2012.01899.x

Los valores de la disponibilidad para pagar variaron de $40/hogar para la recuperación de Oncorhynchus tshawytscha a $73/hogar para la recuperación de Eubalaena japonica. La comparación estadística entre los valores de disponibilidad para pagar sugiere que algunos taxa son más valiosos económicamente que otros, lo cual sugiere que la disponibilidad del público de E.U.A. para pagar por la recuperación puede variar por especie.

Palabras Clave: disponibilidad para pagar, economía, especies amenazadas, experimento de selección, mamíferos marinos, valoración extra mercado

Introduction

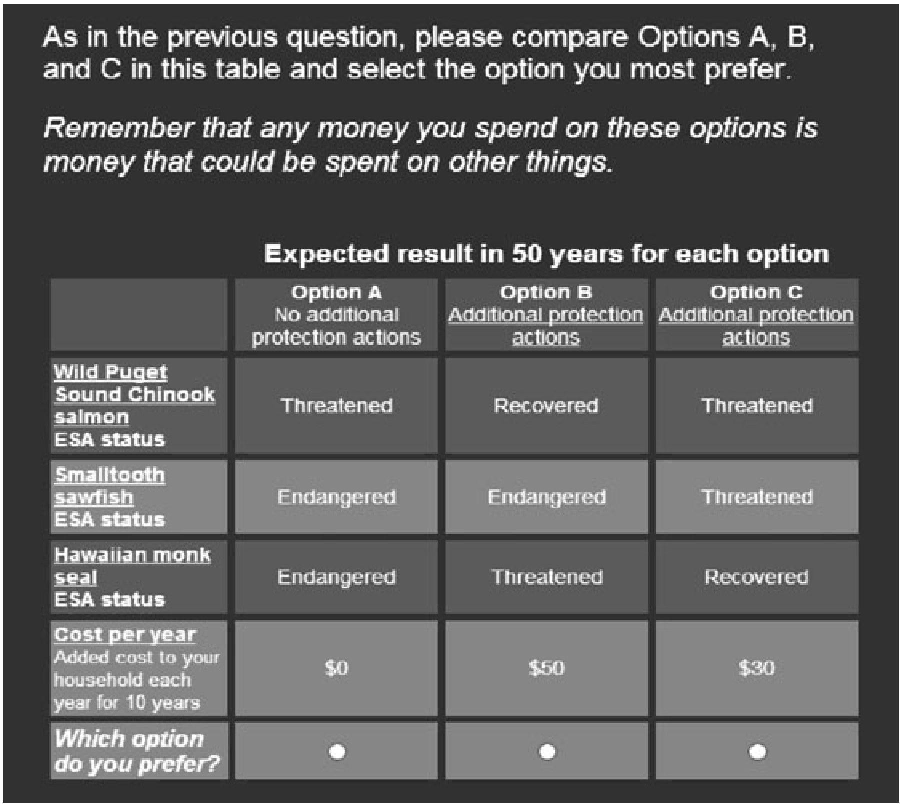
Methods for estimating the value of threatened and endangered species have been evolving since 1988, when Bowker and Stoll (1988) estimated the value of conserving the Whooping Crane (*Grus americana*), a species listed as endangered in 1988 under the U.S. Endangered Species Act. Contingent valuation, one of the earliest methods used by economists to estimate the value of nonmarket goods and services, is a stated-preference method in which survey-based methods are applied to simulate a market situation and elicit survey respondents' willingness to pay for (or willingness to accept) a change in the quality or quantity of a nonmarket good.

In applying the contingent valuation method to an endangered species, Bowker and Stoll (1988) built on previous work that examined specific limitations of the technique (Hanemann 1984). They improved the method by testing the sensitivity of willingness-to-pay estimates, a measure of economic value, to different specifications of the probit and logit models. Subsequent research on issues such as hypothetical bias (the potential bias introduced by not compelling an actual payment) (Berrens et al. 2002; Murphy et al. 2005; Johnston 2006), scope and embedding effects (the potential for respondents' preferences to be insensitive to the magnitude of the change described in the simulated market) (Bateman et al. 2004; Heberlein et al. 2005; Lew & Wallmo 2010), elicitation formats (the specific type of question used to elicit willingness to pay or willingness to accept) (Brown et al. 1996; Champ et al. 1997), and the effect of substitutes (the effect that other similar goods may have on the survey respondents' willingness to pay or willingness to accept) (Whitehead & Blomquist 1999; Loureiro & Ojea 2008; Ojea & Loureiro 2009) has led to improved survey protocols and consequently enhanced credibility of value estimates derived from contingent valuation and other stated-preference methods.

Stated-preference methods have received considerable attention in the academic literature, garnering both support and criticism from philosophical (Ehrenfeld 1988) and economic perspectives (Diamond & Hausman 1994; Hanemann 1994). Despite criticisms, there is general consensus that stated-preference methods are the only way to estimate nonuse economic values, which have utility for policy analyses concerning environmental goods and services. To date, economic values have been estimated for more than 25 species listed under the U.S. Endangered Species Act. Many of these values were documented by Richardson and Loomis (2009) in a meta-analysis. It is generally difficult, however, to directly compare nonuse economic values among studies because of variation in the unit of observation (e.g., household or individual), payment frequencies, size and type of species-level or population-level change (e.g., doubling the population size, preventing extinction, and reducing the risk of extinction), and model specification (for example, how the model treats heterogeneity among respondents) (Brouwer 2000). In addition, studies may vary in the quantity and quality of information they provide, which may bias respondents' willingness to pay or willingness to accept (Hoehn & Randall 2002). This kind of information bias can prevent a comparison of value estimates even among studies that focus on the same species.

Because of the differences in study design, questions related to preference ordering among species (i.e., whether some species are more highly valued than others) have been addressed primarily through meta-analyses. For example, in a meta-analysis of 31 studies on threatened, endangered, or rare species, Richardson and Loomis (2009) found that fishes, marine mammals, and birds yield higher willingness-to-pay values than other taxonomic groups and that charismatic or high-profile species yield higher willingness-to-pay values than noncharismatic species. In a meta-analysis focused on funds spent to recover species, Metrick and Weitzman (1996) conclude that spending on charismatic species may be higher than spending on species that are not seen as charismatic and that mammalian species receive more recovery spending than nonmammalian species.

We conducted a stated-preference choice experiment, a multiattribute extension of the traditional contingent valuation method, to estimate the economic value of recovery and downlisting (i.e., improving an endangered species' status to "threatened") of 8 marine taxa: upper Willamette River Chinook salmon (*Oncorhynchus tshawytscha*), threatened; Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), threatened; loggerhead sea turtle (*Caretta caretta*), threatened; leatherback sea turtle (*Dermochelys coriacea*), endangered; North Atlantic right whale (*Eubalaena glacialis*), endangered; North Pacific right whale (*Eubalaena japonica*),



As in the previous question, please compare Options A, B, and C in this table and select the option you most prefer.

Remember that any money you spend on these options is money that could be spent on other things.

Expected result in 50 years for each option

	Option A No additional protection actions	**Option B** Additional protection actions	**Option C** Additional protection actions
Wild Puget Sound Chinook salmon ESA status	Threatened	Recovered	Threatened
Smalltooth sawfish ESA status	Endangered	Endangered	Threatened
Hawaiian monk seal ESA status	Endangered	Threatened	Recovered
Cost per year Added cost to your household each year for 10 years	$0	$50	$30
Which option do you prefer?	●	●	●

Figure 1. Example of a choice-task question from the multispecies stated-preference choice experiment.

endangered; Hawaiian monk seal (*Monachus schauinslandi*), endangered; and smalltooth sawfish (*Pristis pectinata*), endangered. A stated-preference choice experiment that includes multiple species facilitates statistical comparisons of willingness to pay because it maintains consistency among aspects of study design and model structure. This work is one of the small number of studies in which a stated-preference choice experiment was applied (e.g., Olar et al. 2007; Rudd 2009; Wallmo & Lew 2011) and 1 of 3 stated-preference choice experiments that we are aware of that compares values for different taxonomic groups (Rudd 2009; Wallmo & Lew 2011).

Although contingent valuation has been the traditional method for valuing threatened and endangered species, several authors have used stated-preference choice experiments (Olar et al. 2007; Rudd 2009; Wallmo & Lew 2011). Stated-preference choice experiments may limit yea-saying (expressing preferences that may be perceived as socially desirable or as in agreement with the interviewer rather than true preferences) (Brown et al. 1996; Ready et al. 1996) because the all-or-nothing choice faced in traditional contingent valuation is eliminated (Mitchell & Carson 1989) (Fig. 1). Potential advantages of stated-preference choice experiments over contingent valuation include the ability to estimate the value of individual attributes that make up a good and the opportunity to identify marginal values of attributes (Hanley et al. 1998). For threatened and endangered species, this flexibility can allow respondents to make explicit choices among species under varying conditions (e.g., changes in population status) and allow decision makers to evaluate a greater number of policy scenarios (Wallmo & Lew 2011).

Stated-preference choice experiments are grounded in Lancaster's (1966) consumer theory, which specifies that utility of a good is a function of the good's attributes. For environmental applications, the good is typically a nonmarket good (i.e., one not bought or sold in explicit markets) that is characterized by a suite of policy-relevant attributes. For example, a nature preserve may be the nonmarket good and the policy-relevant attributes may include the size of the preserve, the number of access points to the preserve, or the types of amenities within the preserve. A range of levels is specified for each attribute (i.e., attribute levels), and choices are designed such that attributes with different levels are combined to create the alternatives. Following the example of the nature preserve, alternative A may be a 40-ha preserve with 6 access points and 60 km of hiking trails, whereas alternative B may be a 60-ha preserve with 2 access points and 30 km of hiking trails. Including price or cost as one of the attributes allows willingness to pay (or willingness to accept) to be calculated. Survey respondents are shown choice tasks, which are sets of 2 or more alternatives, and asked to choose their most preferred alternative (or asked to rank-order the alternatives) from the set. Econometric models that quantify the marginal value of each attribute can then be estimated from the data. For a detailed explanation of stated-preference choice experiments, see Adamowicz et al. (1998).

Methods

Survey Design and Implementation

The taxonomic groups included in our stated-preference choice survey included 2 reptiles, 3 marine mammals, 2 anadromous fishes, and 1 cartilaginous fish. Geographic distributions ranged from global for highly migratory species such as marine sea turtles to local for isolated populations of endemic species such as the Hawaiian monk seal. Two of the species, the Upper Willamette River Chinook salmon and the Puget Sound Chinook salmon, are protected under the U.S. Endangered Species Act as distinct population segments.

Surveys were designed from 2006 to 2009, and the design was facilitated by a series of focus groups and cognitive interviews with randomly recruited individuals. To facilitate valid comparisons among taxonomic groups, we condensed complex information about each taxon and distinct population segment (hereafter we use the term *species* to refer to each taxon, including the distinct population segment) into a 2-page information sheet that systematically described species' basic characteristics, geographic range, reasons for population decline, and current population status. The information sheet also described potential mechanisms for improving the species' legal status (i.e., lead to recovery or downlisting). Focus groups revealed that when surveys contained information about 4 or more species, respondents thought there was too much information and the survey was too long. Therefore, we focused each survey on a subset of 3 of the 8 species.

The final survey instrument had 4 sections. The first section provided general information about the Endangered Species Act and asked respondents about their level of familiarity with this act and general questions about the importance they placed on protecting the environment relative to other high-profile national issues. The second section provided information on each of the 3 species that were the focus of the survey and asked respondents about their concern for each species. The third section described specific management actions, beyond those already in place, that would improve the legal status of each species. The final section contained 3 choice tasks. Respondents were asked to choose their preferred alternative from a set of 3 alternatives (hereafter referred to as options) (Fig. 1). Each option consisted of 3 species' attributes (1 attribute assigned to each species) and a cost attribute. Species attributes were a specific subset of the 8 species, and these subsets varied across survey versions. Attribute levels were determined with an experimental design that accounted for main effects and maximized a D-efficiency criterion (i.e., a measure of the goodness of a design relative to an optimal orthogonal design that may be impossible to attain) (Louviere et al. 2000). We used 432 individual survey versions (Supporting Information) blocked into 27 main versions that contained 3 species each. All species appeared an approximately equal number of times across all survey versions.

All options presented outcomes that would be attained 50 years into the future. The option of "no additional protection actions" (option A) maintained the current legal status of all species with no additional management actions undertaken and no additional cost. In options B and C, additional management actions would be undertaken to improve the legal status of one or more species at an increased cost per household. The cost was described in terms of a combination of increased federal taxes and increased costs of goods and services affected by the additional actions (this cost construction is consistent with Lew et al. [2010]). Ultimately, this survey design provided information that was consistent in content, quality, and quantity among all species, presented a consistent payment mechanism, and proposed changes to the species' status on the basis of the same criteria. For example, all changes were cast in terms of legal status in 50 years. This method facilitated statistical comparisons among species and allowed relative preferences to be expressed.

The survey was implemented in May 2009 with a sample of a randomly recruited panel of U.S. households. During the original panel, recruitment demographic information including income, age, education, residence, and gender was collected; thus, it was not necessary to include demographic questions in the survey. Randomly selected panel members ($n = 11{,}971$) were sent an email invitation with a link to the online survey. Nonrespondents were reminded first by email and then by telephone if no response was obtained via email.

Choice Model and Welfare Specification

We applied random utility theory (Manski 1977) to estimate models on the basis of data from the stated-preference choice experiment (choice models). Random utility theory specifies that utility (U) for a good or alternative consists of a systematic (i.e., observable) component (V) and a random component. The utility of the ith individual derives from alternative j (a specific bundle of attributes and their associated levels) and is expressed as U_{ij}:

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \quad (1)$$

where V_{ij} is the measurable portion of utility and ε is the random component that cannot be observed by the researcher. The deterministic portion of the utility of alternative j is commonly modeled as a linear function of its attributes:

$$V_{ij} = \beta X_{ij}, \quad (2)$$

where X_{ij} is a vector of attribute levels for alternative j and β is a vector of attribute-specific parameters to be estimated. Substituting Eq. 2 in Eq. 1 yields:

$$U_{ij} = \beta X_{ij} + \varepsilon_{ij}.$$

Assuming rational behavior (where individuals choose the alternative that yields the greatest utility to them), the probability that individual i chooses alternative j from a set of C alternatives is the probability that the utility derived from j is greater than the utility derived from any other alternative k in set C:

$$\Pr(j \mid C) = \Pr(U_{ij} >= U_{ik}) \forall k \in C. \quad (3)$$

Assuming independent and identical type I extreme value distributions for the error components (Louviere et al. 2000), the probabilities take the following form:

$$\Pr(j|C) = \frac{\exp(\beta X_{ij})}{\sum_{k=1}^{K} \exp(\beta X_{ik})}, \quad (4)$$

which is the conditional logit model (McFadden 1973). This model, which is commonly used to analyze stated-preference choice data, is estimated with maximum likelihood techniques.

The conditional logit model, although commonly used to analyze stated-preference choice experiment data, is limited by the restrictive properties of the error component. For a detailed discussion of conditional logit limitations, see Louviere et al. (2000). The error assumption implies homogenous preferences for the attributes across the sample population, and efforts to relax the assumption have led to more flexible model specifications, including the random parameters logit model (Greene & Hensher 2002). Although computationally intensive, these specifications provide flexibility for incorporating preference heterogeneity, a particularly important consideration if model results are used to inform management (Wallmo & Edwards 2007).

We estimated a random parameters logit model (Train 2003). For a detailed description of the model estimation we used, see Lew and Wallmo (2010). We estimated choice models by pooling data from all 27 main survey versions. Likelihood ratio tests rejected the hypothesis that the different survey versions can be pooled without accounting for scale differences in the errors; thus, we estimated 26 scale parameters and the utility parameters. Louviere et al. (2000) and Layton and Lee (2006) discuss strategies for pooling responses and treatment of the scale parameter for stated-preference choice experiments and other discrete-choice models.

For the model estimation, we assumed that utility was a linear function of the cost of protection and the legal status of each species. We modeled legal status with effects-coded variables because these attributes are ordinal rather than cardinal. Effects coding allowed us to recover the marginal utility of the baseline level that would otherwise be dropped if we had used dummy variables to represent legal status of levels of the attributes. We expected improvements to a species' legal status to increase utility and result in positively signed parameters and a negative cost parameter. We assumed random parameters for all species' legal-status variables and estimated mean and standard deviation parameters. The cost parameter was fixed. We calculated willingness-to-pay estimates over the distribution of parameters following standard formulas for the measurement of compensating variation (Small & Rosen 1981). We calculated household willingness to pay every year for 10 years and expressed all estimates in 2011 U.S. dollars. We calculated 95% confidence intervals for willingness to pay following Krinsky and Robb (1986).

To determine whether willingness-to-pay values were statistically different among the 8 species, we used the method of convolutions (Poe et al. 2005), a computationally intensive but precise method for estimating the difference between 2 (independent) willingness-to-pay distributions. We compared all combinations of recovering 2 different species and all combinations of downlisting 2 different species to a threatened status (total of 38 pairwise comparisons). We also compared all first-level improvements between species (e.g., recovery of a threatened species to the downlisting of an endangered species). This implies a comparison of 2 species whose final legal status differs; however, the magnitude of the improvements being compared are the same. For all comparisons, confidence bounds that included zero indicated that there was no significant difference in willingness to pay between 2 species. Confidence bounds that did not include zero indicated willingness to pay differed between 2 species at $p < 0.05$.

Results

Sample Demographics

The response rate to the survey was 70.8% ($n = 8{,}476$ across the 27 main version). The number of individuals who completed a given survey version ranged from 303 to 328. The mean age of respondents was 49.7 years, and about 51% of respondents were male. Average household size was 2.5 members, and most respondents were white (73%). Mean and median annual household income categories were \$50,000–\$59,999 and \$60,000–\$74,999, respectively. About 35% of respondents had a Bachelor's degree or higher (Table 1).

About 84% of respondents stated that they had heard of the U.S. Endangered Species Act prior to beginning the survey, and about 45% were aware that the act can protect distinct population segments rather than all populations of a species. Approximately 81% of respondents indicated that protecting endangered species was

Table 1. Respondent demographics from stated-preference choice experiment survey of respondents' willingness to pay for recovery and downlisting of marine species.

Demographic parameter	*Respondents* (%)
Gender	
Male	50.9
Female	49.1
Age category	
18–29	14
30–44	24
45–59	33
60 or above	29
Condensed education category	
Less than high school degree	6
High school degree	30
Some college	29
Bachelor's degree or higher	35
Race/ethnicity	
White, non-Hispanic	73
Black, non-Hispanic	10
Other, non-Hispanic	3
Two or more races, non-Hispanic	11
Hispanic	3
Annual income category (U.S.$)	
<30,000	19
30,000 to 74,999	43
75,000 to 124,999	27
≥125,000	11

important to them, and slightly fewer (73%) indicated that protecting threatened species was important.

Choice-Model Estimates

The percentage of respondents who did not respond to the choice-task questions was 13%, 8%, and 8% for the first, second, and third questions, respectively; however, none of the respondents left all choice tasks unanswered. Overall, the option of no additional protection (option A) was selected in about 17% of the choices, and options B and C (which had additional protection actions at an additional cost) were selected in 43% and 39% of the choices, respectively. About 18% of respondents chose option A in all 3 choice-task questions and selected a protest response as a reason for choosing option A. Protest responses are identified by agreement with any of the following statements: protecting threatened and endangered species places too many restrictions on landowners or industries; I do not feel it is my responsibility to pay for protecting these species; I do not trust the government to run the program; I should not have to pay more taxes for any reason; I need more information to make a choice; I am too unsure about how I feel about threatened and endangered species; I do not think the programs will be effective; and more research needs to be done before I would pay for additional protection actions. About 4% of respondents stated that they were not confident about their responses to the choice-task questions, and these respondents were also dropped in the model estimation. Removing the protest respondents and those who were not at all confident in their answers resulted in 6629 responses.

Improving a species' legal status increased utility, and cost was recognized as a constraint (Table 2). For species

Table 2. Choice-model parameter estimates for recovering and downlisting species.

Parameter	*Estimate*	*Asymptotic t*
Recovering loggerhead sea turtle	0.89	8.93
SD parameter for recovering species	0.77	8.39
Recovering upper Willammette River Chinook salmon	0.82	8.89
SD parameter for recovering species	0.65	7.23
Recovering Puget Sound Chinook salmon	0.82	8.88
SD parameter for recovering species	−0.36	−4.84
Downlisting North Pacific right whale to threatened	0.14	3.30
SD parameter for downlisting species	−0.42	−3.67
Recovering North Pacific right whale	1.41	8.97
SD parameter for recovering species	0.85	5.84
Downlisting leatherback sea turtle to threatened	0.11	2.96
SD parameter for downlisting species	0.44	4.53
Recovering leatherback sea turtle	1.32	8.79
SD parameter for recovering species	−0.74	−5.59
Downlisting smalltooth sawfish to threatened	0.17	3.16
SD parameter for downlisting species	−0.43	−3.42
Recovering smalltooth sawfish	0.97	7.96
SD parameter for recovering species	−0.29	−1.38
Downlisting North Atlantic right whale to threatened	0.08	2.05
SD parameter for downlisting species	0.30	1.97
Recovering North Atlantic right whale	1.41	8.83
SD parameter for recovering species	0.54	3.23
Downlisting Hawaiian monk seal to threatened	0.08	2.17
SD parameter for downlisting species	−0.20	−1.26
Recovering Hawaiian monk seal	1.30	8.79
SD parameter for recovering species	0.13	0.67
Cost	−0.04	−9.19

whose legal status was endangered, magnitudes of parameter values for recovery (delisting) were qualitatively larger than for downlisting the species to threatened. Recovery of the North Atlantic right whale and the North Pacific right whale was associated with the 2 largest parameter values, and recovery of the leatherback sea turtle was associated with the third-largest parameter. Standard deviations associated with the random parameters were significant with 4 exceptions: recovery of Hawaiian monk seals, downlisting Hawaiian monk seals to threatened, downlisting North Atlantic right whale to threatened, and recovery of smalltooth sawfish. This suggests that preferences were heterogeneous for recovering or downlisting most species. Delisting and downlisting Hawaiian monk seals were the exceptions for which preferences appeared not to vary significantly among respondents.

Welfare Calculation and Statistical Comparisons

Mean willingness to pay for recovering a species ranged from about $73 for the North Pacific right whale to about $40 for the Puget Sound Chinook salmon (Table 3). The rank order from highest to lowest of recovery values for species was North Pacific right whale, North Atlantic right whale, leatherback sea turtle, Hawaiian monk seal, smalltooth sawfish, loggerhead sea turtle, upper Willamette River Chinook salmon, and Puget Sound Chinook salmon. Mean willingness to pay for downlisting ranged from approximately $42 for North Pacific right whale to approximately $32 for the smalltooth sawfish and followed the rank order as for recovery (last 3 species omitted because they were listed as threatened).

In comparing willingness to pay among species recovery values, 20 of the 28 comparisons (about 70%) were statistically significant (Table 4). Of the 8 comparisons that were not significantly different, 3 included the species whose legal status was threatened (i.e., there were no differences in recovery values for loggerhead sea turtles, upper Willamette River Chinook salmon, and Puget Sound Chinook salmon). Three of the remaining 5 nonsignificant comparisons included leatherback sea turtles. The value for recovering the leatherback sea turtle was not statistically different from North Atlantic right whale, North Pacific right whale, or Hawaiian monk seal. Recovery values did not differ for North Atlantic right whale and the Hawaiian monk seal or for North Atlantic and North Pacific right whales. The majority of comparisons (60%) of willingness to pay for downlisting species were not significant (Table 5). Differences were statistically significant only for all smalltooth sawfish comparisons and for the comparison between the Hawaiian monk seal and the North Pacific right whale. All comparisons that involved first-level improvements were statistically significant.

Discussion

For all first-level comparisons except one, our results suggest that willingness to pay for recovery of a threatened species is significantly higher than willingness to pay to downlist an endangered species. The exception to this was the comparison between North Pacific right whale and the Puget Sound Chinook salmon, for which willingness to pay for downlisting the whale was significantly higher than recovering the salmon. These results indicate that except for the highest and the lowest valued species (North Pacific right whale and Puget Sound Chinook salmon, respectively), greater public benefits would be derived from recovering a species than from downlisting it, regardless of whether the species might be typically considered charismatic.

Our results suggest that recovering marine mammals provides a greater perceived benefit than recovering fishes (at least for the species included in this study) when species have the same initial legal status. This finding is consistent with the results of other research on preferences for charismatic species (Richardson & Loomis 2009). In addition, recovery values for leatherback sea turtles, a species that could be described as high profile or charismatic, were also significantly higher than for the fish species. However, it is important to consider the magnitude of the improvements in species status. When comparing species' full recovery values,

Table 3. Mean willingness to pay[a] for improvements in species status.

Species	*Mean willingness to pay for recovery (95% CI)*	*Mean willingness to pay for downlisting to threatened status (95% CI)[b]*
Loggerhead sea turtle	43.72 (41.13–46.43)	NA
Upper Willammette River Chinook salmon	40.65 (37.94–43.19)	NA
Puget Sound Chinook salmon	40.49 (37.91–42.87)	NA
North Pacific right whale	73.16 (68.54–77.78)	41.72 (38.30–45.24)
Leatherback sea turtle	67.97 (63.87–72.14)	37.96 (34.89–40.91)
Smalltooth sawfish	51.89 (46.76–57.37)	32.45 (28.12–36.95)
North Atlantic right whale	71.62 (67.37–75.71)	38.79 (35.44–42.27)
Hawaiian monk seal	66.31(62.45–70.37)	36.26 (33.23–39.69)

[a]*In 2011, U.S. dollars per household every year for 10 years.*
[b]*Abbreviation: NA, not applicable.*

Table 4. Confidence bounds[*] from method of convolutions comparison of willingness to pay for species recovery.

	Loggerhead sea turtle	*Upper Willammette River Chinook salmon*	*Puget Sound Chinook salmon*	*North Pacific right whale*	*Leatherback sea turtle*	*Smalltooth sawfish*	*North Atlantic right whale*	*Hawaiian monk seal*
Loggerheadsea turtle		−0.53 to 6.43	−0.27 to 6.47	−33.02 to −22.93	−27.52 to −18.48	−13.40 to −2.32	−31.12 to −21.78	−26.03 to −16.89
Upper Willammette River Chinook salmon			−3.24 to 3.53	−35.97 to −25.87	−30.48 to −21.41	−16.36 to −5.24	−34.07 to −24.71	−28.98 to −19.82
Puget Sound Chinook salmon				−36.04 to −26.08	−30.54 to −21.64	−16.44 to −5.46	−34.14 to −24.93	−29.04 to −20.06
North Pacific right whale					−0.85 to 10.79	13.52 to 26.75	−3.44 to 6.43	0.63 to 12.38
Leatherback sea turtle						8.92 to 21.40	−8.95 to 2.02	−3.89 to 6.97
Smalltooth sawfish							−24.97 to −12.29	−19.92 to −7.33
North Atlantic right whale								−0.56 to 10.55
Hawaiian monk seal								

[*] *Confidence bounds that do not include zero indicate the difference is significant at $p < 0.05$.*

differences between charismatic or high-profile species and fishes may be due to preferences for the charismatic species or to the magnitude of the improvement. Two of the 3 fish species—Puget Sound Chinook salmon and upper Willamette River Chinook salmon—were listed as threatened, whereas marine mammals and leatherback sea turtles were endangered. That recovery values for loggerhead sea turtles, another charismatic species but one that is threatened, were not statistically greater than values for recovering either of the salmon species, but were significantly lower than recovering smalltooth sawfish, may support the notion that the magnitude of the improvement may outweigh or be as important as the charisma of a species.

Because of the differences between species' initial legal status (and thus differences in the magnitude of improvement), we could only conclude that charismatic species were more highly valued than fishes when the magnitude of recovery was the same. Our study contained same magnitude comparisons between only one fish (smalltooth sawfish) and charismatic species. A more comprehensive analysis would include comparisons between endangered charismatic species and endangered fishes, invertebrates, and marine plants. However, our results suggest that among the suite of charismatic species we considered, economic values for recovery, and in most cases for downlisting, were indistinguishable. The exceptions to this were the significant differences between recovering Hawaiian monk seal and North Pacific right whale and downlisting both species.

Our results suggest that the public derives a positive economic value from recovering and downlisting threatened and endangered marine species. Values for recovery ranged from about $73 for charismatic mammals, such as the North Pacific right whale, to $40 for recovering the Puget Sound Chinook salmon, a distinct population segment. Values for downlisting endangered species to threatened were lower than those for full recovery, which suggests that preferences are sensitive to the magnitude of the improvement. Recovery of the whale species was assigned the highest economic value, whereas recovery of the 2 salmon populations was assigned the lowest value, although the magnitudes of the improvements differed. Our results suggest that the value the public assigns to fully recovering a species may outweigh any potential value enhancement due to a species' charismatic nature.

Social and economic information is steadily becoming a vital input into management of the marine environment. This is evidenced in part by the increasing focus of U.S. ocean policy toward ecosystem-based management that is inclusive of human behavior (Ocean Policy Task Force 2009) and the National Oceanic and Atmospheric Administration's intent to increase the use of social and economic indicators in the conservation decision-making process (NOAA 2010). Given this, knowledge of the

Table 5. Confidence bounds* from method of convolutions comparison of willingness to pay for downlisting species to threatened.

	North Pacific right whale	Leatherback sea turtle	Smalltooth sawfish	North Atlantic right whale	Hawaiian monk seal
North Pacific right whale		−0.72 to 7.99	3.49 to 13.97	−1.82 to 7.37	0.66 to 9.62
Leatherback sea turtle			0.12 to 10.09	−5.14 to 3.44	−2.67 to 5.66
Smalltooth sawfish				−11.13 to −0.77	−8.66 to 1.51
North Atlantic right whale					−2.04 to 6.77
Hawaiian monk seal					

* *Confidence bounds that do not include zero indicate that the difference is significant at $p < 0.05$.*

value the public assigns to the delisting or downlisting of marine species may provide important information for managers, particularly when they often have information on only the economic effects and costs associated with species recovery actions. Furthermore, economic values of threatened and endangered marine species may be explicitly required for assessments of natural resource damage conducted in response to events such as oil spills, and economic costs and benefits may be considered in the designation of critical habitat and the development of recovery plans (Congressional Research Service 2003).

Our results may also provide some insight into the concept of environmental value transfer. By this we mean the process of transferring a value estimated at a "study site" to a "policy site" (Brouwer 2000). In our case, the study site would be a species for which a value estimate exists and a policy site would be a similar species for which no value estimate exists. Further studies would be needed to determine if and how economic values could be transferred among species, but our results indicate that values may be indistinguishable among some groups of species (e.g., among whales and among anadromous fishes); therefore, it may be appropriate to transfer values between 2 species (e.g., between 2 whale species or between 2 salmon species) if the magnitude of the change is similar.

The values for recovering (or downlisting) species were estimated from choice set data in which each choice set contained 3 species. Respondents were asked to assume that, aside from the species in the choice set, the legal status of all other U.S. threatened and endangered species remained unchanged. This assumption implies that recovery or downlisting values are additive only up to 3 species. Consequently, the model cannot provide an aggregate value for recovering (or downlisting) more than 3 species at once. Additionally, we examined only nonconsumptive values such as observation and existence values; however, recovery of some species may also increase economic value through consumptive-use values such as recreational fishing and traditional or subsistence harvests by some Native Americans. Finally, we recognize that although economic factors alone do not drive policy decisions, providing economic information, in particular, information that reflects public preferences and values, can inform and improve decision making given multiple worthwhile endeavors and limited resources.

Acknowledgments

We acknowledge R. Felthoven, R. Curtis, and one anonymous reviewer for their insightful and valuable comments on the manuscript. We also thank editorial staff for identifying stylistic and grammatical improvements to the manuscript. We acknowledge and thank D. Colpo and L. Leach for their invaluable assistance with the grants under which this work was conducted (grants NA04NMF4370385 and NA04NMF4340350) and that were awarded to the Pacific States Marine Fisheries Commission and Atlantic States Marine Fisheries Commission, respectively. The views and opinions expressed in this article are our own and do not necessarily represent the views of the National Marine Fisheries Service.

Supporting Information

A version of the survey instrument (Appendix S1) is available online. The authors are solely responsible for the content and functionality of this material. Queries (other than absence of materials) should be directed to the corresponding author.

Literature Cited

Adamowicz, W., J. Louviere, and J. Swait. 1998. Introduction to attribute-based stated choice methods. Final report. Damage Assessment Center, National Oceanic and Atmospheric Administration, Silver Spring, Maryland.

Bateman, I., M. Cole, P. Cooper, S. Georgiou, D. Hadley, and G. Poe. 2004. On visible choice sets and scope sensitivity. Journal of Environmental Management **47:**71–93.

Berrens, R., A. Jenkins-Smith, A. Bohara, and C. Silva. 2002. Further investigation of voluntary contribution contingent valuation: fair share, time of contribution and respondent uncertainty. Journal of Environmental Economics and Management **44:**144–168.

Bowker, J. M., and J. R. Stoll. 1988. Use of dichotomous choice nonmarket methods to value the whooping crane resource. American Journal of Agricultural Economics **70:**372–381.

Brouwer, R. 2000. Environmental value transfer: state of the art and future prospects. Ecological Economics **32:**137–152.

Brown, T. C., P. A. Champ, R. C. Bishop, and D. W. McCollum. 1996. Which response format reveals the truth about donations to a public good? Land Economics **72:**152–166.

Champp, P. A., R. C. Bishop, T. C. Brown, and D. W. McCollum. 1997. Using donation mechanisms to value nonuse benefits from public goods. Journal of Environmental Economics and Management **33:**151–162.

Congressional Research Service. 2003. The Endangered Species Act: consideration of economic factors. Report RL30792. Report to Congress. Congressional Research Service, Washington, D.C.

Diamond, P., and J. Hausman. 1994. Contingent valuation: Is some number better than no number? Journal of Economic Perspectives **8:**45–64.

Ehrenfeld, D. 1988. Why put a value on biodiversity? Pages 212–216 in E. O. Wilson, editor. Biodiversity. National Academy Press, Washington, D.C.

Greene, W., and D. Hensher. 2002. A latent class model for discrete choice data analysis: contrasts with mixed logit. Working paper ITS-WP-02-08. Institute of Transport Studies, Sydney, Australia.

Hanemann, M. 1984. Welfare evaluation in contingent valuation experiments with discrete responses. American Journal of Agricultural Economics **66:**332–341.

Hanemann, M. 1994. Valuing the environment through contingent valuation. Journal of Economic Perspectives **8:**19–44.

Hanley, N., R. Wright, and W. Adamowicz. 1998. Using choice experiments to value the environment. Environmental and Resource Economics **11:**413–428.

Heberlein, T., M. Wilson, R. C. Bishop, and N. Schaeffer. 2005. Rethinking the scope test as a criterion for validity in contingent valuation. Journal of Environmental Economics and Management **50:**1–22.

Hoehn, J. P., and A. Randall. 2002. The effect of resource quality information on resource injury perceptions and contingent values. Resource and Energy Economics **24:**13–31.

Johnston, R. 2006. Is hypothetical bias universal? Validating contingent valuation responses using a binding referendum. Journal of Environmental Economics and Management **52:**469–481.

Krinsky, I., and A. L. Robb. 1986. On approximating the statistical properties of elasticities. Review of Economic and Statistics **68:**715–719.

Lancaster, K. 1966. A new approach to consumer theory. Journal of Political Economy **74:**132–157.

Layton, D., and T. S. Lee. 2006. Embracing model uncertainty : strategies for response pooling and model averaging. Environmental and Resource Economics **34:**51–85.

Lew, D., and K. Wallmo. 2010. External tests of scope and embedding in stated preference choice experiments: an application to endangered species valuation. Environmental and Resource Economics **48:**1–23.

Lew, D., D. Layton, and R. Rowe. 2010. Valuing enhancements to endangered species protection under alternative baseline futures: the case of the Steller sea lion. Marine Resource Economics **25:**133–154.

Loureiro, M. L., and E. Ojea. 2008. Valuing local endangered species: the role of intra-species substitutes. Ecological Economics **68:**362–369.

Louviere, J., D. Hensher, and J. Swait. 2000. Stated choice methods: analysis and application. Cambridge University Press, Cambridge, United Kingdom.

Manski, C. 1977. The structure of random utility models. Theory and Decision **8:**229–254.

McFadden, D. 1973. Conditional logit analysis of qualitative choice behavior. Pages 105–142 in P. Zarembka, editor. Frontiers in econometrics. Academic Press, New York.

Metrick, A., and M. Weitzman. 1996. Patterns of behavior in endangered species preservation. Land Economics **72:**1–16.

Mitchell, R. C., and R. T. Carson. 1989. Using surveys to value public goods: the contingent valuation method. Resources for the Future, Washington, D.C.

Murphy, J. J., P. G. Allen, T. H. Stevens, and D. Weatherhead. 2005. A meta-analysis of hypothetical bias in stated preference valuation. Environmental and Resource Economics **30:**313–325.

National Oceanic and Atmospheric Administration (NOAA). 2010. NOAA's next generation strategic plan. NOAA, Silver Spring, Maryland. Available from http://www.ppi.noaa.gov/wp-content/uploads/NOAA_NGSP.pdf (accessed March 2012).

Ocean Policy Task Force. 2009. Final recommendations of the Interagency Ocean Policy Task Force. White House, Washington, D.C. Avaliable from http://www.whitehouse.gov/files/documents/OPTF_FinalRecs.pdf (accessed March 2012).

Ojea, E., and M. L. Loureiro. 2009. Valuation of wildlife: revising some additional considerations for scope tests. Contemporary Economic Policy **27:**236–250.

Olar, M., W. Adamowicz, P. Boxall, and G. West. 2007. Estimation of the economic benefits of marine mammal recovery in the St. Lawrence estuary. Policy and Economics Branch, Fisheries and Oceans Canada, Quebec.

Poe, G., K. Giraud, and J. Loomis. 2005. Computational methods for measuring the difference of empirical distributions. American Journal of Agricultural Economics **87:**353–365.

Ready, R., J. Buzby, and D. Hu. 1996. Differences between continuous and discrete contingent valuation estimates. Land Economics **72:**397–411.

Richardson, L., and J. Loomis. 2009. The total economic value of threatened, endangered, and rare species: an updated meta-analysis. Ecological Economics **68:**1535–1548.

Rudd, M. 2009. National values for regional aquatic species at risk in Canada. Endangered Species Research **6:**239–249.

Small, K. A., and H. S. Rosen. 1981. Applied welfare economics with discrete choice models. Econometrica **49:**105–130.

Train, K. 2003. Discrete choice methods with simulation. Cambridge University Press, Cambridge, United Kingdom.

Wallmo, K., and S. Edwards. 2007. Estimating nonmarket values for marine protected areas: a latent class modeling approach. Marine Resource Economics **23:**301–323.

Wallmo, K., and D. K. Lew. 2011. Valuing improvements to threatened and endangered marine species: an application of stated preference choice experiments. Journal of Environmental Management **92:**1793–1801.

Whitehead, J. C., and G. C. Blomquist. 1999. Do reminders of substitutes and budget constraints influence contingent valuation estimates? Comment. Land Economics **75:**483–484.