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Including risk in stated-preference economic valuations: Experiments on choices for marine recreation

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ABSTRACT

Stated-preference surveys for the economic valuation of environmental resources typically assume no uncertainty in the hypothetical valuation scenarios. However, the outcomes of environmental policies are uncertain. We explored the effects of including information on probabilities of attribute improvement and provision in choice experiments. Our results suggest that stating explicitly a high probability for the occurrence of the valuation scenario can improve the goodness of fit of choice models and the consistency of choices. As the general public becomes more aware of the uncertainty of environmental outcomes under global change, omitting information on scenario risk may contribute to hypothetical bias and impair the validity of stated-preference valuations.

1. Introduction

Stated-preference valuation methods use hypothetical scenarios to estimate welfare impacts of changes to the environment. Hypothetical policies to achieve an environmental outcome are frequently used as scenarios, and they are traditionally described as achieving the outcome goal with certainty. In order for the results of stated-preference valuations to be considered valid, valuation scenarios must comply with the assumption that they are realistic and credible to the respondents (Arrow et al., 1993). However, there is an increased awareness by the general public that the response of the environment to human intervention is uncertain due to gaps in ecological, political, and economic knowledge (Cameron, 2005). For example, the Intergovernmental Panel on Climate Change recently published a widely publicized report on the expected short-term environmental changes due to global warming (IPCC, 2007). The levels of confidence of the Panel's predictions ranged from <1% to >90%, and, for instance, the number of people in Africa expected to face increased water stress in the year 2020 was predicted to be between 75 million and 250 million.

It has long been established that uncertainty reduces the value of benefits derived from the environment (Arrow and Fisher, 1974; Henry, 1974 and the potential impact on stated preferences of including information related to the uncertainty of the valuation scenarios has been considered in previous research. For example, in designing a contingent valuation framework for studying the value of improvements in atmospheric visibility, Fischoff and Furby (1988) recognized that the perceived probability of the effectiveness of the proposed visibility-improvement strategies could affect respondents' stated willingness to pay (WTP). Poe and Bishop (1999) and Johnson et al. (2008) studied the willingness to pay of individuals for programs that would reduce the exposure to pollutants (and by implication, the risk of illness) by a single amount. As part of a contingent valuation

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study on programs to reduce the damages from acid rain in Scotland, Macmillan et al. (1996) examined differences in the WTP for programs that were said to be certain or uncertain. They found that respondents were risk averse; they preferred a program leading to medium recovery from acid rain over a program that was said to achieve full recovery with 50% probability or no recovery with 50% probability. Seemingly, respondents on surveys related to risks from pollutants update their previous perceptions (Poe et al., 1998; Viscusi and Evans, 1998).

In this paper, we used choice experiments to study the impact on goodness of fit, choice consistency, and WTP of including the type of probabilistic information with which respondents participating in stated-preference economic valuations of the environment may be familiar. Because we provided values for probabilities as part of the valuation scenarios, we use the term "risk" rather than "uncertainty" in the remainder of this paper to conform to Knight's (1921) classic distinction: uncertainty entails randomness with unknowable probabilities, while risk presumes that the probabilities of random events are known.

2. Valuation experiment

Choice experiments (Hensher and Johnson, 1981; Louviere et al., 2000) elicit preferences for goods and services by studying the choices made by respondents in survey settings. In choice experiments for the environment, respondents are typically presented with a description of a hypothetical scenario concerning the management of a resource. Respondents are given a number of choice sets related to different management scenarios, where each choice set contains alternatives that are described by unique combinations of attributes at different levels. We studied the effects on stated preferences of including information on scenario risk in two different ways: (1) a probability for the occurrence of the valuation scenarios was included in the description of the valuation exercise, and (2) ranges were provided around mean values for the attributes in the choice sets. These two different measures of risk were chosen because they typify the information on environmental uncertainty with which respondents may be familiar. In addition, these 2 measures of risk are easily comparable. For example, if ranges for an attribute represent the mean ± SD, there is approximately a 90% probability that the level of the attribute encountered will be at least the mean − 1.3(SD).

2.1. Focus group interviews

Our choice experiments were part of a study on the recreational value of marine resources in the Gulf of California, Mexico. We conducted discussions with focus groups of recreational anglers and divers at the Loreto Bay National Park (LBNP) to identify relevant attributes and their expected levels during angling and diving trips, and to develop a comprehensible description of the valuation scenario for the valuation surveys. Two focus groups, comprising 18 anglers and 12 divers, were interviewed during March 2005 using written questionnaires followed by an open discussion. Questionnaires for anglers included questions on the duration of their fishing trips to the LBNP, species that are caught and their sizes, and species preferentially caught. Questionnaires for divers included questions on the number of days in which they dive during their trips to the LBNP (diving operators take divers to 2 dive sites during a day), species that are observed during diving trips and their sizes, and species that are preferentially seen during dives. In addition, anglers and divers were asked if fish size or number was more important in their recreational experience. From the questionnaires it was determined that an average fishing trip to the LBNP was 10 days long, and the average weight of a grouper was 10 lb. However, in the open discussion, anglers who had previously fished in the LBNP remembered catching leopard groupers (*Mycteroperca rosacea*) that were 30 lb in weight. Divers generally dived on a single day during their trip.

Some anglers (56%) considered the number of fish caught as the most important attribute (regardless of species) while others (44%) stated that the weight of the fish was more important. Divers considered small, colorful species associated with corals (e.g., damselfish, butterflyfish, angelfish) and large fish species (e.g., leopard groupers) as the most important attributes (58% and 42%, respectively). The open discussions were also used to determine appropriate levels of risk to include in the valuation study. For example, 83% of the respondents stated that they didn't believe management policies aimed at recovering fish populations at the LBNP would have a probability of success greater than 90%.

2.2. Valuation surveys

The valuation surveys (Spanish and English versions) included a description of the LBNP and explained that with additional funding, the Park Authority could conduct management activities that would lead to increases in the number and/or the size of fish caught by recreational anglers (or observed by recreational SCUBA divers) in the near future (Appendix I).

Three split samples of recreational anglers were presented with questionnaires in which the probability of occurrence of the valuation scenarios was not mentioned (version 1), or was said to be 60% (version 2) or 90% (version 3) (Appendix I). Three split samples of SCUBA divers were presented with questionnaires in which attributes contained no intervals (version 4), or in which the intervals were "narrow" (version 5; mean ± approximately 50%) or "wide" (version 6; mean ± approximately 80%) (Appendix II).

The choice sets included the recreational attributes mentioned above and a cost that was defined as a hypothetical license fee for a fishing trip of 10 days or for 1 day of diving (Appendices I and II). Respondents were presented with 3 scenarios per choice set, including the current situation (*status quo*). Choice sets were constructed by combining all scenarios from the full factorial (27 scenarios) and eliminating sets with dominated scenarios. The remaining 72 choice sets were assigned to orthogonal blocks of 9 sets with the software SAS (SAS Institute Inc., Cary, North Carolina). Each respondent answered the 9 choice sets in a block, and a section with socioeconomic questions (Appendix III).

Recreational anglers were surveyed as they arrived to the marina in the town of Loreto between May and August 2005, and SCUBA divers were surveyed as they arrived to diving centers in the city of La Paz between July and December 2005.

3. Statistical analysis

By allowing the attribute coefficients to vary randomly, mixed logit models incorporate differences in attribute preferences (tastes) among respondents (Train, 1998), and allow testing for covariance among attribute coefficients (Revelt and Train, 1998; Scarpa et al., 2008). Mixed logit models also allow the specification of realistic distributions for attribute coefficients (McFadden and Train, 2000). For example, log-normal and truncated distributions can be specified for attributes whose coefficients are expected to be nonnegative, such as recreational attributes (Train and Sonnier, 2005).

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Bayesian approaches for estimating mixed logits with normally distributed coefficients were introduced by Allenby and Lenk (1994), and were expanded by Train (2001) to include other distribution specifications. Bayesian approaches avoid the problem of a lack of algorithm convergence that is common with the classical approach (i.e., maximum likelihood) when the coefficients of attributes are correlated (Train, 2003). We used Bayesian estimation of mixed logit models because we considered that the angler and diver attribute coefficients could have been correlated; anglers who liked catching many fish might also have liked catching large fish, and divers who liked seeing small, colorful fish may have also liked seeing large fish.

The following is a brief outline of the Bayesian estimation procedure for mixed logit. Details may be found in Train (2003) and Train and Sonnier (2005). In the mixed logit framework of random utility, the utility of individual i from alternative j in choice set c is

$$U_{ijc} = \beta_i' \boldsymbol{x}_{jc} + \varepsilon_{ijc}, \quad (1)$$

where $\boldsymbol{x}$ is a vector of attributes, β_i is a vector of attribute coefficients that varies for each person i in the population, and ε is the unobserved component of utility, with *iid* extreme value. The probability that individual i will choose alternative j in choice set c is the probability that $U_{ijc} > U_{ikc}$ for all k different than j. The probability of the observed choices (y) made by respondent i on all choice sets is the product of logits:

$$L(y_i|\boldsymbol{\beta}_i) = \prod_c \frac{e^{\lambda \beta_{xjc}'}}{\sum_{k=1}^{m} e^{\lambda \beta_{xkc}'}}, \quad (2)$$

where λ is a scale parameter that is inversely proportional to the variance of ε.

The goal in the present study was to estimate the means ($\boldsymbol{b}$) and covariance (Ω) of the vector of coefficients in the populations by observing choices made by individuals. The vector of coefficients for each person was not observed, so the probability given to the choices made by person i is the integral of (2) over all possible values of β_i weighted by the density of β_i:

$$L(y_i|\boldsymbol{\beta}_i) = \int L(y_i|\boldsymbol{\beta}_i)\varphi(\boldsymbol{\beta}_i|\boldsymbol{b}, \Omega) d\boldsymbol{\beta}_i, \quad (3)$$

where $\varphi(\boldsymbol{\beta}_i|\boldsymbol{b}, \Omega)$ is the density of β_i. This integral cannot be mated analytically (Revelt and Train, 1998), but simulation procedures can be used.

In Bayesian estimation, the researcher has some prior notion about $\boldsymbol{b}$ and Ω, which is combined with the outcome of the choice experiment to calculate a joint posterior distribution that updates the information on $\boldsymbol{b}$ and Ω. The prior on $\boldsymbol{b}$ can be specified to be normal and to have very large variance, which allows the researcher to consider all possible values of **b** as being nearly equally likely. The joint posterior distribution of $\boldsymbol{b}$ and Ω for all respondents is proportional to $\prod L(y_i|\boldsymbol{\beta}_i)\varphi(\boldsymbol{\beta}_i|b, \Omega)R(b, \Omega)$. The mean of the posterior distribution of $\boldsymbol{b}$ is an efficient estimator of β, and the variance is the asymptotic variance. Monte Carlo procedures are used to take draws from the posterior distribution and to calculate the means, variances, and covariance of the coefficients.

For our estimates, we used software for mixed logit analysis created for the Matlab statistical package (The MathWorks Inc., Natick, Massachusetts), and available online at http://elsa.berkeley.edu/~train/software.html. The Bayesian procedure uses Monte Carlo Markov Chain (MCMC) methods for taking draws from the posterior distributions of coefficient mean vectors and covariance matrices, and creating draws of coefficients with the specified distributions. For coefficients that are specified to have non-normal distributions, draws of normally distributed coefficients are made and are transformed to obtain draws of coefficients for the utility function (Train, 2001). The software allows the user to retain the draws, so tests of statistical significance based on Monte Carlo estimates of variance can be conducted on the coefficients and other parameters.

We used 10,000 iterations prior to retaining any draws. Every tenth draw was retained from the following 10,000 iterations, for a total of 1000 draws retained to estimate the attribute coefficients and covariance (Train, 2003). To create draws of coefficients entering utility, we used 2000 draws from the posterior distributions (Train and Sonnier, 2005).

4. Model specification

A dummy variable for the alternative specific constant (ASC) was assigned the value of one for alternatives other than the *status quo*, and socioeconomic variables were interacted with the ASC to avoid singularities. The coefficients of these interactions measure the propensity of respondents to select alternatives other than the *status quo* (i.e., environmental improvements). We specified random distributions for the attribute coefficients to study differences in tastes among respondents, and fixed coefficients for costs to (1) avoid problems of lack of convergence that are common when all coefficients are specified as random (Revelt and Train, 1998), and (2) to facilitate the calculation of implicit prices (marginal WTP) for the attributes (see below). A truncated normal distribution with negative values massed at zero was specified for the attributes of recreational fishing (fish size and number) to ensure that all anglers had positive coefficients for these variables (Train, 1998). For divers, the distribution of the coefficient for small colorful fish was specified as a truncated normal, while the distribution of the coefficient for large fish was specified as normal because encountering large fish may have a negative impact on some divers. A normal distribution was also assigned to the coefficients of the interactions between socioeconomic characteristics and the ASC. For normal distributions truncated at zero, the transformation creates a coefficient with a mass at zero; the density above zero is equal to the normal density of the coefficient.

We tested the statistical significance of attribute correlations by calculating the correlation matrix implied by each draw of the covariance matrix, and estimating standard errors (the standard deviations of the draws) and t-values for the matrix elements (Revelt and Train, 1998). To test for differences in model fit between the formats, we calculated the likelihood ratio index (ρ^2) for the log-likelihood of each draw and obtained standard errors for Bonferroni-adjusted t-tests.

Because coefficient estimates are confounded by the scale factor (λ) coefficients from different models can only be compared if the effect of λ is separated. However, parameter ratios are not confounded by scale factors and can therefore be compared directly. Because we specified a fixed coefficient for costs, implicit prices could be calculated directly as the ratio of the attribute coefficients to the cost coefficient (Revelt and Train, 1998). Willingness to pay for changes in the levels of the attributes, expressed as Compensating Variation (CV), was specified as

$$CV = \frac{v(X_0) - v(X_1)}{\beta_c}, \quad (4)$$

where β_c is the coefficient of the cost parameter, and the subscripts (0, 1) refer to environmental states before and after an

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improvement, respectively. We calculated *CV* for unit increases in all attributes.

5. Model comparisons: competing hypotheses and expected results

Information quality, which is the degree to which information is useful to respondents in their selection of choices (Keller and Staelin, 1987) has been shown to have a positive effect on WTP in contingent valuation surveys (Ajzen et al., 1996; Bergstrom et al., 1990). In Contingent Valuation studies of the costs of committing to a payment for an improvement in environmental quality, Zhao and Kling (2004) and Corrigan et al. (2008) found that respondents who were given the opportunity to delay their commitment to pay for improvements in drinking water, and thus had the chance of obtaining future information about the provision and quality of the good, were willing to pay less for an immediate improvement than respondents who were not given an opportunity to delay their commitment. The latter faced a riskier decision because of the limited amount of information that was available at the moment of their decision. Therefore, information on scenario risk may increase WTP and it would be expected that survey versions that included any type of information on risk (anglers, versions 2 and 3; divers, versions 5 and 6) would have a higher WTP than "traditional" versions, in which no information is provided on risk (anglers, version 1; divers, version 4). However, under the neoclassical-economics framework of expected utility (von Neumann and Morgenstern, 1944), individuals have knowledge about the probability of occurrence of different outcomes, and will select the outcome with the highest expected value. The WTP for scenarios of environmental improvements would thus be expected to be higher in a version with a high probability of occurrence. The assumption that respondents confer a high degree of certainty to traditional valuation scenarios would be supported if the WTP in conventional surveys would be equal or greater to WTP in surveys stating high probabilities of occurrence.

When information on the probability of success of environmental policies is absent, users of environmental resources may make their own inferences on this probability (Fischoff and Furby, 1988; Jakus and Shaw, 2003). The respondents' inferred probabilities will be unknown to the researcher, contributing to the random component of utility (Louviere et al., 2000). Additionally, there may be significant variations between the inferred probabilities of different individuals (O'Connor et al., 1999). One implication is that survey versions which explicitly include values for the probability of occurrence of different scenarios (anglers, versions 2 and 3; divers, versions 5 and 6) would also have a higher goodness of fit (ρ^2) than traditional versions (anglers, version 1; divers, version 4).

In contrast to the above, certain forms of information can create a cognitive burden for respondents in stated-preference surveys (reviewed in DeShazo and Fermo, 2002) and lead to confusion, mistakes, and the use of simplifying heuristics by respondents in their choice selection. These factors can reduce a model's ability to fit observations. For example, Dellaert et al. (1999) found that choice consistency was inversely related to the differences in the rices given in the choice sets, and theorized that the greater difficulty in choosing between dissimilar prices led to choice inconsistencies. The cognitive requirements in choice modeling are relatively large compared to other preference elicitation techniques (Bennett and Blamey, 2001), and the inclusion of information on risk may impair model fit and choice consistency.

To study if the inclusion of information on risk affected choice consistency, we estimated the number of selections of the *status quo* made in each of the survey versions. For the alternatives that were not selected in each choice set, we determined if an inconsistent choice was made by the respondent, i.e., if the respondent chose one of the alternatives over the *status quo* in a different choice set.

Table 1
Definitions and levels of explanatory variables in choice experiments for marine recreation at Loreto Bay National Park, Mexico.

Variable	Definition and Levels (in Parenthesis)
	Surveys of recreational anglers
NUMBER	Number of fish caught (4, 6, 8)
WEIGHT	Weight of fish caught (10 lb, 20 lb, 30 lb)
FEE	Access fee for 10 days of fishing (US$60, US$150, US$240)
ASC	Alternative specific constant for the first level of choice, with a value of zero for the current situation and one for the other alternatives
AGE	Interaction of ASC and age of respondent
INC	Interaction of ASC and dummy variable equal to one for household income above average, zero for others
EXP	Interaction of ASC and number of years of fishing experience
EDU	Interaction of ASC and dummy variable equal to one for education at college level or higher, zero for others
	Surveys of recreational SCUBA divers
CORAL	Number of coral fish observed (50, 75, 100)
LARGE	Number of large fish observed (2, 4, 6)
FEE	Access fee for one day of diving (US$2, US$10, US$20)
ASC	Alternative specific constant for the first level of choice, with a value of zero for the current situation and one for the other alternatives
GEN	Interaction of ASC and dummy variable equal to one for gender = male
AGE	Interaction of ASC and age of respondent
INC	Interaction of ASC and dummy variable equal to one for household income above average, zero for others
EXP	Interaction of ASC and number of years of diving experience
EDU	Interaction of ASC and dummy variable equal to one for education at college level or higher, zero for others

6. Results

6.1. Recreational anglers

The 87 recreational anglers who were surveyed were male, and were United States citizens. Their mean age was 46 ± 5.5 (SD).

The *cost* coefficient had the expected sign and was significant in all versions (Tables 1 and 2). The *number of fish* attribute was statistically significant in versions 2 and 3, and the latter yielded the highest number of significant coefficients (5). The *fish weight* attribute was statistically significant in versions 1 and 3. None of the versions had coefficients with significant variances, indicating that tastes were the same among respondents. The attribute coefficients were not correlated (Table 3), suggesting that recreational anglers had a preference for catching either a large number of fish, or larger fish. The interaction of income with the ASC was significant and positive in version 3; preferences for attribute improvements increased with income.

WTP, measured as Compensating Variation, was approximately twice for version 1 than for versions 2 and 3 (Table 2). Goodness of fit, measured as ρ^2, was significantly different between the versions (1 vs. 2: $t = 11.409$, $P < 0.01$; 1 vs. 3: $t = 2.388$, $P < 0.05$; 2 vs. 3: $t = 15.694$, $P < 0.01$; Table 2); it was highest in 3 and lowest in 2. The number of choice sets on which the *status quo* was selected was 37 (15.2%), 65 (22.6%), and 38 (15.1%) for versions 1, 2, and 3, respectively. For version 2, the coefficient for the ASC entering utility was negative and significant, indicating that respondents resisted changes in the current situation when the scenario with relatively high risk was presented. Three choices for the *status quo* were inconsistent in version 1 (8.1%), 19 in version 2 (29.2%), and there were no inconsistent choices in version 3.

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Table 2
Results of mixed logit models for recreational anglers at Loreto Bay National Park, Mexico. Variable definitions are given in Table 1. Version 1 did not state any information on the probability of occurrence of scenarios, version 2 stated a 60% probability of occurrence, and version 3 stated a 90% probability of occurrence. Standard errors for coefficients are given in parenthesis. *CV* is Compensating Variation (in US$, with standard deviation in parenthesis) for unit increases in the two attributes (number and weight). *N* is the number of choice occasions.

Variable	Version 1		Version 2		Version 3	
	Coefficient/*Variance*	Utility Coefficient	Coefficient/*Variance*	Utility Coefficient	Coefficient/*Variance*	Utility/Coefficient
NUMBER	−5.072 (3.9460)	0.813	−3.335** (1.4528)	0.237	−3.991*** (1.393)	0.214
	41.648 (87.2304)		*9.791* (7.3055)		*11.777* (8.2152)	
WEIGHT	−2.816** (1.3462)	0.568	−6.517 (4.7525)	0.459	−1.623** (0.8048)	0.490
	15.400 (18.4938)		*37.301* (58.7930)		*7.554* (6.3317)	
FEE	−0.003* (0.0018)	–	−0.003** (0.0015)	–	−0.003* (0.0018)	–
ASC	−2.843 (10.032)	–	−3.417** (1.7031)	–	5.519* (3.0796)	–
AGE	3.763* (2.0489)	–	0.583 (0.6034)	–	2.428 (1.7295)	–
INC	0.884 (5.6559)	–	0.996 (2.569)	–	11.851*** (2.9969)	–
EXP	−2.638 (2.4345)	–	0.662 (2.2205)	–	−0.404 (4.4937)	–
EDU	13.541 (10.2258)	–	6.963 (1.6314)	–	1.299 (3.2341)	–
CV	$460 (248.2)		$232 (169.5)		$234 (102.2)	
ρ^2	0.405		0.242		0.433	
N	243		288		252	

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

6.2. Recreational divers

The average age of the 98 recreational divers who were surveyed was 38 ± 11 (SD). From them, 42% (41) were female; 87% (86) were citizens of the United States, 7% (7) were European, and 6% (6) were Mexican citizens.

The *cost* coefficient had the expected sign and was significant in all versions (Tables 1 and 4). Both attribute coefficients (*coral fish* and *large fish*) were significant in versions 4 and 6, but neither was significant in version 5. Version 4 had the highest number of significant coefficients (6). Divers had different tastes for the *large fish* attribute, as evidenced from significant variances, but the same tastes for the *coral fish* attribute. There was no correlation in the attribute coefficients (Table 3); divers had a preference for observing either small, colorful fish or large fish. Preferences for changes in the current situation increased with income, and were higher for women than men (but the gender interaction was not significant in version 5).

Compensating Variation was twice as high for version 4 than for versions 5 and 6 (Table 4). Goodness of fit was significantly different between versions (4 vs. 5: $t = 4.046$, $P < 0.01$; 4 vs. 6: $t = 2.177$, $P < 0.05$; 5 vs. 6: $t = 1.921$, $P < 0.10$; Table 4); it was highest in 4 and lowest in 5. The number of choice sets on which the *status quo* was selected was 67 (29.8%), 49 (24.7%), and 38 (20.1%) for versions 4, 5, and 6, respectively. Fourteen choices for the *status quo* were inconsistent in version 4 (20.9%), 13 in version 5 (26.5%), and 8 in version 6 (21.1%).

7. Discussion

Visitors to the Loreto Bay National Park (LBNP) would be willing to pay higher fees than those currently charged to obtain improvements in the park's recreational attributes. Recreational anglers would pay between $232 and $460 for unit (1 lb) increases in fish size and numbers during an average fishing vacation (10 days), and SCUBA divers would pay between $5 and $10 per day for unit increases in coral-associated fish and large fish.

Our results suggest that complementing the information set of a stated-preference valuation with a statement mentioning a high probability of occurrence of the valuation scenario may improve goodness of fit and the consistency of choices. In our experiments, a survey version for recreational anglers that stated that the valuation scenario had a 90% probability of occurrence had a ρ^2 that was significantly higher than the ρ^2 of a version with no information on probability, and of a version mentioning a 60% probability of occurrence. The consistency of choices was also higher for the 90% version than for the other 2 versions. The 90% version was the only version that had significant coefficients for both of the attributes, which may indicate that information on scenario risk may be the type of information that contributes to information quality. However, the inclusion of a 60% scenario probability value may have contributed to the cognitive difficulties of the choice experiments, resulting in the observed lower goodness of fit, higher choice inconsistencies, and the significance of a single attribute (*number of fish*).

If low risk increases WTP, as predicted by expected-utility theory, it seems that anglers assumed a probability of success greater than 90% in the traditional scenario, which had the highest WTP. A possible implication is that a traditional choice experiment may substantially overestimate willingness to pay. By increasing realism in the valuation scenario and reminding respondents that risk is pervasive in their choices, information on risk may prompt respondents to state WTP values that are consistent with economic theory of choosing under risk.

The inclusion of information on risk in the form of intervals decreased goodness of fit and choice consistency, which suggests that including information on scenario risk using intervals around an attribute level may increase the cognitive burden of responses. Results for Compensating Variation for the diver surveys again suggested that the traditional choice format is seen by respondents as having little or no risk. In accordance to expected-utility theory, the value for a traditional version that did not include information on risk was twice that of versions that included narrow and wide intervals around mean attribute levels.

Table 3
Correlation coefficients (and standard errors) for recreational fishing and SCUBA diving attributes at Loreto Bay National Park, Mexico.

	Version 1	Version 2	Version 3
Anglers	−0.124 (0.4610)	−0.014 (0.5048)	−0.091 (0.4327)
	Version 4	Version 5	Version 6
Divers	0.118 (0.3255)	0.255 (0.2489)	0.176 (0.2895)

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Table 4
Results of mixed logit models for recreational divers at Loreto Bay National Park, Mexico. Variable definitions are given in Tables 1 and 2.

Variable	Version 4		Version 5		Version 6	
	Coefficient/*Variance*	Utility Coefficient	Coefficient/*Variance*	Utility Coefficient	Coefficient/*Variance*	Utility Coefficient
CORAL	−4.184*** (1.6115)	0.006	−4.890 (3.4343)	0.621	−2.782* (1.6722)	0.230
	3.785 (3.0126)		*33.265* (41.2912)		*7.909* (7.9721)	
LARGE	0.517* (0.2704)	0.546	0.446 (0.3001)	0.483	1.000*** (0.3086)	1.035
	*1.210** (0.6238)		*1.324** (0.6817)		*1.244*** (0.6124)	
FEE	−0.055*** (0.0256)	–	0.235*** (0.0433)	–	−0.281*** (0.0483)	–
ASC	6.735*** (2.3418)	–	2.836* (1.5150)	–	0.652 (2.5797)	–
GEN	−7.598** (3.7003)	–	−0.401 (2.5135)	–	−7.331*** (1.2278)	–
AGE	1.414 (1.1377)	–	0.022 (0.4129)	–	0.047 (0.5116)	–
INC	9.646*** (1.9471)	–	2.782* (1.6359)	–	4.540*** (1.5369)	–
EXP	−2.827 (2.9525)	–	−0.048 (1.0162)	–	0.870 (1.1700)	–
EDU	1.721 (1.7840)	–	11.423*** (2.3874)	–	−0.226 (1.9108)	–
CV	$10 (4.2)		$5 (1.8)		$5 (2.2)	
ρ^2	0.350		0.265		0.312	
N	225		198		189	

*Significant at the 10% level. **Significant at the 5% level. *** Significant at the 1% level. Notes: Variable definitions are given in Table 1. Version 4 did not include information on attribute level dispersions around the mean, version 5 included narrow dispersions, and version 6 included wide dispersions. Standard errors for coefficients are given in parenthesis. *CV* is Compensating Variation (in US$, with standard deviation in parenthesis) for unit increases in the two attributes (coral and large). *N* is the number of choice occasions.

It is also important to recall that our experiments were conducted in a protected area, where visitors may have a higher trust on the success of environmental management policies than in areas that are not protected. Similar research in areas that are not protected would provide additional insights on the effects of including information on risk in valuation scenarios.

8. Conclusions

Stated-preference valuation surveys are conducted under hypothetical scenarios that depict possible changes in the environmental goods that are being valued. Environmental changes are brought about by interactions between natural and human actions, and they are thus difficult to predict. In addition, the variability and intensity of climatic events is expected to increase under global climate change (Bakun, 1990; Timmermann et al., 1999; Hartmann et al., 2000; Roe and Baker, 2007), and predicting the outcomes of environmental management policies will become even more daunting. As the general public continues to become informed about the uncertainty of the future state of the environment, the current format of stated-preference elicitation methods, which ignores statements concerning the risk of the valuation scenario, may lack the detail required for reliable stated-preference valuations of the environment. Respondents may expect a statement to be provided regarding an assessment of risk, but providing an assessment that is perceived as low may hamper the ability to predict choices.

Our paper studied the effects of including information on probabilities of attribute improvement and provision on the choices made by respondents on choice experiments. Our results suggests that providing an assessment risk of 90% increases fit with respect to a traditional survey that does not include information on risk. Due to relatively small sample sizes in the valuation surveys, the results of this study cannot be considered conclusive. However, our results offer an intriguing first look at the effects of risk-related information on the goodness of fit and consistency of choice models for the economic valuation of the environment.

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Appendix I

(A) Description of the valuation exercise presented to recreational anglers, in which the stated probability of attribute improvements of the management alternatives was 60%. **(B)** Attribute and cost levels (in US$) presented to the respondents. **(C)** An example of a choice set presented to recreational anglers.

(A) Loreto Bay National Park – Sports Fisheries Research Project

The waters of Loreto Bay and its islands have a high abundance and diversity of marine resources. In order to protect these resources, the Mexican Government established the Loreto Bay National Park in 1996. The Park is divided into management areas, and different fishing activities are allowed in each type of area. Some of these areas contain nursing grounds for different species of coastal fish such as groupers. Thanks to the control of fishing activities in the nursing grounds, the Loreto Bay National Park is currently considered to be a prime location for sport fishing of large coastal fish. This survey is part of a joint project between Arizona State University and Scripps Institution of Oceanography to assess the economic benefits of management activities in Loreto Bay National Park. The goal of the project is to provide guidelines to the Park Authority on how to improve recreational fishing in Loreto. Completing this survey will take approximately 5 min.

Your participation is greatly appreciated!

Please read the information below carefully, and select from the given options.

- The Loreto Bay National Park Authority currently charges an average license fee of US $6 for one day of fishing in the Park

(including the Park entrance fee). The funds that are collected are used for management activities, including the enforcement of fishing regulations.
- With additional funds coming from higher license fees, the Park Authority could improve its enforcement activities, protect the spawning grounds of coastal fish, and provide incentives (subsidies) to commercial fishers so that they will reduce their fishing activities inside the Park. These activities are expected to increase the number and/or the size of coastal fish caught by sports fishers in the near future. An example of a species that may benefit from these actions is the leopard grouper (“cabrilla”), which inhabits shallow areas of the Park year-round.
- On average, sport anglers spend 10 days fishing at the Park. In those 10 days, the average number of large coastal fish that are caught is 4, and the average weight of each fish is 10 pounds. Which of the following options would you choose for 10 days of fishing in the Loreto Bay National Park? Each option represents a Park management alternative whose outcome is described in terms of the expected number and weight of large fish such as leopard groupers that you could expect to catch, and the license fee for 10 days that will go to funding the management alternative. Scientists estimate that management alternatives have a 60% probability of achieving the described outcome. If not successful, the expected catch and weight of fish will be the same as the current situation.
- Please circle your preferred option (Park management alternative) for each of the 9 choice sets below.
- When making your selection, please keep in mind all the other costs that you will incur to go fishing (including boat and equipment rental), and your anticipated budget for other activities during your trip.

(B)

Attribute/Cost	Levels
Number of large coastal fish caught during 10 fishing trips	4, 6, 8
Average weight (in lb) of fish	10, 20, 30
License fees for 10 fishing trips	$60, $150, $240

(C)

	Management Alternative 1 (current situation)	Management Alternative 2	Management Alternative 3
Number of leopard groupers caught during 10 fishing trips	4	4	8
Average weight of individual fish	10 pounds	20 pounds	10 pounds
License fees for 10 fishing trips	US$60	US$240	US$150

Appendix II

(A) Description of the valuation exercise and valuation scenario presented to recreational SCUBA divers **(B)** Attribute levels in diver survey versions with narrow ranges (version 5) and wide ranges (version 6) around the average value, which is given in parenthesis. The cost levels used were $2, $10, and $20. **(C)** An example of a choice set (survey version 5) presented to SCUBA divers

(A) Loreto Bay National Park – SCUBA Diving Research Project

The waters of Loreto Bay and its islands have a high abundance and diversity of marine resources. In order to protect these resources, the Mexican Government established the Loreto Bay National Park in 1996. The Park is divided into management areas, and different fishing activities are allowed in each type of area. Some of these areas contain nursing grounds for different species of coastal fish such as groupers and fish that are associated to corals. Thanks to the control of fishing activities in the nursing grounds, Loreto Bay National Park is currently considered to be a prime location for SCUBA diving. This survey is part of a joint project between Arizona State University and Scripps Institution of Oceanography to assess the economic benefits of management activities in Loreto Bay National Park. The goal of the project is to provide guidelines to the Park Authority on how to improve the quality of SCUBA diving in Loreto. Completing this survey will take approximately 5 min.

Your participation is greatly appreciated!

Please read the information below carefully, and select from the given options.
- The Loreto Bay National Park Authority currently charges a daily fee of US $2 for diving in the Park. The funds that are collected are used for management activities, including the enforcement of fishing regulations.
- With additional funds coming from higher fees, the Park Authority could improve its enforcement activities, protect the spawning grounds of coastal fish, and provide incentives (subsidies) to commercial fishermen so that they will reduce their fishing activities inside the Park. These activities are expected to increase the number of coral fish and large groupers, such as the leopard grouper (“cabrilla”).
- SCUBA divers make an average of 2 dives per diving trip in Loreto Bay National Park. Which of the following options would you choose for diving in the Park? Each option represents a Park management alternative whose outcome is described in terms of the expected number of coral fish and groupers that divers can expect to see during each dive (the average number is in parenthesis), and a diving fee that will fund the management alternative.
- Please circle your preferred option (Park management alternative) for each of the 9 choice sets below.
- When making your selections please keep in mind all other costs that you will incur to go diving (including boat and equipment rental), and your anticipated budget for other activities during your trip.

(B)

Attribute/Cost	Version 5 (Narrow)			Version 6 (Wide)		
	Status quo	Low	High	*Status quo*	Low	High
Number of coral fish	25–75 (50)	40–110 (75)	50–150 (100)	10–90 (50)	15–135 (75)	20–180 (100)
Number of large fish	1–3 (2)	2–6 (4)	3–9 (6)	0–4 (2)	1–7 (4)	2–10 (6)

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(C)

	Management Alternative 1 (current situation)	Management Alternative 2	Management Alternative 3
Number of coral fish (such as damselfish, butterflyfish, angelfish, parrotfish and surgeonfish) observed during one dive	Between 25 and 75 (average = 50)	Between 25 and 75 (average = 50)	Between 40 and 110 (average = 75)
Number of large fish (such as leopard groupers) observed during one dive	Between 1 and 3 (average = 2)	Between 2 and 6 (average = 4)	Between 1 and 3 (average = 2)
License fees for one day of diving (two dives)	US$2	US$20	US$20

Appendix III

Socioeconomic questions in the economic valuation surveys presented to recreational anglers and SCUBA divers.

a. From what city and country did you travel to Loreto/La Paz? _____

b. What is your age? _____

c. Sex: M__ F__

d. The average gross annual income per household in the United States is $43,500. Is your household income:

___ Considerably higher than the average

___ Somewhat higher than the average

___ Average

___ Somewhat lower than the average

___ Considerably lower than the average

If you are not a U.S. citizen, please classify your household into the categories above based on your estimate of your country's average gross annual income level.

e. For how many years have you been a sport fisherman/SCUBA diver? _____

f. What is the highest level of education that you had the chance to complete?

Sixth grade	High school	Technical school	College undergraduate	College graduate

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