

CONTINGENT VALUATION OF MARINE PROTECTED AREAS: SOUTHERN CALIFORNIA ROCKY INTERTIDAL ECOSYSTEMS

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ABSTRACT. Designation as Marine Protected Areas (MPAs) can protect coastal ecosystems, but apparently has not effectively protected the rocky intertidal zone in urban Southern California. Here, illegal collecting and habitat disturbance harm coastal marine life. We surveyed day visitors to sandy beaches or adjacent rocky habitats in Orange County. Using the close-ended, double-bounded contingent valuation method, we estimate the benefit of more effective enforcement and management of MPAs designed to avoid coastal ecosystem decay. We solve the problem of sample selection bias, introduced by the likelihood that the sample disproportionately includes respondents who visit more frequently and who may have a higher willingness to pay (WTP). We estimate the WTP for enacting policies to reduce illegal collecting and on-site habitat disturbance to average \$6 per family-visit. Our estimate is consistent with other studies that estimate consumer surplus at \$15 per person-trip for nearby, lower quality beaches, and extrapolates from other studies to \$3.6–\$4.8 million per mile of coastline.

KEY WORDS: Marine Protected Areas, rocky intertidal zone, coastal ecosystems, biodiversity, marine life, contingent valuation, sample selection bias, willingness-to-pay.

I. Introduction. Marine Protected Areas (MPAs) number more than 1300 worldwide, and are an important tool for managing and

protecting coastal populations and ecosystem functioning and arresting the degradation of coastal resources, but the effectiveness of MPAs has not been systematically assessed (Boersma and Parrish [1999]). Recently, Murray [1998] and Murray et al. [1999a] evaluated the effectiveness of MPAs in a heavily-populated section of the Orange County, California coastline. The results are not encouraging. Here, researchers observed human activity at eight sites, four of which had been operating for nearly 30 years under MPA regulations that prohibited the collection of almost all marine organisms. Researchers commonly observed illegal taking at all sites, and particularly those most accessible to the public. There was no statistically discernible difference in the amount of collecting activity between long-standing MPAs and nearby unprotected rocky intertidal zone (RITZ) sites. Moreover, enforcement of MPA regulations was essentially non-existent during the one-year study period. Besides illegal collecting, licensed collectors and fishers are perturbing RITZ communities by extracting marine organisms. In addition, each year some of these sites attract thousands of visitors and school children participating in organized educational field trips. The foot traffic of visitors (Brosnan and Crumrine [1994], Murray [1998], Keough and Quinn [1998], Murray et al. [1999a]) and their exploratory manipulation of organisms and rocky substratum (Addressi [1995]) are known to significantly disturb RITZ communities. The records of local lifeguards contain additional evidence of the extent of human disturbance in Orange County RITZ habitats. During one recent summer, County lifeguards issued more than 25,000 “ecological advisements” to persons engaged in environmentally damaging activity over a single 0.5 km stretch of shoreline in Laguna Beach (Murray et al. [1999a]).

The RITZ is now experiencing “ecosystem decay,” a term originally coined by Thomas E. Lovejoy and presented in this metaphor:

Let’s start by imagining a fine Persian carpet and a hunting knife We set about cutting the carpet into thirty-six equal pieces, each one a rectangle, two feet by three When we’re finished cutting, we measure the individual pieces, total them up—and find that, lo, there’s still nearly 216 square feet of recognizably carpetlike stuff. But what does it amount to? Have we got thirty-six nice Persian throw rugs? No. All we’re left with is three dozen ragged fragments, each one worthless and commencing to come apart. Quammen [1996]

The human population is increasing rapidly in Southern California, and public access to beaches and the RITZ has increased over time as a result of state law. Yet, as MPAs are currently managed, on-site human activities threaten the very biodiversity and abundance of marine life that draw visitors to the RITZ. The consistent presence of enforcement officials, and limitations or restrictions to access at heavily-visited RITZ sites, would reduce the frequency of human disturbances and increase the effectiveness of Southern California's MPAs. Implementation of these management strategies, however, has a cost, and it would be useful to know how much people value the prevention of further deterioration of RITZ ecosystems in urban Southern California.

We estimate the value of policies that avoid some causes of ecosystem decay in the RITZ. The method we use is contingent valuation (CV), with a close-ended, double-bounded value elicitation procedure (Hanemann, Loomis, and Kanninen [1991]). We estimate the value to a sub-population of residents in the greater Los Angeles region of management programs to protect RITZ ecosystems from degrading human activities. This sub-population consists of visitors to the Orange County RITZ and adjacent beaches, where the sample is confined to persons who live close enough to this shoreline for day visits. Although CV has been used to place value on natural resources in national parks and other types of ecosystems, this is the first published CV-based evaluation of the benefits of protecting non-commercial intertidal resources which are increasingly being disturbed by human activities of which the authors are aware.

II. Valuation Method and Related Issues. For many environmental resources, including such amenities as clean air, park land, and biological resources, visitors do not have the option of purchasing the exact amount of the resource that they would like to obtain. Provision and maintenance of the quality of these goods is a collective choice, generally made through legislation and regulation. Many environmental resources cannot be purchased in markets, so there are not observable "prices" that would signal how much visitors value the provision of additional amounts or higher quality of these goods. Consequently, economists have developed a variety of methods to indirectly measure their value. We use the stated preference method known as contingent valuation (CV) for reasons discussed below.

A. Use and Existence Value. We follow the generally accepted typology presented by Mitchell and Carson [1989]. First, use value is classed as either direct or indirect. Direct use is further divided between resource use as an input to economic activity (tide-pooling, recreational and commercial fishing and diving) or waste disposal (nutrient recycling). Indirect use has two components, aesthetic (adjacent beach recreation, routine viewing) and ecosystem (bird-watching—they eat mussels and fish, and support of the ocean food chain). Existence value is divided between vicarious consumption (the value of use to relatives, friends, and the general public) and stewardship (preservation and bequest value). Revealed preference methods, such as travel demand, can measure the use value, but cannot provide the existence values. Existence values are, *prima facie*, an important component of the value of preserving or improving an ecosystem. Revealed preference methods also cannot value preferences for government policies to change ecosystem quality. Stated preference methods, such as CV, can do both.

B. WTP vs WTA and Marine Protected Areas. If we ask respondents what they are willing to accept (WTA) for a reduction in the quality of a public good, e.g., the deterioration of an ecosystem, the amount will usually be higher than if we ask what they are WTP to avoid the loss in quality. For WTA there is no income constraint that affects a respondent's WTP. Moreover, Hanemann [1991] shows that the lack of close substitutes can result in a substantial difference. If we begin with the supposition that the public owns the right to a healthy ecosystem, then it only takes one hold-out, with an infinite WTA value, to trivialize the estimation of the benefit of programs to avoid ecosystem decay. Mitchell and Carson [1989] point out the non-transferable character of the property rights for public goods. Asking respondents what they would be WTA in exchange for ecosystem decay presumes that respondents have the right to sell ecosystem quality and that they would subsequently receive compensation. Mitchell and Carson's point is correct, as far as it goes, but it serves to highlight two deeper issues that they raise. Are we measuring what we want to measure (validity), and can we repeat the survey and get that same (or nearly the same) answer (reliability)? Below we take each of these issues (validity and reliability) in turn. But first we address the issue

of the nature of property rights and the implications of WTP vs WTA for CV of the RITZ or other ecosystem resources.

C. Property Rights and Contingent Valuation. The CV method estimates the direct and indirect use value as well as the non-use value of avoiding further ecosystem decay. It also values the payment mechanism and the method by which the good is provided. The CV results are affected by obvious or subtle shifts in property rights that are concomitant with the payment mechanism (taxes) and provision of the good (through government). A respondent disaffected by government may be unwilling to pay any increase in taxes, or may believe that the provision of the good will be ineffectual; in either case, that individual's WTP value will be zero.

Disputes arise when we have conflicting rights. On the one hand, if a respondent believes that we collectively own the right to a healthy ecosystem, then the respondent may protest with a zero WTP, because to this respondent it would seem that those who cause ecosystem decay are the ones who should pay. The basis for belief in the right to a healthy ecosystem can be found in legislation establishing MPAs. On the other hand, we all have the right to develop and use technologies that increase our abilities per person to use more resources and discard more waste (witness the internal combustion engine). In California, we also all have a coastal zone management act that requires coastal developers to provide public access to the shoreline. And, we have the right to increase the size of the population by sponsoring immigration and rearing a family. These rights presage further ecosystem decay. While the right to a healthy ecosystem and the rights to actions that indirectly lead to ecosystem decay may be in conflict, we can only have the former if collectively we are willing to pay the cost of collective action. If the right to healthy ecosystems dominates the other rights that cause ecosystem decay, then WTA is what we want to measure. If the other rights dominate the right to healthy ecosystems, the converse logic establishes WTP as the goal for CV. Without prejudging how our political and legal system will or should balance the rights involved, we acknowledge that our estimate of WTP is a downward-biased estimate if the objective is to measure WTA.

D. Validity. The technical definition for validity is whether the estimator is statistically unbiased (Mitchell and Carson [1989]). From the perspective of the benefits and costs of policy, it is the policy that we want to value, not the ecosystem itself. Some individuals dislike government to the extent that they would rather live with ecosystem decay than pay one more cent in taxes to achieve improved ecosystem management. While this type of lexicographic ordering is not covered in standard economic analysis, and might be termed “cutting off your nose to spite your face,” it is a real possibility. Also, we cannot truly promise respondents that an increase in taxes would only be used for the purpose specified in the questionnaire. For example, when Orange County experienced bankruptcy, funds earmarked for various purposes were commingled to carry out activities deemed to be of highest priority by County officials. New laws can ease old restrictions. Moreover, the provision of the good requires involvement by government agencies. In our specific case, we are considering restrictions on access to avoid damage to RITZ resources from high concentrations of visitors, and more policing to reduce poaching and enforce access restrictions. Other factors also cause coastal ecosystem decay, including polluted surface water run-off through storm drains, sewage treatment discharge, ultraviolet radiation and global warming (Costanza et al. [1999], Boersma and Parrish [1999]). Moreover, it has been widely recognized (Allison et al. [1998], Murray et al. [1999b]), that even well managed MPAs cannot succeed in protecting coastal ecosystems in the absence of effective management practices outside MPA boundaries. Thus on-site adherence to MPA regulations cannot guarantee the arrest of coastal ecosystem decay in open marine systems that receive inputs of pollutants from sources outside MPA boundaries. Hence, we are measuring the WTP for policies that may provide uncertain amounts of improvement in the quality of RITZ ecosystems, but that are likely to reduce effects of damaging human activities observed to now occur regularly in and outside the boundaries of local MPAs. We routinely purchase private goods with uncertain outcomes, so the uncertainty itself poses no special problem for econometric analyses. While the WTP to avoid ecosystem decay with certainty is of interest in a purely scholarly sense, the practical question is the magnitude of our combined willingness to pay for more effective MPA protection.

E. Reliability. The technical measurement of reliability is the size of the mean squared error (MSE) of the estimator (Mitchell and Carson [1989]), which equals the variance plus the squared bias. If this number is large, replicating the survey will not give results that are close to the original results. The broader question is whether the estimator of the benefit of a policy change is reliable enough to make a good decision about the policy, especially given underlying scientific uncertainty (Boesch [1999]). For example, a large MSE may be acceptable if the cost is low relative to the estimate of the benefit, or if there is a reasonable probability of irreversible damage. If the estimate of the cost is uncertain, it may be easier to get a better estimate of the cost than to increase the sample size and reduce the MSE of the benefit estimator.

The MSE may not even be a good measure of reliability. If we are fickle, and our preferences change from year to year or day to day, then there may not be a “true value” that we want to estimate. This is true for private, as well as public goods, and for revealed preference methods as well as CV. The “true value” we want to estimate, if there is one, varies with factors that cannot be taken into account, even with the best sample design. Preferences may depend on the weather, in which case during a period of drought, no sample design can measure the variation in preferences due to rainfall. Immigration may steadily change the population mix and the preferences of changing cultural values. A shift in cultural values, in turn, can alter the proportion of the population that believes that they have a right to healthy ecosystems, and change whether or not the “true value” is the WTA or the WTP.

III. Survey Design and Implementation. Contingent valuation surveys are vulnerable to errors in both the questionnaire design and the sample selection, but with care the researcher can take steps to avoid the errors. We take up the questionnaire design and sample selection in turn.

A. Questionnaire Design. Mail and telephone questionnaires have limitations that can be overcome by in-person surveys. Complex aspects of a questionnaire may best be presented with photographs or lists of choices that telephone questionnaires cannot convey. Mail questionnaires pose the problem that the respondent may not follow the

order in which the material is presented, skipping ahead and returning to answer questions in a fashion that affects the results. To avoid the limitations of mail and telephone questionnaires, we designed an in-person questionnaire, although in-person interviews are expensive. We used a three-part design for the questionnaire: 1) the description of the hypothetical market, 2) questions to elicit value, and 3) questions to determine the respondent's socioeconomic characteristics.

1. *Hypothetical Market.* Following the generally accepted procedure, the hypothetical market describes: a) the good to be valued, b) the baseline amount of the good, c) the means by which an additional amount of the good will be provided, d) the range of available substitutes, and e) the method of payment for an additional amount of the good.

a. Good to be Valued. The RITZ can be considered as one of three types of shoreline (the others are wetlands and sandy beaches). The good to be valued is preventing further decay of RITZ biological richness and ecosystem structure and functioning resulting from collecting and human visitor disturbance. To describe the hypothetical market, interviewers showed respondents color photographs of representative RITZs in our study sites, and photographs of individual plants and animals found in this ecosystem.

b. Baseline Amount of the Good. The interviewer described for the respondent the baseline amount of the good, reading from the questionnaire. In doing so, the interviewer addressed issues contributing to RITZ ecosystem decay such as visitor foot traffic and illegal taking (Murray [1998]). The interviewer then used examples to explain how illegal taking can damage RITZ populations. For example, the interviewer explained that mussels (*Mytilus californianus* Conrad) form beds in the intertidal zone, with individuals linked to each other by tough strands of protein called byssal threads. One of the most frequently observed forms of collecting on local shores was the removal and use of mussels for fishing bait (Murray [1998]). Because mussels are linked to one another by byssal threads, removal of a few individuals weakens the attachment of connected neighbors causing the collecting damage to extend beyond the individuals taken (Smith and

Murray [unpublished data]). Thus, the removal of a few mussels can result in the loss of others and cause gaps in mussel beds. In addition, Owl limpets (*Lottia gigantea* Sowerby) produce more gametes with increasing size, and change sex from male to female with age. Therefore, harvesting larger, and presumably older, owl limpets can remove a disproportionate number of females and reduce the reproductive capacity of this species.

The interviewer also explained how visitor foot traffic can contribute to ecosystem decay. She/he explained that rockweeds have been found to be particularly vulnerable to human foot traffic and that when trampled suffer considerable tissue loss (Murray [1998], Murray et al. [1999a]). A local rockweed (*Silvetia compressa*) forms a canopy that provides shelter for numerous species of algae and invertebrates thereby increasing biodiversity in upper-shore RITZ habitats where it occurs (Sapper [1998]). Loss of rockweeds due to trampling, therefore, can reduce the amount of algal canopy coverage and alter RITZ ecosystems. In sum, because of human activities, the baseline for the good to be valued is now deteriorating over time. All of this descriptive material in the questionnaire is grounded in published biological field research at these sites. This detailed local scientific data enhanced the validity of this CV study.

c. Means to Provide an Additional Amount of the Good. The management programs proposed to minimize deterioration of RITZ ecosystems have two parts. First, more intensive enforcement of harvesting regulations would reduce poaching or illegal collecting of organisms. Present levels of patrol and enforcement are known to be ineffective (Murray et al. [1999a]). Second, limiting visitor access to environmentally sensitive sections of the RITZ can reduce impacts of human foot traffic. Signs mark entrances to most local RITZ habitats; these signs inform visitors that collecting is not allowed, but without obvious effect (Murray [1998]). An alternative management strategy would be to create refuges by designating selected areas off-limits to visitors to encourage restoration and rejuvenation of RITZ biological resources. Either alternative, as described in the questionnaire, would require more intensive enforcement to prevent poaching and access to restricted RITZ habitats.

d. Substitutes and Payment Method. The questionnaire is designed to make the respondent mindful of her/his constraints—alternative uses of time and money—and other uses of tax dollars. Respondents are asked to rank their preferences for the use of dollars to provide complements to and substitutes for coastal recreation. Interviewers showed respondents a map of local beaches and RITZ habitats, and a map of Southern California that displayed other recreational destinations. Interviewers asked respondents about their visits to the range of available substitutes. The method of payment to provide for policies that would reduce deterioration of RITZ ecosystems was higher taxes.

The payment mechanism, taxes, avoids strategic bias for local visitors. We exclude from the sample overnight and long-distance visitors, since they might not think their taxes would be affected. This exclusion leads to a more conservative estimate.

2. *Questions to Elicit Value.* The elicitation of willingness-to-pay can proceed with a cue card with benchmarks, open-ended amounts, or close-ended amounts. The cue card with benchmarks asks the respondent, “Are you willing to pay \$2? \$3?, \$4?” etc., until the respondent says “No”. The open-ended elicitation asks the respondent, “How much are you willing-to-pay?” but places an undue computational burden on the respondent when there are no familiar benchmarks or similar goods available for comparison. To avoid no response, the open-ended method was usually accompanied with a cue card shown to the respondent with various ranges of values, and the respondent was encouraged to select one of the ranges. The cue card, however, causes a form of starting point bias (Mitchell and Carson [1989]).

To reduce the computational burden on the respondent and to avoid starting point bias, for the questions to elicit value, Arrow et al. [1993] recommend the discrete-response format favored by Hanemann and Kanninen [1996]. The single-bounded referendum style elicitation asks each respondent a single question, “Are you willing to pay \$20?” and varies the amount across respondents. If the variation in amounts across respondents is large enough, the referendum style elicitation avoids starting point bias. The problem is that the amount of information collected from each respondent is small; we only know that the respondent’s WTP is greater or lesser than the amount we ask, depending on the response (yes or no). The referendum (close-ended)

elicitation of willingness-to-pay requires a substantial number of observations relative to the open-ended elicitation in order to achieve the same statistical efficiency. The double-bounded, discrete-response format proposed by Hanemann [1985] and Carson [1985] increases the power of the statistics (Hanemann, Loomis and Kanninen [1991]). Each respondent is asked a follow-up referendum style question, where the second amount depends on the answer to the first elicitation question.

For the survey design, Hanemann and Kanninen [1999] recommend a sequential experimental design with a pre-testing phase. Pre-testing permits the refinement of survey questionnaires prior to executing the second stage of the sampling program. The pre-test survey provides a priori information about the range of values for the double-bounded design, further increasing the statistical power of the estimator for the welfare measure and avoiding a potential bias if the values are not of sufficient range.

Hanemann and Kanninen [1999] recommend 100–200 observations for pre-testing alone. Such large sample sizes are especially expensive to obtain for RITZ surveys. For pre-testing, an open-ended design, however, has greater statistical power (Hanemann, Loomis and Kanninen [1991]) than a close-ended design and therefore does not require as many observations. We used an open-ended design for our pre-testing instrument for the sole purpose of ascertaining the range of values for the WTP elicitation in the second stage, close-ended, double-bounded surveys. Our pre-testing sample size consisted of 53 observations, reducing the cost of determining the range of values required for the main survey. A histogram presents the results in Figure 1.¹ The highest WTP value that we recorded was \$260.

Based upon the results from pre-testing, we modified the questionnaire to be used in the second phase of the study. For the close-ended, double-bounded elicitation of WTP, the histogram from pre-testing gave us the range of values. There are two questions, an initial elicitation followed by a second dichotomous choice question, where the asking price in the second question depends on the response to the first question, as follows:

Interviewer: Would you be willing to pay \$ Asking Price in additional taxes per year? (The Asking Price is a stratified random variable selected from 2, 5, 10, 15, 20, 30, 40, 50, 70, 90, 100)

Respondent: Yes No

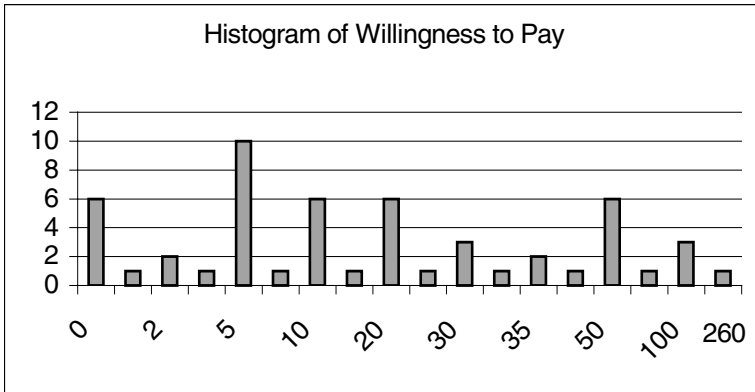


FIGURE 1. Histogram from pre-testing the willingness to pay. (The ordinate gives the number of observations. The abscissa measures the WTP and is unevenly spaced in order to fit the data to a graph. Actual values on the abscissa are given to make the rescaling obvious. To the right of \$100, the highest willingness-to-pay is \$260.)

Interviewer: Would you be willing to pay \$ Asking Price in additional taxes per year? (If previous answer is no, Asking Price equals $0.5 \times$ previous question Asking Price; if previous answer is yes, Asking Price equals $2.0 \times$ previous question Asking Price)

Respondent: Yes No

3. *Questions about Respondents' Characteristics.* The questionnaire includes questions about the respondent's characteristics, preferences for the good, and use of the good, some of which were asked prior to and some after eliciting the respondent's value of the good. Prior to the questions eliciting value, the interviewer asked each respondent to rate the importance of beach cleanliness, maintaining or improving marine wildlife habitat, maintaining or improving parks and greenbelts, marine safety, protecting wildlife, and lifeguards at beaches. The interviewer asked in which recreational activities each respondent engages—fishing, tide pooling, sunbathing, sitting, walking, bird watching, swimming, diving, snorkeling, and surfing, and the frequency of beach visits. After the questions eliciting value, the interviewer requested socioeconomic characteristics, including employment/student status, personal and household income, age, education, and household characteristics.

Since the interviews were in-person, the interviewer recorded gender and race. The interviewer also asked additional questions about preferences, including whether the respondent considers her/himself as a “concerned environmentalist” and if the respondent regularly contributes to environmental causes or groups.

Two variables we measure and use in the empirical section are annual family income and number of trips per year.

4. *Part/Whole Valuation Issues.* While CV measures the sum of use and existence values, there are six² part/whole valuation and aggregation issues in this application to RITZ ecosystem decay. One is the value of improving the RITZ throughout California, in southern California, in Los Angeles and in Orange Counties, or just in the specific region of Orange County targeted by our study. A second issue is the separate values of invoking management strategies for reducing human disturbance caused by illegal collecting, visitor foot traffic, and damaging exploratory activities. Third is separate values of the specific policies under consideration from other policies, such as reducing pollution from surface water run-off or reducing sewage spills. Fourth is the separation of use and existence values. Fifth is the value of the local RITZ to those who live close enough for a day visit and the value to those who have to travel longer distances to reach the shoreline. Sixth is the value to visitors and the value to non-visitors of RITZ resources. We address each of these issues in turn.

First, our survey was conducted in-person at adjacent beaches and RITZ sites where the potential policy change is proposed to occur. Moreover, we estimated the value per visit. If some respondents also visit less desirable sites in adjacent parts of Orange County, they might assume that the policy change also will affect those sites and respond with a lower willing-to-pay (WTP) per visit than if the response is confined to the value of the targeted study sites. Consequently, our estimate of value is biased downward, if at all, and therefore gives a conservative result. Second, we cannot separate values for reducing disturbance from different forms of human activity, e.g., reducing visitor foot traffic and illegal collecting. Third, the questionnaire makes clear to the respondent that the policy options do not include additional controls for surface water run-off or sewage spills. Fourth, we do not present separate estimates of existence value. Fifth, as part of the

survey protocol, interviewers did not select respondents who live too far for a day visit, so the results are specific to persons who live in Los Angeles, Orange, Riverside and San Bernardino Counties. If compared with the cost of implementing new policies (enforcement, access control, and education), the benefit estimate is biased downward because it omits the value to those who live outside the region, and thereby also gives a conservative result. There may, of course, be sources of errors working in the opposite direction, but we have not discovered any that might exist.

The sixth issue, the value of RITZ resources to visitors and non-visitors, is more complex and has two parts. Part one, a CV survey of day-use beach and RITZ visitors, can be used to measure the value that this group places on specific policies to avoid further decay of RITZ biological resources. If compared with the cost of enacting these policies, the benefit estimate is biased downward because it omits the existence value to those who do not visit the beach, again resulting in a conservative estimate of value. Part two, a random sample of visitors to the RITZ and adjacent beaches has a higher chance of including persons that visit the RITZ with greater frequency, an issue we develop below under the heading of sample selection.

B. Sample Selection. We used three methods to reduce the cost of the survey. One is that we used the open ended elicitation method for the pre-test, reducing the number of observations from the recommended 100–200 range. Our pre-testing sample size consisted of 53 observations collected during spring 1997. Two is that in the second stage of the survey, we used the double-bounded elicitation method, reducing the number of observations for any specified power of a statistical test. Third, we conducted the second stage survey at the study site, randomly selecting respondents from beach and RITZ visitors, rather than interviewing respondents randomly selected from households. That is, ours is a random sample of visitors rather than a random sample of potential visitors.

In the second stage, we surveyed beach and RITZ visitors over three years, from April 1998 through April 2000. We interviewed 248 respondents, with a 30% non-response rate. After discarding observations with missing values and inconsistent responses, our final sample size consisted of 220 interviews conducted at nine different RITZ sites dis-

tributed along the Orange County coastline. Our sample was stratified (Cochran [1963]) by study site to reflect the relative numbers of visitors recorded in previous surveys (Murray [1998], Murray [unpublished data]) at these locations.

The traditional econometric analysis of double-bounded CV data predicts annual values, but the estimator would be biased upwards because of sample selection. This is because those who place greater value on RITZ visits presumably visit with greater frequency. Given our survey design, however, we propose unbiased estimators of the value per visit that solves the problem of sample selection bias.

IV. Econometrics. The standard approach to the single-bounded, close-ended WTP elicitation is as follows. We assume that there exists a distribution of WTP, denoted by W below, across the population of Orange County visitors to the targeted RITZ and adjacent beaches, with a mean $\mu_W = X\beta$ and a variance σ_W^2 :

$$(1) \quad W = X'\beta + \varepsilon,$$

where ε has a cumulative distribution function (CDF) with mean and variance $\varepsilon \sim CDF(0, \sigma_W^2)$. The term $X'\beta$ is a scalar found by multiplication of a transposed matrix of explanatory variables times a vector of parameters.

If the probability density function (PDF) is bell-shaped, the CDF will be S -shaped, with values that fall between zero and one. Two distributions typically used are those of the normal random variable and the logistic. Any function can serve for the PDF as long as the area under the function equals one.

The PDFs for the logistic and normal random variables with mean equal to zero and variance σ^2 are given by

$$(2) \quad f(z) = e^z / (1 + e^z)^2$$

$$(3) \quad g(z) = \exp(-z^2/2\sigma^2) / (2\pi\sigma^2)^{1/2}.$$

The CDFs, respectively, give the probability that the random variable takes on a value less than or equal to z , $P(Z \leq z)$ and is geometrically

equal to the area under the bell-shaped PDF to the left of z :

$$(4a) \quad P(Z \leq z) = \int_{-\infty}^z \{e^y/(1+e^y)^2\} dy \equiv F(z) = e^z/(1+e^z) \\ = 1/(1+e^{-z}),$$

where

$$(4b) \quad P(Z > z) = 1 - P(Z \leq z) = 1 - 1/(1+e^{-z}) = 1/(1+e^z),$$

and

$$(5) \quad P(Z \leq z) = \int_{-\infty}^z \exp(-y^2/2\sigma^2)/(2\pi\sigma^2)^{1/2} dy \equiv G(z),$$

where y is just a variable of integration. The details presented in (4) relative to (5) show that closed form solutions for the logistic random variable are easier to derive than for the normal random variable. For symmetric PDFs, the mean, median, and mode all occur at the same value, which is the case for the normal and logistic functions. The maximum of the probability density function is higher for the standard normal random variable compared with the logistic random variable. Because the area under both curves equals one, the tails of the logistic probability density function (2) are fatter than the normal probability density function (3). For analytical convenience, we use the logistic below.

The WTP, W , is the unobserved or latent variable. What we observe is either “yes” or “no” to the asking price, A . To connect the underlying latent variable model to the CDF, note that the conditional probability of a randomly selected visitor responding “yes” is just the probability that the visitor’s unobservable WTP is greater than the asking price. From (4b), this is just

$$(6) \quad P(\text{Yes}|X) = P(W > A) = P(X'\beta + \varepsilon > A) \\ = P(\varepsilon > A - X'\beta) = P(\varepsilon/\sigma > A/\sigma - X'\beta/\sigma) \\ = P(Z > A/\sigma - X'\beta/\sigma) = 1/(1 + e^{A/\sigma - X'\beta/\sigma}).$$

Most standard econometric computer packages include probit and logit routines that estimate the parameters σ and β and provide “prob

values" to test the hypotheses that the vector of parameters β equal zero. The approach is maximum likelihood using non-linear estimation. The weakness with single-bounded close-ended analysis, however, is that the power of the tests is low, so the cost of obtaining a large enough sample becomes burdensome.

Hanemann, Loomis, and Kanninen [1991] show the increase in efficiency when the questionnaire adds a second, follow-on question eliciting the WTP with an asking price that takes advantage of the information obtained from the first question. The power improves for the estimators of the parameters β , lowering the sample size necessary to obtain statistically significant results when testing hypotheses. A few statistical packages provide double-bounded logit or probit routines. We used the routine called the LIFEREG procedure in SAS/Stat (Statistical Analysis Systems - SAS). This routine includes the options for the normal, the log-normal, the logistic, and the log-logistic distributions, among others.

Once we have estimated the parameters β , we can predict the value of W for each observation, conditioned on the observation's values of X . The predicted values for the sample are given by

$$(7) \quad \hat{W}_i = X_i' \hat{\beta}.$$

The problem with the estimator (7) of the WTP per year is that our sample is a random sample of visitors, not a sample randomly drawn from the population of potential visitors, so that the estimators of β might be biased. Our sample is randomly drawn on site from visitors to the RITZ and adjacent beaches, so the probability of being selected is higher for those who visit with greater frequency. If those who visit more often have a higher WTP, then the estimators for β in (7) are biased, and the predicted willingness-to-pay in (7) is biased upward.

Here is our solution. Let V equal the number of visits per year, I equal income, Φ equal the opportunity cost (price) of a visit (converting travel time and cost into dollars), and Q equal the quality of the RITZ.³ Then the primal consumer's problem is to maximize utility with respect to V subject to the budget constraint, with the Lagrangian given by

$$(8a) \quad \max_{\{V, \lambda\}} L = u(V, Q) + \lambda(I - \Phi V).$$

where I is annual family income, not income expended to visit the RITZ. The dual problem is to minimize expenditures subject to a utility constraint, with the Lagrangian

$$(8b) \quad \min_{\{V, \mu\}} \Lambda = \Phi V + \mu[u - u(V, Q)]$$

The first order conditions for the primal (8a) and the dual (8b) include, respectively:

$$(9a) \quad L_V = 0 = u_V - \lambda \Phi, \quad \text{or } \lambda = u_V / \Phi;$$

$$(9b) \quad \Lambda_V = \Phi - \mu u_V; \quad \text{or } \mu = \Phi / u_V.$$

From the first order conditions of the primal and dual, we can solve for the Marshallian and Hicksian demand functions that give the optimal number of visits as functions of the cost of a trip, environmental quality, and, respectively, income or utility:

$$(10a) \quad V = m(\Phi, Q, I);$$

$$(10b) \quad V = h(\Phi, Q, u).$$

Substituting the optimal number of visits (10a,b) into the primal (8a) and dual (8b) objective functions, we derive the indirect utility function and the expenditure function:

$$(11a) \quad u = u(V, Q) = u[m(\Phi, Q, I), Q] = v(\Phi, Q, I);$$

$$(11b) \quad \Phi V = \Phi h(\Phi, Q, u) = e(\Phi, Q, u).$$

For a change in the quality of the environment from Q^0 to Q^1 , *ceteris paribus*—holding constant the values of Φ and I —we can define the Compensating Surplus, C, and the Equivalent Surplus, E, using either the indirect utility function from the primal, or the expenditure function from the dual. With ecosystem decay, Q^0 is the environmental quality after decay and Q^1 is the environmental quality attained with enforcement and better management of MPAs. For Compensating Surplus, the consumer with income I , travel cost Φ and environmental quality Q^0 , reaches utility level $u^0(V, Q^0)$; i.e., *the original property right is Q^0* and we are considering how much the consumer would

give up for environmental quality to be at a higher level Q^1 . For Compensating Variation, the consumer starts with income I , travel cost Φ , and environmental quality Q^1 , and reaches utility level $u^1(V, Q^1)$; i.e., *the original property right is Q^1* and we are considering how much the consumer would have to be compensated to give up environmental quality to a lower level Q^0 .

$$(12a) \quad v(\Phi, Q^1, I - C) = v(\Phi, Q^0, I);$$

$$(12b) \quad C \equiv e(\Phi, Q^0, u^0) - e(\Phi, Q^1, u^0)$$

$$(13a) \quad v(\Phi, Q^1, I) = v(\Phi, Q^0, I + E);$$

$$(13b) \quad E \equiv e(\Phi, Q^0, u^1) - e(\Phi, Q^1, u^1)$$

where u^0 and u^1 gives the utility with Q^0 and Q^1 levels of environmental quality, *ceteris paribus*.

The compensating surplus, C , is the amount the consumer is willing to pay (subtract from income) such that with the improvement in environmental quality to Q^1 , utility is just equal to the righthand side of (12a). On the righthand side of (12a), we have the original utility with the original level of environmental quality and original income. From the dual problem, the willingness to pay is equal to the reduction in expenditures on other goods necessary to maintain utility at u^0 in exchange for a higher level of environmental quality. In (12), the reference level of utility, and the implicit property right, is the original income and the lower level of environmental quality, Q^0 . Consequently, the original income, I , equals the minimum expenditure necessary to achieve utility u^0 , given environmental quality Q^0 , and we can substitute I for $e(\Phi, Q^0, u^0)$ in (12)

$$(14) \quad C = I - e(\Phi, Q^1, u^0).$$

The first term on the righthand side of (14) is the original income that the consumer uses to reach the original utility level $u^0(V, Q^0)$. The second term is the expenditure needed to remain at the original utility level u^0 if the consumer has the higher level of environmental quality Q^1 .

The amount the consumer is willing to accept, E , is the amount added to income on the righthand side of (13a), so that the utility remains the

same when environmental quality is lowered from Q^1 to Q^0 . From the dual problem shown in (13b), the willingness to accept is equal to the increase in expenditures on all goods necessary to maintain utility at u^1 and accept a reduction in environmental quality from Q^0 to Q^1 . In (13a,b), the reference level of utility and the implicit property right corresponds to the higher level of environmental quality, Q^1 , given by the lefthand side of (13a). Consequently, the original income, I , equals the minimum expenditure necessary to achieve utility u^1 , given environmental quality Q^1 , and we can substitute I for $e(\Phi, Q^1, u^1)$ in (13b)

$$(15) \quad E = e(\Phi, Q^0, u^1) - I$$

The first term on the righthand side of (15) is the expenditure needed to remain at the original utility u^1 if the consumer has a lower environmental quality Q^0 . The second term is the original income that the consumer uses to reach the original utility level $u^1(V, Q^1)$.

Now substitute (12a) into (14) and (13a) into (15) to obtain:

$$(16a) \quad C = I - e(\Phi, Q^1, v(\Phi, Q^0, I));$$

$$(16b) \quad E = e(\Phi, Q^0, v(\Phi, Q^1, I)) - I.$$

The compensating surplus, C , is just the willingness to pay, denoted by W in (1). Based upon (16a,b), we can define the WTP and WTA functions

$$(17a) \quad W \equiv w(\Phi, I, Q^1; Q^0)$$

and

$$(17b) \quad E \equiv \varpi(\Phi, I, Q^0; Q^1)$$

where the original property on the right follows the semicolon.

Equation (17a) is the basis for standard estimation of the annual WTP for an improvement in environmental quality. For example, if the error term is additive, and we use the number of miles driven for a visit as a proxy for the cost of a visit, Φ , then we might specify

$$(18) \quad W = \beta_0 + \beta_\Phi \Phi + \beta_I I + \varepsilon, \quad \varepsilon \sim \text{Logit CDF}(0, \sigma_w^2)$$

as a special case of (1) with the linear logit CDF. If the error term is multiplicative, then we can write:

$$(19) \quad W \equiv w(\Phi, I, Q^1; Q^0) \cdot \varepsilon.$$

Taking logs of both sides, and specifying the log of $w(\Phi, I, Q^1; Q^0)$ as a linear function of Φ and I ,

$$(20) \quad \log(W) = \beta_0 + \beta_\Phi \Phi + \beta_I I + \log(\varepsilon), \quad \log(\varepsilon) \sim \text{Logit CDF}(0, \sigma_w^2)$$

Equation (20) is another special case of (1) with the log-linear logit. The problem with (18) or (20) is sample selection bias, as noted above. We now provide a solution to the sample selection bias.

Rewrite (10a) as follows, with a multiplicative error term:

$$(21) \quad V = m(\Phi, I, Q^0) \cdot \varphi$$

Now divide (19) by (21) and define $Y = w(\Phi, I, Q^1; Q^0)/m(\Phi, I, Q^0)$ and $e = \varepsilon/\varphi$ to obtain the willingness to pay per visit, Y :

$$(22) \quad Y = W/V = \psi(\Phi, I, Q^0, Q^1) \cdot e.$$

Taking the log of both sides of (22), and specifying a linear function in the variables Φ and I , we obtain the model⁴:

$$(23) \quad \begin{aligned} \log Y = \log(W/V) &= \beta_0 + \beta_\Phi \Phi + \beta_I I + \log(e), \\ \log(e) &\sim \text{Logit CDF}(0, \sigma_w^2). \end{aligned}$$

The standard statistical package can compute unbiased estimates of the parameters that give the WTP per visit from observations randomly taken from visitors at the RITZ and adjacent beaches. The required adjustment to the raw data is that we divide the asking price, A , by the number of visits, V , and then use the standard, double-bound, log-linear logit.

TABLE 1. Equation (23) parameter estimates of WTP per visit.

Double bounded LogLogit model:

$$\log Y = \log(W/V) = \beta_0 + \beta_\Phi \Phi + \beta_I I + \log(e),$$

where $\log(e) \sim \text{Logit } CDF(0, \sigma_W^2)$

Variable	Estimate	Standard error	Chi-square	Prob>Chi-square
β_0 : intercept	1.12690	0.24688	20.8357	< .0001
β_Φ : miles	0.01743	0.0056139	9.6398	0.0019
β_I : income	1.23864E-6	1.5951E-6	0.6030	0.4374
σ_W : scale	1.07085	0.08490		
Log Likelihood	-312.0276552			

Dependent Variable: Lower bound A/V —Asking Price divided by number of Visits per year.

Dependent Variable: Upper bound A/V —Asking Price divided by number of Visits per year.

Number of Observations: 220

V. Results, Extensions and Implications. Equation (23) is an estimable function that relies on variables included in our data. Table 1 presents the estimates of the β 's and σ , along with the prob-values and other statistics. The coefficients have the correct signs, although the sample size is not sufficient for the coefficient on income to be statistically discernible from zero.

The signs of the coefficients are consistent with a priori expectations, enhancing the validity of the results. A priori, we expect that a higher quality RITZ ecosystem is a normal good, so that higher income causes a higher WTP, as well as a higher WTP per visit, $\beta_I > 0$. We also expect that the number of visits is inversely related to the distance the visitor must travel; since the dependent variable is the asking price divided by the number of visits, we therefore expect that β_Φ is positive. The use value portion of WTP per visit can be thought of as the price of a unit (visit) of the commodity. Borcherding and Silberberg [1978] explain why, when adding the shipping cost to close substitutes (a higher quality apple and a lower quality apple), the relative price to consumers differs by the distance, and associated shipping costs. By analogy, we expect that the sign of β_Φ is positive.

TABLE 2. Predicted WTP per visit.

$$\hat{W} = \exp\{\beta_0 + \beta_\Phi \Phi + \beta_I I\}$$

Loglinear model	Predicted (wtp/visit)
Average	6.114883
Median	4.554603
Max	72.25021
Min	3.110664

Table 2 summarizes the predicted WTP per visit for an improvement in RITZ environmental quality from Q^0 to Q^1 based upon programs to enforce regulations against illegal taking and additional control of access. From (23), we can estimate the per visit WTP conditioned on the sample values of income and miles for each observation. Table 2 presents the minimum, maximum, median and mean predicted values of willingness-to-pay per visit for reducing RITZ ecosystem decay for the sample. The mean value equals \$6.11 per family-visit. This estimate is consistent with the results of other studies, a comparison we now present.

In the legal case of the *American Trader* oil spill off of Huntington Beach,⁵ Orange County, Hanemann [1996] reviews three studies that estimate the value of beach recreation, with results shown below in Table 3. These studies show that the value per visit varies with the quality of the beach. Compare the more polluted Cabrillo-Long Beach value (\$8.16/person-visit) to the slightly better beaches in northern Orange County (\$9.94-\$10.58/visit), and the Santa Monica beaches (\$18.36/visit). Table 4 presents Hanemann's [1997] survey of estimates of consumer's surplus for lost beach trips and consumer's surplus per trip because the beaches were closed due to the oil spill. These estimates are for lost use value; the estimates do not include non-use value (Chapman, Hanemann, and Ruud [1998]). Hanemann's estimate of the value of a visit is \$15/person-visit (\$11-\$23/person-visit) along a 14 mile stretch of northern Orange County beaches. These beaches are closed more frequently due to pollution and are lower quality compared to the southern Orange County beaches, where we estimate use and

TABLE 3. Table from Hanemann [1996], Consumer Surplus from Beach Recreation in 1990\$.

Author	Location	Activity	Value per Day Trip
Dornbusch et al. ¹ [1987]	Northern Orange County	water-dependent activities (including swimming/surfing)	\$9.94
Dornbusch et al. ¹ [1987]	Northern Orange County	water-enhanced activities (including sunning, beach activity)	\$10.58
Bell & Leeworthy ² [1986]	Florida residents in 1984	general beach recreation	\$13.19
Leeworthy & Wiley ³ [1993]	1989 NOAA survey, Cabrillo-Long Beach	general beach recreation	\$8.16
Leeworthy & Wiley ³ [1993]	1989 NOAA survey, Santa Monica beaches	general beach recreation	\$18.36
Leeworthy & Wiley ³ [1993]	1989 NOAA survey, Leo Carillo State Beach	general beach recreation	\$51.94
Leeworthy ⁴	1990 NOAA survey, San Diego County beaches	general beach recreation	\$60.79
Leeworthy ⁴	1990 NOAA survey, San Onofre State Beach	general beach recreation	\$57.31
Leeworthy ⁴	1990 NOAA survey, Pismo Beach State Beach	general beach recreation	\$26.20
Leeworthy ⁴	1990 NOAA survey, Half Moon Bay State Beach	general beach recreation	\$20.70
Leeworthy ⁴	1990 NOAA survey, Patrick's Point State Park	general beach recreation	\$17.78
Leeworthy ⁴ truncated model	1989 & 1990 NOAA survey, So. Calif. Region	general beach recreation	\$23.58
Leeworthy ⁴ untruncated model	1989 & 1990 NOAA survey, So. Calif. Region	general beach recreation	\$44.52

¹ David M. Dornbusch & Co., *Impacts of Outer Continental Shelf Development on Recreation and Tourism*, Vol. 3: *Detailed Methodology*, prepared for Minerals Mgmt. Serv., San Francisco, Apr. 1987.

² Frederick W. Bell & Vernon R. Leeworthy, *An Economic Analysis of the Importance of Saltwater Beaches in Florida*, Sea Grant Report SGR-82, Feb. 1986.

³ Vernon R. Leeworthy & Peter C. Wiley, *Recreational Use Value for Three Southern California Beaches*, NOAA Strategic Environ. Assess. Div., Off. of Ocean Resources & Conserv., Rockville, MD, Mar. 1993.

⁴ Vernon R. Leeworthy personal communication to Hanemann.

non-use value of \$6/family-visit to avoid ecosystem decay by reducing illegal collecting and habitat disturbance by visitors to the RITZ.

In order to estimate the total value per year for policies to avoid ecosystem decay, we need to know the number of family-visits per year. The Santa Monica Bay restoration project estimates a total of 79 million person-visits per year in a similar stretch of coastal area in the Southern California Bight. Based upon the estimates⁶ of Chapman, Hanemann and Ruud [1998], Newport Beach has an annual total of approximately 8.6 million person-visits. If we define Newport Beach to extend from the mouth of the Santa Ana River to the opening of the Newport Harbor, we estimate 5 miles⁷ of coastline, for an average of 1.7 million person-visits per coastline mile-year. Based upon a subsequent survey, Chapman, Hanemann and Ruud revised downward their estimate of person-visits by 8.6%,⁸ so this would be an average of 1.57 million person-visits per coastline mile-year. From Seal Beach in the north to the opening of the Newport Harbor, we estimate there are 18 miles of coastline. We estimate another 14.5 miles of coastline from little Corona at the south of Newport Harbor to Dana Point, our study area. Dunford [1999, p. 18] reports that 29% of summertime beach visits are by children under 16, and that 11% of visits are by children during the school year. In order to translate person-visits into adult-visits, we use the Newport Beach monthly visit data revised downward by 8.6%, and discount by 29% the person-visits for the period September 16 through June 15 and discount by 11% the person-visits for the remainder of the year, giving an average of 1.235 million adult-visits per coastline mile-year in Newport Beach. This intensity of visits, or more, is likely applicable to the 2 miles extending either side of Main Beach in Laguna, as well as a few additional locations in our study area, although not as many visitors go to other south Orange County beaches.

If we assume that annually (1) the 1.235 million adult-visits per mile translates into 1 million family-visits, (2) there is between 60 and 80 percent of the Newport Beach visits per mile in southern Orange County, and (3) apply the estimate from our survey, then \$6 per visit translates into between \$3.6 to \$4.8 million per mile of coastline as the annual willingness-to-pay by day-visitors per family to avoid damage from trampling and illegal taking. A survey⁹ presently underway should provide more definitive estimates of the number of family visits.

TABLE 4. Hanemann's [1997] summary of *Consumer's Surplus for Lost Beach Recreation Trips* and *Consumer's Surplus for Trips with Pollution*, in 1990 \$.

Author	Location	Activity	Value Per Trip
Curtis & Shows [1982]	Delray Beach, Florida	beach recreation	\$3.00
Curtis & Shows [1984]	Northeast Florida	beach recreation	\$5.73
Dornbusch et al. [1987]	Northern Orange County	beach recreation	\$9.94–\$10.58
Tyrrell [1982]	Rhode Island	beach recreation	\$12.82
Bell & Leeworthy [1986]	Florida	beach recreation	\$13.19
Meta Systems [1985]	Boston area	beach recreation	\$13.60
Leeworthy ¹ et al. (most conservative judgments)	Island Beach State Park, N.J.	beach recreation	\$21.05
Leeworthy ¹ et al. (most conservative judgments)	Cabrillo–Long Beach	beach recreation	\$8.16
Leeworthy ¹ et al. (most conservative judgments)	Santa Monica beaches	beach recreation	\$18.36
Leeworthy ¹ et al. (most conservative judgments)	Pismo State Beach	beach recreation	\$26.20
Leeworthy ¹ et al. (most conservative judgments)	Leo Carillo State Beach	beach recreation	\$51.94
Leeworthy ¹ et al. (most conservative judgments)	San Onofre State Beach	beach recreation	\$57.31
Leeworthy ¹ et al. (most conservative judgments)	San Diego County beaches	beach recreation	\$60.79
Department of Interior (Hanemann [1997, p. 7])	average for U.S. beaches	beach recreation	\$11.00

TABLE 4. Continued

Author	Location	Activity	Value Per Trip
Hanemann [1997] conservative estim.	No. Orange County beaches	beach recreation	\$15.00 \$11–\$23
Hanemann [1997] conservative estim.	No. Orange County beaches	surfing (25% higher)	\$18.75
Spectrum Economics [1991]	Southern California reservoirs	Private Boating	\$34.00
Mannesto [1989]	San Joaquin/Sacramento delta	private boating	\$32.00
Walsh, Johnson & McKeon [1988]	literature review	private motorized boating	\$36.13
Walsh, Johnson & McKeon [1988]	literature review	private nonmotorized boating	\$55.73
Hanemann [1997] conservative estim.	Northern Orange County	private boating	\$40.00 \$32–\$50
Center for Natural Areas [1980]	Southern California	party/charter boat fishing	\$131.54
Huppert & Thompson [1984]	Newport Harbor	party/charter boat fishing	\$49.44–\$67.52
Rowe et al. [1985]	Orange County	party/charter boat fishing	\$38.00
Jones & Stokes [1989]	Southern California	party/charter boat fishing	\$87.12
Jones & Stokes [1989]	Southern California	private/rental boat fishing	\$29.60
Walsh, Johnson & McKeon [1988]	literature review	all saltwater fishing combined	\$83.00
Hanemann [1997] conservative estim.	Northern Orange County	party/charter boat fishing	\$83.00

¹ The PARVS study is a NOAA study of beach recreation on the east and west coasts, directed by NOAA economist Dr. Robert Leeworthy, whose reports include beaches in Southern California (Hanemann [1997, p. 6]).

As discussed above, the \$6 per family-visit is conservative. We estimate WTP, not WTA. As discussed in the section above, "Property Rights and Contingent Valuation," the legal establishment of MPAs implies that the public has the right to healthy coastal ecosystems. If this is the case, and the right to healthy ecosystems outweighs other rights (to use damaging technologies and access to the shoreline), then WTA would be the appropriate measure. As noted previously, in "Part/Whole Valuation Issues," these results do not reflect any value for visitors from greater distances or existence value for non-visitors. Moreover, some responses may be low if the respondent included visits to less desirable locations in their WTP.

The implication of these results is that regional visitors to the targeted shorelines along the Orange County coast place considerable value on protecting and preserving RITZ biological resources, even if the implementation of measures to accomplish this goal requires modest tax increases and potential limits on access to selected MPAs. This is an important consideration for policy makers since the population continues to grow, simultaneously placing greater pressure on heavily-used RITZ resources while increasing the number of residents who value its preservation. Major new coastal developments slated for two of the study sites (Crystal Cove State Park and Treasure Island) are likely to increase the number of visitors to their RITZ habitats. Major new developments are scheduled for coastal areas adjacent to two, and perhaps three of our study sites, and are likely to increase the number of visits to our study area. With new coastal developments and the growing regional population, it is important that economists and biologists continue to collaborate to investigate the potential value of enacting measures to protect threatened coastal resources from human activities.

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APPENDIX

Sample Selection Bias. The stratified random sample reduces the cost of sampling and increases the power of the statistics, but introduces sample selection bias. The sample selection bias occurs because recreational visitors who visit often quite likely have a higher willingness to pay than those who visit less frequently. A random sample of visitors taken at the study site has a higher probability of including those who visit more frequently relative to a random sample of the overall visitor population. Consequently, the average willingness to pay of the sample of recreational visitors is a biased estimator of the mean willingness to pay by the population of visitors. Divide the population between visitors and non-visitors

$$(A.1) \quad P = M + N$$

where M is the number that have visited one or more times during the year, N is the number that have not visited, and P is the total number in the population that live close enough to make a day-trip. Let the expected value of the annual willingness-to-pay (WTP) of each group be given by $E(W^M)$ and $E(W^N)$, respectively. What we wish to estimate is the total value for the population, the product of P and $E(W^P)$, $P \cdot E(W^P)$, which is given by

$$(A.2) \quad P \cdot E(W^P) = M \cdot E(W^M) + N \cdot E(W^N).$$

From the census and other sources, we know P . Since we know P , we need to be able to estimate either M or N and we automatically have

an estimate of the other. We can estimate the expected value in the second term, $E(W^N)$, with a sample of observations from non-visitors, although we have not yet done so.

The problem of bias is caused by estimating the expected value of the first term, $E(W^M)$, using a sample of visitors at the study site, and then multiplying by M . The traditional econometric method estimates annual values, but the estimator would be biased upwards because of sample-selection. That is, if we use the annual values for each respondent, W_r , the estimator is biased for estimating $E(W^M)$. We can solve this problem if, instead, we can find a way to estimate the product $M \cdot E(W^M)$ directly.

For many locations such as beaches, we have estimates of the total number of visits, T , but not the number of visitors, M . Let V_m be the number of visits per year by visitor m , and the total number of visits is just the sum

$$(A.3) \quad T = \sum_{m=1}^M V_m.$$

By definition,

$$(A.4) \quad E(W^M) = (1/M) \sum_{m=1}^M W_m$$

and so what we want to estimate is

$$(A.5) \quad M \cdot E(W^M) = \sum_{m=1}^M W_m.$$

Now, the value per visit of each visitor, S_m , is just

$$(A.6) \quad S_m = W_m/V_m.$$

Multiplying both sides by V_m and summing,

$$(A.7) \quad \sum_{m=1}^M W_m = \sum_{m=1}^M V_m \cdot S_m.$$

Alternatively, we can define the population, $Y = \{Y_1, \dots, Y_T\}$, where Y_t is the per-visit willingness to pay for the t th visit. For example, a visitor who visits twice contributes Y_t and Y_{t+1} to this set. Then by definition,

$$(A.8) \quad \sum_{m=1}^M V_m \cdot S_m = \sum_{t=1}^T Y_t.$$

Substituting (A.8) into (A.7),

$$(A.9) \quad \sum_{m=1}^M W_m = \sum_{t=1}^T Y_t.$$

Taking the expected value of both sides,

$$(A.10) \quad \sum_{m=1}^M E(W_m) = \sum_{t=1}^T E(Y_t).$$

Since $E(Y_i) = E(Y_j) = E(Y)$ and $E(W_m) = E(W^M)$, we can simplify (A.10) as follows

$$(A.11) \quad M \cdot E(W^M) = T \cdot E(Y).$$

Therefore, we can solve our problem, which is to estimate $M \cdot E(W^M)$. We know T and we have an unbiased estimator for the expected value of Y , as follows.

When we designed our questionnaire, we included questions to determine the number of times per year that the respondent visits the site(s). We elicit the annual willingness to pay (WTP) for the policy using the dichotomous choice, double-bounded method. Therefore, we know for each respondent the willingness to pay per visit, Y_r ,

$$(A.12) \quad Y_r = W_r/V_r$$

which is a random draw from $Y = \{Y_1, \dots, Y_T\}$. Since our sample is randomly drawn from visitors at the site, it provides the basis for an unbiased estimator of the value per visit. Application of the standard method for estimating the WTP to the sample of visitors, using the

values Y_r instead of W_r , produces an unbiased estimator of the expected value of Y . We then need to know the total number of visits to the study sites, T , which is available from other sources, and we can then multiply our estimator by the number of visits to obtain an unbiased estimator of the first term on the righthand side of (A.2).

ENDNOTES

1. The abscissa measures the WTP and is not evenly spaced in order to fit the data to a graph. Actual values are given to make the rescaling obvious.
2. We discuss other whole/part bias issues following presentation of our results.
3. We can generalize this presentation by letting V be a vector of commodities, where the first element is the number of visits and, letting Φ be a vector of the prices of the commodities, where the first element of the vector is the opportunity cost of visits.
4. See the Appendix for further discussion of the correction of sample selection bias.
5. The *American Trader* oil spill breaks new legal ground as the first natural resource damage case that ever went to a jury. Chapman, Hanemann and Ruud [1998] present the winning side, while Dunford [1999] presents the other view.
6. They give average daily attendance in Newport Beach, "5,000 in January, 10,000 in February, 15,000 in March, 22,000 in April–May, 40,000 in June, 65,000 in July–August, 22,000 in September, and 5,000 in October–December," (Chapman, Hanemann, and Ruud [1998, p. 14]).
7. The City of Newport does not extend north to the Santa Ana River, so the estimate per mile is conservative.
8. "Overall, . . . officially reported attendance at the five beaches combined exceeded our counted attendance by just 9.4% (Chapman, Hanemann, and Ruud [1998, p. 21]). This corresponds to $[1 - 1/(1 + 0.094)] = 0.0859$.
9. By W. Michael Hanemann and others.

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