2. Economic Valuation

In this chapter we define the environmental “goods” to be valued (Section 2.2), discuss the total valuation framework (Section 2.3), lay out the methodological foundations of the Team’s approach (Section 2.4), and outline the approach for total value estimation (Section 2.5).

2.1 Introduction

As noted in Chapter 1, some threats to coral reef ecosystems occur over broad areas while others are more localized. This study estimates values of expanding MPAs around the MHI (broad) and repairing coral reefs damaged by ship strikes (localized).

Because many environmental services provided by coral reefs are not valued in markets, measuring the total value of MPAs and ship strike repairs requires a nonmarket valuation approach. In this study, we used an SP approach. SP methods elicit individuals’ WTP by directly presenting tradeoffs between obtaining the good or service in question and paying some additional costs and, in turn, foregoing the proposed change and not incurring any additional costs. Among SP methods, traditional CV methods (Boyle, 2003) and so-called attribute-based methods (ABMs; Holmes and Adamowicz, 2003) are alternative approaches. Most often, CV applications focus on a single program to improve the environment. ABMs allow for the valuation of multiple programs within the same survey instrument. Each alternative program (including baseline conditions) is described in terms of a series of attributes that combine to represent a state of the environment. Different alternatives for improving the environment are defined by changing the attribute levels.

Several variants of ABMs have appeared in the literature, with two being prominent. One is what we will call the “stated-choice approach.” As described in Section 2.4, stated-choice questions present survey respondents with two or perhaps three alternatives in a table format that makes the attributes easy to compare. Respondents are asked to choose their most preferred alternative. The other SP approach is ranking or rating[1] (also considered in Section 2.4). In this approach, attributes are described for several alternatives, and respondents are asked to either rank the alternatives from most preferred to least preferred or to rate them on a qualitative scale.

In this study, we adopted a *hybrid approach,* which is explained in Section 2.5. Our approach has much in common with CV, yet uses an attribute-based format that allowed us to estimate values for expansion of MPAs, or the implementation of a ship damage repair program, or *both*

1. For simplicity of exposition, we treat ranking and rating together.

programs within a single survey. And, through internet administration, we were able to gain a full ranking of the three alternatives and baseline.

2.2 Environmental Goods Defined

Overfishing is the most widespread threat to the coral reef ecosystems of the MHI. In his popular book on coral reef ecology, Gulko (1998, p. 189) put it this way:

> When I was a kid, there were so many more reef fish than there are today.… Although there are many causes to the decline of nearshore fisheries in Hawai`i, a prominent one is simply overfishing. Our population has steadily grown and more and more people want to fish. This, along with an increased ability to catch fish and a decrease in habitat space for recruitment, has led to a dramatic decrease in fish populations. When was the last time you saw a really large school of anything?

Fishery statistics show that commercial catches in recent years have been around 10% of historic highs (Dye and Graham, 2004). Even allowing for unsustainable high catches as exploitation of stocks expands rapidly, there is clear evidence that fishing levels far exceed the amounts that would produce maximum sustainable yields. The result is that few large fish are present on the reefs, especially primary consumers that keep undesirable algae levels under control and allow corals to thrive.

In recent years there has been increasing interest in no-fishing zones (a type of MPA) as a strategy to combat overfishing (Bohnsack and Ault, 1996; Davis, 1998; Sanchirico, 2000, 2004, 2005; Roberts et al., 2001; Gell and Roberts, 2002; Meester et al., 2004). The idea is that no-fishing zones provide a refuge for young fish to mature and become more fecund. For coral reefs, the hope is that this will lead to more coral growth and associated coralline algae, enhance nonconsumptive recreation like snorkeling and scuba diving, and increase quantities of catchable and viewable fish outside the MPA. This strategy has succeeded in restoring coral reef ecosystems and catches in several locations around the world.

For this case study, we valued an increase in MPAs around the MHI from the current level of 1% to 25%. The increase to 25% protection was arrived at through consultation with NOAA scientists and available literature (Sladek Nowlis and Roberts, 1999; Gell and Roberts, 2002; Sladek Nowlis and Bollermann, 2002). Expanding the MPA to 25% would provide the minimum amount of protection needed (a threshold) to restore reef ecosystems and catches of reef fish outside of the MPA. With 25% of the MHI reef ecosystems protected from fishing, catches would increase to roughly 50% of historical levels, although rebuilding the stocks could take 10 years to be fully realized. In the judgment of the scientists, the ecosystem, both inside and outside the MPAs, would be enhanced by the presence of more birds, seals, corals, and other sea life. Thus, expansion of no-fishing areas served as a good case study for considering the values to the public for protection and restoration of coral reef ecosystems more generally. We are not aware of any proposals to expand MPAs around the Hawaiian Islands by this magnitude.

The second environmental good evaluated in this study was repair of coral reefs damaged by ship strikes. Ship strike injuries and their repair are fairly well defined, easy to describe, and have specific policy relevance to NOAA. It also served as a good case study of the values the public would place on restoration after other localized injuries to coral reefs, such as oil spills and urban pollution.

Coast Guard records indicated that damage to MHI reefs varies significantly from year to year. NOAA scientists estimated that, on average, about 5 acres of reef per year are damaged. Studies in Florida and elsewhere show that reefs that have been seriously damaged can easily take 50 years to grow back but that active restoration can restore reefs in about 10 years. This involves planting coral raised elsewhere and restoring living coral that has been broken up. Under the scenario developed in the survey, about 5 acres of reef per year would be restored. We are unaware of any such proposal to repair damaged reefs in Hawaii.

2.3 Total Valuation Framework

Below we present the total valuation framework employed in our study using the specific changes in the two environmental goods: expanding MPAs and repairing ship strike injuries.

As a starting point, take the indirect utility function of a typical person:

$$U = \eta(P, M, MPA, S) \tag{2.1}$$

where:

- P = a vector of market prices
- M = money income
- MPA = 1,25 = percent of coral reef ecosystems in MPAs around the MHI
- S = 0 for “no repair of ship damage”; 1 for the “ship damage repair program.”

For simplicity, we will suppress the price vector, assuming that enlarging MPAs and/or establishing a ship damage repair program will not affect market prices. Baseline utility is given by:

$$U_0 = \eta(M, 1, 0) \tag{2.2}$$

Enlarging the MPAs alone would yield utility of:

$$U_{M,25,0} = \nu(M, 25{,}0) \geq U_0 \tag{2.3}$$

Equality would hold if this person would receive no benefit from expanding MPAs. WTP for the expansion of the MPAs to 25%, assuming no ship repair program, is WTP_F defined by:

$$\nu(M - WTP_F, 25{,}0) = \nu(M, 1{,}0) \tag{2.4}$$

Likewise, WTP_S, WTP for the ship repair program and given no expansion in the MPAs, is defined by:

$$\nu(M - WTP_S, 1{,}1) = \nu(M, 1{,}0) \tag{2.5}$$

And WTP for both MPA expansion and ship damage repair is symbolized by WTP_B and defined by:

$$\nu(M - WTP_B, 25{,}1) = \nu(M, 1{,}0) \tag{2.6}$$

Even such a simple model can hide significant complexities. Both direct use and passive use values could be embedded in the WTP definitions. Increasing the areas protected by MPAs is particularly interesting.[2] Many U.S. residents may support expanding the MPAs for reasons that have nothing to do with their personal use in the future. Indeed, focus groups conducted in preparation for our survey, as described in Chapter 3, indicated that many people who never plan to visit Hawaii, or otherwise benefit from the MPAs through direct use, still support their expansion. For example, many support expanding MPAs in order to pass along improved ecosystems to future generations. In such cases, the three WTP definitions would represent pure passive use values. For someone who uses Hawaiian reefs, the motives underlying the WTP values may be more complex. Such a person may still hold passive use values, but if MPAs enhance their visits to Hawaii for snorkeling, diving, fishing outside MPA boundaries, or other activities, then direct use values would be added in. The effect of the MPAs on trips taken and utility obtained is implicit in the individuals' optimization process leading to their maximization of their indirect utility function.[3]

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2. Since the size of ship damages is so small relative to the acres of coral reefs that are available for direct use, we speculate that the total value of ship damage repairs is predominantly a passive use value. For most users, there are hundreds of thousands of undamaged acres available as substitutes.

3. The assumption that the price vector, *P*, is not affected by expanding the MPAs is important here. If prices are affected, then this would need to be explicitly accounted for by introducing the price change into the analysis.

No attempt will be made here to unravel direct use and passive use values, either theoretically or empirically. The theoretical challenges are formidable, and it is not clear that they have been fully resolved.[4]

Furthermore, and most important, what matters most is the total economic value, not the direct use or passive use value considered separately. Economics has a long tradition of avoiding the motives for value. One small exception in environmental economics, which goes back to Milgrom (1993), relates to passive use values motivated by altruism (see also Freeman, 2003). Supposedly, if such altruism is "nonpaternalistic," then resulting passive use values should not be counted in measuring welfare. However, regardless of what the theoretical merits of this argument are, so far it has been entirely void of empirical content. A valid way of asking people in the real world to distinguish between their passive use values that are paternalistic and nonpaternalistic has not panned out.

In principle, as the term implies, total value is very comprehensive in its coverage of possible economic values, but there are practical limitation. Consider the possible benefits and costs to commercial fishers from expanded MPAs. In principle, commercial fishers have as much chance as anyone else of being included in a national sample for our survey and would incorporate expected gains and losses from fishery restoration in their values for WTP_F. In practice, however, commercial fishers might not have much confidence in this answer. If it were desirable to know the benefits and costs to commercial fishers from expansion of MPAs, for example, to better understand the income distributional implication of the proposal, then a separate study of commercial fishing impacts might be warranted. Such a study is beyond the scope of our work. It should be added that it would not be correct, from a theoretical point of view, to add these commercial fishing benefits and costs to the results of the work reported here.

2.4 Methodological Issues and Opportunities

The Team considered two methods for measuring total value: CV and stated choice. A CV method has the virtue of directness and simplicity. In a typical CV study, respondents are asked about their values for a single program. Here, for example, we might have asked about their values for expanding MPAs from 1% of MHI reefs to 25%. Our goal, however, was to value three alternatives to the status quo: expansion of MPAs alone, repairing ship strikes alone, and both programs together. Valuing all three options in a single survey using traditional CV methods would have been challenging. Three standalone CV questions would have been

4. For an attempt, see Freeman (2003). Freeman bases his analysis on weak complementarity; passive use value becomes the residual when the price of direct use becomes prohibitive. But, in most cases, the actual price of direct use will not be prohibitive for everyone, and the boundary between direct use and passive use values becomes murky.

required. Splitting the sample and conducting three separate CV surveys would have increased overall sampling costs. If implementing one of the programs alone and implementing both are really options, one could argue that respondents need to know this in order to make informed choices. Performing three separate surveys would have ruled out the ability to inform respondents about all three alternatives to the status quo. ABMs are capable of valuing more than one program in the same survey, and we turned in that direction to incorporate these issues.

Stated-choice questions, as the term is used here, involve presenting respondents in a survey with two or more alternatives. Each alternative is described in terms of its characteristics or attributes. In a recreational fishing study, for example, fishing sites might be described in terms of their catch rates, distance from home, and other characteristics. Where monetary values are sought, the cost or price of the alternatives is also included as one of the characteristics. A group of alternatives defined in this way is known as a choice set. Alternatives are distinguished by having different characteristics or attribute levels. Traditionally, in stated-choice studies, respondents have been asked to reveal which of the alternatives from the choice set they most prefer.

The stated-choice approach is well established in the literature on environmental economics (Kanninen, 2007). It evolved from conjoint analysis, a method used extensively in marketing and transportation research (Louviere et al., 2000). Conjoint studies have most often asked respondents to rank or rate alternatives (Holmes and Adamowicz, 2003). Choice questions used in environmental economics have typically been less demanding than the conjoint questions used in marketing and transportation. Rather than asking respondents to fully rank a number of alternatives or rate them depending on their relative preferredness, they require only that respondents choose the most preferred alternative (a partial ranking) from multiple alternative goods (i.e., a choice set). This procedure seeks to capitalize on the fact that choosing the most preferred alternative from some set of alternatives is a common experience in everyday life.

Morikawa et al. (1990) note that responses to choice questions often contain useful information on tradeoffs among characteristics. Quoting from Mathews et al. (1997), who studied recreational fishing, stated-choice "models provide valuable information for restoration decisions by identifying the characteristics that matter to anglers and the relative importance of different characteristics that might be included in a fishing restoration program." Johnson et al. (1995, p. 22) note, "The process of evaluating a series of pair wise comparisons of attribute profiles encourages respondents to explore their preferences for various attribute combinations." Furthermore, Adamowicz et al. (1998a) note that the repeated nature of choice questions makes it difficult to behave strategically. As mentioned previously, choice questions allow for the construction of alternatives with characteristic levels that currently do not exist. This feature is particularly useful in marketing studies whose purpose is to estimate preferences for proposed goods, where various characteristics can be manipulated in arriving at final product designs. For example, 30 years ago, Beggs et al. (1981) assessed the potential demand for electric cars.

Similarly, researchers estimating the value of environmental goods are often valuing a good or condition that does not currently exist, e.g., MPAs around coral reefs that are currently open to exploitation.

Examples of environmental economic applications are numerous. Magat et al. (1988) and Viscusi et al. (1991) estimate the value of reducing environmental health risks; Adamowicz et al. (1994, 1998b, 2004), Breffle et al. (2005), and Morey et al. (1999a) estimate recreational site choice models for moose hunting, fishing, and mountain biking, respectively; Breffle and Rowe (2002) estimate the value of broad ecosystem attributes (e.g., water quality, wetlands habitat); Adamowicz et al. (1998a) estimate the value of enhancing the population of a threatened species; Layton and Brown (1998) estimate the value of mitigating forest loss resulting from global climate change; and Morey et al. (1999b) estimate WTP for monument preservation in Washington, DC. In each of these studies, a price (e.g., tax or a measure of travel costs) is included as one of the characteristics of each alternative, so that preferences for the other characteristics can be measured in terms of dollars. Other examples include Swait et al. (1998), who compare prevention versus compensation programs for oil spills, and Mathews et al. (1997) and Ruby et al. (1998), who ask anglers to choose between two saltwater fishing sites as a function of site characteristics.

Alternatively, a number of environmental studies have followed a more conventional conjoint approach by using ranking or rating questions. Ranking studies present respondents with three or more alternatives and ask them to rank them from most preferred to least preferred. Rating studies ask respondents to rate the degree to which they prefer one alternative over another, often on an integer scale such as 1 to 10. For example, Opaluch et al. (1993) and Kline and Wichelns (1996) develop a utility index for the characteristics associated with potential noxious facility sites and farmland preservation, respectively. Johnson and Desvousges (1997) estimate WTP for various electricity generation scenarios using a rating scale in which respondents indicate their strength of preference for one of two alternatives within each choice set. Other environmental examples include Rae (1983), Lareau and Rae (1989), Krupnick and Cropper (1992), Gan and Luzar (1993), and Mackenzie (1993).

Adamowicz et al. (1998b) provide an overview of choice and ranking/rating experiments applied to environmental valuation. They argue that choice questions better predict actual choices than do rating questions because choice questions mimic the real choices individuals are continuously required to make, whereas individuals rank and rate much less often.

Although CV and stated-choice methods both provide unique avenues for economic valuation, neither method alone would help us accomplish our goals of using one survey instrument to evaluate the three alternatives to the status quo and to obtain a full ranking of the programs. As a result, the Team developed a *hybrid* approach to measure total value. This approach, discussed in more detail in the next section, allowed the Team to address the methodological issues discussed above and provided the opportunity to explore a new approach to estimate total values for environmental goods.

2.5 A Hybrid Stated-Preference Approach for Total Value Estimation

The hybrid approach we implemented maintained some of the simplicity associated with CV. A full attribute-based survey could have been used to evaluate more than one program to expand MPAs and more than one program to repair ship injuries. However, we did not need to make the valuation exercise that complex in order to achieve project objectives. Valuing only one program for MPA expansion, one for ship strike repairs, and one for both made the effort somewhat comparable to a traditional CV study. On the other hand, we were able to adapt ABMs to summarize the information presented to respondents in a single table that allowed them to review relevant information and make easy comparisons across the alternatives. Such comparisons should help them to more thoroughly explore their preferences and values at the beginning of the valuation exercise and hence make better-informed choices.

Choice questions - and rating/ranking questions - normally describe the alternatives in terms of a relatively small number of characteristics. For example, Opaluch et al. (1993) characterize noxious facilities in terms of seven characteristics; Adamowicz et al. (1998b) use six characteristics to describe recreational hunting sites; Johnson and Desvousges (1997) use nine characteristics to describe electricity generation scenarios; Mathews et al. (1997) use seven characteristics to describe fishing sites; Morey et al. (1999a) use six characteristics to describe mountain bike sites; and Morey et al. (1999b) use two characteristics to characterize monument preservation programs.

In our study, each alternative was characterized by three attributes: whether there was a program to repair damages to coral reefs from ship strikes, whether no-fishing zones would remain at 1% of the coral reef ecosystems or be increased to 25%, and the cost to the respondent, to be assessed as an increase in federal taxes each year.

Using an internet survey, we were able to preserve the traditional stated-choice format, yet obtain a full ranking of four alternatives. Through focus groups and cognitive interviews, we found that most respondents had little or no difficulty with choice questions involving up to four alternatives. The first choice question, a version of which is presented in Figure 2.1, asked respondents to choose their most preferred alternative from a choice set containing four alternatives. This is similar to a traditional stated-choice question. But then, thanks to internet administration, we were able to show each respondent the remaining three alternatives - those that were not chosen as most preferred in the first choice question. They were then asked to

	Current Program	Reef Repair Program	No-Fishing Zones Program	Full Program
% of coral reefs protected by no-fishing zones (acres)	**1% protected (3,000 acres)** Declining marine life	**1% protected (3,000 acres)** Declining marine life	**25% protected (75,000 acres)** Increasing marine life More fish caught outside zone	**25% protected (75,000 acres)** Increasing marine life More fish caught outside zone
Acres of coral reefs repaired from ship injuries per year	**No acres repaired** Injuries last about 50 years	**5 acres repaired** Injuries last about 10 years	**No acres repaired** Injuries last about 50 years	**5 acres repaired** Injuries last about 10 years
Added federal taxes paid by your household each year[5]	$0	$55	$45	$100
Which program is your most preferred?	c	c	c	c

Figure 2.1. First choice question from the survey instrument.

choose their most preferred alternative from the remaining three. Once this choice was made, a new screen presented respondents with their remaining two alternatives and asked them to choose their most preferred (see Chapter 4 and Appendix A).

The first alternative in Figure 2.1, labeled the "Current Program," was the status quo; nothing would be done about overfishing or ship damage, and the cost is zero. The Current Program was always the first alternative presented. In Figure 2.1, the second column involves only repair of ship damage - no-fishing zones remain at 1% and the cost is $55. The third column would increase no-fishing zones to 25% but no ship damages would be repaired. The cost in this version is $45. Finally, the fourth alternative involved both additional no-fishing zones and repair of ship damages, and the cost is $100.

5. The figure provided here is an example of 1 of the 16 versions of the survey. The only attribute that varies between each version is the cost. The Current Program is always $0 and the alternative programs are always greater than $0.

Based on experience gained in several previous studies involving choice questions, giving respondents a direct opportunity to choose to do nothing new and pay nothing is helpful. In a properly designed study, some respondents will not prefer any of the alternatives involving changes from the status quo that will cost them the specified amounts of money. Forcing them at the outset to choose between two or more alternatives, none of which they like, can alienate respondents and lead to unreliable responses. Including the status quo as an explicit choice allows them to immediately express such feelings.

Within a given survey, the dollar costs of each alternative remained the same. This avoided the confusion that might have been introduced if costs were varied from one choice question to the next within the same survey. Varying the costs in order to estimate WTP was accomplished by having different versions of the survey with different cost structures. The different versions of the survey were randomly assigned to different respondents. The construction of the cost combinations in different versions of the survey is explained in Appendix B.

As noted, once follow-up choice questions were completed, a complete ranking of the four alternatives was obtained. We maintained the traditional choice question format, which asks only that the respondents choose their most preferred alternative from a choice set, yet through internet administration of follow-up choice questions, the full ranking was obtained.

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