Title: Divers' willingness to pay for improved coral reef conditions in Guam: an untapped source of funding for management and conservation?

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Abstract

Coral reefs are increasingly threatened despite being essential to coastal and island economies, particularly in the Pacific. The diving industry relies on healthy reefs and can be positively and/or negatively impacted by ecological change. Quantifying divers' ecological preferences that influence economic outcomes can help inform managers and justify conservation. Utilizing non-market valuation, we assess SCUBA divers' preferences for ecological attributes of coral reef ecosystems in Guam, estimate WTP for coastal and watershed management, and investigate drivers influencing preferences. A discrete choice experiment grounded in ecosystem modeling reveals divers prefer reefs with greater ecological health (higher fish biomass, diversity, and charismatic species). Individuals with stronger environmental values expressed stronger ecological preferences. Fish biomass improvement from low (<25g/m^2) to high (>60g/m^2) was worth >$2 million/year. The presence of sharks and turtles together was the preeminent attribute, worth $15-20million/year. Divers are willing to voluntarily contribute ($900thousand) towards watershed sediment-reduction projects that could benefit divers by improving reef conditions. Few policies are in place worldwide collecting fees from divers for coral reef management, and none in Guam. Our results suggest that understanding divers preferences and the drivers behind them may assist managers in designing policies that capture divers WTP and create partners in conservation.

Keywords: Coral reefs, sharks, Guam, ecosystem-based management, tourism

1. Introduction

Coral reefs support the social, cultural, and economic well-being of millions of people around the world through extractive activities, such as fishing, as well as non-extractive activities, such as cultural identity and recreation (Cinner, 2014; Wilkinson and Buddemeier, 1994). Yet coral reef ecosystems are declining globally due to local and global anthropogenic stressors, including unsustainable fishing, land-based pollution, and climate change (Pandolfi et al., 2003). Sharks, a keystone species critical for supporting healthy coral reefs, are also under global threat due to shark-finning (Dulvy et al., 2008; Robbins et al., 2006), targeted fishing pressure (Fisher and Ditton, 1993), and high bycatch rates in large-scale commercial fisheries (Mandelman et al., 2008).

Effectively managing coral reefs can be costly in terms of both operations and enforcement, and often involves trade-offs between competing sectors using or affecting the reef (Brown et al., 2001; Fernandes et al., 1999; Hicks et al., 2009). Management strategies can impact these sectors in diverse ways, sometimes resulting in "winners" and "losers" (Cinner et al., 2014; Weijerman et al., 2016b). Management that efficiently balances competing uses can improve species abundance and ecological quality, and provide net economic gains for diverse sectors (Barbier et al., 2008; Kittinger et al., 2012). In turn, economic benefits can be leveraged to garner support for management, i.e., certain sectors can become partners in meeting coral reef conservation goals (Sorice et al., 2007). However, achieving this requires a clear understanding of how and why different sectors value specific ecological conditions associated with coral reefs, and how these conditions are linked to management and conservation goals.

SCUBA diving is one of the most valuable recreational activities associated with coral reefs, generating billions of dollars per year for local economies (Brander et al., 2007; Cesar and Van Beukering, 2004; van Beukering et al., 2007). SCUBA divers (referred to here as "divers") can have strong preferences for ecological conditions and may care a lot about ecological changes in the coastal and marine environment (White and Vogt, 2000). Management strategies that target what matters most to divers can potentially leverage diver fees to support coral reef health (Sorice et al., 2007). Recognizing this, a handful of studies have used non-market valuation techniques to estimate divers' WTP for: diving in marine protected areas (MPAs) (Parsons and Thur, 2008), improving or maintaining reef quality (Parsons and Thur, 2008), the size and abundance of fish species (Gill et al., 2015; Rudd and Tupper, 2002), fish species diversity (Schuhmann et al., 2013), the presence of charismatic species (Rudd and Tupper, 2002; Schuhmann et al., 2013), and different recreational diving management restrictions (Sorice et al., 2007). Here, we build on this existing work by contributing a more comprehensive understanding of why and how the diving industry might be leveraged as a partner for coral reef conservation.

We focus on Guam as a case study to meet two specific objectives. The first objective is to understand divers' ecological preferences in relation to specific management targets (e.g., fish biomass), their marginal WTP for changes in ecological conditions, and how these preferences may be influenced by their environmental values and awareness. To assess divers' ecological preferences, we build on previous work by applying a discrete choice experiment (Gill et al., 2015; Parsons and Thur, 2008; Rudd and Tupper, 2002), however we coordinate our design with an ecological model being used to evaluate coral reef management scenarios (Weijerman et al., 2016a, 2014). Considering the important role sharks play as keystone species and in supporting dive tourism (Cisneros-Montemayor et al., 2013), we also specifically explore diver preferences for the presence or absence of sharks. We expected that divers would prefer coral reef dive environments with better dive conditions, represented by high fish species diversity, high fish biomass, and larger and more numerous charismatic reef species (Gill et al., 2015; Rudd and Tupper, 2002; Schuhmann et al., 2013). We also expected that there would be economic gains or losses, measured by WTP estimates, would result from management-induced ecological changes (Gill et al., 2015; Schuhmann et al., 2013).

To understanding if qualitative criteria may influence diver preferences for specific ecological conditions, we use environmental values and threat knowledge as segmentation variables to look for differential preferences. While demographics have traditionally been used to segment populations, psychographic criteria such as values and opinions are especially useful when considering ecological issues (Bohlen et al., 1993; Fraj and Martinez, 2006; Straughan and Roberts, 1999). This is because people relate to, or value, environmental resources in a variety of ways, for example, for consumption (direct use value), to mitigate storm surge (indirect use value), for the assurance that resources will be available for future generations (bequest value), or just simply knowing that a resource or ecosystem is present elsewhere (existence value) (Tietenberg, 1988). Many of these values are difficult to place a dollar value on (Tietenberg, 1988), however, that does not make them less important than those that are more easily quantified (Chan et al., 2012). Indeed, understanding these values can help target conservation efforts (Barnes-Mauthe et al., 2015; Oleson et al., 2015) To this end, we use Likert-type summated rating scales to explore how diver preferences for specific ecological conditions relate to diver characteristics, values, and knowledge. Based upon the value-belief-norm theory (Stern et al., 1999), we expect that individuals who value the environment, particularly for altruistic purposes such as existence values, and those who think the environment are threatened are more likely to support environmental policies and adopt pro-environmental behaviors. This expectation is in line with other research demonstrating that people are more likely to exhibit pro-environment behaviors when they have strong environmental values (Schultz et al., 2005; Wesley Schultz and Zelezny, 1999) or believe the environment is threatened (Baldassare and Katz, 1992; O'Connor et al., 1999).

Our second objective is to explore whether the dive industry would be willing to contribute conservation-related funding for broader ecosystem-based management activities that indirectly affect coral reefs. Consistent with other regions across the globe, fisheries management alone will not be sufficient to support Guam's coral reefs, which are under heavy stress from land-based sedimentation (Burdick et al., 2008; Fabricius, 2005; Weijerman et al., 2016a). Thus, the most ecologically and economically preferable outcomes for Guam's coral reefs from a governance perspective involve a multi-pronged approach of fisheries management alongside watershed restoration (Weijerman et al., 2016b). To assess the possibility of raising conservation related funding from the dive industry for broader ecosystem-based management, we employ a contingent valuation to investigate whether ocean-based beneficiaries are willing to contribute to land-based management that can indirectly affect coral reef ecosystem health. We expect to find that although divers are not the direct beneficiary of such management, they would be willing to contribute to such efforts, with the caveat that individuals who were more aware of the threats facing coral reefs would be willing to contribute more (Baldassare and Katz, 1992).

2. Study Area

Guam's nearshore waters contain approximately 108km^2 of coral reef, including several well-developed lagoons (Burdick 2006). Guam's reefs support a high level of biodiversity (Veron, 2013), hosting over 5,100 marine species, including over 300 species of coral and at least 1,000 nearshore fish species (Paulay, 2003; Porter et al., 2005). Sedimentation, crown of thorns starfish outbreaks, fishing, and human development place increasing pressure on Guam's coral reefs (Birkeland and Lucas, 1990; Burdick et al., 2008; Richards et al., 2012; Robertson, 2011), and have been cited as primary drivers of an 86% decline in Guam's fish stocks since the 1950's (Zeller et al., 2007). Of these many stressors, sedimentation has been singled out as the most serious threat to Guam's coral reefs (Burdick et al., 2008).

As residents of a small Pacific island with a land area of only 549km^2, Guam's 168 thousand people are dependent on healthy coral reefs economically for Guam's tourism industry (van Beukering et al., 2007) and culturally for the perpetuation of traditional Chamorro identity (Allen and Bartram, 2008). Healthy coral reefs and reef-associated fish are essential for tourism, one of the most important sectors of Guam's economy. Guam's GDP was $4.5 billion in 2011 (Bureau of Economic Analysis, 2013); the direct, indirect, and induced income from tourism generated an estimated 20% of GDP in 2010 (Tourism Economics, 2012). Over 80% of tourists arrive from Asia (Ruane, 2013). Approximately 6% of all visitors go diving, sustaining a number of dive operators and shops, and an estimated 3% of tourists visit Guam with diving as the primary motivation for their trip (Guam Visitors Bureau, 2001, L. Webber, personal communication, Nov. 2014).

Information collected from dive operators in 2000 revealed 13 legally operating dive companies in Guam (van Beukering et al., 2007) as well as "fly by night" operators, who are nearly impossible to track. There are a number of popular dive sites along Guam's coral reefs (Figure 1). An estimated 256,000-340,000 dives occur on Guam's reefs per year (van Beukering et al., 2007). Guam's dive operators had a self-reported customer composition in 2001 of approximately 87% Japanese, 9% local, 2% from the U.S. and Hawaii, and less than 0.5% each from Taiwan, Hong Kong, Europe, Korea, and the Philippines (Guam Visitors Bureau, 2001). Tourism in Guam and many other Pacific Islands is largely dependent on the Asian tourism market, and due to the potential for differences in preferences, a benefit transfer from similar studies in the Caribbean is likely inappropriate.

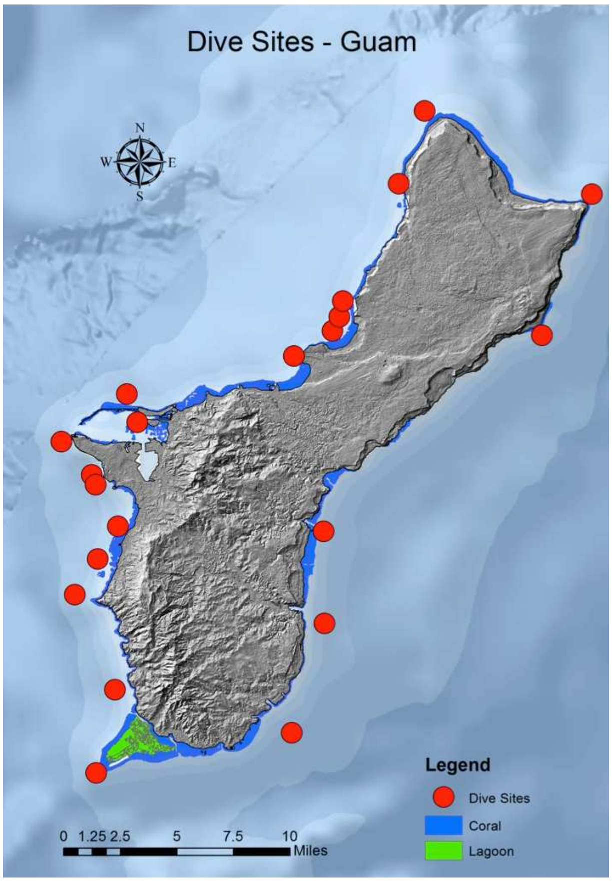

Figure 1. Dive sites of Guam. The most heavily utilized sites are along the Western shore of the island. Data sources: (Chamberlin, 2008; Guam Visitors Bureau, n.d.; NOAA, 2011)

3. Methods

To achieve our research objectives we employ a mixed methods design utilizing both quantitative and qualitative methods (Starr, 2014). Specifically, we employed economic non-market valuation methods coupled with summative rating methods. Non-market valuation methods can provide an economic value for ecosystem goods or services whose value is not directly observable (Adamowicz et al., 1994). Two of the more commonly used non-market valuation methods in evaluating reef quality are discrete choice experiments and contingent valuation (Asafu-Adjaye and Tapsuwan, 2008a; Bhat, 2003; Dixon et al., 1995; Gill et al., 2015; Park et al., 2002; Parsons and Thur, 2008; Rudd and Tupper, 2002; Schuhmann et al., 2013), both of which are employed here. To better understand how divers' ecological preferences relate to individual characteristics, knowledge, and values, we also collected data on individual levels of knowledge regarding the threats facing Guam's coral reefs, attitudes towards environmental resources, and socio-demographics (Baldassare and Katz, 1992; Fraj and Martinez, 2006; Schultz et al., 2005; Wesley Schultz and Zelezny, 1999). To gather these data, we designed and administered a survey questionnaire consisting of four sections: (1) diver characteristics, (2) a discrete choice experiment, (3) environmental values and knowledge, and (4) a contingent valuation question. Survey sections are each described in turn. The full survey is provided in the supplmenetal information.

3.1 Diver Characteristics

We collected demographic information including year of birth, gender, country of residence, and income. We also collected diving-specific information, including total number of dives an individual had completed, whether or not they had been diving in Guam before, and whether or not they were currently involved with, or donated money to, an environmental nonprofit organization.

3.2 Discrete Choice Experiment

3.2.1 Theory

We employed a discrete choice experiment (DCE) to understand what ecological conditions divers prefer, and their willingness to contribute financially to achieve these conditions. DCEs allow for evaluation and analysis of an individual's utility for several characteristics of a good or service simultaneously (Gill et al., 2015; Hanley et al., 2001; Parsons and Thur, 2008; Rudd and Tupper, 2002; Sorice et al., 2007). DCEs dissect attributes of a good or service into various levels that are randomly grouped together as hypothetical goods/services which respondents choose between. This unique design reveals the relative importance respondents place on attributes, and their levels, as well as respondents' WTP for variations in levels. An assumption is that the consumer's utility for a particular good can be broken down into her utility for the individual characteristics of that good (Lancaster, 1966), and that her utility is dependent on the presented attributes as well as her socio-demographic characteristics (Hanley et al., 1998). Choice experiments thus provide a reasonable approximation for actual utility values (Adamowicz et al., 1994), and in some cases may be an ideal method for environmental valuation because respondents are forced to make tradeoffs between attributes and levels (Hanley et al., 2001). As such, they have been used in a handful of investigations of coral reef diving environments (Gill et al., 2015; Parsons and Thur, 2008; Rudd and Tupper, 2002; Schuhmann et al., 2013).

The theoretical framework for DCEs derives from random utility theory (McFadden, 1972; Thurstone, 1927), which describes discrete choices made in a utility maximizing framework, drawing inferences about the utility a person gains from a good or service based on their behavior when presented with tradeoffs among competing attributes and their levels. The random utility model assumes that the utility an individual derives is comprised of an observable (V_{in}) and unobservable component (ε_{in}) and is influenced by the attributes of that good or service (Z_n) and the attributes of the individual respondent (S_i) described using the following formula (Hanley et al., 1998):

$$U_{in} = V(Z_n S_i) + \varepsilon(Z_n S_i) \quad (1)$$

U_{in} total utility (U) experienced by individual i for alternative n

V_{in} observable utility (V) experienced by individual i for alternative n

ε_{in} unobservable utility (E) for individual i from alternative n

Z_n the attributes of the good/service Z in alternative n

S_i attributes of the individual, i

This allows for the comparison between alternatives, based upon the likelihood of an individual choosing one alternative over another when considering the random utility of each option. The probability of an individual choosing alternative n is demonstrated in comparison to alternative z (Boxall et al., 1996; Hanley et al., 1998). The total utility (U_{in}) of a single alternative (n) cannot be determined, however the probability of choosing one alternative (n) over another alternative (z) within the same model can be estimated (Hoyos, 2010). The probability of an individual choosing alternative n over alternative z is given in the following equation (Boxall et al., 1996):

$$P_{in}=Prob(V_{in}+\varepsilon_{in}>V_{iz}+\varepsilon_{iz}) \forall n \neq z \in C \quad (2)$$

After eliciting preferences of the sample, WTP for changes in attribute levels can be estimated by using the change in the marginal utility from one attribute level to another and the payment attribute assuming all other variables remain constant. The formula used for estimating WTP is:

$$WTP_{attribute} = \frac{-\beta_{attribute}}{\beta_{payment}} \quad (3)$$

3.2.2 Experimental Design

3.2.2.1 Attributes and Levels

To determine appropriate attributes and levels, we conducted a thorough literature review, held two focus groups with ten and twelve participants each, and garnered expert opinion (n=5) to break down a hypothetical dive environment into specific attributes important for the quality of the dive experience. We selected six attributes focusing on ecological conditions: (1) fish biomass, (2) fish species diversity, (3) the number of Napoleon wrasse *Cheilinus undulatus* present, (4) the size of Napoleon wrasse, (5) the presence or absence of sharks and/or sea turtles, and (6) a hypothetical management fee per dive. Each attribute consisted of either three or four associated levels. Given our objective to connect our results to an ecosystem model (Atlantis) being used to evaluate alternative management scenarios in Guam, we synchronized attributes and levels to the outputs of the Atlantis ecosystem model (Weijerman et al., 2016a, 2014). This approach ensured our results can be used to predict the economic consequences of management scenarios under consideration. Digitally altered photographs were used to represent coral reef conditions. Detailed descriptions of the ecological values that underlie attribute levels are presented in turn below.

(1) *Fish biomass:* Levels were low, medium, or high on the survey instrument. Based on the visual survey results of Pacific reefs, including inside and outside of MPAs in Guam, these correspond to: <25g/m^2 is low, 25-60g/m^2 is medium, and >60g/m^2 is high (Williams et al., 2012, 2010) (Figure 2).

Figure 2. Low, medium, and high biomass photos utilized in survey (Photo credit: David Burdick, guamreeflife.com)

(2) *Fish species diversity:* Due to Guam's naturally high fish diversity, applying explicit, quantitative levels for this attribute is challenging. We therefore decided to have respondents select low, medium, or high diversity. In the photos utilized in the survey, there were two fish species/m^2 in the low diversity photo, four fish species/m^2 in the medium diversity photo, and eight fish species/m^2 in the high diversity photo (Figure 3).

Figure 3. Low, medium, and high diversity photos utilized in survey (Photo credit: David Burdick, guamreeflife.com)

(3) *Napoleon wrasse abundance: Cheilinus undulatus* was selected as an icon species because it is visually impressive and is currently listed as endangered by the IUCN (Russell, 2004). Abundance levels were set at one, few (2-3), or many (4+).

(4) *Napoleon wrasse size: Cheilinus undulatus* are capable of growing to over 1.8m in length. Although most Napoleon wrasse currently observed in Guam are considerably smaller than this biological maximum, the biological range of small (<70cm), medium (70-150cm), and large (>150cm) values were selected to avoid shifting baselines (Figure 4).

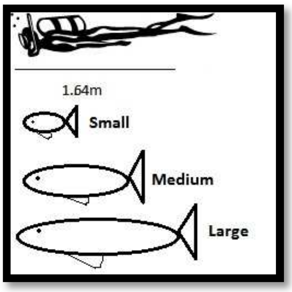

Figure 4. Cheilinus undulatus sizes shown alongside a 6’ tall human

(5) *Presence/absence of sharks and/or turtles:* Sharks are ecologically and economically important, particularly for marine-based tourism (Cisneros-Montemayor et al., 2013), and previous research suggests divers may be willing to pay more for dives with turtles (Schuhmann et al., 2013). Levels used in the survey were: neither sharks nor turtles, turtles only, sharks only, both sharks and turtles.

(6) *Management fee*: The management fee was $2.50, $5.00 or $7.50, which would be an additional cost to the current amount of money divers are paying per dive. This was selected based upon an average dive price of USD $100 and thus represents a price increase of 2.5%, 5%, or 7.5%. This is also an amount reflective of what is typically charged to divers utilizing MPAs throughout South-East Asia (Depondt and Green, 2006). Given an estimated 250,000-340,000 dives per year (van Beukering et al., 2007) this hypothetical fee represents an annual value of USD $625,000 to $2.5 million. The annual budget of Guam’s Department of Aquatic and Wildlife Resources was just over USD $8 million in 2011 (Guam Department of Agriculture, 2011). These estimated values therefore represent a possible 7-31% increase in the department’s budget.

3.2.3 Statistical Design

The attributes and levels in the survey design generated a possible 972 combinations of hypothetical dive environments. We used Sawtooth software (Sawtooth Software, Utah, US) to optimize the survey design, creating six unique survey versions consisting of eight choice tasks each. Each choice task asks respondents to choose one of three possible dive environments. The algorithm utilized meets three of four Huber-Zwerina criteria for efficient choice designs: orthogonality, levels of each attribute vary independently of one another; level balance, levels of each attribute appear with equal frequency; and minimal overlap between attribute levels (Huber and Zwerina, 1996). Balanced utilities of each attribute is not met by this design. Efficiency increases as the expected utility of each attribute becomes more similar, however meeting this criterion can impinge on orthogonal design (Johnson and Orme 2006). A randomized design in which each respondent has a unique set of questions would be ideal, but is less feasible when not using computer-based surveys and was therefore not a reasonable option for in-person surveys (Johnson and Orme 2006). Using Sawtooth CBC Software with a target sample size of 200, we compared the design for between 1-8 survey versions consisting of 5-12 questions, ultimately selecting six versions of eight questions each. Utilizing six survey versions allows for the presentation of more attribute combinations than a single survey version and strengthens the study design. Requiring too many tasks of each respondent may induce respondent fatigue (Johnson and Orme 2006), which was of particular concern in this study because respondents were all on recreational dive trips. A target sample size of 200 was used in design efficiency estimations based upon time constraints and is within the range of sample sizes for similar studies and within the typical range (150-1200 respondents) for choice studies (Gill et al., 2015; Orme, 2010; Rudd and Tupper, 2002). The formula used to determine the sample size is:

$$\frac{nta}{c} \geq 500 \qquad (4)$$

n respondent number (200)

t number of questions per respondent (8)

a the number of options per question (3)

c the maximum number of attribute levels (4)

Each task asked respondents to choose one of three hypothetical dive environments, requiring them to make tradeoffs between different attribute levels. For a sample choice task see Figure 5. In total, the survey presented 144 dive options. We chose not to include an opt-out or no choice alternative in the choice cards. While it is an option that has been said to increase ‘realism’ in choice experiments (Batsell and Louviere, 1991), it also causes a loss of responses particularly when alternatives are relatively homogenous (Kontoleon and Yabe, 2003). Because our respondents have already committed to SCUBA diving due to our sampling method, and ecological conditions were set within realistic bounds of likely dive sites, divers were unlikely to be ambivalent to or reject all the alternatives (Simonson et al., 2001). Our choice was further supported by the fact that none of the respondents objected to the lack of an opt-out or verbally stated that they would not choose any of the presented options.

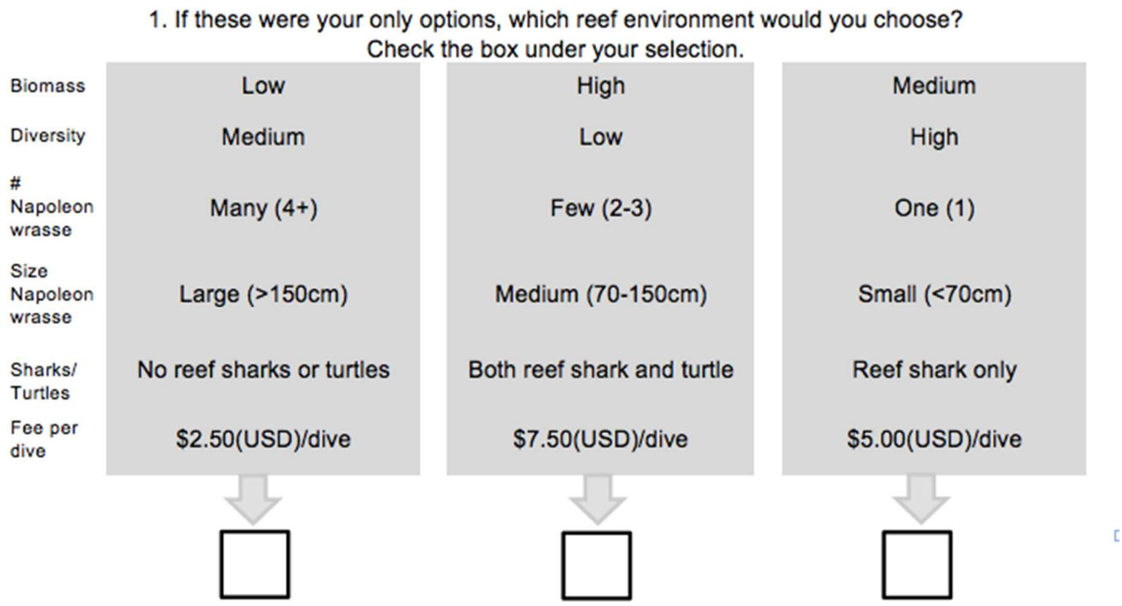

Figure 5. Respondents check box under the dive environment they find most favorable

3.2.4 Statistical Model

Based upon the theoretical model outlined in Section 3.2.1, we compared numerous analytical models for discrete choice data (conditional logit, mixed logit, asc logit, and latent class) using STATA. We elected to use both a conditional logit model and a latent class model for respondent preferences based upon having the lowest Akaike's information criterion (AIC) score (Bozdogan, 1987). We utilized dummy coding in our model, a binary system in which a 1 indicates a chosen attribute, and a 0 indicates an attribute that was not chosen. We chose dummy coding over effects coding given that they are functionally equivalent and we did not have a constant term, in which case effects coding may have been preferable (Bech and Gyrd-Hansen, 2005). This binary coding system assumes that our "low" attribute levels are the baseline in the survey, and medium and high attribute levels are improvements above this. We elected to use Latent Class Analysis to test for preference heterogeneity and the existence of different classes, or subpopulations, within the study sample based upon responses to the choice questions or preferences (DeSarbo et al., 1992). The advantage of this approach is that it allows for the elicitation of different preferences among sub-sets of the sample which can reveal more nuanced results versus a standard random utility model (Boxall and Adamowicz, 2002).

3.3. Environmental Values and Knowledge

3.3.1 Theory

To better understand some of the factors influencing diver preferences for ecological conditions, we used a summative rating scale to assess both values and environmental knowledge. We asked people to rate proxy statements on a summative 5-point scale to assess use, indirect use, bequest, and existence values. The proxy statements presented were: (1) use value: "People should be able to use the ocean for swimming, diving, and fishing", (2) indirect use value: "Reefs do not provide protection from coastal storms", (3) bequest value: "We should protect coral reefs now so that future generations are able to enjoy them", and (4) existence value: "I do not support the creation of marine protected areas in places I will never visit." Respondents selected their level of agreement with each statement from strongly disagree (1) to strongly agree (5). Questions for indirect use and existence values were reverse coded in the survey, but were reverted to standard coding for analysis. Because these values together represent a more complete valuation[1], responses were then summed into an environmental value score for each respondent that we used in our statistical analysis, as sums of Likert-type questions are more reliable than single question values (Gliem and Gliem, 2003). The formula used in estimating the environmental value score follows:

$$Environmental\ value_n = \sum(u_n + i_n + b_n + e_n) \qquad (5)$$

u_n use value of respondent *n*

i_n indirect use value of respondent *n*

b_n bequest value of respondent *n*

e_n existence value of respondent *n*

In examining environmental knowledge, we specifically focused on knowledge of environmental threats. We had respondents rate current or potential threats to Guam's reefs using a 5-point Likert-type scale, similar to that utilized by Rudd (2004). Threats included: land-based pollution, fishing, SCUBA diving or snorkeling, the use of jet skis, the proposed U.S. military buildup, climate change, and non-native species introduction. Respondents independently rated each threat from a weak=1 to strong=5 impact on coral reef quality. The survey contained no information on the nature, severity, or ecological consequences of each threat as we sought to determine respondents' baseline knowledge of the threats to Guam's reefs, without potentially biasing results with explanations.

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[1] The total economic value framework acknowledges that ecosystems benefit humans in numerous dimensions and breaks values down into several categories. In addition to use values, the framework also considers indirect use, bequest, and existence values (Tietenberg, 1988).

3.3.2 Statistical Design

Environmental values and knowledge data was analyzed using SPSS Version 22. We utilized an ANOVA to test for variance between the two groups that emerged in the latent class analysis. We also used a chi^2 test to determine if there was a significant association between value and knowledge variables and diver characteristics and WTP of the contingent valuation in section 3.4

3.4 Contingent Valuation

3.4.1 Theory

The final portion of the survey employed a contingent valuation (CV) to determine if divers were willing to contribute to management efforts that span the land-sea system. In a CV respondents directly state their WTP for a good or service or their willingness to accept a certain level of payment for the loss of that good or service. This method is based on the theory that much of an individual's utility is based on unpaid costs for which an operating market does not exist (Bowen, 1943; Ciriacy-Wantrup, 1947; Clark, 1915). Though CV is controversial due to the tendency of respondents to see their responses as non-binding, it remains a useful tool for economic valuation when there is no functioning market for a good or service (Arrow et al., 1993).

The CV portion of the survey (SI) estimated respondents' WTP for upland restoration projects that can reduce sedimentation, thereby indirectly improving Guam's coral reef ecological state (Fabricius 2005). We provided basic information about sediment problems and photos of a sediment-affected reef and an upland re-vegetation project. While it would have been possible to include variations in the level of sedimentation or water clarity in the choice experiment, we decided to conduct a separate contingent valuation for two reasons. First, areas most heavily used by divers are not the areas of Guam's reefs that suffer from the most severe sediment issues; most diving occurs in central Guam on the West shore, while the most severe sedimentation issues are in the reef flats of Southern Guam (Burdick et al., 2008). Despite this lack of immediate overlap, improvements in an area of coral reef can improve the status of the fish stocks in adjacent areas (Tupper, 2007), which would be beneficial to divers. Second, water clarity is essential to the activity of SCUBA diving, and we were concerned that it would overpower the results for the fish-based ecological indicators.

3.4.2 Statistical Design

Using a payment card (Boyle and Bishop, 1988), respondents were asked to select a level of payment they would be willing to make as a one-time contribution to sediment reduction in Guam: USD $5.00, $10.00, or $15.00, or opt-out. As the goal was to determine if ecosystem-based conservation financing was possible, payment values were vetted by a local watershed restoration non-profit, the Humåtak Project. A wider range of values would have allowed us to capture total WTP for ecosystem-based management, however we were focused on attaining practically useful results for managers. Respondents who opted out of the payment were given five further options to explain their choice: (1) I do not believe this is a problem, (2) I do think soil damaging coral is a problem, but I don't think it will impact my SCUBA experience, (3) It is not fair to expect visitors to pay for land use problems in Guam, (4) I find all of these amounts too high but would be willing to pay $ (write in amount), or (5) Other (please explain). Responses were coded so that a selection of $5.00 was inputted as (1), $10 was (2), $15 was (3), and opt out (4). Opt out explanations were input as a separate column with coding corresponding to the five options presented.

3.5 Survey Validation and Sampling

We piloted the survey in Hawaii a few months prior to rollout in Guam, and analyzed the first 50 surveys collected in Guam, concluding that no survey design changes were required. We ensured the survey was available in English and Japanese and that a translator was available to explain the survey to Japanese respondents. Because we were targeting a specific group (i.e., divers), we used non-probabilistic (purposive) sampling (Fink, 2003), surveying divers at seven beaches (Agana bay, Cocos island, Fisheye marine park, Outhouse beach, Piti, and Merizo pier), one harbor (Apra harbor), one dive shop, and aboard two dive boats.

4. Results

In-person surveys were administered to 220 adults (at least 18-years-old) who were diving in Guam in August 2013. Fifty nine percent (59%) of surveys were administered in Japanese, with the remaining 41% in English. All currency is reported in current (2013) USD.

4.1 Respondent Characteristics

Twenty-four percent of survey respondents were Guam residents while seventy-six percent were non-residents (Table 1), which is in line with previous studies (Guam Visitors Bureau 2001, Van Beukering et al., 2007). Among non-residents sampled, their country of origin breakdown was 76% Japan, 15% United States, 4% South Korea, 3% Micronesia, and 1% each for Australia, Taiwan, and Europe. The sample captured by this study is similar to 2001 estimates of diver countries of origin, and the slight difference is consistent with the diversification of Guam's tourist arrivals (Guam Visitors Bureau 2001, 2011). We had a similar number of local divers captured in this survey as previous studies.

The sample was 57% male and 43% female. Respondents ranged from 18 to 70 years old (Mean = 33). Self-reported dives ranged from 0-20,000 (mean = 1008, median = 5), with 13% of respondents reporting over 1,000 lifetime dives. Dive experience was correlated with age, with older divers generally having more dive experience on average than younger divers ($r= -0.23$, $p < 0.01$). Over a third (35%) of respondents checked the box stating, "I have not been diving on Guam before", indicating that they were interviewed prior to their first dive completed in Guam.

4.2 Choice Experiment Results

We compared numerous models for analyzing the DCE results (conditional logit, mixed logit, asc logit, and latent class) using STATA. We elected to use both a conditional logit model and a latent class model for respondent preferences based upon having the lowest Akaike's information criterion (AIC) score (Bozdogan, 1987). Latent class models with two, three, four, and five classes were tested, and a two-class was selected due to having the lowest AIC score, indicating that it was the best fit for our sample. Table 1 enumerates specific results, where preferences are significant at the 0.05 level if t absolute ≥ 1.96.

In our conditional logit model applied to the entire sample, we found that divers had significant preferences for nearly all indicators of ecological quality, particularly at the "high" levels. The strongest preference was for the presence of both sharks and turtles.

Turning to the latent class results, we found that one of the groups, representing nearly half (46%) of the sample, had stronger environmental preferences (i.e., preferred more biomass, larger fish, etc.). We refer to this group as the "environmental group." The remainder (54%) of respondents had weaker environmental preferences (i.e., did not care as much about achieving "high" levels, so long as they were not "low"). One noticeable difference between the two groups is the environmental group's very strong positive preference for sharks.

We examined differences in demographics between the two groups (Table 1). Divers in the environmental group were generally more experienced divers, and slightly older. Gender did not appear to influence group assignment. Individuals in the environmental group were more likely to have taken the survey in English (x^2=20.696, p<0.000) and be involved with an environmental nonprofit organization (x^2=7.877, p<0.000). The environmental group contained a significantly greater proportion of Guam residents than the other group (x^2=34.955, p<0.000).

Table 1. Estimated parameters of the conditional logit (applied to entire sample) and latent class (applied to groups) models

Attribute	Entire Sample (n=180) log likelihood (-2718.97)		Environmental Group 46% log likelihood (-1490.67)		Other Group 54% log likelihood (-1490.67)	
	Coef.	SE	Coef.	SE	Coef.	SE
Med. fish biomass	.358***	.081	.453**	.156	.157*	.096
High fish biomass	.578***	.079	.838***.	.161	.271**	.098
Med. fish diversity	.432***	.081	.657***	.174	.160*	.096
High fish diversity	.572***	.080	.880***	.174	.211**	.104
Few (2-3) wrasse	.315***	.079	.214	.153	.224**	.090
Many (4+) wrasse	.384***	.080	.396**	.156	.192**	.094
Medium wrasse	.213**	.078	.136	.136	.133	.087
Large wrasse	.076	.080	.167	.155	-.023	.093
Shark only	.165*	.099	1.118***.	.235	-.203	.123
Turtle only	.697***	.094	1.323***	.246	.303**	.111
Both shark/turtle	1.51***	.092	3.370***	.348	-.039	1.605
Fee/dive	-.043**	.015	.018	.031	-.046**	.019
			Demographics and Diving			
	Value	SD	Value	SD	Value	SD
Average Age (years)	33	11	35	12	31	9
Median # Dives	5	2360	52	2885	2	2352
Average Income (USD)	$50,000-74,999		$50,000-74,999		$50,000-74,999	
English Survey	57%		42%		17%	
Env. Nonprofit	12%		20%		8%	
Guam Residents	24%		21%		5%	

*** p<0.01
** p<0.05
*p<0.10
All currency is in USD.

We converted these results, which indicate preferences for improved coral reef ecological attributes, into marginal WTP estimates based upon our conditional logit model for the entire sample (Table 2). Because the management fee attribute was not significant for the environmental group, we cannot analyze WTP based upon our latent class model. These WTP values represent the additional amount divers would be willing to pay as a management fee if conditions changed from "low" to "medium" or "medium" to "high".

Table 2. Diver WTP for ecological attributes of a coral reef environment relative to base conditions

Attribute	Average WTP	95% Confidence Interval	
Medium biomass	$8.34	$1.23	$15.45
High biomass	$13.48	$3.15	$23.82
Medium diversity	$10.10	$1.94	$18.24
High diversity	$13.33	$2.94	$23.72
Few wrasse	$7.35	$0.90	$13.78
Many wrasse	$8.95	$1.54	$15.36
Sharks alone	$3.86	$-1.49	$9.21
Turtles alone	$16.27	$3.71	$28.83
Sharks and turtles	$35.14	$9.38	$60.91

4.3 Environmental Value and Knowledge Rating Results

Environmental value scores tested direct use of coral reefs through activities such as fishing or diving, indirect use through shoreline protection, bequest value of protecting reefs for future generations, and existence value of distant MPAs that would protect coral in other places. Scores aggregated across all four value categories (use, indirect use, bequest, and existence) ranged from a low of 4 (the minimum possible) to a high of 20 (the maximum possible), with a mean of 16 (SD 3). The mean for the environmental group was 17, while the mean of the other group was 14 ($F=12.343$, $p<0.001$). Bequest values were especially high for both groups with a mean value of 5 and a lower SD (0.8) than use, indirect use, or existence values which had a mean of 4 and an SD of 1.1. The percentage of respondents selecting each category is displayed in Figure 6. Guam residents scored higher than nonresidents ($x^2=31.468$, $p<0.005$).

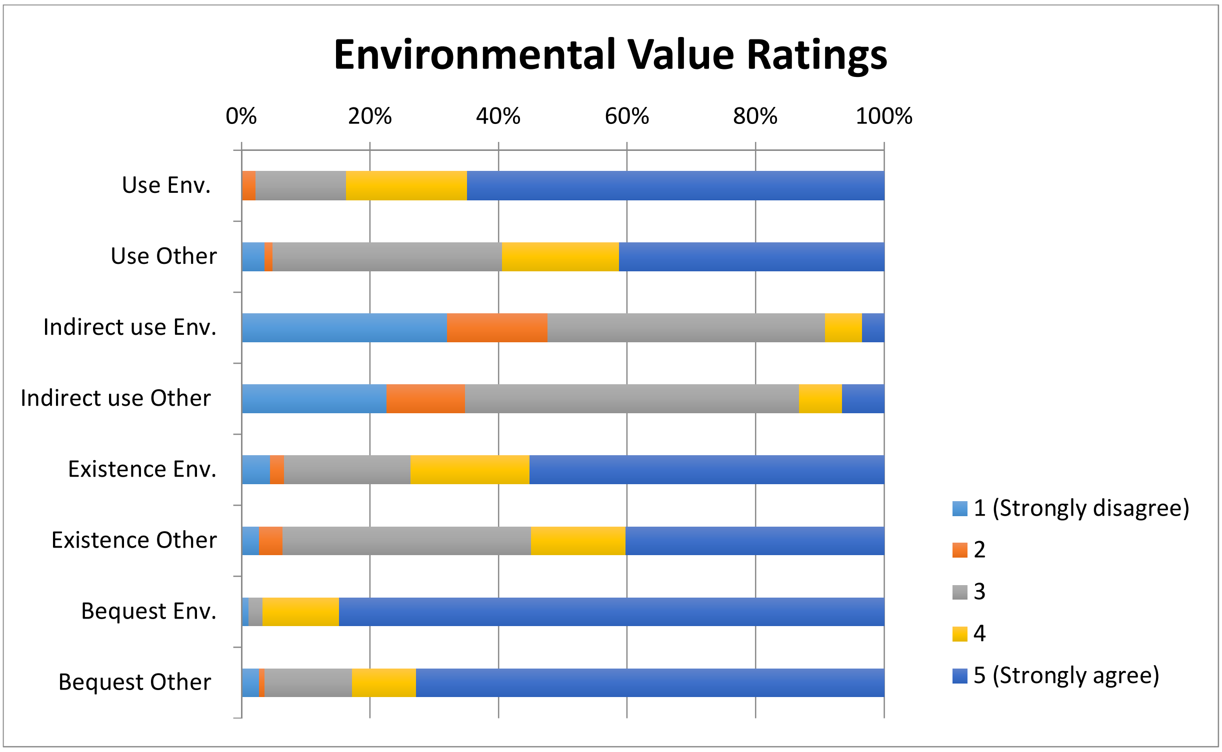

Figure 6. The proportion of respondents for the environmental and other group that selected a given score per environmental value.

The majority of respondents selected a moderate impact for all environmental threats except land-based pollution, with a near normal distribution (mean=3, SD=1.15). Threat knowledge sums were higher for individuals who had completed more dives (x^2=1316.484, p<0.000). There was no statistically significant difference in summed threat knowledge between groups, however the environmental group rated land based pollution higher than the other group (x^2=12.224, p<0.05). Ratings for land-based pollution were generally higher than the other threats (mean=4, SD= 1.3), particularly for Guam residents (x^2=15.689, p<0.005).

4.4 Contingent Valuation Results

The mean reported value for a one-time payment to sediment reduction projects was $10 (Median= $10, SD ± $5). Individuals in the environmental group were willing to pay more than individuals in the other group ($x^2 = 8.30$, $p < 0.05$), as were individuals with higher environmental value ratings (x^2=65.008, p<0.05). An individuals' willingness to contribute to sediment reduction projects was 20% correlated at the 0.05 level with the severity they assigned land-based pollution in the threats ranking, indicating individuals who recognized sedimentation as a threat were more willing to pay to reduce that threat. Guam residents were willing to pay significantly more than nonresidents for sediment reduction (x^2=17.689, p<0.001). Ten percent of respondents, including ten percent of nonresidents, would not donate money to such projects, commonly (43%) selecting the protest option "it is unfair to expect visitors to pay for land use problems in Guam." Guam residents who opted out thought the amount was too high, that this was the government's failure, or that they would need more information before deciding.

5. Discussion

Linking ecological changes with economic outcomes is a valuable management exercise (Farber et al., 2006). This is especially important in tourism-dependent areas such as Guam where ecological degradation can negatively impact local recreation and the economically important tourism sector. Information on how individual preferences are related to socio-economic demographics, knowledge, and values can provide managers with useful insights into management design and implementation (Fraj and Martinez, 2006). In this study, we sought to determine if divers could be leveraged as partners in conservation. We found that (1) divers have preferences for ecological indicators of coral reef quality, (2) there may be economic gains if diver preferences are realized and economic losses should ecological quality degrade, and (3) divers are willing to directly contribute financially to upslope watershed management, which is crucial to maintaining the health of Guam's coral reefs (Weijerman et al., 2016b).

5.1 Objective One: Ecological Preferences

People cared about the quality of the reef, but differently. Our environmental group cared about almost everything but the size of wrasses. The group with weaker environmental preferences cared about fish diversity and abundance, the number of wrasse, and turtles. This group also had a negative, though insignificant, preference for sharks, although that aversion was less when turtles were present. Perhaps the presence of turtles was perceived as a safety net from negative shark encounters. Our study design grouped turtles and sharks into one attribute, under the assumption that people would have positive preferences for both. This makes interpretation of this coefficient difficult, but also points to the need for education about the ecologically critical role of sharks (Heithaus et al., 2008), relative shark related risks while diving, and proper behavior around sharks (Apps et al., 2015). For the environmental group, the presence of multiple charismatic species on a single dive was an especially desirable attribute, even more desirable to most divers than fish biomass or diversity. Our results thus parallel those from a terrestrial setting where charismatic mammals and the presence of large predators were far more important to tourists than bird or plant diversity (Lindsey et al., 2007).

We had an unexpected result regarding the management fee for individuals in the environmental group: the coefficient was positive and insignificant. Typically as prices increase, quantity demanded decreases, so we expected a significant, negative coefficient for the management fee – which would indicate that respondents wanted the lowest possible fee. Based on a pilot of 50 surveys collected during the initial two days of sampling, the fee coefficient was negative and significant. However, as the sample size increased and likely reached more environmentally minded individuals, this significant result dissipated. It is possible that the dollar values in the survey were too low for the environmental group (they did not reach their maximum WTP, and thus the price may not have been taken into account when making trade-off decisions), the levels of ecological attributes were below a threshold where price would become a determining factor in an individual's tradeoff decisions, or environmental or social values simply trumped price (Popp, 2001).

We expected that people with higher environmental values and threat awareness would have stronger ecological preferences and higher willingness to pay. Here, we found that the environmental group had higher environmental value scores. However, overall threat knowledge was not associated with ecological preferences. One exception was threat knowledge of land-based pollution in particular was associated with ecological preferences. An important caveat is that other factors not included in our survey may also drive diver preferences, such as past experiences and diminishing marginal utility. Still, the differences in values between individuals within our sample may partially explain why we found two different groups in our latent class analysis. This may be linked to individuals' motivation for diving. Individuals who had taken the survey in Japanese were more likely to be placed into the other group (x^2=20.696, p<0.000), which scored lower for environmental values. Many Japanese tourists who go diving in Guam access the activity as part of a vacation package deal, in which diving is one of many activities accessible to them. Tourists from other areas and local residents are more likely to seek out diving as an activity, rather than have it provided in a package deal.

Environmental perceptions are known to be heavily dependent on place of residence (Petrosillo et al., 2007), a result we encountered here, i.e., many more Guam residents had stronger environmental preferences (and were therefore in the environmental group). Characterizing resource users based upon place of residence can be a means to focus efforts improving education regarding ecological awareness. Individuals aware of their presence within protected marine areas are willing to adopt more environmentally friendly behaviors (Petrosillo et al., 2007), thus increasing tourist awareness may be a simple means of encouraging pro-environmental behaviors. A diver education program could potentially create partners in conservation by drawing the dive and tourism industry into coastal conservation and develop more knowledgeable and environmentally aware divers. Indeed, diver education programs have been linked to positive ecological outcomes in other areas (Medio et al., 1997).

If management improves the ecological conditions valued by divers who pay to dive on those reefs, this could result in large economic gains, while reef degradation could incur significant losses. Our results are consistent with other studies showing that environmental conditions are important for divers. For example, our result for a change in WTP/dive for one to many Napoleon wrasse was $8.95/dive, which is similar to the value ($7.47/dive) for increases in abundance of the charismatic Nassau Grouper in the Turks and Caicos (Rudd and Tupper, 2002). A study across several Caribbean Islands also found higher WTP for higher fish abundance (Gill et al., 2015). In addition to being willing to pay more to see charismatic fish, divers were also willing to pay more for improved biomass ($13.48/dive, for moving from low to high levels) and diversity ($13.33/dive, for moving from low to high levels), both indicators of fisheries health, and for a change from no sharks or turtles to both sharks and turtles ($35.14). Because we did not reach the maximum WTP of the environmental group, these estimates should be interpreted as conservative. If a higher range of management fee prices was included that resulted in a negative coefficient, the WTP of the environmental group would likely have exceeded that of the other group.

Our results suggest that potential WTP for improvements in fish biomass alone may be upwards of $3.4 -4.5 million; equivalent to roughly 1/3 to 1/2 of Guam's Department of Aquatic and Wildlife Resources (DAWR) 2011 operating budget. This is based on van Beukering's (2007) estimate of 256,000 to 340,000 dives/year. Should fish biomass in Guam's marine preserves degrade to our "low" level (Williams et al., 2012), we would expect an economic loss upwards of $850,000 to $1 million per year in terms of diver WTP alone, 1/8 of the current funding of DAWR. This finding is consistent with research with Bonaire's SCUBA community that found the potential for economically significant losses under degraded environmental conditions (Parsons and Thur, 2008). Our estimate in economic decline solely considers a decrease in biomass (none of the other attributes), assumes that 50% of dives occur in preserves (likely an underestimate), and does not include any decline of tourist visitation rates or expenditures that would likely arise if Guam were perceived as a lower quality dive vacation destination.

5.2 Objective Two: Ecosystem Based Management Funding

Our second objective was to assess divers' willingness to directly contribute to broader environmental management that considers the land-sea interface. Sedimentation is the most significant local threat to Guam's reefs (Burdick et al., 2008) and can have negative impacts on diving by causing water quality problems that impair visibility and, eventually, coral reef health (Fabricius, 2005). Sediment mitigation, which we directly asked respondents about their willingness to contribute to, can improve ecological conditions, particularly when implemented alongside fisheries management actions (Weijerman et al., 2016b). We found that divers were willing to contribute to this type of ecosystem-based management. While visibility is a likely primary reason people were concerned about sedimentation, we suspect this willingness to contribute is also driven in part by people's knowledge of the severity of sedimentation as a threat to coral reef health. This is supported by the fact that respondents rated sedimentation higher than other threats in our survey. It may also be driven by broader environmental values. For example, our results show that divers hold strong bequest values and are therefore concerned about the preservation of Guam's coral reefs for future generations, a result that has recently been found among reef users in other contexts (Oleson et al., 2015).

Willingness to contribute financially to upslope revegetation activities was unsurprisingly higher for local residents. This likely reflects the broader benefits that Guam residents would incur, but may also be tied to local knowledge, as Guam residents ranked sediment as a higher threat than non-residents. Despite these differences, the fact that tourists, as well as residents, were willing to contribute to watershed restoration efforts that indirectly affect coral reef health is a new and significant finding. Ecosystem-based management approaches such as watershed restoration tend to be long term efforts whose benefits can take years to be realized (Gilman, 2002). Yet previous studies have suggested that tourists are primarily concerned with the immediate physical or spatial condition of coral reefs, rather than their long-term temporal condition (Petrosillo et al., 2007).

5.3 Management Implications

A growing body of literature regarding diver WTP for ecological conditions provides economic values which can be invoked to set user fees. In many cases, the funds raised could be significant and critical to conservation success. For example, a small contribution ($2.50-$7.50 per dive based on a conservative result of the choice experiment) by the 100 thousand people per year who dive on Guam's reefs would generate $625 thousand to $2.5 million annually. This represents a non-trivial addition to the $8 million annual operating budget of the Guam's Department of Aquatic and Wildlife Resources responsible for coastal management (Guam Department of Agriculture, 2011). Global examples of divers paying for management costs of marine parks, such as those in South-East Asian countries where the practice is increasingly common, offer promising lessons for Guam, and our study could underpin eventual user fees (see Depondt and Green 2006 for a list of areas charging diver fees). In Tubbatha Reefs Natural Marine Park in the Philippines, a WTP study helped set management fees which covered 28% of recurring costs and 40% of core costs (Tongson and Dygico, 2004). Implementing diver management fees in Thailand could provide enough money to cover the management costs of a protected marine park with additional surplus income (Asafu-Adjaye and Tapsuwan, 2008b). Similar results were reported in Bonaire National Marine Park in the Caribbean (Thur, 2010). Moreover, Pascoe et al (2014) allay concerns that management or entry fees would dissuade divers, finding that increasing fees is likely to have very little impact on the number of divers. In practice, few places have effectively collected adequate diver fees to pay for the management of marine protected areas, and fees are often far below divers' actual WTP (Depondt and Green, 2006).

While current management financing mechanisms have all focused on divers WTP for marine management, we have demonstrated that divers are also willing to contribute to terrestrial management projects. Divers expressed a willingness to support upslope restoration efforts, which could generate an additional $900 thousand if 90% of divers contributed $10, the mean value respondents reported they would contribute. Importantly, this equates to an amount that a local non-governmental organization reported would be practically useful for watershed restoration efforts in Guam (Humåtak Project, personal communication). Quantifying the willingness of marine beneficiaries to contribute to upland management of social-ecological systems is going to be increasingly called upon as ecosystem-based management becomes the norm (Alvarez-Romero et al., 2011).

Understanding diver preferences and WTP in isolation is helpful, but coupling economic and ecological considerations together can provide a better assessment of ecological systems (Bockstael et al., 1995). The results of this study have been used to evaluate the economic implications of different fisheries management scenarios (Weijerman et al., 2016b). Some of the ecological indicators utilized in this study were used in an Atlantis Ecosystem Model for Guam (Weijerman et al., 2014). The coupling of economic and ecological criteria can be beneficial to managers who require a full breadth of information when making decisions.

6. Conclusion

In this study, we assessed divers' ecological preferences and the environmental values and awareness that influence them. We assessed WTP for ecological gains achievable through management. Finally, as reefs are at the base of watersheds, we assessed diver willingness to contribute to watershed management as a form of ecosystem-based management. We found that divers typically fell into one of two groups, with one group having stronger preferences for better ecological conditions all around, and higher environmental value summative ratings. The presence of both sharks and turtles was by far the most preferred attribute of the study, however divers were also willing to pay more to dive under conditions of improved fish biomass, improved fish diversity, and with more numerous Napoleon wrasse. We found that individuals' preferences are connected to their demographics, level of dive experience, and environmental values. Land-based pollution was the only threat that significantly influenced preferences, a positive finding given the severity of Guam's sedimentation problem (Burdick et al., 2008). Finally, we found that the potential for economic gains (or losses) for the dive sector due to ecological improvements (or degradation) are significant, and that people are willing to make a voluntary direct contribution to broader upslope environmental management efforts.

Coral reef managers require information on the full breadth of uses for coral reef resources in order to make more holistic, well-informed, and balanced management choices. Restoring and protecting reefs can have clear economic benefits to multiple sectors. We focused on just one sector that stands to gain from improved management, demonstrating that divers are willing to pay for improved ecological conditions. The results of this study have been qualitatively linked with an ecosystem model to evaluate how different management strategies may impact a wider range of coral reef users (Weijerman et al., 2016b). Our findings could also help inform payment schemes (i.e., management fees) to leverage much-needed dollars to support management actions and/or compensate potential "losers". Reef declines were associated with a reduction in WTP, which has important implications for a tourism dependent economy. The novel finding that divers are willing to contribute to upslope watershed management should ignite a land-sea systems approach in stakeholder engagement efforts. Capturing divers WTP for the provision of the ecological conditions that matter to them could generate much needed revenue for coastal management and engage divers as partners in conservation.

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