DIVERS' WILLINGNESS TO PAY FOR IMPROVED CORAL REEF CONDITIONS IN GUAM

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Dedication

This thesis research would not have been possible if not for the love, support, and encouragement of my parents Laura and Andrew, and my late grandmother Anne who tirelessly supported my ideas and interests.

I would also like to dedicate my thesis research to my husband, “SANMAN”. Josh, you have been my source of inspiration and motivation to keep going on my most difficult days.

And finally, a haiku dedicated to my four wonderful sons.

Pursue your passions

The journey is not easy

But it is worth it

Acknowledgements

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Abstract

Coral reefs are degrading globally, yet are essential to coastal and island economies, particularly in the Pacific. The diving industry benefits from coral reef management and can be positively or negatively impacted by ecological change. Quantifying divers' ecological preferences can help inform managers and justify conservation. Utilizing non-market valuation, we assess SCUBA divers' preferences and willingness to pay (WTP) for ecological attributes of coral reef ecosystems in Guam, and investigate socioeconomic drivers influencing preferences. A discrete choice experiment grounded in ecosystem modeling revealed divers were willing to pay user fees in reef ecosystems with greater ecological health (higher fish biomass, diversity, and charismatic species). Improvement in fish biomass from low ($<25 g/m^2$) to high ($>60 g/m^2$) was worth over $2 million/year. The presence of sharks and turtles together was the most favored attribute, with a WTP of $15-20 million/year. Contingent valuation results suggested divers were willing to make voluntary payments of $900 thousand towards sediment-reduction projects in upland watersheds. These payments could benefit divers and the broader tourism industry by improving reef conditions. Relatively few policy instruments are in place worldwide collecting fees from divers for coastal management, and none in Guam. My results suggest this remains an untapped funding source for coral reef management and conservation.

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1.0 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 (Wilkinson and Buddemeier, 1994). Yet coral reefs are declining globally due to local and global anthropogenic stressors, including unsustainable fishing, land-based pollution, and climate change (Pandolfi et al., 2003). Sharks, as keystone species of coral reefs, are also under global threat due to shark-finning, climate change, and habitat degradation (Dulvy et al., 2008; Robbins et al., 2006).

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 such as fisheries or recreation(Brown et al., 2001; Hicks et al., 2009). Effective management can improve species abundance and ecological quality, potentially resulting in net ecological and economic benefits. In many areas, the SCUBA diving industry benefits from coral reef management and can be positively or negatively impacted by ecological change. Understanding how recreationalists value ecological conditions in coral reef ecosystems is therefore an essential step towards designing cost-efficient, balanced management. This is globally relevant in all areas where coral reefs and associated species support recreational activity.

The diving industry can be impacted by changes in coastal management and can be strongly affected by ecological changes in the coastal and marine environment. SCUBA diving on coral reefs is a valuable economic activity, generating billions of dollars per year for local economies (Brander et al., 2007; Cesar and Van Beukering, 2004; van Beukering et al., 2007). Quantifying the economic-ecological links, i.e. how changes in the ecology of coral reefs impact the economic outcomes experienced by related sectors such as fishing or tourism, that support the diving industry can provide an understanding of what matters most to recreational SCUBA divers and guide the design of management strategies that leverage diver fees to support coral reef health. Recognizing this, a handful of studies have used non-market valuation techniques to estimate recreationalists' willingness to pay (WTP) for coral reef attributes such as fish biomass, species diversity, coral cover, ecological quality, coral restoration, the presence of sharks, and the size of particular species (Asafu-Adjaye and Tapsuwan, 2008a; Parsons and Thur, 2008; Rudd and Tupper, 2002; Wielgus et al., 2002). Yet this previous work has focused solely on the Caribbean and South-East Asia, overlooking the Pacific Islands where coral reef-related tourism is a dominant economic sector. The Asian tourism market may have distinct differences from the North American and European tourism markets and their preferences have not yet been explored.

In my study, I apply a discrete choice experiment to assess divers' preferences and willingness to pay for ecological attributes of coral reef ecosystems in Guam, and investigate the underlying socioeconomic factors contributing to diver preferences. Considering the important role sharks play as keystone species and in supporting dive tourism (Cisneros-Montemayor et al., 2013), I also specifically explore diver preferences for the presence or absence of sharks, in addition to other important ecosystem attributes. As coastal and marine management shifts towards an ecosystem-based approach, there is an increasing need to understand the connections between a much broader social-ecological system, such as that utilized in the traditional ridge to reef or ahupuaʻa management of Hawaii (Kaneshiro et al., 2005). I therefore also use contingent

valuation to investigate whether ocean-based beneficiaries are willing to contribute to land based management that can indirectly affect coral reef ecosystem health.

1.1 Study site: Guam

Guam is a U.S. territory located at the southernmost end of the Mariana Archipelago, at 13°N, 144°E (Bureau of Statistics and Plans, 2006). The nearshore environment is dominated by hard corals of varying live coral cover, interspersed with areas of sandy bottom, particularly near river or stream outlets (CRED 2012). Fringing reefs surround most of the island, but patch reefs, submerged reefs, barrier reefs, and offshore banks are also present. Guam's nearshore waters contain approximately 108 km^2 of coral reef, including several well-developed lagoons (Burdick 2006) and 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).

As residents of a small Pacific island with a land area of only 549 km^2, Guam's 168 thousand people are dependent on healthy coral reefs, both culturally through the perpetuation of traditional Chamorro identity (Allen and Bartram, 2008) and economically by supporting the tourism industry (van Beukering et al., 2007). Although Guam has a long history of humans utilizing coastal resources, the population of Guam today is far above pre-contact populations (Amesbury and Hunter-Anderson, 2003). It is estimated that at first contact with Europeans in 1521, there were fewer than 20,000 Chamorros on Guam (Amesbury and Hunter-Anderson, 2003). Today's population on Guam is at least seven times this pre-contact population size and was reportedly 159,358 during the last census (Guam Bureau of Statistics 2010). Many people on Guam are fishers. A recent household study of randomly selected households estimated that 35 to 45% of respondents were active fishers (van Beukering et. al. 2007), which, if applied to Guam's estimated population as of the 2010 census (Guam Bureau of Statistics 2010), indicates a potential fisher population of between 50,000 to 70,000 individuals. This represents an immense growth in fishing pressure over the past few hundred years as the number of fishers is now more than 2.5 – 3.5 times the estimated pre-contact population, who were entirely dependent on Guam's resources.

Contrary to this historical pattern, in recent years, fisheries participation has declined. In 1975, 65% of the population was participating in fishing (Klimek 1975 as cited in Allen and Bartram 2008). The decline in estimated fisheries participation from 1975 to 2007 may be a reflection of Guam's shifting economy. Although a smaller proportion of Guam's population is now participating in fishing, due to population growth and the efficiency of modern fishing gear, this does not correlate with less fishing pressure. Traditional Chamorro fishing methods reflected a deep understanding of fish life histories, and marine resources were managed at the local level (Vaughn 1999), but modern fishing methods are far more effective than traditional Chamorro fishing methods, which reduces the skill required for a successful catch. Almost all of Guam's reef fish that are caught are either consumed by the fisher or his/her family, or shared with extended family and friends (Allen and Bartram 2008). A small group of fishers sell their catch,

however it is typically for the purpose of recovering costs of fishing and is considered to be a negligible amount, with such fishers earning about $250/month (van Beukering et al., 2007).

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, particularly Japan (Ruane, 2013). The tourism industry has fared especially well in recent years, with a total of 1.3 million visitors in 2012 (Guam Visitors Bureau 2012). This is driven in part by increased numbers of Korean tourists, who have reached an all-time high (Guam Visitors Bureau 2013). Approximately 6% of all visitors go SCUBA diving, sustaining a number of dive operators and shops (Guam Visitors Bureau, 2001), and an estimated 3% of tourists visit Guam with SCUBA diving as the primary motivation for their trip (Guam Visitors Bureau, 2001). Diving occurs all over the island and a large variety of dive options are available including beach entry dives, reef dives, drift (open ocean) dives, and shipwreck dives (Figure 1). The most heavily utilized dive sites are along the West Coast of the island near the tourism center of Tumon Bay, and MPA's along the West coast of the island are especially popular (dive shop owner personal comm.)

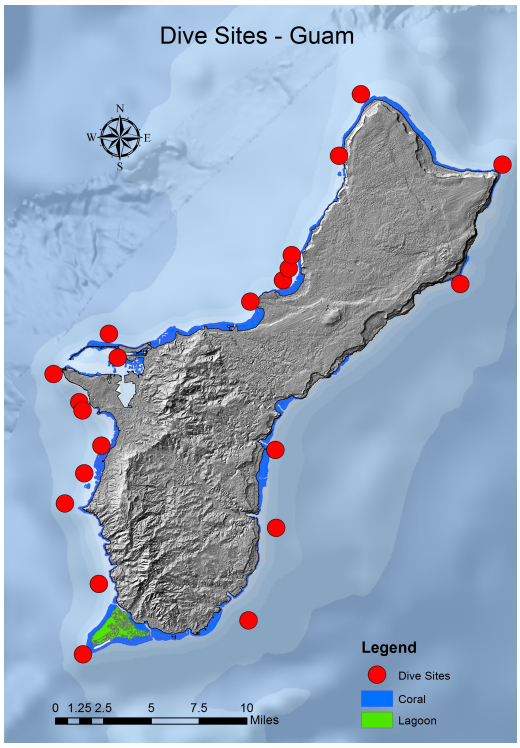

Figure 1. **Dive sites of Guam.**
The most heavily utilized sites are along the Western shore of the island. UTM, WGS 1984 (Chamberlin, 2008; Guam Visitors Bureau, n.d.; NOAA, 2011)

Information collected from dive operators in 2000 revealed that there were 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. Many of the dive operations heavily cater to Japanese tourists, and it is common for a dive operations phone to be staffed by a Japanese speaking or bilingual individual. Van Beukering et al. (2007) used the number of air fills occurring each year to estimate that Guam's reefs support between 256,000 and 340,000 dives per year, with approximately 1/3 being local dives and 2/3 tourist dives. 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).

1.1.2 Threats to Guam's reefs

Guam's coral reefs are currently affected by several threats both anthropogenic and natural including: sedimentation, crown of thorns starfish outbreaks, overfishing, and increasing human development.

Sedimentation is one of the most significant threats to Guam's reefs (Burdick, 2008). Sediment particles can harm reefs by physically smothering coral reefs, reducing available light, and/or altering water chemistry by enriching it with excessive nutrients (Rogers, 1990). Due to the island's topography, reefs on the southern part of the island have naturally higher sediment loads than reefs in the Northern part (Burdick, 2008). However, human actions have greatly exacerbated natural sedimentation processes. Intentionally set wildfires, poor road construction practices, use of recreational vehicles, and the presence and grazing of feral ungulates all contribute to Guam's sedimentation problem (Burdick, 2008).

Crown of thorns starfish*, Acanthaster planci,* grow up to 2ft wide and are voracious grazers of corals (Birkeland 1990). This species grazes on coral, which under normal conditions encourages coral growth by selectively targeting fast growing corals (Colgan 1987). There have historically been periodic outbreaks of crown of thorns starfish recorded, some of which have had severely damaging effects to corals (Birkeland 1990). *Acanthaster* is a naturally occurring organism on Guam's reefs, and therefore reefs should be capable of recovery after predation (Colgan 1987) although the level to which that actually occurs is less well known. Also unknown is if there are thresholds in crown of thorns density or other reef conditions that make recovery less likely. Terrestrial runoff has been suggested as a cause of *Acanthaster* outbreaks (Birkeland 1982, Fabricius 2010) in which case sedimentation may be increasing crown of thorns starfish recruitment. In recent years, there have been numerous crown of thorns starfish outbreaks reported on Guam, and there is evidence that these outbreaks have become more severe and widespread (Burdick 2008).

There is also concern that overfishing has impacted Guam's reef fish. Despite significant technological gains, fisheries harvests have been estimated to have declined by as much as 86% since the 1960s (Zeller 2008). There is concern that Guam's reefs are overfished, which is largely attributed to the shift in fishing gear towards more efficient spearfishing (Richards 2012). The use of SCUBA spearfishing, in particular, is problematic because it has expanded the habitat that is available to fishermen, effectively removing the "depth refuge" which may be important in maintaining fish biomass in the Indo-Pacific region (Tyler 2009, Goetze 2011). Spearfishing allows for a much higher degree of selectivity than other methods, and spear fishermen generally

target larger fish which may be more damaging than harvesting higher numbers of juveniles due to the life history of slow growing fishes (Birkeland 2005).

In addition to these, human development is negatively impacting Guam's coral reefs by increasing many other stressors. The United States Military is expected to relocate 26,000 additional individuals to Guam by 2020 (Government Accountability Office 2011). The military relocation to Guam could increase the total population by as much as 38%, which is a huge increase for such a short timespan (Guam Civilian Military Task Force, 2007). It is likely that development will increase sedimentation, and will otherwise stress Guam's natural systems through increased human population and associated development (Burdick 2008). There has been a proposal to dredge a portion of Apra Harbor, which could directly disturb high quality coral habitat popular with divers and fishermen (Burdick 2008). The rapid development and influx of a large human population is a serious threat to the integrity of Guam's coral reef ecosystems.

1.1.3 Management of Guam's Reefs

Management of Guam's reefs is difficult due to competing human uses for resources. The Government of Guam currently is collaborating with NOAA to study coastal fisheries regulations with the aim of improving reef health. Currently, 27% of Guam's coral reef ecosystem habitat is within a marine protected area (MPA), although only 2% of MPA's are "no take" areas (NOAA 2009) (Table 1). Current management measures focus on size limits for invertebrates, a ban on destructive practices such as the use of poisons, explosives, or the physical damage of coral, and gear restrictions within Guam's MPAs (Guam Department of Agriculture 2013) (Table 1).

The three marine preserves in Guam with the goal of "sustainable" production were implemented in 1997 (Table 1). These preserves are believed to be effective and fish sizes have increased within these preserves (Gutierrez 2003 as reported in Burdick 2008). However, there is still more to be done to help Guam's fish stocks recover from decades of overfishing. The choice of an optimal fisheries management policy would consider the impacts for all stakeholders over time. Fisheries restrictions will likely cost fishers short-term revenue, but have long-term benefits for Guam's population through sustained fish stocks, and positive non-market benefits for tourists who would see more fish.

TABLE 1. SUMMARY INFORMATION REGARDING GUAM'S MARINE PROTECTED AREAS

The Tokai Maru, Cormoran, and Aratama Maru are all sunken ships and limited information regarding what activities are permitted at those locations is available, however they are popular dive locations. (Guam Department of Agriculture 2013, NOAA 2009, NOAA 2013, SWCA Environmental 2010a, SWCA Environmental 2010b)

MPA Name	Year established	Total area (km^2)	Conservation Goal	Fishing regulations
Achang Reef Flat	1997	4.66	Sustainable production	No fishing allowed, special permits issued for seasonal runs of mackerel, juvenile fusillers, and rabbitish
Aratama Maru	1988	.02	National heritage (assumed)	
Cormoran	1974	.02	National heritage (assumed)	
Haputo Ecological Reserve	1984	1.24	Natural heritage & Cultural heritage	No fishing allowed
Orote Ecological Reserve	1984	.76	Natural heritage	No fishing allowed
Pati Point	1997	20.11	Sustainable Production	Only shore-based hook & line allowed
Piti Bomb Holes	1997	3.66	Sustainable production	No fishing allowed, special permits may be granted for runs of juvenile fusillers
Sasa Bay	1997	3.14	Sustainable production	No fishing allowed
Tokai Maru	1988	.01	National heritage (assumed)	
Tumon Bay	1997	4.57	Sustainable production	Hook & line, cast net from shore allowed for rabbitfish, convict tang, juvenile goatfish, and juvenile jack. Cast net allowed along reef margin for rabbitfish and convict tang

2.0 MATERIALS AND METHODS

2.1 Mixed methods design

A mixed methods design is employed by utilizing both qualitative and quantitative methods in the same study (Starr, 2014). 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 stated preference non-market valuation methods used in evaluating reef quality are discrete choice experiments and contingent valuation, both of which are employed here. Previous studies applied these methods to estimate SCUBA divers' WTP for diving in marine protected areas (MPAs) (Arin and Kramer, 2002; Asafu-Adjaye and Tapsuwan, 2008a; Parsons and Thur, 2008), improved or maintained reef quality (Bhat, 2003; Dixon et al., 1995; Park et al., 2002; Parsons and Thur, 2008), the size and abundance of charismatic fish species (Rudd and Tupper, 2002), and different recreational diving management restrictions (Sorice et al., 2007). Broadly stated, all of these examples found increases in diver WTP under conditions of better ecological quality.

WTP provides important information on preferences, but a deeper understanding of people's characteristics such as their knowledge of environmental threats or environmental values that determine individual preferences can help managers better design and target strategies. For instance, individuals who feel the environment is threatened are more likely to adopt environmentally friendly practices (Baldassare and Katz, 1992; O'Connor et al., 1999), and environmental values, i.e., how they perceive their relationship to the ecological world can also help explain pro-environment behavior (Schultz et al., 2005; Wesley Schultz and Zelezny, 1999). People relate to, or value environmental resources in a variety of ways; for example through directly utilizing resources such as for consumption (use value), indirectly utilizing resources such as storm surge mitigation (indirect use value), ensuring resources are available for future generations (bequest value), or just simply knowing that a resource or ecosystem is present elsewhere (existence value) (Tietenberg, 1988). To better understand how an individual's characteristics were related to these preferences, we collected data on individual levels of knowledge regarding the threats facing Guam's coral reefs, attitudes towards environmental resources, and socio-demographics.

I hypothesized that divers prefer coral reef dive environments that have better dive conditions, represented by high fish species diversity, high fish biomass and larger and more numerous charismatic reef fish, and that they were willing to pay for an improved reef environment (Gill et al., 2015; Rudd and Tupper, 2002).

2.2 Survey Design and Administration

My questionnaire consisted of four sections: (1) demographics and diving, (2) a discrete choice experiment, (3) environmental values and awareness of threats to Guam's reefs, and (4) a contingent valuation question (see appendix).

2.2.1. Demographics and diving

Demographic information collected included year of birth, gender, country of residence, and income. Diving-specific information included total number of SCUBA 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.

2.2.2. Discrete choice experiment

Theory

Discrete choice experiments have been used in a handful of studies investigating coral reef diving environments because the method allows for evaluation and analysis of an individual's utility for several characteristics of a good or service simultaneously (Hanley et al., 2001; Parsons and Thur, 2008; Rudd and Tupper, 2002; Sorice et al., 2007). A choice experiment's design dissects the attributes of a good or service and assigns various levels to each attribute. Attribute levels are randomly grouped together as a hypothetical good, which respondents then choose between. This design reveals the relative importance they place on attributes, on the various levels of each attribute, and their WTP for variations in levels. Latent class analysis can expose different classes, or subpopulations, within the study sample based upon responses to the choice questions or preferences (DeSarbo et al., 1992).

The theoretical framework for this method derives from random utility theory (McFadden, 1972; Thurstone, 1927), which describes discrete choices made in a utility maximizing framework, and draws 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. It is assumed 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 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).

Attributes

We conducted a thorough literature review, two focus groups with ten and twelve participants, 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 in total, with a focus on ecological conditions: fish biomass, fish species diversity, the number of Napoleon wrasse *Cheilinus undulatus* present, the size of Napoleon wrasse, the presence or absence of sharks and/or sea turtles, and a hypothetical management fee per dive. Each attribute consisted of either three or four associated levels. Because one of our study goals was to connect our results to an ecosystem model being used to predict management outcomes in Guam, we synchronized attributes and levels to the outputs of the Atlantis ecosystem model (Weijerman et al., 2014) and focused on fish-based metrics of coral reef ecological health. This approach ensured our results would be relatable to local resource managers. Digitally altered photographs were utilized in the survey with the attempt to best represent coral reef conditions. Detailed descriptions of the ecological values that underlie attribute levels are presented in turn.

Fish biomass: Levels were low, medium, or high on the survey instrument. Based on the preliminary results of the ecosystem modeling work, these correspond to: < 25 g/m^2 is low, 25-60 g/m^2 is medium, and > 60 g/m^2 is high (Williams et al., 2012) (Figure 2).

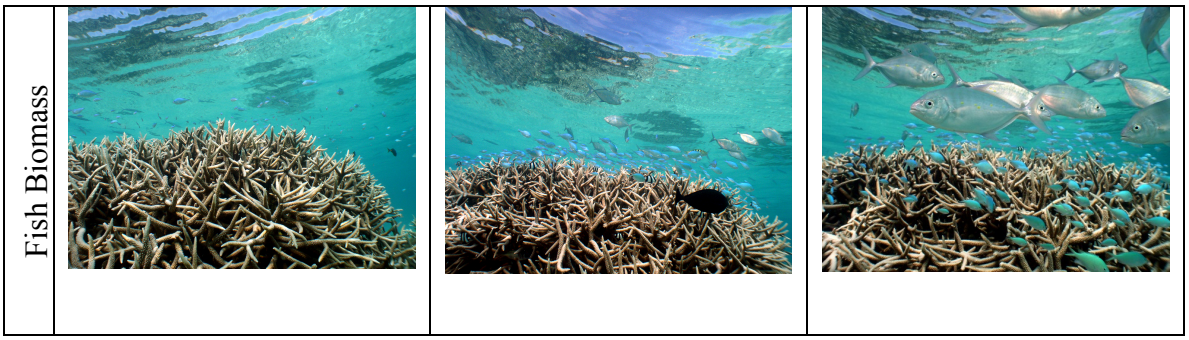

FIGURE 2. **LOW, MEDIUM, AND HIGH BIOMASS PHOTOS UTILIZED IN SURVEY**

(Photo credit: David Burdick, guamreeflife.com)

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 in the low diversity photo, four fish species in the medium diversity photo, and eight fish species in the high diversity photo (Figure 3)

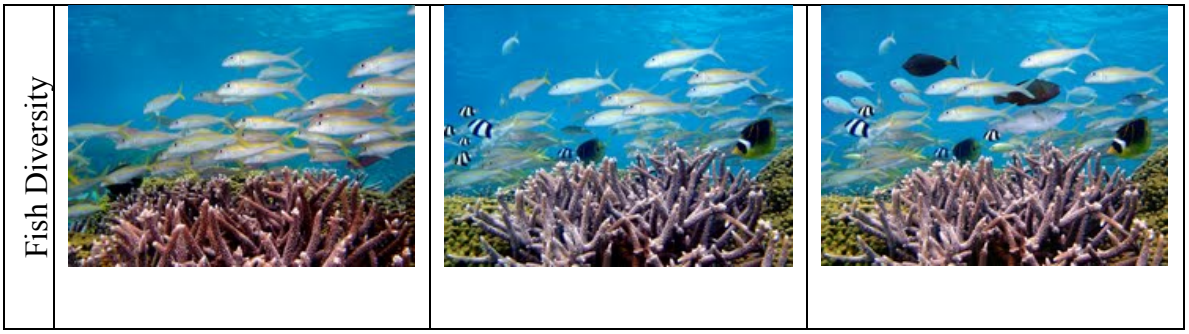

FIGURE 3. **LOW, MEDIUM, AND HIGH DIVERSITY PHOTOS UTILIZED IN SURVEY**

(Photo credit: David Burdick, guamreeflife.com)

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+).

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).

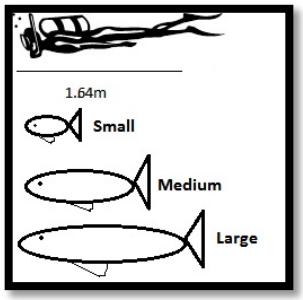

***FIGURE 4. CHEILINUS UNDULATUS* SIZES SHOWN ALONGSIDE A 6' TALL HUMAN**

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, and both sharks and turtles.

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.

Statistical design

The number of attributes and levels included 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 tasks each. A randomized design in which each respondent has a unique set of questions would be the ideal way to conduct a conjoint choice survey (Johnson and Orme 2006). However, this is only possible when using computer-based surveys and was therefore not an option for in-person surveys. Utilizing six different 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 tourists on dive trips. However, as the number of versions increases it becomes more difficult to manage the surveying effort and ensure that the number of respondents is evenly distributed among versions. Using Sawtooth CBC Software with a target sample size of 200, I compared the "design efficiency value" for between 1-8 survey versions consisting of 5-12 questions. 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 (Rudd and Tupper 2002, Gill 2015). The selected design of six versions with eight tasks has a design efficiency value of 820.676. The algorithm utilized meets three out of four Huber-Zwerina criteria for designing efficient choice designs: orthogonality, when the levels of each attribute vary independently of one another; level balance, when the 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 criteria can impinge on orthogonal design (Johnson and Orme 2006).

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.

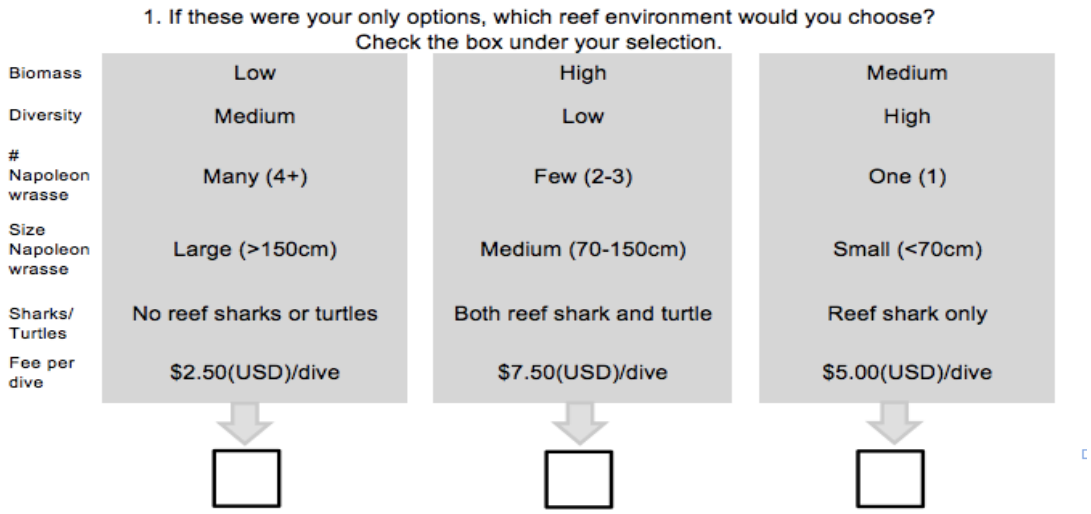

FIGURE 5. SAMPLE CHOICE TASK

Respondents check box under the dive environment they find most favorable

2.2.3. Environmental threats and values

Respondents rated 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 ranked 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.

Our choice experiment measured changes to the use value of Guam's coral reefs, which captures only a small portion of the total value coral reefs provide to people. We therefore employed a ranking system to allow respondents to express additional values for Guam's reefs to determine whether or not they do in fact value multiple benefits from coral reefs[1]. Specifically, we used a separate 5-point scale and proxy statements to assess use, indirect use, bequest, and existence values. The value 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: "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, 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).

2.2.4. Contingent Valuation

Contingent valuation (CV) is a stated preference economic valuation method where respondents directly state their willingness to pay 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 contingent valuation portion of the survey estimated respondents' WTP for upland restoration projects that can reduce sedimentation, thereby indirectly improving Guam's coral reef ecological state. Sedimentation has been identified as one of the most serious threats to Guam's coral reefs (Burdick et al., 2008), yet the extent to which divers in Guam are concerned about, and willing to contribute to, land remediation measures that would reduce sedimentation of Guam's reefs is currently unknown. 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). However, improvements in an area of coral reef can improve the status of the fish stocks in adjacent areas (Tupper, 2007). 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 that are the focus of this study.

After respondents completed the choice tasks, we provided basic information about sediment problems and photos of a sediment-affected reef and an upland re-vegetation project. Using a

[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).

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. Payment values were vetted by a local watershed restoration non-profit, the Humåtak Project. 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).

2.2.5 Survey validation and sampling

We piloted the survey in Hawaii a few months prior to rollout in Guam, and then analyzed the first 50 surveys done 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, we used non-probabilistic convenience 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.

2.3 Statistical Analysis

I compared numerous logistic regression models for the discrete choice experiment results (conditional logit, mixed logit, asc logit, and latent class) using STATA (StataCorp, Texas, United States). Based on having the lowest Akaike Information Criterion (AIC) score and the most significant result for our management fee variable, we elected to use a conditional logit model to analyze preferences of the sample as a whole, and chose to use a latent class model to analyze preferences of different groups within the sample. 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). 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):

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

where

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):

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

Willingness to pay (WTP) for changes in attribute levels can be estimated by using the change in the marginal utility and the payment attribute assuming all other variables remain constant. The formula used for estimating WTP is:

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

SPSS Version 22 (IBM, New York, United States) was used to analyze demographic, threat, and values data using an ANOVA to test for variance between groups and chi-square test to test for independence between variables (Brown et al., 1974).

3.0 RESULTS

In-person surveys were administered to 220 adult (at least 18 years old) individuals who were SCUBA diving in Guam in August 2013 (Appendix). Surveys were conducted during 7 week days and 3 weekend days. Thirty-nine (39) surveys were incomplete, without all eight questions in the conjoint choice experiment answered, leaving 181 surveys for analysis. Incomplete survey questionnaires were retained for inclusion for the remaining survey sections. Fifty nine percent (59%) of surveys were administered in Japanese, with the remaining 41% in English. All currency is reported in current (2013) USD.

3.1 Respondent Demographics

Twenty-four percent of survey respondents were Guam residents while seventy six percent were non-residents (Table 1). Among non-residents sampled, 76% were from Japan, 15% were from the United States, 4% were from South Korea, and 3% were from Micronesia while Australia, Taiwan, and Europe each made up 1% of non-residents sampled. The sample captured by this study is not dramatically different from the 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).

The sample was 57% male and 43% female. The oldest respondent was 70 years old and the youngest respondent was 18 years old. Mean respondent age was 33. The number of self-reported dives completed by individuals in the survey ranged from 0 (no prior dives) to 20,000 and was correlated with age, with older divers generally having more dive experience on average than younger divers (r = -0.23, p < 0.01). Twenty-four divers reported completing over 1,000 lifetime dives, which impacted the average number of dives completed by the sample (Mean=

736, Standard Deviation [SD]= 2360). 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.

3.2 Choice Experiment Results

Results were analyzed for a two, three, four, or five-class model. A two class model was selected due to having the lowest Akaike's information criterion score, indicating that it was the best fit for our sample (Bozdogan, 1987). Almost half (46%) of the sample had strong environmental preferences (i.e., preferred more biomass, larger fish, etc.), while 54% had weak environmental preferences (i.e., did not care about changes in the dive site attributes so long as they were not "low"). The groups were most strongly divided along preferences to see sharks and/or turtles on a dive, which was also the attribute to which both groups responded most strongly. Table 1 enumerates specific results, where group preferences are significant at the $p>0.05$ level if t absolute ≥ 1.96. Conditional logit degree of freedom=12, latent class degree of freedom=26.

We examined differences in demographics that explain the two groups (Table 2). Divers in the environmental group were generally more experienced divers, had a higher income, and were slightly older. Gender did not have a significant impact on group assignment. Individuals in the environmental group were also more likely to have taken the survey in English (x^2=20.696, $p<0.001$ and be involved with an environmental nonprofit organization (x^2=7.877, $p<0.001$). The environmental group contained a significantly greater proportion of Guam residents than the other group (x^2=34.955, $p<0.001$).

We then analyzed preferences of the entire sample as one group using a conditional logit model to estimate the WTP of the larger diver population for ecological improvements. Ideally, we would have estimated WTP for each latent class separately, but unfortunately, the stronger environmental preferences group did not have statistically significant results for the price attribute.

Table 2. Estimated parameters of the latent class and conditional logit models

Conditional logit and latent class results						
Attribute	Entire Sample (n=180)		Environmental Group **46%**		Other Group **54%**	
	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**
μ Age (years)	33	11	35	12	31	9
μ # Dives	736	2360	1018	2885	565	2352
μ Income (USD)	$50,000-74,999		$50,000-74,999		<=$25,000	
English Survey	57%		42%		17%	
Env. Nonprofit	12%		20%		8%	
Guam Residents	24%		21%		5%	

*** p<0.01

** p<0.05

* p<0.10

3.3 Environmental Threat and Value Ranking 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. Bequest values were especially high with a mean (μ) of 5 and a lower SD (0.8) than use, indirect user, or existence values which had an average of 4 and an SD of 1.1. The percentage of respondents selecting each category is displayed in Figure 6. Scores were insignificant between groups, however Guam residents scored higher than nonresidents (x^2=31.468, p<0.005).

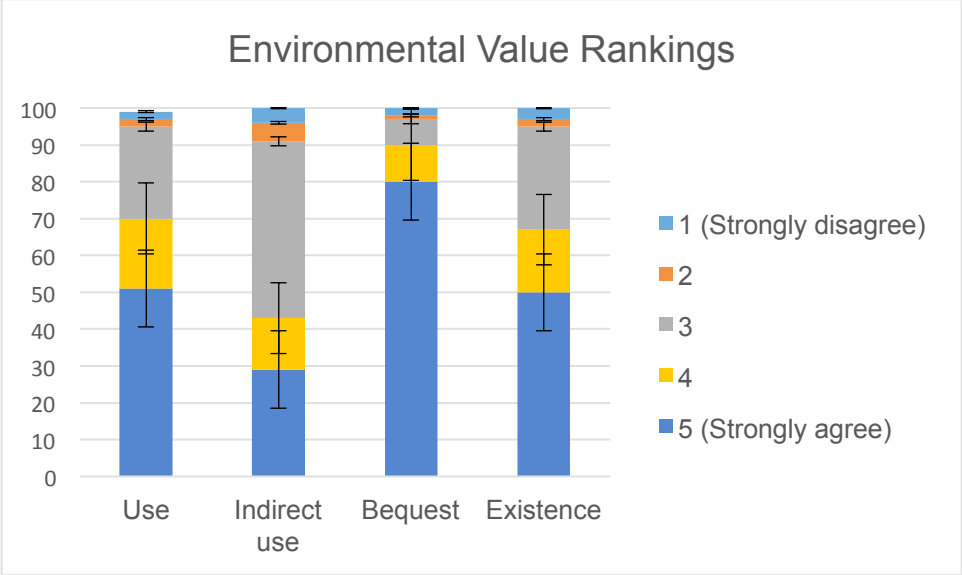

***FIGURE 6*. ENVIRONMENTAL VALUE RANKINGS**

This study focuses on a portion of use values (recreation). However this is a small subset of the total value society holds for coral reefs.

Results from the environmental threats ranking display insignificant variation between the two groups. The majority of respondents selected a neutral impact for all threats except land-based pollution, with a near normal distribution (μ=3, SD=1.15). Threat rankings for land-based pollution were generally higher than the other threats (μ=4, SD= 1.3) and Guam residents were more aware of the threat posed by land-based pollution than nonresidents (x^2=15.689, p<0.005).

3.4 WTP For Ecological quality

Our results indicate that SCUBA divers in Guam have preferences for improved coral reef ecological attributes, and are willing to pay more for a dive environment on a reef with an improved ecological state. The management fee for the entire sample was significant at the 0.05 level, allowing for the estimation of diver WTP for specific attributes (Table 3). I estimated μWTP for the entire sample and have also included the lower and upper limits for each attribute using the equation three given in section 2.3 above. β levels of attributes fall within the 95% confidence interval (Table 2 above). The logistic regression model utilized assumes a linear preference for attributes, however the actual preferences and associated WTP are likely log-linear indicating that at a certain point, further improvements in ecological condition are no longer associated with a higher WTP (Hoyos, 2010). Therefore, these values may not be valid in other situations or for ecological improvements above the "high" levels applied in this study.

TABLE 3. DIVER WTP FOR ECOLOGICAL ATTRIBUTES OF A CORAL REEF ENVIRONMENT

Attribute	μ WTP
Low-High Biomass	$13.48
Low-High Diversity	$13.33
None-Many wrasse	$8.95
Neither-Sharks alone	$3.86
Neither-Turtles alone	$16.27
Neither-Sharks & Turtles	$35.14

Our contingent valuation results showed that the mean value respondents were willing to contribute a one-time payment of $10 (SD ± $5) to sediment reduction projects. Individuals in the environmental group were willing to pay more than individuals in the non-environmental group ($x^2 = 8.30$, $p < 0.05$). 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 previous environmental threats ranking, indicating individuals who recognized sedimentation as a threat were more willing to pay to reduce that threat. In addition, residents of Guam as a group 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 a project, with the most frequently selected (43%) protest option being "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.

4.0 DISCUSSION

Improvements in the ecological conditions of Guam's reefs could result in large economic gains, and degradation could cause significant losses. Using van Beukering's (2007) estimate of 256,000 to 340,000 dives/year, 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. Conversely, if Guam's coral reefs are further degraded, their recreational use value will degrade as well. Our study revealed a lower WTP for reefs with degraded ecological quality, a finding that 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). Should the high 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 estimate 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.

The ability to link ecological changes with economic outcomes is a valuable management tool (Farber et al., 2006). Diver WTP for improved ecological health could be leveraged to support reef management. 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 $625,000 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 in charge of coastal management (Guam Department of Agriculture, 2011). While current management financing mechanisms have all focused on SCUBA divers WTP for marine management, we have demonstrated that SCUBA divers are also willing to contribute to terrestrial management projects. Divers expressed a willingness to support upslope restoration efforts, which could generate an additional $900,000 if 90% of divers contributed $10, an amount that a local non-governmental organization reported would be practically useful for watershed restoration efforts (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).

These results are consistent with other studies showing that environmental conditions are important for tourists and local residents. For example, our result for a change in WTP/dive for few 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 conducted across several Caribbean Islands also found that divers were WTP more 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) and diversity ($13.33/dive), both indicators of fisheries health, and for a change from no sharks or turtles to both sharks

and turtles ($60.86). Overall, our results indicate that divers have strong environmental preferences.

A growing body of literature regarding diver WTP for ecological conditions provides economic analysis required to set user fees. In many cases, the funds raised could be significant and critical to conservation success. Implementing SCUBA 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). 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). However, in practice, few places have effectively collected adequate diver fees to pay for the management of marine protected areas, and actual fees are often far below divers' actual WTP (Depondt and Green, 2006). 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). 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.

Turning to the choice experiment, the environmental group did not have a significant result for the management fee, and the coefficient was positive, an unexpected result. Typically as prices go up, demand goes down, so we expected results would display a significant, negative management fee indicating that respondents wanted to pay the lowest possible fee. Standard economic theory states that individuals will have a downward sloping demand curve, as represented by a negative coefficient for price, assuming that individuals are rational and will always want to pay the lowest possible amount of money in a situation (Tietenberg, 1988). 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. Displayed in Table 2, the environmental group had a positive but insignificant WTP, which indicates the management fee levels in the survey were too low for the environmental group, 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 trumped price (Popp, 2001). Individuals who had taken the survey in Japanese were more likely to be placed into the non-environmental group. Many of the Japanese tourists who go SCUBA diving in Guam access the activity as part of a vacation package deal, in which SCUBA 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 as part of a package deal.

Individuals were far more amenable to observing sharks on a dive if there were also turtles present, and preferred to see turtles alone much more strongly than sharks alone. Sharks and turtles together was the most preferred attribute of the study, indicating that these may be complementary goods. It is interesting that divers who did not want to see sharks alone strongly wanted to see sharks and turtles together. The model utilized in this

study sets the presence of sharks and/or turtles as one attribute "the presence of charismatic megafauna" with multiple levels. It is possible that individuals do not consider both sharks and turtles together to be the same attribute as either turtles or sharks alone, perhaps interpreting both in tandem as a measure of biodiversity rather than charismatic megafauna. Given sharks' critical ecological role as a reef keystone species and the economic opportunities associated with shark watching, this may be an area where improved environmental education is warranted (Heithaus et al., 2008). Although divers had a positive preference and WTP for turtles alone ($16.27/dive), it was less than the combination of both sharks and turtles. WTP for sharks alone was much less ($3.86/dive). Perhaps the presence of turtles is perceived as a safety net from negative shark encounters, or the presence of multiple charismatic species on a single dive is an especially desirable attribute. Diver beliefs can influence behavior near sharks (Apps et al., 2015). While we cannot be certain of the mechanism behind our result, in general, our results 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), just as we found that the presence of sharks and turtles was more important to most divers rather than fish biomass or diversity.

The environmental and non-environmental groups had similar stated environmental values, but significantly different willingness to pay in the choice experiment. When faced with concrete tradeoffs within the choice experiment, respondents may not have acted consistently with their stated use, indirect use, existence, and bequest values. However the individuals in the environmental group selected in favor of ecological quality so strongly that their maximum WTP was not encountered in the survey. Although it was easy for respondents to state that they cared about the environment, when the choice experiment required them to make tradeoffs, the environmental group held to their stated values while the non-environmental group traded them off for a lower management fee.

Environmental perceptions are heavily dependent on place of residence (Petrosillo et al., 2007), a result we encountered as we found that many more Guam residents were in an environmental group. Guam residents were also more aware of the threat posed by land-based pollution and were willing to contribute more financially to upslope revegetation. The ability to characterize resource users based upon place of residence can be a means to focus efforts improving education regarding ecological perceptions. Recreationalists 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 to 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. Diver education programs have demonstrated positive ecological outcomes in other areas (Medio et al., 1997).

In our study, respondents were generally unaware of the severity of the threats facing coral reefs, which is surprising given that sedimentation is the most significant local threat to Guam's reefs (Burdick et al., 2008) and can have negative impacts on SCUBA diving by causing water quality problems that impact visibility and, eventually, coral health (Fabricius, 2005). Previous research has suggested that tourists appear to be

primarily concerned with the immediate physical or spatial condition rather than the long-term temporal condition of the reefs (Petrosillo et al., 2007). However our results show that divers also hold strong bequest values and are therefore concerned about the future of the reefs, a result that has recently been found among reef users in other contexts as well (Oleson et al., 2015). Diver education programs that link the spatial context of reefs being used by divers today with the temporal context of reefs through their bequest value may be especially helpful (Davidson-Hunt and Berkes, 2003). Although this study was conducted in Guam, the threats considered here are degrading coral reef health all across the globe, indicating that improved diver education may be universally beneficial.

There are several limitations to the study that should be taken into consideration. First, while the sampling design makes every attempt to be representative of the population, there are no official statistics other than a 2001 report in which dive shops voluntarily estimated customer country of origin (Guam Visitors Bureau 2001) with which to compare this sample to ensure representativeness. The sample captured in this study is slightly different in that the proportion of Japanese divers is slightly less and divers from other regions is slightly more, consistent with official reports on the diversification of Guam's tourist arrivals (Guam Visitors Bureau 2001, 2011). That this study reflects this shift in tourist composition provides support that the sample is representative of Guam's 2013 diver population. The proportion of local to tourist divers in this study (24% local, 76% tourist) is similar to a 30% local, 70% tourist breakdown that was described in 2007 (van Beukering et al., 2007). This survey was not a "random sample" in which all individuals in the total population have an equal chance of inclusion. Because a very specific population was being targeted for this effort, "convenience sampling" was utilized instead with individuals surveyed in areas where they were likely to be. Relevant to the goal of assessing the preferences of a very specific target group, convenience sampling is a valid method (Fink 2003). By conducting surveys at a variety of locations on different days of the week and times of day, more variability in potential respondents was introduced to the design but it remains a convenience sample. A second limitation is that this study uses "stated preference" rather than "revealed preference". Stated economic preferences are when people state how much they would pay for a good or service under hypothetical conditions. Revealed preference methods work by observing how much people are actually paying for a good or service. Stated preference methods are especially useful when valuing goods outside of the market, such as ecological attributes. Using the market value of a SCUBA dive as a proxy value for reef health would have been a poor choice, as the utility derived from a SCUBA dive is dependent on a number of factors in addition to ecological condition.

5. CONCLUSION

Management of coral reefs is difficult because there are many different sectors utilizing the reef that may have different preferences for coral reef attributes. Quantifying the preferences that dive tourists hold for coral reefs provides resource managers with more complete information with which to make decisions. This study demonstrates that divers are willing to contribute financially to facilitate improved ecological conditions of coral reefs. 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. In addition to simply preferring improved conditions, divers were willing to make financial contributions in the form of both a management fee and a direct financial contribution that could leverage a significant amount for coral reef conservation. The fact that marine based resource users were willing to make financial contributions to upslope management is a novel finding that suggests resource managers should consider the entire system across the land-sea interface when igniting stakeholder engagement. Reef declines were associated with a loss of demand represented by a lower WTP, which has real implications for a tourism dependent economy. Finally, we found that preferences are affected by more than personal environmental values, and revealed potential areas where improved diver education is warranted.

The nonmarket implications of a potential loss from continued coral reef degradation (or gains from improvement) should factor into decision-making alongside market values, which are more readily quantified. Coral reef managers require information on the full breadth of uses for coral reef resources in order to make more holistic, well-informed management choices. Our analysis indicates that restoring and protecting reefs will have clear economic benefits for tourists. We focused exclusively on the recreational value for the dive sector, but declines in coral reef quality could diminish multiple ecosystem services important for the broader tourism industry and local resident well-being. Trade-offs between market- and non-market ecosystem services are common to the management of reefs globally, and our study is one of the first in the Pacific that quantifies these hidden benefits with the aim to inform decision-making. Additionally, sharks are increasingly threatened worldwide in spite of their key ecological role. In line with recent research (Cisneros-Montemayer et al. 2013), we demonstrate that sharks are economically valuable for more than their fins, and that tourism can benefit from the presence of sharks. On a broader scale, there exists the opportunity to make divers global partners in conservation by capturing their WTP and generating much needed revenue for coastal management.

My study provides support for an overarching project utilizing an Atlantis Ecosystem Model (CSIRO, Australia) in Guam (Weijerman et al., 2014). Atlantis is a complex model ranging from bathymetry and currents to the biomass and distribution of apex predators. The use of such a model allows for the consideration of management scenarios so that likely ecological outcomes can be projected into the future and managers can make more fully informed decisions. A fisheries sub-model allows for the consideration of fisheries economic outcomes in management scenarios. This is relatively straightforward because fish have a market value that facilitates valuation. While the SCUBA diving industry in Guam also benefits from marine management, it is not as straightforward to estimate how the values obtained by the dive sector may change. Because my study estimates these values, they can be qualitatively considered contingent upon the results of ecological outputs of different management scenarios. This qualitative model has been developed and when a variety of management options were considered, it was determined that fisheries management in form of bag and size limits alongside watershed restoration provided positive benefits for both the dive tourism and fishery sectors (Weijerman et al., 2016).

Appendix: Sample Survey

Version #1 Date:_____ Surveyor:_____

Survey #:_____ Location:_____

HåfaAdai! This is a survey on how coral reef and fish quality impact SCUBA diving on Guam that is being conducted by researchers from University of Hawai'i at Manoa . The goal of this NOAA funded project, entitled "SCUBA Diver Preferences on Guam", is the evaluation your perception of the interactions between coral reef health and SCUBA diving . Your participation in this survey is voluntary and you are free to stop at any time. In addition, your anonymity is guaranteed as results are based on aggregated averages. Full details about how information will be collected, stored, and used is available in the *Consent to Participate* handout. This survey consists of three sections and should take 5-10 minutes to complete. Thank you for giving your time and opinions for this study, your participation is greatly appreciated!

A. Background Information

a. Please circle your gender.

1. Male 2. Female

b. What year were you born?

_____

c. How many dives have you completed? (Total # of lifetime dives)

_____ dives

d. How much did you pay for your most recently completed dive on Guam? (in US dollars)

_____

☐ I have not been diving in Guam before

e. Do you currently belong to or donate money to any environmental non-profit agencies?

1. Yes 2. No

f. Please circle the location of your primary residence.

1. Japan
2. Guam
3. Micronesia (not Guam)
4. United States of America (including Hawaii)
5. South Korea
6. Taiwan
7. Philippines
8. Europe
9. Hong Kong
10. Australia
11. New Zealand
12. Other (Please specify):

_____

g. Please circle your annual pre-tax household income (in US dollars).

1. $25,000 or less
2. >$25,000-$49,999
3. >$50,000-$74,999
4. >$75,000-$99,999
5. >$100,000-$124,999
6. >$125,000-$149,999
7. >$150,000 or greater

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B. Environmental Perception and Coral Reef Health

1. The quality of coral reefs and dive sites can be impacted by a number of environmental and human related factors. For this question, please select a number from One (1)to 5 (5 being the strongest) that indicates how strongly you feel each of the following factors impacts the health of Guam's reefs.

Impact on Reef Quality in Guam	Weak Impact	Somewhat Weak Impact	Neutral Impact	Somewhat Strong Impact	Strong Impact
Land-based pollution	1	2	3	4	5
Fishing	1	2	3	4	5
SCUBA diving or snorkeling	1	2	3	4	5
Use of jet ski's	1	2	3	4	5
Proposed U.S. Military Buildup	1	2	3	4	5
Climate change	1	2	3	4	5
Non-native species introduction	1	2	3	4	5
	No Impacts →		**Some Impacts** →		**Significant Impacts**

2. To what extent do you agree with the following statements related to human activities and coral reefs? Please select a number from One (1) to 5 (5 being strongly agree) that indicates how much you identify, or agree with, each of the following statements.

Environmental Perception	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
People should be able to use the ocean for swimming, diving, and fishing.	1	2	3	4	5
Reefs do not provide protection from coastal storms.	1	2	3	4	5
We should protect coral reefs now so that future generations are able to enjoy them.	1	2	3	4	5
I do not support the creation of marine protected areas in places I will never visit.	1	2	3	4	5

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C. Choice Experiment

Beginning on the next page, you will be shown eight questions, each with three options for a reef environment and you will choose which one you would like to dive in. Please review this page so that you are familiar with your options. Each option will have a different "management fee" of $2.50, $5.00, or $7.50 per dive.

Fish biomass: The number and size of fish present can be **low, medium, or high**.

LOW biomass

MEDIUM biomass

HIGH biomass

Fish Species Diversity: This describes the amount of different types of fish on the reef.

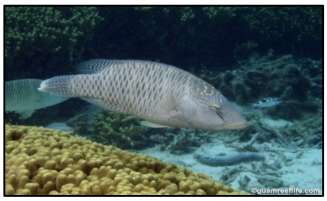
LOW diversity

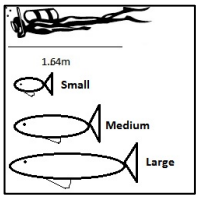
MEDIUM diversity

HIGH diversity

 # Of Napoleon Wrasse Seen: The Napoleon wrasse is an endangered species that is important for Guam's reefs. You can choose between **ONE, FEW (2-3), or MANY (4+)**

Average size of Napoleon Wrasse seen: The Napoleon wrasse can grow to over 1.8m (6 feet) in length, but most are much smaller than that. What size Napoleon wrasse would you like to see?





SMALL: <70cm

MEDIUM: 70-150cm

LARGE: >150cm

Presence of sharks or turtles: Would you want to see reef sharks, turtles, both, or none?

Reef shark only

Turtle only

Both reef shark and turtle

None

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1. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	Low	High	Medium
Diversity	Medium	Low	High
# Napoleon wrasse	Many (4+)	Few (2-3)	One (1)
Size Napoleon wrasse	Large (>150cm)	Medium (70-150cm)	Small (<70cm)
Sharks/ Turtles	No reef sharks or turtles	Both reef shark and turtle	Reef shark only
Fee per dive	$2.50(USD)/dive	$7.50(USD)/dive	$5.00(USD)/dive
	☐	☐	☐

2. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	Low	High	Medium
Diversity	Medium	High	Low
# Napoleon wrasse	One (1)	Many (4+)	Few (2-3)
Size Napoleon wrasse	Medium (70-150cm)	Small (<70cm)	Large (>150cm)
Sharks/ Turtles	Both reef shark and turtle	Turtle only	Reef shark only
Fee per dive	$5.00(USD)/dive	$2.50(USD)/dive	$7.50(USD)/dive
	☐	☐	☐

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3. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	Low	Medium	High
Diversity	High	Low	Medium
# Napoleon wrasse	Few (2-3)	One (1)	Many (4+)
Size Napoleon wrasse	Small (<70cm)	Medium (70-150cm)	Large (>150cm)
Sharks/ Turtles	No reef sharks or turtles	Turtle only	Reef shark only
Fee per dive	$7.50(USD)/dive	$2.50(USD)/dive	$5.00(USD)/dive
	☐	☐	☐

4. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	Low	Medium	High
Diversity	Low	Medium	High
# Napoleon wrasse	Many (4+)	Few (2-3)	One (1)
Size Napoleon wrasse	Medium (70-150cm)	Small (<70cm)	Large (>150cm)
Sharks/ Turtles	Turtle only	Both reef shark and turtle	No reef sharks or turtles
Fee per dive	$5.00(USD)/dive	$2.50(USD)/dive	$7.50(USD)/dive
	☐	☐	☐

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3. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	Low	Medium	High
Diversity	High	Low	Medium
# Napoleon wrasse	Few (2-3)	One (1)	Many (4+)
Size Napoleon wrasse	Small (<70cm)	Medium (70-150cm)	Large (>150cm)
Sharks/ Turtles	No reef sharks or turtles	Turtle only	Reef shark only
Fee per dive	$7.50(USD)/dive	$2.50(USD)/dive	$5.00(USD)/dive
	☐	☐	☐

4. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	Low	Medium	High
Diversity	Low	Medium	High
# Napoleon wrasse	Many (4+)	Few (2-3)	One (1)
Size Napoleon wrasse	Medium (70-150cm)	Small (<70cm)	Large (>150cm)
Sharks/ Turtles	Turtle only	Both reef shark and turtle	No reef sharks or turtles
Fee per dive	$5.00(USD)/dive	$2.50(USD)/dive	$7.50(USD)/dive
	☐	☐	☐

Ver. 1

7. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	Medium	Low	High
Diversity	High	Medium	Low
# Napoleon wrasse	Many (4+)	One (1)	Few (2-3)
Size Napoleon wrasse	Large (>150cm)	Medium (70-150cm)	Small (<70cm)
Sharks/ Turtles	Both reef shark and turtle	Reef shark only	No reef sharks or turtles
Fee per dive	$2.50(USD)/dive	$7.50(USD)/dive	$5.00(USD)/dive
	☐	☐	☐

8. If these were your only options, which reef environment would you choose?
Check the box under your selection.

Biomass	High	Low	Medium
Diversity	Medium	Low	High
# Napoleon wrasse	Few (2-3)	One (1)	Many (4+)
Size Napoleon wrasse	Small (<70cm)	Large (>150cm)	Medium (70-150cm)
Sharks/ Turtles	Turtle only	No reef sharks or turtles	Both reef shark and turtle
Fee per dive	$7.50(USD)/dive	$2.50(USD)/dive	$5.00(USD)/dive
	☐	☐	☐

Ver. 1

D. Soil runoff reduction

When too much soil is washed onto the reef it can kill coral and fish. If there was less soil entering the ocean, there would probably be more fish on nearby reefs.

Coral covered in soil.

An example of a project to capture soil from The Humåtak Project, a local nonprofit.

We can stop soil from reaching the reef by planting trees and shrubs. A healthier reef has more fish. As a one-time payment, how much would you pay to help stop soil from damaging Guam's reefs? Please circle your answer.

a.$5.00 b. $10.00 c. $15.00 d. I would not pay this

If you chose "I would not pay this fee", please select by circling the reason that best explains why:

a. I do not believe this is a problem
b. I do think soil damaging coral is a problem, but I don't think it will impact my SCUBA experience
c. It is not fair to expect visitors to pay for land use problems in Guam
d. I find all of these amounts too high, but I would be willing to pay $_____(fill in amount)
e. Other (please explain)

Thank you for completing this survey!

Ver. 1

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