

The value of coral quality to SCUBA divers in Barbados

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Abstract. The objective of this research is to estimate the economic value of coral reef quality related to SCUBA diving in Barbados. This value is derived using a stated preference survey of resident and tourist divers in Barbados conducted in 2007. In addition to a variety of demographic variables, divers were asked about their level of participation, expenditures related to travel and diving and encounters with specific species. Divers also identified characteristics of their most recent dive including price, crowding, fish diversity, encounters with marine turtles and coral reef quality and indicated their maximum willingness to pay for the dive. Coral quality was represented via a series of photographs representing a known range of coral cover. Hence, a quantifiable measure of coral cover is presented in a qualitative fashion that divers can understand. Results indicate that willingness to pay for increased coral quality varies with diver experience and the quality of their most recent dive. The results of this study can be used to inform management decisions regarding reef use and can aid in the development of policies aimed at maximizing the returns from diving while reducing the negative impacts of tourism activities.

Keywords: Coral quality, willingness-to-pay, marine turtles

Introduction

Barbados, like many tropical small island developing states, relies heavily on healthy coral reef ecosystems to maintain its shoreline and world famous white sand beaches, support nearshore artisanal fisheries and the tourism industry on which the GDP is now largely dependent (National Commission on Sustainable Development 2004). However, the very activities that depend on the reef, have taken their toll on reef condition, particularly those nearshore, and these reefs are now generally considered to be degraded through eutrophication, heavy use and over-harvesting (Government of Barbados 2002). This has compromised the resilience of Barbados' reefs to withstand additional external threats such as mass bleaching from elevated water temperatures associated with the global warming trend. The need for more effective conservation and management of the reef ecosystem in Barbados is clear, urgent and recognized by the Government (Coastal Zone Management Act 1998).

The purpose of this work is to understand the economic value of marine amenities in Barbados including coral reef quality, fish species diversity and marine turtles through econometric modeling of SCUBA divers' willingness to pay for dive quality characteristics. The analysis presented here represents

a preliminary view of one component of a larger study examining the economic value of coastal and marine resources in the Caribbean.

Background and Literature Review

Coral reefs in the Caribbean provide a wide range of goods and services including seafood, numerous recreation opportunities, habitat, and coastal protection. Reefs also provide benefits indirectly via the jobs, income, and tax revenue generated via fisheries and marine tourism, and support human lives and livelihoods through the provision of food and materials, nutrient cycling, waste processing, and other essential goods and services. Coral reefs also have value in terms of their historic, cultural, medicinal and ecological significance.

The economic value of coral reef ecosystems is widely recognized as significant, receiving considerable attention in the popular press and academic literature in the past two decades. Numerous studies have used economic valuation methods to estimate willingness to pay for coral reef quality and the costs associated with coral reef degradation. Cesar et al. (2003) provide estimates of the value of coral reefs throughout the world, while Cesar (2000) and Gustavson and Huber (2000) provide summaries of the coral reef valuation

literature. Applications in the Caribbean include Dixon et al (1993), Spash (2000) and Parsons and Thur (2007). Brander et al. (2006) provide a meta-analysis of the recreational value of coral reefs from the literature through 2006.

Despite this attention to and recognition of value, coral reefs throughout the world continue to suffer from over-use and degradation. In the Caribbean, NOAA estimates that only 25 percent of reefs are in good health (Waddell and Clarke 2008). That the source of such significant value continues to be degraded is in large part due to the open-access nature of most reef ecosystems coupled with the failure of markets to properly allocate these resources to their highest valued use or provide proper incentives for conservation. Understanding how and why society values coral reef ecosystems can help alleviate the dearth of conservation-based management by calling attention to the degree to which reefs are undervalued and highlighting differences between potential and actual economic benefits derived from reefs. As is pointed out in Brander et al. (2006), coral reef values associated with recreation vary significantly across location and type of use, hence it is important from a policy perspective to have estimates of localized value.

Data

From June 2007 to April 2008, SCUBA divers were interviewed at dive shops in Barbados at the conclusion of their dives. In order to prevent bias associated with choice-based, on-site sampling, the distribution of surveys was matched with the exogenously determined distribution of actual divers across time and dive shop locations. In addition to a host of demographic information, divers described their most recent dive in terms of quantitative measures of fish species encountered, price paid, on-site crowding, marine turtles viewed, quality of coral cover viewed (via photo representation), and maximum willingness to pay for the dive. Divers also described their perceptions of dive quality using a series of five-point Likert scale ratings for water quality, amount of living coral on reefs, on-site crowding, level of supervision and amount and diversity of fish species encountered.

Nearly 70 percent of the 114 divers interviewed were male. The average age of divers in our sample was 38 years. Most divers in our sample were highly educated. Approximately 50 percent of the divers interviewed were visiting Barbados for the first time while only 13 percent were visiting the Caribbean for the first time. Over 57 percent of divers interviewed stated that they took vacations for the purpose of SCUBA diving. Divers in our sample have logged an average of 46 dives in the Caribbean over their

lifetimes and had been diving for an average of seven years. Our sample of divers therefore has a varying degree of dive experience, Caribbean diving and general familiarity with the Caribbean.

While in Barbados, these individuals participated in numerous other recreations including beach going (79 percent), swimming (71 percent), swimming with turtles (26 percent), snorkeling from shore (41 percent), snorkeling from a boat (25 percent), sailing (19 percent), motor boating (17 percent), jet skiing (12 percent) and waterskiing (10 percent). Divers paid an average of US \$104 for their 2-tank dive, had an average stated maximum willingness to pay of US \$163, and expressed a high level of overall satisfaction with their dives in Barbados.

Methods

In order to estimate diver willingness to pay for coral reef quality, we regress stated maximum willingness to pay on dive quality variables, including a variable representing coral cover. This variable was acquired by showing divers four pictures of coral reefs and asking them which picture best represented the coral cover they encountered on their dive. These pictures were of reefs in Barbados where actual coral cover has been measured; actual coral cover ranged between five and 35 percent. Using this simple method however, proved ineffective as the quantitative measure of coral cover was not a significant determinant of willingness to pay. Examination of the data revealed the cause of this seemingly counterintuitive result: experienced divers viewed relatively high coral cover as poor while inexperienced divers viewed relatively low coral cover as good. That is, similar to results found elsewhere in the literature (e.g. Dearden et al. 2006), perceptions of coral quality varied greatly according to diver characteristics, including experience, number of visits to the Caribbean and participation in diving clubs and marine conservation organizations.

To account for variation in diver experience and other individual characteristics that may affect quality perceptions, we employ a two-stage econometric estimation of willingness to pay for coral cover. In the first stage, we regress divers stated satisfaction with coral cover (five point scale) as a function of actual coral cover viewed (measured coral cover in chosen photo representation) while controlling for experience and a host of individual and dive characteristics. Because the objective of this first stage of the estimation is to form a useful and accurate proxy for satisfaction with coral cover while controlling for diver characteristics, we are less interested in interpreting the coefficients from this model than in using the fitted values in our estimation of willingness to pay in the second stage. As such, we leave

statistically insignificant variables in the first stage model, noting that all variables in the model contribute to fit, and that the lack of individual coefficient significance may simply be the result of multicollinearity. In the second stage, we use the fitted values of satisfaction from the first stage as an independent variable in the estimation of maximum willingness to pay. Willingness to pay for quantitative improvements in coral quality can then be estimated by incorporating a hypothetical change in coral cover into the first stage (satisfaction) model and then adjusting the resulting fitted value in the second stage (willingness to pay) model.

Results

Results from the first stage (satisfaction with coral cover) model are shown in Table 1. When controlling for dive and diver experience variables, perceptions of coral quality are positively and significantly related to actual amount of coral cover viewed. Notably, divers visiting Barbados and the Caribbean for the first time, who were more satisfied with the dive overall, had a lower level of dive certification, and belonged to dive clubs, had better perceptions of coral quality. Males and divers who viewed Barbados diving as worse than most places where they have dived, tended to view coral quality as less favorable. Importantly for our purposes, the actual level of coral cover viewed is a positive and highly significant determinant of diver rating of coral quality while controlling for these

Table 1: Parameter Estimates Satisfaction with Coral Model

Variable	Coefficient	P-value
Intercept	1.66**	0.02
Clear sky indicator	-0.64***	0.004
Partly cloudy sky indicator	-0.25	0.15
No wind indicator	0.44*	0.1
Light wind indicator	0.15	0.32
First visit to Barbados indicator	0.51***	0.003
First visit to Caribbean indicator	0.42**	0.05
Take dive vacations indicator	-0.20	0.19
Gender indicator (male)	-0.30**	0.05
Boating this trip	0.35*	0.08
Sub ride this trip	-0.90***	0.007
Jet ski this trip	-0.19	0.45
Water ski this trip	0.60**	0.03
Played golf this trip	0.44*	0.07
Went swimming this trip	0.36**	0.03
Swam with turtles this trip	-0.61***	0.001
Tanks usually used diving	0.30*	0.07
Level of dive certification	-0.16**	0.03
Subscribe to dive magazines	0.62	0.20
Number of dive magazines	-0.548	0.18
Belong to dive clubs	0.58**	0.016
Rating of fish diversity this dive	0.40***	0.0001
Rating of viewing big fish this dive	-0.12	0.18
Rating of dive site crowding	-0.17*	0.05
Rating of satisfaction with dive	0.33***	0.005
Rating of Barbados diving (high = worse)	-0.27***	<.0001
Charter price includes gear rental	0.26	0.11
Coral cover viewed during dive	0.02***	0.002

$R^2 = 0.773$

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

other variables.

The coefficients shown in Table 1 were used to generate fitted values of coral quality rating for each diver in the sample. These fitted values were then used as an independent variable along with the number of marine turtles viewed, the level of on-site crowding (number of other divers at the dive site), number of fish species encountered, and income, in a model of willingness to pay. These results are shown in Table 2. Divers' maximum willingness to pay is positively and significantly related to their perceptions of coral quality (modeled in stage 1), and the number of turtles encountered. On-site crowding significantly decreases willingness to pay. The relatively low goodness-of-fit in the second stage estimation is not unexpected given the small sample size and small number of explanatory variables included in the model, and is consistent with other estimates of willingness to pay in the literature (Asafu-Adjaye and Tapsuwan, 2008, for example).

Table 2: Parameter Estimates Willingness to Pay Model

Variable	Coefficient	P-value
Intercept	97.22*	0.08
Predicted value of coral quality rating (1 st stage)	30.60***	0.01
Number of turtles encountered	10.35*	0.10
Number of fish species encountered	-1.32	0.39
Crowding (number of other divers on site)	-5.17**	0.05
Income	-0.0003	0.20

$R^2 = 0.20$

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

Conclusion

In order to use these results to approximate willingness to pay for improvements in coral cover, we work through both stages of the modeling effort. For example, a 10-percent improvement in coral cover would result in a 0.2 increase in the predicted value of coral quality rating. When incorporated into the willingness to pay model, this results in willingness to pay increasing by approximately US \$6.12. Hence, our results suggest that divers are willing to pay an additional US \$6.12 per two-tank dive for a 10-percent improvement in coral cover in Barbados. Other notable results include divers' willing to pay US\$10.35 per dive per additional marine turtle viewed, and US \$5.17 per dive to avoid sharing dive boat and dive site with an additional diver.

Between 30,000 and 50,000 divers visit Barbados each year. If each diver participates in only one dive per visit to Barbados, additional economic value from dive tourism from a 10 percent increase in coral cover at dive sites could be as high as US\$306,000. This estimate is most likely a lower bound on the true value to divers of such an improvement, as this estimate assumes the number of divers remains constant following an improvement in coral quality

and assumes each diver dives only once per visit. Coupling this result with divers' willingness to pay to avoid crowded sites would suggest that managing and restricting use at dive sites would both improve coral quality and economic gains.

Coral reefs in Barbados and throughout the Caribbean provide a significant source of economic value. Yet, coral reefs are declining in quality and may not be given due attention in policy formation and land use decisions. This work has shown that significant economic gains can be realized through efforts to improve coral quality.

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