

Using a Stated Preference Choice Model to Understand Scuba Diver Preferences for Coral Reef Conservation

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ABSTRACT

Management of coral reefs is moving toward a new paradigm where the greatest challenges involve the management of people and resources. An understanding of the relationship between people and protected areas is essential for both protecting resources and providing recreational use opportunities. To protect coral reefs from negative impacts associated with scuba diving, managers need to understand the extent to which divers support management strategies. Traditional opinion measurement research designs do not provide insight on the relative importance of each alternative or the tradeoffs divers are willing to make. Stated preference choice models use hypothetical choice sets to derive individuals' preferences in a holistic manner. Our study objectives were to:

- i) Identify realistic management measures for protecting coral resources,
- ii) Estimate the relative importance of each management measure to divers, and
- iii) Estimate the aggregate importance of various management measures using scenarios.

We used a fractional factorial design of six attributes (access, use levels, supervision levels, required education, access fee, and amount of flora/fauna observed) and generated 72 choice sets. Using nine versions of a mail questionnaire with eight choice sets in each, we mailed questionnaires to 639 scuba divers who were selected via purposive sampling in 2004. Based on the estimation of conditional logit model, divers did not prefer lower use levels, increased access with no additional access fee; they preferred some supervision in the water but not guided tours; and 30 minutes of coral reef education over no education. By identifying the tradeoffs divers are willing to make, the scenario analysis can help managers maximize constituent satisfaction and support while achieving biological management objectives.

KEY WORDS: SCUBA divers, coral reefs, preferences

Uso de Modelos de Elección Discreta en la Comprensión de las Preferencias de los Buceadores por las Medidas de Conservación de los Arrecifes de Coral

En la actualidad el manejo de los arrecifes de coral se está orientando hacia un nuevo paradigma cuyo desafío es tratar de incluir el manejo de la gente y los recursos. Un buen conocimiento de las relaciones entre los usuarios y las áreas protegidas es esencial, tanto para proteger los recursos como para proveer oportunidades de uso recreativo. Para proteger los arrecifes de coral de los impactos negativos asociados con el buceo los gestores necesitan entender hasta dónde harán concesiones los buceadores en relación a las estrategias de manejo. Los diseños tradicionales de investigación para medir la opinión no permiten conocer la importancia relativa de cada alternativa o las concesiones que los buceadores están dispuestos a hacer. Los modelos de elección discreta ('stated preferente choice' models) utilizan conjuntos de alternativas hipotéticas para inferir las preferencias individuales en una forma holística. Los objetivos de nuestro estudio fueron:

- i) Identificar medidas realistas de manejo para proteger los recursos coralinos;
- ii) Estimar la importancia relativa para los buceadores de cada medida de manejo; y
- iii) Estimar la importancia agregada de varias medidas de manejo usando escenarios.

Utilizamos un diseño factorial fraccional de 6 atributos (acceso, niveles de uso, niveles de supervisión, entrenamiento requerido, tarifa de acceso, y cantidad de flora / fauna observada) y generamos 72 conjuntos de alternativas. Se usaron nueve versiones de una encuesta con 8 conjuntos de alternativas cada uno, enviándose por correo a 639 buceadores, los cuales fueron seleccionados según un muestreo de conveniencia en 2004. Según la estimación del modelo logit condicional, los buceadores no prefirieron bajos niveles de uso, un incremento en el acceso sin aumento de la tarifa, alguna supervisión dentro del agua pero sin excursiones guiadas, y 30 minutos de entrenamiento frente a ningún tipo de entrenamiento. Mediante la identificación de las concesiones que los buceadores están dispuestos a hacer, el análisis de escenario puede ayudar a los gestores a maximizar el componente de satisfacción y de apoyo por parte de los buceadores, a la vez que se alcanzan los objetivos de manejo biológico.

PALABRAS CLAVES: Buceadores, arrecifes de coral, preferencias

INTRODUCTION

While Marine Protected Areas (MPAs) were established for the primary purpose of conservation or preservation (Agardy et al. 2003), their multiple-use designation often incorporates a recreation and tourism component (e.g., Salm et al. 2000). This is, in part, because tourism revenue is one major benefit an

MPA can have on a local, state, or regional scale. Yet tourism and recreation participation can pose various threats to marine resources, especially with fragile ecosystems such as coral reefs (1998 Year of the Ocean 1998). This is the concern regarding recreational scuba diving on coral reefs.

Considerable attention has been paid to the negative impacts divers have on coral reefs, including proximate impacts such as breaking and abrading coral (e.g., Zakai and Chadwick-Furman 2002), as well as indirect impacts from re-suspension of sediment (Rogers 1990). Moreover, diver impacts can be cumulative, not only affecting coral cover but community structure (e.g., Hawkins et al. 1999) and species diversity (e.g., Tratalos and Austin 2001).

Researchers have explored ways to minimize these impacts in three main ways. First, some studies have looked strictly at the relationship between the number of users and the amount of degradation to determine appropriate carrying capacities for various coral reef dive sites (e.g., Zakai and Chadwick-Furman 2002). Second, research has looked at diver characteristics and behavior to identify groups of divers that may have greater impacts on reefs. For example, while “naïve” divers who used cameras were not more likely to impact reefs than divers without cameras, “specialized” underwater photographers with more and bulkier equipment were the most damaging of all divers as observed by Roupheal and Inglis (2001). Third, some research has looked at modifying diver behavior. For example, Medio et al. (1997) found that an in-depth briefing significantly decreased damaging contact with reef substrate.

In previous studies examining impacts, authors provide indirect and direct management strategies they expect to enhance reef protection while still allowing use. Indirect strategies include better education of both instructors and guides as well as the divers themselves (e.g., Medio et al. 1997, Tratalos and Austin 2001, Zakai and Chadwick-Furman 2002). Direct strategies include zoning (Schleyer and Tomalin 2000), restricting the number of dives per year (e.g., Zakai and Chadwick-Furman 2002), and lessening the pressure from high-use dive sites by resting the site (Tratalos and Austin 2001), or shifting use to artificial sites (Zakai and Chadwick-Furman 2002). Additionally, Walmsley and White (2003) emphasize the need for formal enforcement of regulations while Barker and Roberts (2004), for example, suggest that divemasters need to intervene to reduce diver-caused reef damage. Regulatory strategies proffered include the use of permits (Tratalos and Austin 2001) and user-pay strategies (e.g., Green and Donnelly 2003).

Multiple-use MPAs serve as a conservation tool as well as a tourism and recreational resource (Salm et al. 2000). MPAs are increasingly challenged to maintain or increase benefits (i.e., tourism experience and revenue) while protecting the resource (Dixon et al. 1993). Currently, impacts on coral reefs due to scuba diving continue because resource managers do not have a good understanding of users, their willingness to play a greater role in coral conservation, and an effective means for dealing with their impacts. To successfully enhance coral reef conservation while maintaining the site as a tourism attraction, managers must know which of the aforementioned strategies and tactics are preferred and not preferred, as well as which *combinations* of strategies (i.e., management scenarios) are most preferred.

Past research on management preferences has utilized traditional opinion

measurement in which a sample of the population is asked to provide their preferences in a series of single-item questions. However, the *Stated Preference Discrete Choice Model* (SPDCM) offers a more holistic approach to opinion measurement because it is drawn from the assumption that complex decisions are based on several factors considered jointly rather than on one factor or criterion. Thus, the SPDCM can identify tradeoffs divers are willing to make and provide managers with a predictive understanding of how divers are likely to respond to new policies.

An increasing number of studies dealing with environmental use and protection have used a choice model framework to better understand preferences and predict responses. In this study, a SPDCM required participants to choose their preferred management strategies from a range of hypothetical choices. Once preferences were determined, policy scenarios based on probability estimates were created and user policy preferences predicted.

Choice models have been employed previously to understand user preferences for environmental resources as well as estimate the value of associated non-market goods and services (Adamocwicz et al. 1998). For example, Lawson and Manning (2002) examined the relative importance overnight wilderness hikers place on various social, resource, and managerial management conditions. Based on this information they predicted that hikers generally prefer a management regime that is based on opportunities for solitude over one that permits greater freedom (i.e., less regulation). In this study, we wanted to understand how scuba divers would react to various combinations of coral reef conservation management strategies. The study objectives were to:

- i) Identify realistic management measures for protecting coral resources;
- ii) Estimate the relative importance of each management measure to divers; and,
- iii) Estimate the aggregate importance of various management measures using scenarios.

METHODS

Steps in using a SPDCM include identifying salient management attributes and level, administering the SPDCM experiment, analyzing the results using an appropriate model, and creating a scenario analysis to predict which management policies are preferred.

Target Sample

Divers with saltwater diving experience constituted the target sample for this study. Because there are no lists of current divers, we used a two-pronged purposive sampling strategy to obtain divers with varying skill levels. First, we solicited scuba divers (n = 325) at the 2003 Seaspaces Adventure Sports and Travel Exposition in Houston, Texas, USA. Second, we recruited participants via the internet by posting announcements on listservs, forums, and by emailing dive clubs/organizations (n = 321). Divers who did not scuba dive in saltwater in the previous 12 months were excluded from the sample.

Identifying Management Attributes and Levels

Management attributes are the strategies being tested (e.g., amount of diver supervision) and levels are the alternatives for that strategy (e.g., no supervision to fully supervised). Initial attributes and levels were tentatively developed based on a review of the diving literature and subsequently revised via a focus group conducted with primary stakeholders from the Flower Gardens Banks National Marine Sanctuary, an MPA administered by the National Oceanic and Atmospheric Administration. In addition, the survey attributes and levels were further refined using two pretests with divers. The final survey included six attributes: five represented potential changes in management strategies (PEOPLE, AREA, SUPERV, FEE, and EDU) and one dealt with diver expectations for observing marine wildlife (EXP; Table 1).

Table 1. Attributes and levels used for in the SPDCM experiment..
S = Status quo.

Attribute	Description	Level
PEOPLE	Number of people diving at a site at any one time	S. The usual number of people at the dive site 1. 15% fewer people at the dive site 2. 30% fewer people at the dive site
AREA	Amount of MPA open for diving	S. 100% of MPA open to diving 1. 50% of MPA open to diving 2. 25% of MPA open to diving
SUPERV	Level of underwater supervision for divers using an MPA	S. Divers not supervised 1. Divemasters supervise divers in the water 2. All dives are completely guided
FEE	Fee for accessing the MPA (in addition to the cost of the dive itself). All proceeds are invested in management of that particular MPA	S. No additional fee to access MPA 1. \$15 additional fee to access MPA 2. \$30 additional fee to access MPA
EDU	Time spent receiving education on coral reef protection and conservation prior to the dive	S. No coral reef conservation education provided 1. 30 minutes of coral reef conservation education 2. 1 hour of coral reef conservation education
EXP	The amount of marine life the diver expects to see on a diving trip	S. Expect to see usual amount of fish and coral-related marine life. 1. Expect to see 20% more fish and coral-related marine life 2. Expect to see 50% more fish and coral-related marine life

Experimental Design and Distribution

For each choice set (i.e., hypothetical scenario), respondents were asked to choose between two trips (or choose *neither* trip). Thus, there were 1,458 possible choice sets to compare. Because of the impracticality of asking respondents to evaluate all choice sets, we employed a fractional factorial design with blocking. This design included an effective random selection of

the combination of all scenarios but maintained the orthogonality of the full factorial experiment by splitting the profiles into uncorrelated blocks (Bennett and Adamowicz 2001). This resulted in the generation of 72 choice sets (Figure 1 provides an example).

Participants were mailed a self-administered questionnaire using a slightly modified Dillman (1978) Total Design Method with three mailings and a thank you/reminder postcard. In order to collect data from the 72 choice sets, nine versions of the questionnaire were created and each participant was presented with eight choice sets. In addition, we collected data on their recent diving behavior, skill level, and their perceived level of commitment to diving as a leisure activity.

1. Suppose that you could only choose from the diving trips below (Trip A, Trip B or neither trip). Which would you prefer?

TRIP A	ATTRIBUTES	TRIP B
<i>15% fewer people at the dive site</i>	NUMBER OF PEOPLE	<i>15% fewer people at the dive site</i>
<i>50% of MPA open to diving</i>	MPA AREA	<i>50% of MPA open to diving</i>
<i>Divemasters supervise divers in the water</i>	LEVEL OF SUPERVISION	<i>All dives are completely guided</i>
<i>\$30 additional fee</i>	MPA ACCESS FEE	<i>No additional fee</i>
<i>30 minutes of coral reef conservation education provided</i>	CORAL REEF EDUCATION	<i>No coral reef conservation education provided</i>
<i>Expect to see usual amount of fish and reef-related marine life</i>	TRIP EXPECTATION	<i>Expect to see 50% more fish and reef-related marine life</i>

I prefer... (check one box below)

<input type="checkbox"/> TRIP A	<input type="checkbox"/> I WOULD NOT TAKE EITHER TRIP	<input type="checkbox"/> TRIP B
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Figure 1. One of 72 choice sets used in the choice experiment for scuba divers.

Model

The stated preference choice model (SPDCM) is based on random utility theory, which posits that individuals consider the relative importance of two or more factors involved in making a decision about management preferences and make choices to maximize their utility (McFadden 1974). Thus, the model includes a deterministic component (i.e., the measurable utility as well as random error component (to account for unobserved influences). However, because utility cannot be directly observed, probabilities are used to predict whether one scenario will be chosen over another. We used a conditional logit model, which assumes the error terms to be independently and identically distributed as well as Gumbel distributed. The distributional assumptions for this model require the satisfaction of the independence of irrelevant alternatives (IIA) property so individual specific variables (ISV), which take into account interaction effects, were included to alleviate inaccuracies due to IIA violations.

Scenario Analysis

Once the model was estimated, attributes could be changed to reflect possible management scenarios. A probability of selection was calculated for each scenario based on Bates et al. (2002) and Blamey et al. (1999) to gain insight on the degree of differences in diver preferences. A representative selection of scenarios was chosen by the authors for inclusion in this paper. They represent the status quo option, the most restrictive option and three intermediate options.

RESULTS

Of the 646 questionnaires distributed, we received 476 replies for a raw response rate of 74%. Considering non-deliverable and unusable questionnaires, the effective response rate was 78%.

Divers responding to the survey generally considered themselves as skilled as or more skilled than other divers in general. Almost 70% of respondents were 40 years or older, 58% were male and 44% reported annual household incomes of greater than \$100,000.

Model

Table 2 shows the parameter estimates for the conditional logit models, including ISVs. The alternative specific constant (ASC), which represents the value of a diving trip to an MPA with everything else held constant, shows that divers favored taking trips in terms of current management strategies. Looking at ISVs in terms of the ASC, the table shows that younger divers, divers with higher annual household incomes, and divers who place more importance on diving as a priority leisure activity were more likely to choose a trip based on current management strategies. Gender and diving club membership had no significant influence on trip choice.

All primary attributes were significant except for the EDU2 variable; and, all estimated coefficients had expected signs except SUPERV1 and EDU2 variables. The implicit prices in Table 2 show that, in general, divers did not prefer regulatory strategies that increased restrictions on the number of people allowed to dive at a site (PEOPLE), the amount of an MPA available to dive (AREA), or that increased the amount of supervision (SUPERV). However, while divers did not prefer increased supervision overall, the coefficient associated with having divemasters in the water (SUPERV1) was positive indicating that they preferred this option over no supervision. Divers also did not prefer access fees (FEE). In contrast, they showed a preference for education as a management strategy. Required education (30 minutes) was favored over no education (EDU1), although the coefficient for requiring one hour of education (EDU2) was not significant. Finally, the expectation variable of seeing either 20% more marine life (EXP1) or 50% more fish (EXP2) was strongly preferred.

Table 2. Parameter estimates for conditional logit examining preferences of scuba divers for coral reef management options. A likelihood ratio test shows that this model is superior to a main effects-only model ($c^2 = 83.65$, $p < 0.001$). Note: Dummy variables are used for qualitative attributes. Variables ending with a “1” represent level 2 for that attribute while those ending with a “2” represent that attribute’s level 3 condition.

Model		Conditional Logit		
Attribute	Coefficient	Std. error	Z-value	Implicit Price (\$)
ASC	2.9219**	0.314	9.32	
PEOPLE1	-0.6924**	0.067	-10.38	
PEOPLE2	-0.4424**	0.072	-6.12	-23.2
AREA1	-0.1876**	0.070	-2.69	
AREA2	-0.5069**	0.069	-7.38	-11.2
SUPERV1	0.1590**	0.066	2.42	
SUPERV2	-0.4985**	0.072	-6.92	-2.3
FEE	-0.0262**	0.002	-11.4	
EDU1	0.3956**	0.070	5.61	
EDU2	0.0933	0.068	1.38	11.2
EXP1	0.6761**	0.070	9.67	
EXP2	1.3233**	0.071	18.73	34.0
AGEASC	-0.0465**	0.005	-8.54	
INCOMEASC	0.0407**	0.019	2.11	
CLUBASC	0.0868	0.113	0.77	
IMPORTASC	0.1176**	0.046	2.55	
GENDERASC	-0.0403	0.115	-0.35	
**significant at $\alpha = 0.05$				
Model Statistics				
number of choice sets	3305			
Log L	-2847.2			
McFadden ρ^2	0.2158			

Scenario Analysis

For this analysis, five possible scenarios were chosen from least to most restrictive under the assumption that divers could expect to see increased amounts of marine life as restrictions increased (and impacts decreased) (Table 3). Scenario 1 represents the status quo management conditions (i.e., no increased restrictions) and Scenario 5 contains the most restrictive management options. When presented with these five choices, we would expect divers to choose the status quo 31% of the time; this is the most preferred option by

divers. Scenario 3 was the second-most preferred option with a selection probability of 30% and Scenario 4 was the least preferred with a selection probability of 11%.

DISCUSSION

Previous studies using SPDCM show that, in general, natural resource users prefer the least amount of restrictions (e.g., Oh et al. in press). Scuba divers showed a similar predilection by preferring Scenario 1, the status quo over other more restrictive options. The fact that Scenarios 3 and 2 were the second and third most preferred (respectively) can be understood by looking specifically at the coefficients of the supervision (SUPERV1, SUPERV2) and education (EDU1, EDU2) variables.

As shown in Table 3, having divemasters in the water (SUPERV1) and 30 minutes of required education (EDU1) did not meet our *a priori* expectations that these options would be less preferred compared to the status quo of no supervision and no required education. Because these variables are associated with positive utility, scenarios incorporating these options will increase their probability of being selected. Moreover, because the coefficients for the amount of marine life expected (EXPI and 2) are high, the selection probability of Scenario 3 is very close to Scenario 1, the most preferred option. One caveat here, however, is that managers cannot control diver expectations in the short term, nor can they control the change in the amount of marine life due to restrictions. With that understood, Scenario 3 provides a good example of the tradeoffs divers are willing to make to see more marine life; they are willing to have restrictions on the number of divers at the site, have somewhat restricted access, as well as pay a moderate access fee.

The fact that EDU1 and SUPERV1 had positive utility may reflect the willingness of divers to contribute to coral reef conservation. That is, divers appear to understand the need to protect the resource even from “non-consumptive” recreational uses like diving. This willingness may be explained by our sample, which tended to be older and have a high household incomes. Dunlap and Heffernan (1975) found that people with these characteristics who participate in nature-based activities tend to be more pro-environment. While our study is limited in that we used a purposive sampling strategy, similar diver characteristics have been found in previous studies (e.g., Ditton and Baker 1999, Thailing and Ditton 2001).

The other variable that did not meet our *a priori* expectations was one hour of required education (EDU2) which was not significant (Table 2). Nonsignificant attribute levels could mean that divers did not perceive a difference between one hour of education and the status quo situation of no education. However, because EDU1 was significant, this explanation is not logical. Thus, we suspect that either the amount of education in general was not of major importance in decision making relative to other factors, or that divers may have discounted one hour of education as an unrealistic amount when making choices.

Table 3. Scenario analysis showing predicted probability of selection for each scenario

	PEOPLE	AREA	SUPERV	FEE	EDU	EXP	Conditional Logit Prob. (%)
S1	Usual number	100% open	No supervision	No fee	No education	Usual amount	31.2
S2	15% fewer	50% open	Divemasters	\$15 fee	30 minutes of education	Usual amount	15.2
S3	15% fewer	50% open	Divemasters	\$15 fee	30 minutes of education	20% more	29.9
S4	15% fewer	25% open	Guided	\$15 fee	1 hour of education	20% more	11.2
S5	30% fewer	25% open	Guided	\$30 fee	1 hour of education	50% more	12.5

We advise managers against generalizing the results of this model to specific MPAs. Instead, this modeling approach can be used concomitantly with other scoping activities such as focus groups to get feedback from the relevant recreational diver constituency. Moreover, this specific model can be used as a basis for informed hypotheses against which actual behavior can be tested.

This study illustrates how managers can get a better understanding of divers, divers' willingness to accept restrictions, as well as the tradeoffs they make in doing so. In our model, it seems possible that divers are amenable to restrictions if environmental quality is improved and it means they can see more marine life. There may be other expectations that also mediate tradeoffs for restrictions (e.g., higher variety of marine life, greater visibility, more charismatic species, etc.) that can be addressed in future research.

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