Effects of Great Barrier Reef Degradation on Recreational Demand: A Contingent Behaviour Approach

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Summary

Degradation of coral reefs may affect the number of tourists visiting the reef and, consequently, the economic sectors that rely on healthy reefs for their income generation. A Contingent Behaviour approach is used to estimate the effect of reef degradation on demand for recreational dive and snorkel trips, for a case study of the Great Barrier Reef (GBR) in Australia. We assessed how reef degradation affects GBR tourism and to what extent reef-trip demand depends on the visitors' socio-economic characteristics. A count data model is developed, and results indicate that an average visitor would undertake about 60% less reef trips per year given a combined 80%, 30% and 70% decrease in coral cover, coral diversity and fish diversity, respectively. This corresponds to a decrease in tourism expenditure for reef trips to the Great Barrier Reef Marine Park of about A$ 136 million per year.

Keywords: Coral Reef, Recreation, Contingent Behaviour Model, Count Data Models

JEL Classification: Q25, Q26, Q51

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1. Introduction.

The Great Barrier Reef (GBR) is the world's largest coral reef ecosystem, worldwide known for its aesthetic beauty. The GBR stretches for more than 2,300 km along the coast of Queensland, Australia (Fig. 1) and about 2500 individual reefs which support a great diversity of corals and fish species. The area has been listed under the World Heritage Convention in 1981 and is the largest World Heritage Area ever established. Next to its ecological significance, the GBR is of economic importance for industries operating in the area, of which the tourism industry is the most important. The GBR attracts about 1.6 million reef visitors each year (GBRMPA, 2004) and the tourism industry provides more employment than any other industry in the GBR region (Productivity Commission, 2003).

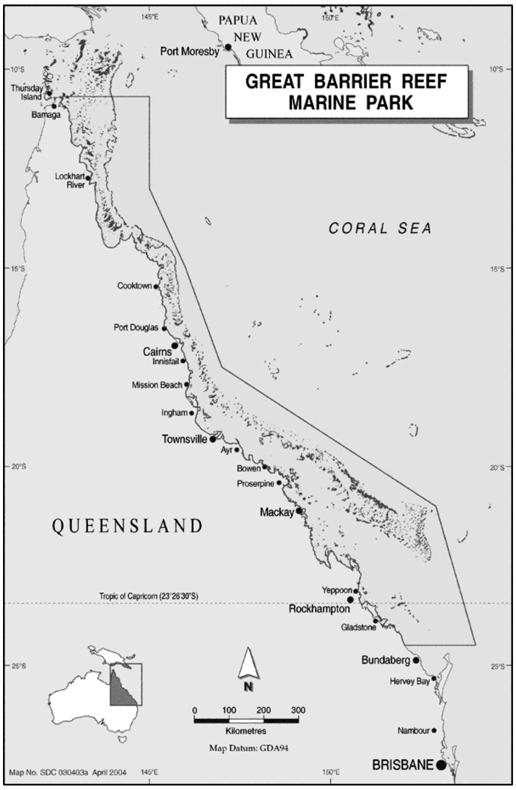

Fig. 1. The Great Barrier Reef World Heritage Area. (source: Great Barrier Reef Marine Park Authority).

The reef-tourism industry relies on healthy coral reefs for its income generation and reef degradation can have negative effects on the profits made by the reef-tourism industry. Despite increasing evidence of reef quality decline (see for example Productivity Commission, 2003; Brodie et al., 2005; Fabricius, 2005), the relationship between reef-trip demand and reef quality remains unknown (Wielgus et al., 2002).

The objective of this paper is to estimate to what extent a decline in the quality of the

GBR influences the demand for recreational reef trips by divers and snorkellers. The relationship between reef-trip demand and reef quality is shown to be more complex than the usually assumed 1:1 relationship (see for example Ruitenbeek and Cartier, 1999). Measuring changes in reef-trip demand not only provides insight into the welfare effects for reef visitors, but also allows for an estimation of the income effects for the reef-tourism industry. Economic valuation of these welfare effects is needed to improve the development of efficient reef management policies (State of Queensland and Commonwealth of Australia, 2003).

This study combines actual (revealed) and stated preference data of reef-trip demand from a Contingent Behaviour (CB) survey in a model for reef recreation.[1] A Negative Binomial model is used to analyse the demand for recreational reef trips of current visitors to the GBR, conditional to a hypothetical decline in reef quality. This study is the first to apply a combination of revealed and stated preference techniques to analyse how reef visits are related to reef degradation. CB surveys have been employed in a number of previous recreation studies. Richardson and Loomis (2004) recently used CB to analyse the effects of climate change on Rocky Mountain National Park recreation.

Various authors combine CB with a travel cost approach to determine recreational demand (see, for example, Eiswerth et al., 2000; Whitehead et al., 2000; Bhat, 2003; Hanley et al., 2003), while Adamowicz et al. (1994) use CB in combination with Choice Modelling in a random utility framework to analyse recreational site choice. An important difference with previous recreation research is that this study does not model environmental improvements but studies the effects of environmental degradation on recreational demand. Results from Haener et al. (2001) and Grijalve et al. (2002) indicate that the CB method is a valid approach to determine recreation behaviour.

The paper is organised in five sections. The following section provides an introduction to the behavioural model for recreational demand and the econometric count model that is used to analyse reef-trip demand. In Section 3 we present the contingent behaviour questionnaire design and the descriptive statistics of the survey. Section 4 presents and analyzes the results of the reef-trip demand model and the welfare estimates related to GBR quality decline. The paper concludes with a discussion on the welfare effects of reef degradation for current visitors and the reef-tourism industry.

2. *A demand model for reef trips.*

In this section, the theoretical model of reef-trip demand is presented. First, it is shown how reef quality enters an individual's utility function and how reef quality influences the

[1] Reef recreation encompasses tourists who take a reef-trip with commercial operators to the GBR Marine Park for diving or snorkelling purposes.

recreational demand function. Subsequently the econometric count data modelling framework, that will be used to analyse recreational reef-tip demand of current visitors to the GBR, is described.

2.1 Economic specification of reef-trip demand.

Consider an individual i that maximizes utility $u_i(.)$ subject to budget constraint $m_i(.)$. The individual's utility function is given by $u_i(y_{i,},q,\mathbf{Z}_i)$, where y_i is the number of recreational reef trips undertaken, q is reef quality and $\mathbf{Z}_i$ is a vector of all other goods and services, and the individual's budget constraint is given by $m_i = p_y y_i + \mathbf{Z}_i$, where m_i is the individual's income and p_y is the price of a reef trip. Utility maximization now yields a system of Marshallian reef-trip demand functions $y_i(p_y,q,m_i)$, with y_i decreasing in p_y, increasing in reef quality, and increasing in m_i provided that y_i is a normal good (Whitehead et al., 2000).

Fig. 2 shows the Marshallian reef-trip demand curve for an individual that demands $y_i^{q=0}$ reef trips at an average price p_0 and current reef quality q=0.[2] Given a decrease in reef quality from q=0 to q=1, the individual's reef-trip demand curve shifts inwards from $D^{q=0}$ to $D^{q=1}$. At the current price for reef trips p_0, this reef quality decline leads to a decrease in reef-trip demand from $y_i^{q=0}$ to $y_i^{q=1}$ and, consequently, to a reduction in net consumer surplus (CS). Changes in net consumer surplus are represented by the area ΔCS, which is the difference between both demand curves above the price line p_0.

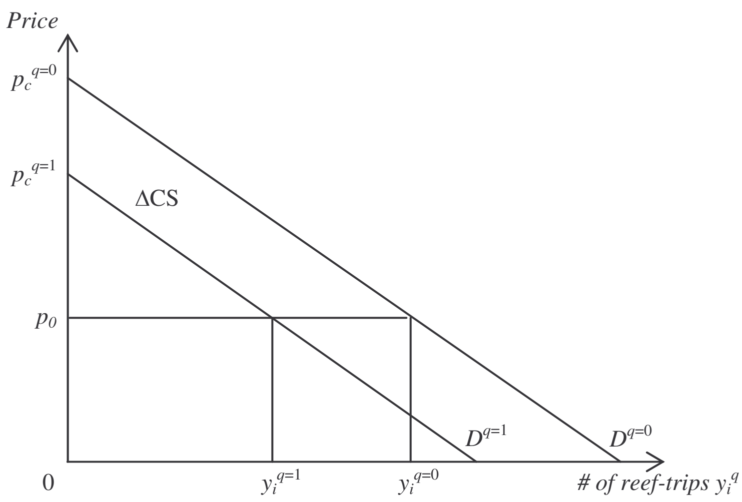

Fig. 2. Recreational reef-trip demand at current ($D^{q=0}$) and degraded ($D^{q=1}$) reef quality levels.

The number of recreational reef trips an individual makes is either zero or some positive number. Therefore the demand function should ensure that y_i^q is restricted to non-negative integers. This requirement is met by specifying a log-linear demand function for reef trips at

[2] Note that the demand curves are presented as linear functions for illustrative purposes only.

reef quality q. The number of reef trips y_i^q is not only related to reef quality, but also depends on visitors' individual characteristics. These characteristics are included in the following demand function specification

$$\ln(y_i^q) = c + \beta_k X_{ik} + \varepsilon_i \tag{1}$$

where y_i^q is the number of reef trips by individual i (i = 1,2,…,N) to reefs of quality q (q=0 for status quo and q=1 for degraded reef quality), X_{ik} (k = 1,2,…,K) are the independent variables (which include reef quality q and trip price p_y), β_k are the corresponding regression coefficients, and where ε_i is a random error term for individual differences that follows a gamma distribution with mean 1 and variance σ.

The consumer surplus (CS) associated with recreational trips to the reef is equal to the area below the inverse demand function and above the implicit price of a reef trip p_0. Let β_{price} be the coefficient of the reef-trip price variable and λ^q the mean number of reef trips for all individuals at price p_y, then the consumer surplus at reef quality q, which follows from demand function (Eq. 1), is given by

$$CS_i^q = \int_{p_0}^{p_c^q} \lambda^q(p_y)dp_y = \frac{\lambda^q(p_0)}{\beta_{price}} \tag{2}$$

where p_0 is the current price of a reef trip at reef quality q=0 and where p_c^q is the choke price at which an individual does not take any reef trips at quality q. The individual's i consumer surplus CS can be estimated with Eq. (2) by substituting for $\lambda^q(p_y)$ the number of trips y_i^q that the individual makes (Bhat, 2003).

If reef quality declines from q=0 to q=1, the change in an individual's consumer surplus is (see Whitehead et al.,2000):

$$\Delta CS = \int_{p_0}^{p_c^{q=1}} \lambda^{q=1}(p_y)dp_y - \int_{p_0}^{p_c^{q=0}} \lambda^{q=0}(p_y)dp_y = \frac{\lambda^{q=1}(p_0) - \lambda^{q=0}(p_0)}{\beta_{price}} \tag{3}$$

where $p_c^{q=0}$ and $p_c^{q=1}$ are the choke prices of reef-trip demand at current and degraded reef quality q=0 and q=1, respectively, and where β_{price} is the coefficient of the reef trip price variable in the demand model.

2.2 Econometric specification of reef-trip demand.

In the demand function specification (Eq. 1), the dependent variable y_i^q is a count of the total number of reef trips an individual makes or is planning to make to the reef. This variable has a discrete distribution, and is limited to non-negative values. A standard ordinary linear regression (OLS) model, as used by Richardson and Loomis (2004), is not appropriate to model recreational reef-trip demand for two reasons (Shrestha et al., 2002). First, the distribution of data on reef-trip recreation is positively skewed with many observations in the data set having a value of zero. The high number of zeros in the data set prevents the transformation of a skewed distribution into a normal one. As a linear regression model assumes a normal error distribution, applying OLS is not appropriate when dealing with count data. A second problem with linear models is the likelihood that the regression model will produce negative predicted values, which are theoretically impossible for reef-trip demand (Grace-Martin, 2000).

A more appropriate specification of recreational demand data is provided by a count data regression model. This type of model allows for a skewed, discrete distribution and is restricted to nonnegative values (Haab and McConnell, 2002). Two commonly used count data models are the Poisson and the Negative Binomial model.

A Poisson model is similar to an ordinary linear regression model but assumes that the errors follow a discrete (Poisson), instead of a normal, probability distribution (Grace-Martin, 2000). The model assumes the log of mean demand λ^q to be a linear function of the independent variables, implicitly determining a log-linear function (SSTARS, 2004). In a Poisson model, the probability that an individual takes $\hat{y}_i^q$ trips per year is given by the following probability function:

$$\Pr(y_i^q = \hat{y}_i^q) = \frac{\left(\lambda^q\right)^{\hat{y}_i^q} \exp(-\lambda^q)}{\hat{y}_i^q!} \qquad (4)$$

where $\hat{y}_i^q$ is the given number of recreational reef trips individual i makes to the reef and λ^q is both the mean and the variance of the number of trips at quality q, taking strictly positive values (Shrestha et al., 2002). Thus the Poisson model requires the variance of the dependent variable to be equal to the mean, mathematically denoted as $E(y_i^q)=var(y_i^q)=\lambda^q$.

However, in the case of reef visits, the equality of the mean and variance in the Poisson distribution is not realistic (Shrestha et al., 2002). There are many observations of zero and single trips, which easily leads to overdispersion in the dataset, violating the Poisson requirement. A more appropriate model, and therefore used in this study, is the Negative Binomial regression model (Loomis, 2002; Park et al., 2002; Shrestha et al., 2002). This is a generalisation of the Poisson model with a gamma distributed error term in the mean. The Negative Binomial model takes overdispersion into account and does not require the variance to be equal to the mean. In particular, the Negative Binomial probability function is given by (Haab and McConnell, 2002)

$$\Pr(y_i^q = \hat{y}_i^q) = \frac{\Gamma(\hat{y}_i^q + 1/\alpha)}{\Gamma(\hat{y}_i^q + 1)\cdot\Gamma(1/\alpha)}\left(\frac{1/\alpha}{1/\alpha + \lambda^q}\right)^{\frac{1}{\alpha}}\left(\frac{\lambda^q}{1/\alpha + \lambda^q}\right)^{y_{iq}} \quad (5)$$

where Γ is a gamma discrete probability density function defined for y_i^q (Shrestha et al., 2002) and where α is the overdispersion parameter. The mean of reef trips is still λ^q, but the variance is now equal to $\lambda^q + \alpha(\lambda^q)^2$. Like the Poisson model, the Negative Binomial model determines a log-linear demand function.

3. Contingent Behaviour survey.

This study estimates the changes in reef-trip demand resulting from a quality decline of the GBR. There are several approaches to estimate recreational demand changes conditional to environmental quality changes. One approach involves pooling travel cost data to recreational sites with different quality levels (Smith and Desvousges, 1986; Bockstael et al., 1989). The differences in the number of trips taken to different sites are assumed to relate to the site's environmental quality. A drawback of this method is that it requires variation in quality between sites, which is not documented amongst recreational dive sites of the GBR. There is a growing amount of literature that avoids this problem by combining actual trip data with stated preference data. For example, Cameron (1992) and Kling (1997) combine Travel Cost data with a Contingent Valuation Method to estimate the welfare effects of quality changes. A third approach has been employed by Adamowicz et al. (1994), who use Choice Modelling and Contingent Behaviour (CB) in a random utility framework to analyse recreational site choice. The fourth approach has been used by Eiswerth et al., (2000), Whitehead et al. (2000), Bhat (2003) and Hanley et al. (2003), and involves a combination of travel cost and CB data.

An advantage of the stated preference approaches is that they can be applied to site quality changes that are currently outside the range of observed qualities. As degradation of GBR recreational dive sites has not been historically documented, this study uses a CB approach to derive the demand function for recreational trips to the GBR. This approach typically employs a survey method that describes a hypothetical change in environmental quality and asks people directly for the changes in their behaviour contingent to the quality change. Section 3.1 describes the survey questionnaire used for this study in more detail, while Section 3.2 presents the descriptive statistics of the survey sample.

3.1 Questionnaire design.

Data have been collected through on-site interviews with GBR visitors in Port Douglas.[3] The survey was conducted in September 2004 on board of commercial tourism vessels. Interviews were directed at divers and snorkellers during their day-trip to the GBR in order to obtain information on their current number of recreational reef trips and the number of reef trips planned for the coming 5 years. Respondents also identified the maximum price they were willing to pay before they would cease visiting the GBR, allowing an estimation of the choke price for reef-trip demand.

Respondents were presented with a reef degradation scenario and were asked if they would change their number of reef trips in the coming 5 years would reef degradation occur. The answers to these CB questions were pooled with the data on current reef-trip demand and used to develop a demand model for recreational reef trips.

The contingent scenario included two picture sets, showing: (i) a healthy coral reef representing current quality of the GBR (picture set A), and (ii) a degraded coral reef representing possible future quality of the GBR (picture set B). Picture set B showed a visible decline in coral cover, coral diversity and fish diversity of approximately 80%, 30% and 70% respectively. This choice of picture sets was based on scientific evidence that coral cover and coral biodiversity declines when moving from a pristine, undisturbed reef to a reef that has been exposed to pollution. As changes in fish abundance are usually not apparent while fish diversity generally declines on degraded reefs (Fabricius et al., 2005), the picture sets showed only a small decline in fish abundance though a considerable decline in fish diversity.

The survey also collected important explanatory variables, including the respondent's socio-economic characteristics, knowledge of threats to the GBR and the perception of current reef quality. Following the guidelines of the National Oceanographic and Atmospheric Administration (NOAA) Panel on Value Elicitation Surveys (Arrow et al., 1993), the survey included reminders of budget and time constraints before as well as follow-up questions after the CB questions.

3.2 Descriptive statistics.

The survey yielded 180 interviews of which 176 were suitable for further analysis. Descriptive statistics of the interviews are provided in Table 1. The data set contained slightly more men than women (100 to 76) and more snorkellers than divers (118 snorkellers to 58 divers). Of all respondents, 45% came from Australia, mainly from Victoria and New South Wales, and 31% came from Europe. Most respondents (59%) came to the Port Douglas region with the primary purpose of seeing the reef. Although the majority of respondents (77%)

[3] A copy of the complete survey is available upon request from the authors.

Table 1. Descriptive statistics of survey sample (n=176)

Variable	% of sample
Gender	
Male	57
Female	43
Origin	
Queensland	7
Rest of Australia	38
Europe	31
USA/Canada	13
Reef activity	
Diving	33
Snorkelling	67
Reef as a primary reason to come to Port Douglas	59
Making one trip this year	77
Planning to come back in the coming 5 years	64
Would make the same number of trips at q=1	19
Would make fewer trips at q=1	76
Would not come back to the region at q=1	35

visited the GBR only once this year, 64% is planning to make more trips in the coming 5 years. If reef quality would decline as presented in the CB scenario, 76% of the respondents would make fewer reef trips and 35% of the visitors would not come back to the Port Douglas region at all.

The number of recreational reef trips that the average respondent makes to the GBR this year is 1.4 trips. Including the number of planned trips for the coming 5 years at quality q=0, an average respondent would make 3.8 trips in 6 years or 0.64 trips per year. If reef quality declines to q=1, the number of planned reef trips declines, leading to a total of 1.6 trips in 6 years or 0.26 trips per year. The median price of a reef trip in the sample is A$ 150 for a full-day trip. The maximum willingness to pay for a current reef trip is found to be A$ 237.

Reef visitors were asked to rate different aspects of the reef they had seen on a 5-point Likert scale ranging from very bad to very good. This rating is assumed to represent the visitor's perception of the reef seen that day. The average rating of reef perception was 3.9 with the lowest rating for the 'amount of coral cover' (3.7) and the highest rating for 'water visibility' (4.1). Respondents were also asked what they thought is the most important threat to the GBR. Global warming, too many visitors and pollution were mentioned by respectively 19%, 16% and 13% of the respondents. Out of 176 respondents, 25 persons stated that they were not familiar with any problems facing the GBR.

4. Results of the reef-trip demand model.

This section presents results of the Negative Binomial model for reef-trip demand, followed by the welfare estimates related to reef trips and GBR quality degradation. Welfare estimates are determined for both current reef visitors as well as the marine based tourism industry.

4.1 Reef-trip demand model.

Table 2 gives the explanatory variables that are used to analyse reef-trip demand. Each respondent's total demand for reef trips is calculated for 6 years (combining the trips made this year and the planned trips for the coming 5 years). Reef-trip demand is expected to be negatively correlated to the price of a reef trip and positively with the visitor's perception of the reef. It is expected that visitors from Queensland and other Australian states make more trips to the GBR than overseas visitors so two dummy variables, DumQLD and DumAUS, are introduced. The possibility that divers make more reef trips than snorkellers is captured by adding a dummy variable for reef activity. Socio-economic characteristics (Gender, Education, Household size and Income) are also included in the analysis. Finally, a dummy variable for reef quality is included to test for the difference between the number of reef trips at current reef quality and the number of reef trips at degraded reef quality.

Data about actual and contingent recreational behaviour are combined in a single equation to estimate the demand function for reef trips.[4] The data are pooled, providing three observations for each respondent (current visits, planned visits at $q=0$ and planned visits at $q=1$). This leads to a total of 416 observations. EViews4 is used to estimate demand function (4) in a Poisson and Negative Binomial model. The distribution of the demand variable indicates overdispersion, as the sample mean was 1.91 trips with a standard deviation of 4.89 and skewness of 8.62. A Log-Likelihood Ratio (LR) test, as proposed by Cameron and Trivedi (1990), is used to verify overdispersion. The null hypothesis in this test is that no

[4] This approach has been successfully applied by Englin and Cameron (1996), Bhat (2003) and Hanley et al. (2003). Englin and Cameron (1996) used this combined approach in a panel data model to CB data of recreational fishing, in which they asked visitors to Nevada for changes in their fishing behaviour conditional to changes in travel costs. Bhat (2003) and Hanley et al. (2003) also combined revealed and contingent data on recreational behaviour in a single model, though focussing on a change in environmental quality rather than a change in price. While Bhat studied changes in the number of visits to the Florida Keys subject to a hypothetical increase in reef quality, Hanley et al. studied changes in the number of beach visits in Scotland subject to a hypothetical change in bathing water quality.

Table 2. Description of variables used in demand model

Variable	Definition
Dependent variable	
Demand	Number of per person-trips to the GBR[1]
Explanatory variable.	
Price	Current price paid for a reef trip
Perception	Rating of reef quality during the last trip[2]
DumQLD	Dummy for coming from Queensland (0 = not from Queensland)
DumAUS	Dummy for coming from Australia (0 = not from Australia)
Diver	Dummy for activity on the reef
Gender	Gender (0 = male)
Education	Number of years education
House	Number of members in household
Income	Net monthly income[3]
DumQ	Dummy for reef quality decline (0 = current quality, 1 = degraded quality)

[1] Calculated as present demand plus the number of planned reef trips the coming 5 years.

[2] On a 5-point Liker scale with 1=very bad to 5=very good.

[3] From seven net monthly income categories ranging from A$ 0-1.000 to A$ 10.000 and over.

overdispersion is present, in which case the Poisson model can be used. The LR-statistic indicates that overdispersion is indeed present and that the Negative Binomial model is preferred over the Poisson model. Consequently, the Negative Binomial model is used for further analysis.

A redundant variables test for the variables Gender, Education and Income in Eviews4 shows that these variables are not significant at the 90% level of significance and, therefore, can be excluded from the model. Even though Income is hypothesised to be positively correlated with reef-trip demand, its coefficient proves to be insignificant. It should be noted that other recreation studies (see for example Park et al., 2002; Bhat, 2003) have also found insignificant coefficients for income.

Table 3 shows the estimation results for the full and reduced Negative Binomial model. Most of the variables have the expected sign. Price of a reef trip is negatively and significantly correlated to the number of demanded reef trips, indicating that fewer trips are made at higher prices. The coefficient of reef quality decline is negative and significant, indicating that fewer trips are made when reef quality declines. Results show that visitors from Australia and especially from Queensland are likely to make more reef trips than overseas visitors. Divers

Table 3. Full and reduced Negative Binomial model for GBR reef-trip demand*

Variable	Full model		Reduced model	
	Regression coefficient	z-statistic	Regression coefficient	z-statistic
Intercept	1.152	2.331	1.405	0.456
Price	-0.016	-10.164	-0.016	0.002
DumQ	-0.307	-2.704	-0.309	0.114
DumAUS	0.220	1.831	0.210	0.118
DumQLD	0.870	4.693	0.848	0.185
Perception	0.289	3.061	0.284	0.095
Diver	1.482	10.756	1.451	0.139
Gender	0.177	1.604		
Education	0.068	1.352		
Household	0.131	2.677	0.113	0.047
Income	-0.036	-1.096		
Adjusted R^2	0.42		0.42	
Log likelihood	-646.47		-655.46	
LR statistic	1106.43		1101.06	
Observations	414		416	

*Dependent variable: Number of recreational reef trips (6 years).

are also likely to make more reef trips than visitors who go on a snorkelling trip. The rating of coral quality is positively correlated with reef-trip demand, indicating that visitors who are satisfied with the reef are likely to visit the reef more often. The household coefficient is positive, which is unexpected as it means that larger households will take more reef trips even though total household costs will be larger than for smaller households. The household coefficient is, however, not significant at a 95% significance level. Other recreation studies (see for example Park et al., 2002; Bhat, 2003) have also found insignificant coefficients for the variable Income.

4.2 Welfare estimates of reef quality decline.

The reef-trip demand at current and degraded quality is determined by the Negative Binomial model with DumQ set at zero and one respectively. The GBR visit rate is shown to decrease with 59% if reef quality declines: from a yearly average of 0.64 trips to 0.26 reef trips per

Table 4. Welfare estimates from recreational demand changes under GBR quality decline

Estimate	Current reef quality	Degraded reef quality
Number of reef trips per person (#/yr)	0.64	0.26
Number of GBR visitors (million/yr)	1.54	0.63
Consumer surplus per person-trip (A$/trip)	62.50	
Consumer surplus per person-year (A$/year)	39.79	16.25
Total consumer surplus for all GBR visitors (million A$/yr)	96.35	39.60
Total tourism expenditure on reef trips (million A$/yr)	231	95

respondent. This means that instead of an annual 1.54 million full-day reef visitors,[5] the GBR will only attract 634 thousand reef visitors per year.

Using Eq. (3) and the estimated change in reef-trip demand, it is possible to calculate the change in consumer surplus (CS). Using β_{price} = -0.016 implies that the current CS per trip is A$ 62.5 per visitor. With an average number of 0.64 reef trips per year, the average annual CS is A$ 39.8 per person. When reef quality declines, an individual will make an average of only 0.26 reef trips per year, which corresponds to an annual CS of A$ 16.3 per person. The reduction in annual CS following the reef quality decline therefore corresponds to A$ 23.5 per person (Table 4).

The results for this survey may be extrapolated to all visitors to the GBR Marine Park on commercial vessels. However, as the welfare estimates are based on a limited number of interviews, caution should be taken when interpreting the results for the entire GBR. Multiplying the CS per trip with the total number of current reef visitors, gives an annual CS for all current GBR visitors of A$ 96 million. If the number of reef trips falls from 1.54 million to 0.63 million per year due to a decline in reef quality, total annual CS decreases to A$ 40 million – a reduction of nearly A$ 57 million per year for all GBR visitors (Table 4).

Additionally, the income effects for the tourism industry can be calculated by multiplying the reduction in annual reef-visitor numbers with the median price these visitors pay for a reef trip. When taking the median price of A$ 150 the decline in demand will lead to a decrease in tourism expenditure A$ 136 million per year, which accrues as a potential profit loss to the reef-tourism industry.

[5] The average number of reef visitors on full-day reef trips is derived from GBRMPA Environmental Management Charge data from 1994-2003.

5. Discussion and conclusions.

This research responds to the need for economic valuation of coral reef damage indicated by Wielgus et al. (2002) and the State of Queensland and Commonwealth of Australia (2003). This paper is the first to combine actual and contingent behaviour data to estimate a demand function for recreational reef trips to the Great Barrier Reef (GBR) and to assess the effects of reef quality decline on reef-trip demand by divers and snorkellers. This is a viable approach for reef quality changes that are outside the range of currently observed conditions. The demand model includes key factors that influence reef-trip demand, including origin, reef quality perception, reef activity, price of a reef trip and reef quality. The use of a Negative Binominal – instead of an OLS – demand model recognises that recreational GBR trips are measured as count data.

Results from the model show that the consumer surplus per person is A$ 62.5 per reef trip, or an annual A$ 96 million for all current GBR visitors. An hypothetical reduction in fish abundance, coral cover and coral diversity of 80%, 30% and 70% respectively, is shown to lead to a 59% decrease in the number of reef trips taken by divers and snorkellers (i.e. from 0.64 to 0.26 reef trips per visitor per year). This equates to an annual decrease in consumer surplus for current reef visitors of A$ 23.5 per person or nearly A$ 57 million for all current GBR visitors.

GBR visits are characterised by many single day-visits and a dive or snorkel trip is usually part of a longer holiday in the region. These characteristics make it difficult to compare our results to other reports. However, the estimates of a consumer surplus of A$ 62.5 per person per trip are in line with estimates of Park et al. (2002) and Bhat (2003), who find a user value of reef trips of respectively US$ 43 (A$ 55) and US$ 122 (A$ 156) per person per trip to the Marine Park of the Florida Keys.

Carr and Mendelsohn (2003) employ a travel cost method to estimate the use value of visitors to the whole GBR region. As these estimates include all visitors to the GBR region instead of divers and snorkellers specifically, it is expected that their results are much higher than estimates for reef visitation alone. Indeed, Carr and Mendelsohn (2003) find a higher annual recreational value of the GBR, ranging from US$ 700 million (A$ 895 million) to US$ 1.6 billion (A$ 2.0 billion). This is presented as the use value of the reef but disregards the fact that not all visitors to the region are necessarily attracted by the GBR.

Furthermore, our results indicate that the 59% reduction in reef-trip demand leads to a reduction in reef-tourism expenditure of some A$ 136 million per year when using our results of current annual expenditure of A$ 231 million. There is one other study that has estimated tourism expenditure in the GBR for reef trips specifically – KPMG (2000) finds a total annual expenditure of A$ 454 million for reef trips. When this estimation of reef-tourism expenditure is used, the decrease in reef-tourism expenditure stemming from reduced reef-trip demand will be much higher, potentially up to A$ 268 million per year, accruing as a potential profit loss to the reef-tourism industry.

It should be noted, however, that our research does not estimate the flow-on effects of a decline in the number of reef trips. As 35% of the respondents state that they would not visit the region when the quality of the GBR would decline, flow-on effects will be considerable, affecting tourism sectors other than the reef-tourism industry as well.

A general concern about contingent behaviour models is whether intended trips are a robust indicator of actual trips, should the reef degradation described to respondents actually occur (Hanley et al., 2003). Several papers have been published that test the validity of contingent behaviour responses. Loomis (1993) uses a test-retest analysis of recreational visits and finds no statistical difference between actual and intended behaviour. Two more recent studies (Grijalva et al., 2002; Haener et al., 2001) also test whether stated preference answers reflect actual behaviour. The results of both reports indicate that contingent behaviour is an appropriate indicator of actual recreation choices. When this also holds for reef visits, the intended number of reef trips at a specific reef quality will be a valid measure of the actual number of trips under the described circumstances.

With increasing evidence that the coral reefs of the GBR are degrading, establishing non-market values of the reef is gaining importance. The results of this research will be a valuable input in evaluating the effects of policy measures that influence reef quality and can be used to assess the overall cost effectiveness of coral reef management programmes. However, further research is required to estimate how reef-trip demand is related to marginal changes in reef quality, by determining demand contingent to different quality levels. Also, to fully consider the total economic value of the GBR it is necessary to extend the environmental valuation of this research to: i) more sample locations and periods to reach a variety of GBR visitors, ii) economic sectors other than the reef-tourism industry alone, and iii) include non-use values for non-visitors to the reef.

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