The value of recreational fishing along the Capricorn Coast: A pooled revealed preference and contingent behaviour model

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Abstract:

Given the focus on protecting natural assets in the Great Barrier Reef Marine Park (GBRMP), it is important for managers and policy makers to understand the value of recreational activities such as fishing in the area, and how changes in management may affect those recreational values. This paper reports research estimating the value of recreational fishing along the Capricorn Coast in Central Queensland. Travel cost methods were used to estimate the value of recreational fishing using data from on-site surveys conducted at boat ramps along the Capricorn Coast. The study also uses contingent behaviour models to estimate the change in the value of recreational fishing as conditions vary. Results indicate that there are high values associated with recreational fishing activity along the Capricorn Coast, that the demand for recreational fishing is inelastic and that values are not sensitive to changes in catch rates.

Key words: recreational fishing, count data, contingent behaviour, Great Barrier Reef

Introduction

Recreational fishing is a significant economic activity not just in Australia but also in Queensland, especially in the Great Barrier Reef Marine Park (GBRMP). The fisheries resources in the GBRMP used for recreational fishing compete very closely with the commercial fishing sector and indigenous subsistence fishing. Considering these conflicting interests it is essential to estimate and understand the economic value of recreational fishing in the GBRMP so that the scarce resources could be managed to provide maximum benefits not just to the local communities but also to state and national economies.

Valuation of recreational fishing has received relatively less attention in Australia and New Zealand compared to the USA, Canada and Europe. Although there have been many studies on recreational fishing, very few studies have involved estimation of the value of recreational fishing, few researchers have attempted to estimate the value of recreational fishing – either in the GBRMP, in Queensland or in other parts of Australia. Furthermore, there is a scarcity of data about recreational fishing activities at specific locations/regions within the GBRMP.

The research described in this paper addresses some of that information deficit by estimating values for the activity and investigating the responsiveness of recreational fishing demand to changes in costs and other factors such as catch rates and conditions along the Capricorn Coast region of the GBRMP. The paper has two main sub-studies: a travel cost model is used to estimate the value of recreational fishing in the Capricorn coast; and then contingent behaviour models are used to make predictions about the changes in the value of recreational fishing that would occur in different situations.

As far as the authors are aware this study is one of only a few studies to estimate the value of recreational fishing in Australia and especially in the GBRMP region. It is also one of the first studies to use contingent behaviour models to estimate changes in the value of recreational fishing in Australia that might occur in different situations. It is anticipated that this study will contribute to the growing literature on valuing recreational fishing on the GBRMP in Queensland and will be valuable to fisheries management, research and government agencies.

Models

The travel cost model (TCM) is one of the oldest non-market valuation techniques (Hanley and Spash 1993; Haab and McConnell 2002). It is well accepted because it is grounded in consumer theory, uses real data from market transactions, and has the ability to represent consumer choices and preferences accurately (Smith 1989; 1993). It has also been used frequently and routinely in the past to value outdoor recreational activities (Hanley and Spash 1993; Garrod and Willis 1999; Haab and McConnell 2002; Shrestha *et al.* 2002) including recreational fishing (Smith 1989; Ward and Beal 2000; Haab and McConnell 2002). Indeed recreational fishing studies in general accounted for about 20% of recreational valuation studies conducted all over the world (Kaval and Loomis 2003; EVRI 2008). Kaval and Loomis (2003) found that there were about 129 studies that estimated benefits for recreational fishing conducted in the United States of America and Canada between 1967 and 2003. Johnston *et al.* (2006) identified over 450 non-market valuation studies dealing with recreational fishing benefits and values, mostly conducted in the United States of America, Canada and European countries.

The TCM operates by explaining a frequency of visit rate (either of an individual or a population segment) in terms of the travel costs incurred and other site relevant characteristics and socio-economic factors. The amount of opportunity costs incurred and visitation rates determines the recreation values. While earlier TCMs employed standard regression techniques to estimate relationships, the non-negative integer and truncated nature of the dependent variable (number of trips) means that it is often more appropriate to estimate recreational fishing demand models using count data specifications like Poisson, negative binomial or truncated negative binomial probability structures (Cameron and Trivedi 1986; Creel and Loomis 1990; Grogger and Carson 1991; Hallerstein and Mendelsohn 1993; Winkelmann 2003). Count data models have been used to estimate recreational values routinely in valuation literature (Hausman *et al.* 1984; Shaw 1988; Grogger and Carson 1991; Creel and Loomis 1992; Englin and Shonkwiler 1995; 1995a; Bowker and Leeworthy 1998; Chakraborty and Keith 2000; Eiswerth *et al.* 2000; Ovaskainen *et al.* 2001; Shrestha *et al.* 2002). It is this approach that is applied in this study.

In recent years recreation analysts have begun supplementing standard TCM approaches with additional information about how users might change their behaviour if certain contingent conditions existed (Morton *et al.* 1995; Englin and Cameron 1996; Eiswerth *et al.* 2000; Grijalva *et al.* 2002). These contingent behaviour (CB) models differ from the more traditional contingent valuation method (CVM) in that the respondents are asked whether they would be willing to change their behaviour in response to changes in the environment instead of their reaction to cost increases. In a recreation context respondents are presented with the hypothetical scenario with different site conditions and then asked if they would change their intended number of visits.

Case study

The Capricorn Coast is in the southern part of the GBRMP in Central Queensland, spanning about 95kms of coastline from Byfield and Shoalwater Bay in the north to Keppel Sands in the south. Much of the northern half is occupied by the military and off limits to unauthorised personnel. The southern part of the coast boasts several beaches and boat ramps that provide excellent conditions for recreational fishing all year round. Rockhampton is the key city in this region together with several coastal towns such as Yeppoon, Emu Park and Keppel Sands.

CapReef is a community based monitoring group established in 2004 to improve community involvement and knowledge in management of the Capricorn part of the Great Barrier Reef ecosystem. This group already collects some data on recreational fishing and is also an umbrella organisation for linking all data being collected in the Capricorn part of the GBR. In this study, a series of questions were developed which were added to the existing CapReef survey so that there was no duplication of information collected. These questions were specifically designed and used only for this study.

The add-on survey was divided into 3 sections. The first section collected information about the costs of fishing in the region, current and future visit rates and reasons for visiting the region. In the second section the respondents were asked several open ended contingent behaviour questions such as how many fishing trips they would make if conditions of the fishing trip changed (for example if there were changes in overall catch rates). The last section of the survey collected general socio-economic information which was used to ensure that the sample was reliable and representative.

The sample was randomly selected at boat ramps as the anglers were either just starting their fishing trip or just returning from the fishing trip. The surveys were collected over a period of about 28 weeks from late January to mid August in 2007. The collection periods were selected to include weekdays and weekends, periods of high and low fishing seasons, public holidays and different seasonal visitation rates which allowed for the capture of not just local recreational anglers but also recreational anglers for other parts of Queensland and Australia (interstate anglers). In all about 318 surveys were collected, of which 311 were usable, while 7 were either duplicates or contained insufficient information.

The variables used in both the travel cost and the contingent behaviour models are listed in Table 1. The dependent variable for both models is the visit rate over a one year period (CURRENTV). For the TCM this variable contains just the number of fishing trips taken by the respondents to the Capricorn Coast in the last 12 months. For the CBM this variable contains the hypothetical number of likely trips in the next 12 months under different hypothetical scenarios. In the models a key variable is the cost incurred for the fishing trip (TOTCOSTS) which include costs of travel, food, accommodation, boat fuel, bait, tackle, ice and other costs.

Table 1: Definition of variables in the models

Variable	Definition
CURRENTV	dependant variable TCM - number of recreational fishing trips to the Capricorn Coast in the last 12 months CBM - expected number of trips in the next 12 months and the number of trips under different hypothetical scenarios
DUMMY	dummy variable identifying the source of the data (0 = expected trips and 1 = contingent behaviour data)
TOTCOSTS	total travel costs of trip as reported by the respondents
DAYSFISH	days spent fishing on this trip
GRPSIZE	size of the group
DIST1WAY	one way distance to the boat ramp
CATCHRAT	Number of fish caught on this trip
AGE	age of the respondents in years
BOATVALU	value of the boat
LOGINCOME	Log of annual household income of the respondents

Approximately 55% of the respondents lived along the Capricorn Coast and less than 10kms from the boat ramp, while more than 90% of the respondents lived in the local region and less than 50kms from the boat ramp. The average distance travelled to the boat ramp was about 78kms while the median distance travelled was 8.78kms. The descriptive statistics showing the characteristics of recreational anglers for the variables included in the analysis are presented in Table 2.

Table 2: Descriptive statistics of the variables used in the models

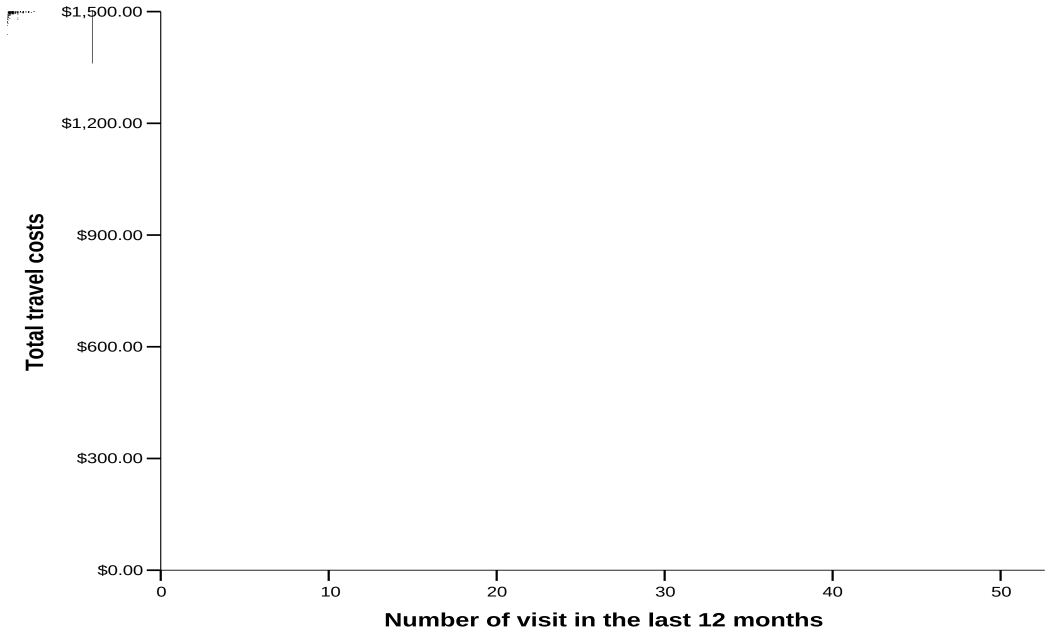
Variables	Mean	Std. dev.	Skewness	Kurtosis	Minimum	Maximum
CURRENTV	12.98	10.72	1.37	4.37	1	50
DUMMY	1.00	0.00	0.00	0.00	1	1
TOTCOSTS	195.58	257.69	4.35	28.99	18	2510
DAYSFISH	1.54	1.59	7.78	78.67	1	20
GRPSIZE	2.31	0.72	0.78	3.46	1	4
DIST1WAY	77.65	246.18	5.32	33.02	2.5	2049.14

CATCHRAT	18.72	24.90	4.78	38.48	1	257
AGE	44.61	10.49	0.20	2.98	21	70
BOATVALU	18971.40	12620.20	2.11	9.53	2500	90000
LOGINCOM	11.20	0.36	-1.73	6.89	10.13	11.74

Model specification

Figure 1 provides a graphical representation of visit rates against the total costs of travel for recreational fishing as reported by the respondents. One outlier with very high travel costs was omitted from the data. The data shows the expected inverse relationship between the number of visit and travel costs where as costs of travel increase the number of fishing trips decrease. The figure also indicates that the relationship between travel costs and visit rates is not likely to be linear. Characteristics of over dispersion can be identified in the data set with multiple visitation rates for many levels of trip cost, indicating that substantial heterogeneity exists in the data set.

Figure 1: Relationship between visit rates and travel costs



The collection method for the study means that the data is characterised by endogenous stratification, which is over-representation in the sample of more frequent anglers. This was corrected for by subtracting one trip from the dependent variable (Shaw 1988; Englin and Shonkwiler 1995a; Haab and McConnell 2002; Loomis 2003). The current study uses count data models to analyse the data because they are appropriate for the integer and non-negative nature of the dependant variable. In addition the negative binomial specification is appropriate to address problems of over dispersion (Grogger and Carson 1991). For this study it was considered appropriate to estimate both the TCM and CBM models using a truncated negative binomial specification.

A count data model assumes a semi-log function which has the simple and attractive property of allowing the estimation of consumer surplus per trip as the inverse of the travel cost coefficient. The demand for recreational fishing takes the semi-log form as in equation 1, where *Vr* is the expected number of trips, *tc* is the travel costs per trip, and X_n represent other individual characteristics (independent variables) that might affect demand for recreational fishing trips.

$$\ln Vr = \beta_0 - \beta_1 tc + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + ... + \beta_n X_n \quad (1)$$

The consumer surplus (CS) per trip is simply the inverse of the coefficient of the travel cost variable given in equation 2 (Creel and Loomis 1990; Englin and Shonkwiler 1995a; Eiswerth *et al.* 2000; Betz *et al.* 2003).

$$CS = -\, {}^{1}\!/_{\beta_{TC}} \quad (2)$$

Model estimation

The results of the analysis are presented in two parts, with the first focused on the TCM models and the second on the CB models.

Travel cost model estimation

Travel cost models can be estimated in different ways by changing the definition and inclusion of variables. Traditionally there are three methods for the estimating travel costs (Bateman 1993). The first method uses only estimated fuel costs as a function of distance while the second method considers estimated full car costs that include fuel, insurance and maintenance as a function of distance. The last method uses the perceived costs as reported by the respondents. It was considered appropriate to apply reported costs in the current study[1] because it is most likely to represent the opportunity costs that respondents considered when making their trip decision (Bateman 1993; Bennett 1996). As well, the model with reported costs had a much higher R-squared or explanatory power than the model with estimated costs.

[1] For the purposes of comparison travel costs were also estimated using the second method and CS estimates generated were compared with the CS estimates generated by the reported costs model. Results indicated that the reported costs model generated higher values than the estimated costs model.

The travel cost model using reported costs is presented in Table 3. The change between the log-likelihood parameters suggests that a high level of model fit is being achieved. The over-dispersion parameter Alpha is statistically significant, indicating that the truncated negative models are preferred.

Table 3: Travel cost model estimated with Negative binomial specification

Variables	***Left truncation*** ***V=0***	
	Coefficient	Std. Err.
ONE	2.7880**	0.2262
TOTCOSTS	-0.0026**	0.0004
DAYSFISH	-0.0548	0.0406
GRPSIZE	0.0014	0.0552
DIST1WAY	-0.0048**	0.0011
CATCHRAT	0.0003*	0.0001
AGE	-0.0008	0.0039
BOATVALU	1.73E-05**	4.51E-06
LOGINCOM	0.0002	0.0004
Alpha	0.5037**	0.0704
Log likelihood	-994.1562	
Restricted log likelihood	-1523.975	
Chi-squared	1059.637	
Consumer surplus/group	**$385.34**	
95% Confidence interval	***$294.61 - $562.81***	
Consumer surplus/angler	**$166.82**	
95% Confidence interval	***$127.54 - $243.64***	
*** = significant at 1% level; * = significant at 5% level*		

In general the signs and significance of the variables included in the models were as expected and consistent with economic theory and past recreational demand studies. The coefficient of TOTCOSTS was highly significant at the 1% level (with a P value ≤ 0.01) and negatively signed as expected. This is the primary result of the recreation demand models, suggesting a downward sloping demand curve where anglers take fewer recreational fishing trips as costs of travel increase.

Other explanatory variables that were significant in the model included the One Way Distance (negatively signed as expected), Catch Rate (positively signed as expected) and Boat Value (positively signed). The data indicate that the average number of fish caught along the Capricorn Coast was approximately 19 fish per trip, while the average value of boats used for fishing along the Capricorn Coast is approximately $18,971.

In summary, the annual number of fishing trips decreased as the costs of travel, the number of days spent fishing, the distance from residence to boat ramp and as the age of recreational anglers increased. On the other hand the annual number of fishing trips increased as the number of people in the group, catch rates and the value of the boat increased. Including other demographic variables like age, boat value, log of income, and group size improved the model fit and confirmed that the data for recreational fishing are heterogeneous.

Estimation of contingent behaviour models

The contingent behaviour models for recreational fishing are estimated using the truncated negative binomial (left truncated at 0) which is the preferred model in the TCM analysis. Each respondent provided two observations for every CBM model. The first was the expected number of fishing trips in the next 12 months, and the second was the contingent number of trips for a contingent scenario. Differences in visit intentions could then be linked to the presence of the contingent scenario. Respondents were presented with different scenarios of decreasing and falling catch rates and deteriorating (over crowding and increased algal blooms) and improving (presence of more red emperor fish) environmental conditions. The responses were stacked to create a panel data set of 622 observations for each contingent behaviour scenario. The data set also included a dummy variable (DUMMY) which is used to indicate if the data pertained to expected number of trips in the next 12 months (DUMMY = 0) or the contingent behaviour data (DUMMY = 1). To maintain consistency all the explanatory variables included in the travel cost model were retained regardless of their significance in estimating all the contingent behaviour models.

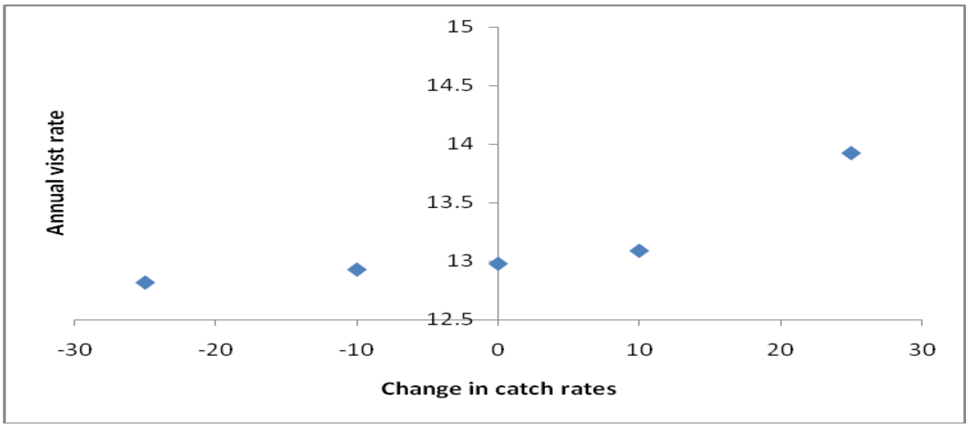
CB models for changes in catch rates

The CB models for catch rates are estimated to evaluate the effects of changes in catch rate on planned visitation patterns of recreational anglers. The respondents were asked how many times they are likely to go fishing in the next 12 months if catch rates changed (either increased or decreased). The expected average annual number of visits for possible changes in catch rates in Capricorn Coast region of the GBRMP is given in Figure 2. This figure indicates that the expected average visits decline as catch rates decline and increase as catch rates also increase. However this effect was only marginal and not statistically significant. This indicates that recreational anglers value factors other than just catch rates and would still go fishing even when catch rates fall.

The changes in expected visit rates with different catch rates are consistent with consumer theory, providing some level of validation for the results. Expected visits were only marginally higher for a 10% increase in catch rates but the increase in expected visits was significantly higher for a 25% increase in catch rates. This indicates that expected visits may not increase significantly unless catch rates increase substantially.

The CB models for catch rates are presented in Table 4. The estimated coefficient on CATCHRAT is positive as expected and statistically significant at the 1% level across all models estimated, indicating that groups with higher catch rates plan to have more fishing trips. The estimated coefficient of TOTCOST is negative as expected and statistically significant at the 1% level across all models estimated, implying that as travel cost increases the number of fishing trips decline.

Figure 2: Expected average annual visit rate for changes in catch rates



The estimated coefficient on DAYSFISH is negative and statistically significant at 1% level across all models estimated, indicating that anglers spending more days fishing per trip make fewer fishing trips. The coefficient of DIST1WAY is negative as expected and significant at 1% level across all models estimated, indicating that as distance increases fewer fishing trips are made. The over-dispersion parameter, Alpha is statistically significant at the 1% level.

Table 4: Results for contingent behaviour models for changes in catch rates – truncated negative binomial

Variables	Catch rates up 10%		Catch rates up 25%		Catch rates down 10%		Catch rates down 25%	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
ONE	2.9815**	0.1843	3.0375**	0.1598	2.9619**	0.1901	2.9758**	0.1820
DUMMY	0.0095	0.0618	0.0667	0.0625	-0.0030	0.0619	-0.0186	0.0616
TOTCOSTS	-0.0024**	0.0003	-0.0024**	0.0003	-0.0024**	0.0003	-0.0024**	0.0003
DAYSFISH	-0.2515**	0.0742	-0.2715**	0.0753	-0.2386**	0.0756	-0.2391**	0.0753

GRPSIZE	0.0015	0.0430	0.0015	0.0195	0.0015	0.0464	0.0015	0.0396
DIST1WAY	-0.0043**	0.0008	-0.0045**	0.0008	-0.0044**	0.0008	-0.0044**	0.0008
CATCHRAT	0.00026**	0.00008	0.00030**	0.00008	0.00025**	0.00008	0.00025**	0.00008
AGE	-0.0009	0.0031	-0.0008	0.0027	-0.0009	0.0032	-0.0009	0.0031
BOATVALU	0.00002**	3.30E-06	0.00002**	3.29E-06	0.00002**	3.33E-06	0.00002**	3.26E-06
LOGINCM	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Alpha	0.4797**	0.0468	0.4897**	0.0474	0.4813**	0.0470	0.4789**	0.0466
Number of observations	608		610		606		610	
Log likelihood function	-1940.053		-1968.148		-1928.36		-1941.21	
Restricted log likelihood	-2923.245		-3032.679		-2902.091		-2913.121	
Chi squared	1966.384		2129.062		1947.46		1943.821	
** = significant at 1% level; * = significant at 5% level								

The coefficient for the indicator variable (DUMMY) is positive as expected when catch rates are hypothetically increased by either 10% or 25% but is not significant for either of the models estimated. This implies that intended number of future fishing trips is not statistically different from intended trips when catch rates are hypothetically increased by 10% or 25%. The coefficient on the DUMMY variable is negative as expected when catch rates are hypothetically reduced either by 10% or 25%, indicating that as the decline in catch rates increases the number of fishing trips decline, but again is not statistically significant in any of the estimated models. Evidently changes in expected catch rates do not have a major impact on trip plans; recreational anglers may be driven by factors other than catch rates when planning a recreational fishing trip[2].

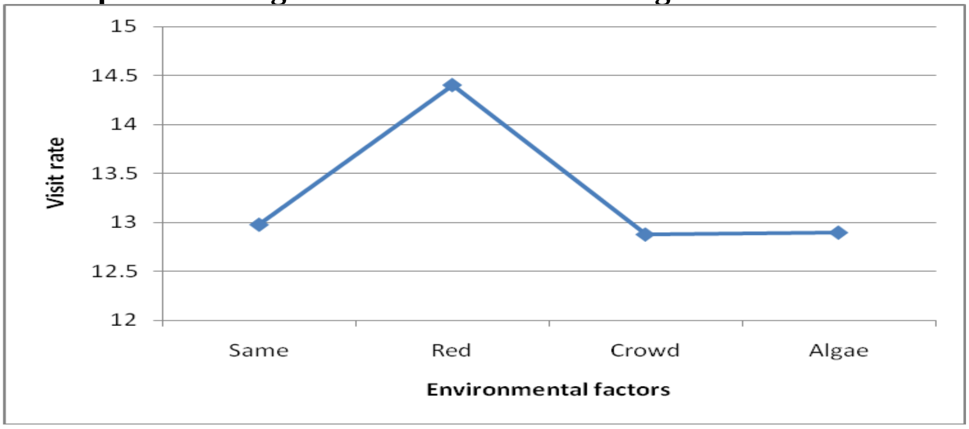
CB models for changes in environmental factors

The CB models were also used to evaluate environmental quality on visitation patterns of recreational anglers. The respondents were asked how many times they are likely to go fishing in the next 12 months if there was (a) an increased chance of catching ‘red emperor’; (b) increased crowding at boat ramps and (c) prolonged presence of algal blooms. The expected average number of visits under different environmental scenarios is given in Figure 3. In line with expectations, this shows that expected visits increase with increases in the

[2] Recreational fishing is price inelastic, income inelastic and catch inelastic indicating that other factors like enjoyment, being outdoors, being with family etc. are more important.

chance of catching a legal sized red emperor and decrease with an increase in crowding and the prolonged presence of algal blooms.

Figure 3: Expected average annual visit rate for changes in environmental factors



The CB models for changes in environmental factors are estimated using the truncated negative binomial specifications with results presented in Table 5. Model performance is similar to the CB models estimated for catch rates, but the estimated coefficient for the DAYSFISH variable has a lower level of significance.

The coefficient on the DUMMY variable is positive for the CB model for a 50% increased chance of catching a legal sized red emperor, negative for the CB model where crowding at boat ramps was 30% worse on holidays and weekends, and negative for more persistent algal (*trichodesmium)* blooms of 4 months instead of the normal 3 months in the next year. However, none of the DUMMY variable coefficients were significant.

Table 5: Results for contingent behaviour models for changes in environmental factors – truncated negative binomial

Variables	Red emperor		Crowding		Algal blooms	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
ONE	2.8319**	0.1394	2.8084**	0.1530	2.7910**	0.1553
DUMMY	0.0942	0.0627	-0.0207	0.0610	-0.0183	0.0609
TOTCOSTS	-0.0028**	0.0003	-0.0027**	0.0003	-0.0027**	0.0003
DAYSFISH	-0.0520*	0.0258	-0.0659*	0.0293	-0.0514#	0.0297
GRPSIZE	0.0015	0.0144	0.0014	0.0308	0.0014	0.0317
DIST1WAY	-0.0048**	0.0008	-0.0046**	0.0008	-0.0046**	0.0008
CATCHRAT	0.0003**	0.0001	0.0003**	0.0001	0.0003**	0.0001
AGE	-0.0008	0.0028	-0.0008	0.0028	-0.0008	0.0029
BOATVALU	0.000017**	3.26E-06	0.000018**	3.16E-06	0.000018**	3.16E-06
LOGINCM	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002
Alpha	0.5145**	0.0489	0.4834**	0.0467	0.4814**	0.0464

Number of observations	620		618		618	
Log likelihood function	-2023.325		-1975.399		-1975.736	
Restricted log likelihood	-3191.119		-2974.79		-2967.494	
Chi squared	2335.588		1998.783		1983.516	
** = significant at 1% level; * = significant at 5% level; # = significant at 10%						

A comparison of all the estimated CB models indicates that the estimated parameter coefficients are robust and similar to the travel cost models estimated with revealed preference data (trips over the past 12 months). This indicates that the contingent behaviour and revealed preference data both lead to the same welfare estimates. All the CB models indicate that intended visits in the next 12 months and number of trips under the CB scenarios are statistically similar across the different contingent behaviour scenarios. This is substantiated in literature where the strongest motivations for going fishing for recreational anglers were found to be 'for rest and relaxation', 'to be outdoors', 'enjoy nature' and other similar motivations (Ditton *et al.* 1992; Fedler and Ditton 1994; Henry and Lyle 2003; Ormsby 2004). Many of the studies on recreational angler motivations found that it was not necessary to catch fish to enjoy the trip and that the recreational anglers would still go on fishing trips even if they did not catch fish on every trip.

Results and discussion

Consumer surplus per group is estimated using equation 2. The consumer surplus per trip estimated for the travel cost model is $385.34 per group and $166.82 per angler. This equates to about $20.54 per caught and kept fish. Recreational fishing by the recreational anglers surveyed generated a consumer surplus of about $1.55 million annually[3]. The annual number of fishing trips in the Capricorn Coast is estimated to be approximately 14,340[4] for 2006-2007. The total annual consumer surplus for recreational fishing along the Capricorn Coast is therefore approximately $ 5.53 million.

[3] Total number of fishing trips made by recreational anglers surveyed in the last 12 months was 4036 trips. This multiplied by per trip CS/group provided the annual estimate.
[4] The annual number of recreational fishing trips from Rosslyn Bay boat ramp for 2006-07 was 13,279 (Platten *et al.* 2008). 92.6% of all fishing trips along the Capricorn Coast were from Rosslyn Bay (chapter 6B - data collection). From these data the total number of fishing trips along the Capricorn Coast was estimated to be 14,340.

The effect of changes in catch rates and environmental factors on the Capricorn Coast on the value of expected fishing trips, known as marginal effects, is estimated using the results of the CB models. A marginal effects value indicates how much the predicted value of the consumer surplus associated with an average trip changes with a unit change in the CB variable. Marginal effects are estimated using equation 3, where β_{tc} is the estimated coefficient of TOTCOSTS and β_{cb} is the estimated coefficient of the DUMMY variable.

$$ME = \beta_{cb} * \left[\frac{-1}{\beta_{tc}} \right] \quad (3)$$

Consumer surplus estimates and their 95% confidence intervals are calculated for all the models estimated and marginal effects and their 95% confidence intervals are estimated for all the CB models estimated. Confidence intervals were calculated based on the Krinsky and Robb's (1986) procedure which has been widely used in economic valuation literature (Creel and Loomis 1991; Loomis 2006). A simple comparison of confidence intervals is indicative of the significance level of any differences between models (Loomis 2006).

The estimated marginal effects values are given in Table 6. An examination of the estimated values and their confidence intervals indicate that there were only marginal differences in the estimates and that the confidence intervals of all the estimated models overlap. This implies that the estimated models were not statistically different for each other.

Table 6: Changes in per trip value

Estimated values	Catch rates				Red emperor	Crowding	Algal blooms
	Up 10%	Up 25%	Down 10%	Down 25%			
Marginal effects / group	$3.96	$28.02	-$1.26	-$7.74	$33.99	-$7.71	-$6.72
95% Confidence Interval	*-$46.29 - $58.03*	*-$24.97 - $84.33*	*-$51.19 - $52.20*	*-$59.48 - $44.64*	*-$12.46 - $82.95*	*-$52.26 - $39.28*	*-$50.35 - $39.00*
Marginal effects / angler	$1.71	$12.13	-$0.54	-$3.35	$14.71	-$3.34	-$2.91
95% Confidence Interval	*-$20.04 - $25.12*	*-$10.81 - $36.51*	*-$22.16 - $22.60*	*-$25.75 - $19.32*	*-$5.39 - $35.91*	*-$22.62 - $17.00*	*-$21.80 - $16.88*

The marginal value of fishing trips increased when catch rates increased and fell when catch rates decreased. The increase in the marginal value of a trip is greater for a 25% increase in catch rate than a 10% increase in catch rate. The marginal value of a trip for an angler group decreased as expected for decreases in catch rates but the decrease in trip value for decreases in catch rates is less that the increases in trip value for increases in catch rates.

The change in trip value was greatest for a 50% chance of catching a legal sized red emperor per trip; the marginal value of a trip per angler group increased by approximately $34. However, as indicated by Figure 2, responses to changed catch rates are somewhat asymmetric: the marginal value of a trip declined by approximately $1.26 per angler group for a 10% decrease in catch rates and the marginal value of a trip declined by $7.74 per angler group for a 25% decrease in catch rates.

As might have been expected *a priori,* the marginal value of a trip decreased both for ‘if crowding at the boat ramp was 30% worse on holidays and weekends’ and ‘if the *trichodesmium* algal blooms persisted for 4 months, instead of the normal 3 months in the next year’. The decline in the value of a trip was comparable for both crowding and algal blooms at approximately $7.71 and $6.72 respectively.

Conclusion

The current study demonstrates that recreational anglers have a high value for the opportunity to fish in the Capricorn Coast region of the GBRMP. The consumer surplus per trip for fishing on the Capricorn Coast estimated from the travel cost model is $385.34 per group, which extrapolates to a total annual consumer surplus value of approximately $ 5.53 million.

The change in the total value of recreational fishing under different contingent behaviour scenarios is presented in Table 7. The change in the value of recreational fishing ranged from a decrease of $110,992 for catch rates down 25% to an increase of $487,416.60 for a 50% chance of catching a legal sized red emperor. Most changes, apart from catch rates up 25% and an increased chance of catching a red-emperor, generate less than a 10% change in total CS, indicating that recreational fishing values are relatively ‘insensitive’ to a range of variables – including price, income, crowding, algae and minor changes in catch rates.

Table 7: Changes in total CS

Model	Change in total CS
Catch rates up 10%	$56,786.40
Catch rates up 25%	$401,806.80
Catch rates down 10%	-$18,068.40
Catch rates down 25%	-$110,991.60
Red emperor	$487,416.60
Crowding	-$110,561.40
Algal bloom	-$96,364.80

These results are of particular interest to resource managers and the management of the GBRMP since the resources used for recreational fishing are likely to compete closely with commercial fishing sector. Specifically, in an idealistic economic 'test-tube', one would seek to maximize the net social benefits of fish resources by equating the marginal value of its 'uses'. The high TOTAL values associated with recreational fishing highlight the importance of that 'sector', and clearly indicate that policy makers need to engage recreational anglers when considering policy changes. But it is the marginal effects which provide useful information to those interested in CHANGING from the current, status quo, to other alternatives. Interestingly, these results indicate that the marginal value of *"a 50% chance of catching a red emperor"* and of *"a 25% increase in catch rates"* is relatively high (although further research is needed to determine if such changes are statistically significant) and that the marginal value of other changes is relatively low.

Whether or not those marginal values are higher or lower than the marginal values associated with other, competing uses (such as increased commercial catches, increased 'sightings' of fish by tourists) remains as a vitally important issue for further investigation – since it is only by comparing these marginal values with the marginal values of competing uses that one is able to determine if changes affecting all sectors are (potential) *Pareto* improvements. This research provides an important piece of that puzzle, but there are yet many pieces to find.

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