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Valuing protection of the Great Barrier Reef with choice modelling by management policy options

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Abstract:

In this paper the results of a choice modelling experiment to value increased protection of the Great Barrier Reef in Australia is reported. The experiment is novel in two important ways. First, different management policies to increase protection have been included as labels in the choice experiment to test if the mechanisms to achieve improvements are important to respondents. Second, the level of certainty associated with predicted reef health has been included as an attribute in the choice profiles, helping to distinguish between outcomes of different management policies. The results show that protection values vary with the policy scope of the improvements being considered. Values are sensitive to whether protection will be generated by improving water quality entering the reef, increasing conservation zones or reducing greenhouse gas emissions, and the level of certainty of outcomes. The average household willingness to pay for each additional 1% of protection is approximately $22.50 when the broad management options to generate improvements were included in the choice sets.

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1. Introduction

The protection of the Great Barrier Reef (GBR) is a major policy issue in Australia because of its iconic status and international significance (Figure 1). The area of approximately 35 million hectares is protected by the Australian and Queensland Governments as a marine park, and has had World Heritage site status since 1981. While the GBR remains one of the most healthy coral reef ecosystems in the world, its condition has declined significantly since European settlement and the overall resilience of the reef has been reduced (Furnas 2003; GBRMPA 2009). The 2009 GBR outlook report (GBRMPA 2009) identifies climate change, declining water quality from catchment run-off, and impacts from fishing as three of the key priority issues reducing the resilience of the GBR.

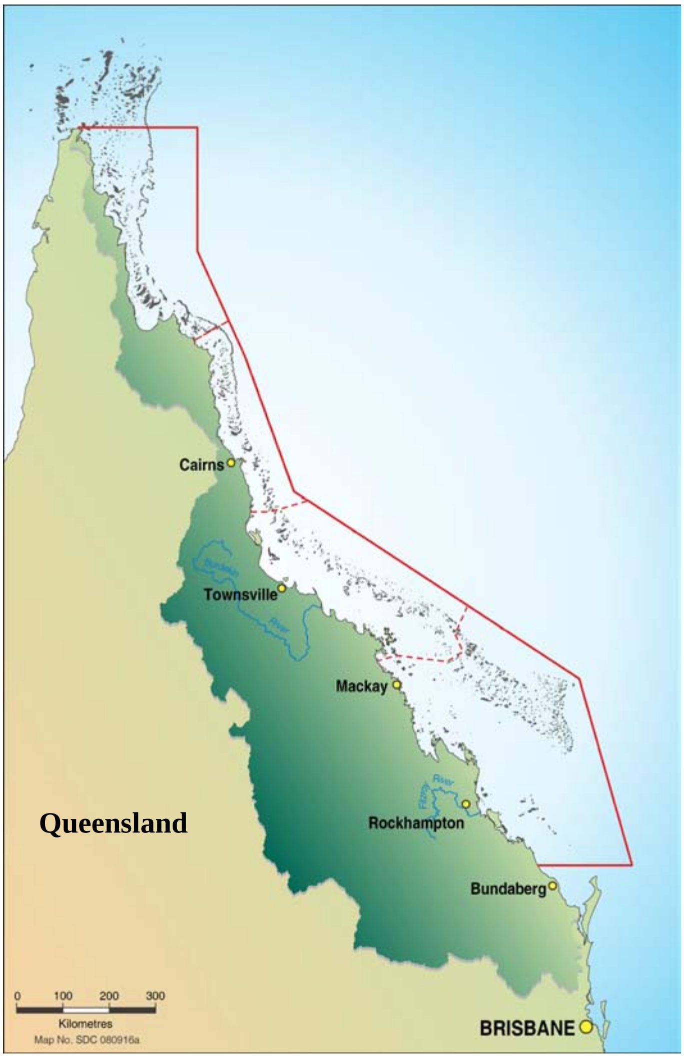
The Australian and Queensland Governments have been investing significant effort to avoid current and future declines in condition of the GBR. Examples of increased protection measures include the increase in conservation zones to 33% of the reef in 2004, on-going measures to reduce commercial fishing in the reef, the Reef Rescue program to improve water quality entering the reef lagoon, and proposals to limit the emissions of greenhouse gases. These initiatives have public and private costs, so a key policy issue is to identify whether the benefits of increased protection measures outweigh the level of costs incurred. This type of economic analysis can also help to determine if there are additional benefits to be gained from further investment in protection measures.

Specialist non-market valuation techniques are required to assess the community or public benefits of increased protection measures. Additional protection of the GBR will generate some direct benefits for people by maintaining recreation and fishing opportunities. As well, there will be non-use benefits where people think it is important to preserve the reef without necessarily using or visiting it, and indirect benefits such as maintenance of ecosystem services and regional communities. These different benefits can be estimated jointly with the application of techniques such as choice modelling (CM). These involve the presentation of contingent scenarios about future protection measures at different levels of cost to a random sample of households in the community of interest. The subsequent choices of preferred scenarios reveal community preferences for protection levels.

A major challenge in the application of the choice modelling technique to reef protection measures is to condense the important issues into scenarios that are relevant to the wider community. A key factor is the amount of the GBR that will remain in good condition into the future under different protection scenarios. The choice of policy mechanisms may also be important (Johnston and Duke 2007), with the level of support sometimes sensitive to measures such as controls over fishing or agricultural practices. The certainty associated with policy outcomes may also influence support levels (Roberts et al. 2008, Wielgus et al. 2009), with higher support expected for mechanisms that lead to larger, more certain and quicker improvements in reef protection.

The research reported in this paper involved a series of choice modelling applications to valuing improved protection of the GBR. A sample of households in Brisbane, the state capital, have been surveyed to generate estimates of willingness to pay (WTP) for increased protection of the GBR and to test how those values may be sensitive to different policy options and outcome certainty. The paper is structured as follows. Previous literature is reviewed in the next section, followed by a description of the design of the choice modelling experiment in section three. Results are provided in section four, and discussion and conclusions follow in the final section.

Figure 1. Great Barrier Reef



Source: Great Barrier Reef Marine Park Authority

2. Previous studies

There is a very small pool of economic valuation studies for the GBR. Most economic studies have focused on the value of commercial activities associated with the GBR and the commercial impacts that changes in condition would generate (e.g. Driml 1994, Access Economics 2008). These approaches are not suitable for inclusion in cost-benefit analysis, as they do not measure economic values, do not include the value of non-market impacts, and are typically one year snapshots (Oxford Economics 2009). It is more appropriate to use a Total Economic Value (TEV) approach, where economic valuation methods are used to identify how much people would be willing to pay to visit and to protect the reef and to preserve it for future generations (Oxford Economics 2009).

The focus of the limited pool of valuation studies has been to estimate values for recreation activities, and the sensitivity of those values to future changes in environmental conditions. The travel cost method has been used to estimate values for recreation use (e.g. Hundloe et al. 1987 (reported in Driml 1994), Carr and Mendelsohn 2003, Kragt et al. 2009) and recreational fishing (e.g. Blamey and Hundloe 1993, Prayaga et al. 2010). Consumer surplus estimates per visitor vary from $166 per trip for fishing (Prayaga et al. 2010) and $184 per trip for diving (Kragt et al. 2009) to $600 - $1500 for all activities (Carr and Mendelsohn 2003). Both Kragt et al. (2009) and Prayaga et al. (2010) also report contingent behaviour models where future reductions in environmental conditions and recreation experiences would significantly reduce visitation rates and recreation values.

There is a smaller pool of studies that report non-use values for protection of the GBR. Hundloe et al. (1993) report the use of a contingent valuation survey to estimate non-use protection values held by the national population at $62.3 Million in 1986 dollars. Windle and Rolfe (2005) estimated values for a 1% improvement in the health of a local inshore area of the GBR (the Fitzroy estuary) to be an average of $3.21 per household per year (in 2003 dollars). In the absence of any more accurate or recent studies, Oxford Economics (2009) combined and extrapolated the results of Hundloe et al. (1993) and Windle and Rolfe (2005) to estimate non-use values of $15.2 Billion for the GBR as a whole. However this estimate is unlikely to be useful for policy purposes because of the dated source studies, the large number of assumptions involved in the extrapolation of values, and the focus on estimating the total rather than marginal value of the GBR.

The current study is designed to address the gap in non-use values for the GBR in four important ways. First, it avoids some of the technical issues that limited the application of the Hundloe et al. (1987) results (Oxford Economics 2009). Second, it utilises a range of more recent developments in non-market valuation techniques, including the application of the choice modelling technique. Third, it focuses on estimating values for marginal improvements in protection measures so that results are more useful for future policy evaluation. Fourth, it incorporates information about policy management and outcome uncertainty into the valuation experiment to make the tradeoffs and subsequent values more relevant to the current policy situation.

3. The choice modelling case study

The CM technique requires respondents in a survey format to choose a single preferred option from a set of a number of resource use options (Bennett and Blamey 2001). The economic theory underlying CM assumes that the most preferred option yields the highest utility for the respondent (Louviere et al. 2000; Bennett and Blamey 2001). The options presented to respondents use a common set of underlying attributes that vary across a set number of levels. The variation in the levels of attributes differentiates the options to respondents. By offering the combinations of attributes and levels in a systematic way through the use of an experimental design, the key influences on choice can be identified.

3.1 Selection of labels, attributes and levels

The main aim of the research reported in this paper was establish whether protection values for the GBR varied according to the type of management option implemented to achieve improvements. Pressures impacting on the condition of the GBR were identified as coming from three main sources (GBRMPA 2009):

- Land-based activities: Poor water quality comes mainly from agriculture, as well as from urban and industrial activities (Furnas 2003; Haynes et al. 2007; GBRMPA 2008).
- Ocean-based activities: These include the impacts of tourism, recreational use, fishing, and shipping (Hoegh-Guldberg 2008, GBRMPA 2009).
- Natural events and climate change: This includes natural events, such as major flooding and cyclones and other events such as coral bleaching and outbreaks of the crown-of-thorns starfish. Climate change may lead to increased frequency of some events (Lough 2007, Garnaut 2008).

To reflect these pressures, three management options were included as labelled alternatives in the choice sets:

- improve water quality;
- increase conservation zones (within the GBR); and
- reduce greenhouse gas emissions.

The use of labelled alternatives allowed respondents to choose a preferred one when selecting potential protection measures for the GBR. There were a total of four policy alternatives offered in each choice set (Figure 2). The first was a constant base depicting the amount of the GBR expected to be in good condition in 25 years time under current policy settings and with no additional investment. Based on the predictions of Wolanski and De'ath (2005), Lough (2007) and Garnaut (2008) this was set at 65% of the GBR, down from approximately 90% in current times (Wolanski and De'ath 2005, GBRMPA 2009), The other labelled alternatives provided scenarios where protection of the GBR could be improved through additional investment.

Two key attributes were initially used in the choice sets to show the differences between the policy alternatives. The first described the amount of the GBR in good condition, using both percentage and area terms to convey the information. The second showed the level of cost associated with each improvement option, with the cost to be incurred annually for five years. A general payment vehicle was used where money could be paid through:

- increased taxes by Commonwealth or State governments,
- higher rate payments to local councils,
- higher prices for goods and services as farmers and businesses meet tighter environmental standards.

The inclusion of policy management options as labelled alternatives in the choice sets complicates the depiction of scenarios because the extent, timing and certainty of outcomes can be expected to vary across management options. This has been addressed in three important ways in this experiment. First, an additional attribute to represent the certainty of outcomes occurring has been added to the choice profiles to help distinguish between the policy alternatives. Inclusion of this attribute provides the additional advantage of assessing the value of improving outcome certainty. Second, respondents were provided with framing information about the time involved to generate improvements, with *Increasing Conservation Zones* delivering benefits within 3 – 5 years, *Improving Water Quality* delivering benefits within 10 – 15 years, and *Reducing Greenhouse Gas Emissions* delivering benefits after more than 25 years. Third, the levels used to describe each attribute in the choice sets were tailored to the management alternatives, (see Table 1 for details) as follows:

- improve water quality (WQ)

- o medium levels of improvement in GBR CONDITION
  - o medium levels of CERTAINTY
  - o medium levels of COST
- increase conservation zones (CZ)
  - o lower levels of improvement in GBR CONDITION
  - o higher levels of CERTAINTY
  - o lower levels of COST
- reduce greenhouse gases (GG)
  - o higher levels of improvement in GBR CONDITION
  - o lower levels of CERTAINTY
  - o higher levels of COST

Designing the experiment in this way allowed the potential outcomes of the different alternatives to be summarised in a realistic way. For example, increasing conservation zones was an option that could generate improvements with high certainty at relatively low cost, but only limited gains were possible. In contrast, reducing greenhouse gas emissions has more potential to make larger improvements to the protection of the GBR, but is associated with higher cost and lower levels of certainty. The constant base option was assigned a certainty level of 80% to reflect the reality that this was only a prediction of the future outcome.

3.2 Experimental design and survey collection details

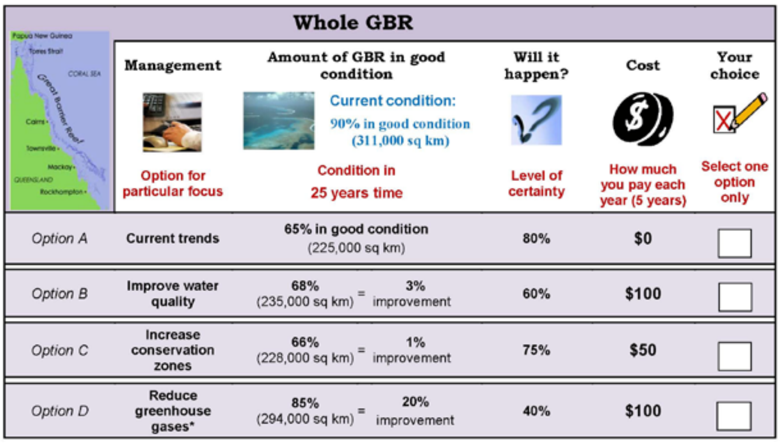
To test how the labelled alternatives might influence choice processes, a split-sample experiment was used with another unlabelled version of the survey collected at the same time. Both versions of the survey were identical apart from the labels in the choice sets. The assignment of attributes and levels across the different alternatives for both split samples is summarised in Table 1, while an example of the choice sets is shown in Figure 2.

Table 1. Attribute levels for choice alternatives

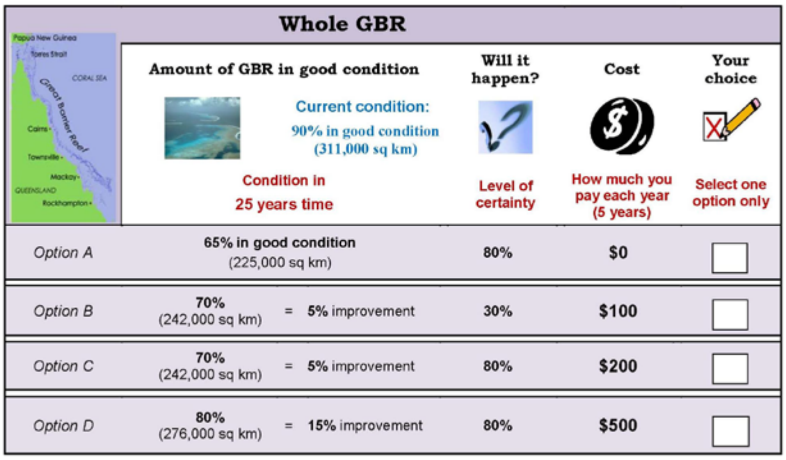
	Amount of GBR in good condition[1,2]	Will it happen? Level of certainty	Cost
Option A Current trends	65% (225,000 sq km)	80%	$0
Option B Improve water quality	68%, 72%, 76% (235,000, 249,000, 263,000 sq km)	50%, 60%, 70%	$50, $100, $200, $300
Option C Increase conservation zones	66%, 68%, 70%, (228,000, 235,000, 242,000 sq km)	75%, 80%, 85%	$20, $50, $100, $200
Option D Reduce greenhouse gases	75%, 80%, 85% (259,000, 276,000, 294,000 sq km)	10%, 20%, 40%	$100, $200, $300, $500
Unlabelled version Options B-D	70%, 75%, 80% (242,000, 259,000, 276,000 sq km)	30%, 60% 80%	$50, $100, $200, $500

[1] Amounts were presented in both percentage and absolute terms in the choice sets.
[2] The current situation was presented as 90% of the GBR being in good condition

Figure 2. Example choice sets



Whole GBR						
	Management Option for particular focus	Amount of GBR in good condition Current condition: 90% in good condition (311,000 sq km) Condition in 25 years time	Will it happen? Level of certainty	Cost How much you pay each year (5 years)	Your choice Select one option only
Option A	Current trends	65% in good condition (225,000 sq km)	80%	$0	
Option B	Improve water quality	68% (235,000 sq km) = 3% improvement	60%	$100	
Option C	Increase conservation zones	66% (228,000 sq km) = 1% improvement	75%	$50	
Option D	Reduce greenhouse gases*	85% (294,000 sq km) = 20% improvement	40%	$100	



Whole GBR					
	Amount of GBR in good condition Current condition: 90% in good condition (311,000 sq km) Condition in 25 years time	Will it happen? Level of certainty	Cost How much you pay each year (5 years)	Your choice Select one option only
Option A	65% in good condition (225,000 sq km)	80%	$0	
Option B	70% (242,000 sq km) = 5% improvement	30%	$100	
Option C	70% (242,000 sq km) = 5% improvement	80%	$200	
Option D	80% (276,000 sq km) = 15% improvement	80%	$500	

An experimental design is used to assign the levels to choice profiles in a CM application. An efficient design process over several stages was used in this experiment to maximise design efficiency. A test survey was initially run with focus group participants to develop a set of priors for each attribute. This was then used to create an efficient design using ©Ngene software. Once half the surveys had been collected, the data was analysed and the updated priors were then used to generate a new design for the second stage. The design for the labelled version had a D efficiency of 0.0035 and 0.00064 in the first and second rounds respectively. No improvements were required in the unlabelled survey version and the same design (D efficiency of 0.00019) was applied in both rounds.

The experimental designs required 12 choices sets to be collected. To avoid respondent fatigue, the designs were blocked into two sets so that each respondent was assigned a random block of six choice sets. The choice sets were contained within a questionnaire which included questions about the use and attitudes towards the GBR, framing information about the survey, the series of choice sets, followup questions, and requests for socio-demographic characteristics of respondents. The questionnaire and framing of the choice tradeoffs were developed with the aid of a series of focus groups held in Brisbane. The framing information reminded respondents that:

- The link to reduced impacts of climate change will depend on international reductions, not just reductions made by Australia.

- The benefits of reducing greenhouse gas emissions may be wide ranging and they should consider only the benefits for the GBR.

Both drop-off and collect and online (internet panel) collection methods were used in the main survey, with the latter method used exclusively in the last round of survey collection. The paper based surveys were collected to provide a check on the accuracy of the online responses. The survey was collected in Brisbane, the state capital, between August and December 2009.

3.3 Respondent characteristics

A total of 415 surveys were collected, including 160 online surveys and 92 drop-off and collect for the labelled split sample, and 162 online surveys for the unlabelled split sample. The paper-based survey yielded a high response rate of 91%. It was more difficult to estimate response rates for the online survey because of the two rounds of survey collection, several experiments being conducted concurrently, and the use of age and gender quotas. In the second round, emails were sent to 21,288 panelists and 2466 people (15%) responded before the target sample size was attained and the survey closed. After incomplete responses and quota effects were considered, a total of 1012 surveys were collected, giving an effective response rate of 5%. Only 16% of the online surveys were relevant to the two split sample experiments reported in this paper.

The socio-demographic characteristics of survey respondents were well aligned with those of the population (Table 2), apart from education levels which were higher for the sample than the population. There were also fewer people represented in the highest income category as well as the highest age category compared with the population.

Table 2. Respondent characteristics

		Survey sample	Population (ABS 2006 census)
Gender	Female	54%	50%
Children	Have children	68%	n/a
Age	18-29 years	20%	24%
	30-45 years	34%	31%
	46-65 years	35%	30%
	66-89 years	11%	16%
Average age	Details for online only	44 years	43 years
Education	Post school qualification	62%	56%
	Tertiary degree	35%	24%
Income	less than $499 per week	14%	17%
	$500 – $799 per week	23%	18%
	$800 – $1199 per week	22%	21%
	$1200 – $1999 per week	27%	24%
	$2000 or more per week	14%	21%

A third of respondents (35%) had never visited the GBR; with 25% having visited only once and 40% had visited it more than once. About 22% of respondents had been fishing on the GBR. The majority of respondents intended to visit the GBR in the future with 80% planning to visit the GBR in the next 5 years. About 26% thought they would visit the GBR in the next year, and 47% thought they would visit at least once in the next 5 years.

The majority of respondents (72%) thought the condition of the GBR had declined over the past 10 years and only 2% thought the condition had improved. This confirms that the framing of the choice experiment in terms of declining future condition under current policy settings is likely to be appropriate for the survey respondents.

4. Results

In this section the influence of the different management options is examined, first in terms of the outputs from the choice models and then in relation to other attitudinal data collected in the surveys.

4.1 Valuing improvements in environmental condition

The CM experiment was designed to value improvements in the environmental condition of the GBR in the next 25 years and to examine the influence of changes in management policy scope on those values. Models were developed to compare the results from the labelled and the unlabelled versions of the survey. Two versions of each model were generated according to whether the attribute levels for improved GBR condition were analysed in terms of the percentage values or absolute values. Details of the model variables are presented in Table 3.

Table 3. Model variables

Main variables	Description
Main attributes	
COST	Annual payment for a 5-year period
GBR CONDITION	Amount of GBR in good condition (% and absolute amounts)
CERTAINTY	Level of certainty that stated outcome will occur (%)
Management Options	Labelled alternatives
SQ…	Prefix to denote management option: Current situation
WQ…	Prefix to denote management option: Improve water quality
CZ…	Prefix to denote management option: Increase conservation zones
GG…	Prefix to denote management option: Reduce greenhouse gases
ASC	Alternative specific constant
Other variables	
AGE	Age in years. Only categorical details (see Table 1 for details) were collected in the paper survey. The mid point of each category was applied.
GENDER	Male = 0; Female = 1
CHILDREN	Children = 1; no children = 2
EDUCATION	Coded from 1= primary to 5 = tertiary degree or higher
INCOME	Categories 1-5 (see Table 1 for details). The mid point of each category was used for analysis with an additional 25% added to the last category.

The choice data were analysed with mixed logit (random parameter) models (Table 4). While the effects of collection mode were tested for the labelled model, they are not included in these results to maintain consistency with the unlabelled models. Little significant difference could be identified between the collection modes, supporting the results of Olsen 2009.

Table 4. Mixed logit models for labelled and unlabelled survey versions

	Model 1a. labelled % values		Model 1b. labelled Absolute values		Model 2a. unlabelled % values		Model 2b. unlabelled Absolute values	
Variables	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Random parameters in utility functions								
CERTAINTY	0.033	0.007	0.034***	0.007	0.043***	0.006	0.043***	0.006
Non Random parameters in utility functions								
SQ_ASC					1.436**	0.751	1.436*	0.751
COST	-0.005***	0.000	-0.004***	0.000	-0.004***	0.000	-0.004***	0.000
GBR CONDITION	0.100***	0.014	0.029***	0.004	0.058***	0.017	0.017***	0.005
AGE	-0.011**	0.005	-0.011***	0.005	-0.011	0.007	-0.011	0.007
GENDER	-0.347**	0.140	-0.347***	0.140	0.081	0.190	0.081	0.190
CHILDREN	-0.167	0.139	-0.167	0.139	-0.181	0.219	-0.181	0.219
EDUCATION	-0.224***	0.064	-0.224***	0.064	-0.332***	0.079	-0.332***	0.079
INCOME	-0.1E-5***	0.2E-6	-0.1E-5***	0.2E-6	-0.5E-6*	0.3E-6	-0.5E-6*	0.3E-06
WQ_ASC	-2.170***	0.593	-2.154***	0.592				
CZ_ASC	-2.546**	0.564	-2.532***	0.565				
GG_ASC	-3.358***	0.713	-3.322***	0.711				
Derived standard deviations of parameter distributions								
CERTAINTY	0.058***	0.006	0.0581***	0.006	0.058***	0.006	0.058***	0.006
Model statistics								
No of Observations	1500		1500		972		972	
Log L	-1755		-1756		-1161		-1161	
Halton draws	150		150		150		150	
Chi Sqrd	648		648		373		373	
McFaddon R--sqrd	0.1558		0.1558		0.1384		0.1384	

*** significant at 1%; ** significant at 5%; * significant at 10%

Only the CERTAINTY attribute was randomised in the mixed logit model as GBR CONDITION was not significant as a random variable in the unlabelled version. The socio-demographic variables were modelled to explain the choice of the status quo or base level option. The ASC constants were modelled with each management alternative in the labelled version and with the status quo option in the unlabelled model.

The results of the labelled and unlabelled models are compared in turn by the significance of the different variables and then the willingness-to-pay (WTP) estimates. Subsequently, more in-depth information is presented about the labelled version of the survey.

All models are significant (high chi squared values) and the three main attributes are all significant and signed as expected. Higher levels of GBR CONDITION and CERTAINTY and lower levels of COST are all preferred consistently across models. The significance of the derived standard deviations for CERTAINTY indicates there are high levels of preference heterogeneity. There is some difference in the significance of the socio-demographic variables in the two model versions suggesting that these variables may be more influential in the choice of different management options in the labelled version. The income variable always significant and signed as expected.

The willingness to pay estimates for the models were calculated as the ratio of each attribute coefficient to the price coefficient (Louviere et al. 2000, Bennett and Blamey 2001), with confidence intervals estimated with the Krinsky Robb (1986) procedure (Table 5). The results for the labelled model indicate the average household's willingness to pay for a 1% improvement in the condition of the GBR is $22.47 (each year for five years) or $6.42 for every 1000 sq km of improvement. The willingness to pay estimates are lower for the unlabelled version of the model ($14.32 for a 1% improvement). The higher values estimated when management options are included in the models suggest that people are more likely to support additional protection measures when they know how they will be implemented. However, the confidence intervals in the different models are overlapping for both the percentage and absolute value versions (Table 5) and a Poe et al. (2005) test confirms there is no significant difference in these WTP estimates between models at the 5% level of significance[1].

Table 5. WTP estimates for improvements in the condition of the GBR

	Labelled version		**Unlabelled version**	
	Per 1%	Per 1000 sq km	Per 1%	Per 1000 sq km
mean WTP	$22.47	$6.42	$14.32	$4.21
Lower CI	$15.85	$4.50	$4.42	$2.11
Upper CI	$29.87	$8.57	$20.03	$5.90

The extrapolation of these results to the broader Queensland community requires assumptions to be made about the relevant population and response rates. In 2006 the population of Queensland was 3,904,534 people with approximately 1,501,744 households, 53% of which were in Brisbane (ABS 2006). While it is likely that people living close to the GBR will have higher protection values, a conservative approach is to assume that all Queensland households have the same values as those elicited from the survey.

A further adjustment can be made by assuming that non-respondents to the survey had zero protection values, with extrapolation of that proportion across the population. However it is difficult to determine an accurate response rate to the survey as noted above. While response rates to the internet panel were low, results from the drop-off and collect survey suggest at least 90% of the population shared these protection values for the GBR.

Two extrapolation rates are applied in the following exercise, assuming that 75% or 100% of the population hold the same values as the random sample of respondents. The extrapolation applies household WTP values associated with the labelled and unlabelled models (Table 6). A 5% discount rate is used to determine the present values of the five year benefits assessed in the surveys. The results are presented in Table 6, indicating that the public values (of Queenslanders) for each 1% improvement in the condition of the GBR vary from $69.8 million to $146.1 million depending on which underlying assumptions are applied. The equivalent values for an improvement in a 1000 sq km range from $20.5 million to $41.7 million.

These benefit estimates imply that for the Queensland public to receive the full benefit of the $200 million invested in the Reef Rescue five year funding program, there would need to be between a 1.4% and 2.9% improvement in the condition of the GBR. Alternatively, an improvement over an area of between approximately 5,000 and 10,000 sq km would be required.

[1] The proportion of differences greater than zero was 0.035 and 0.049 for the percentage and absolute values respectively.

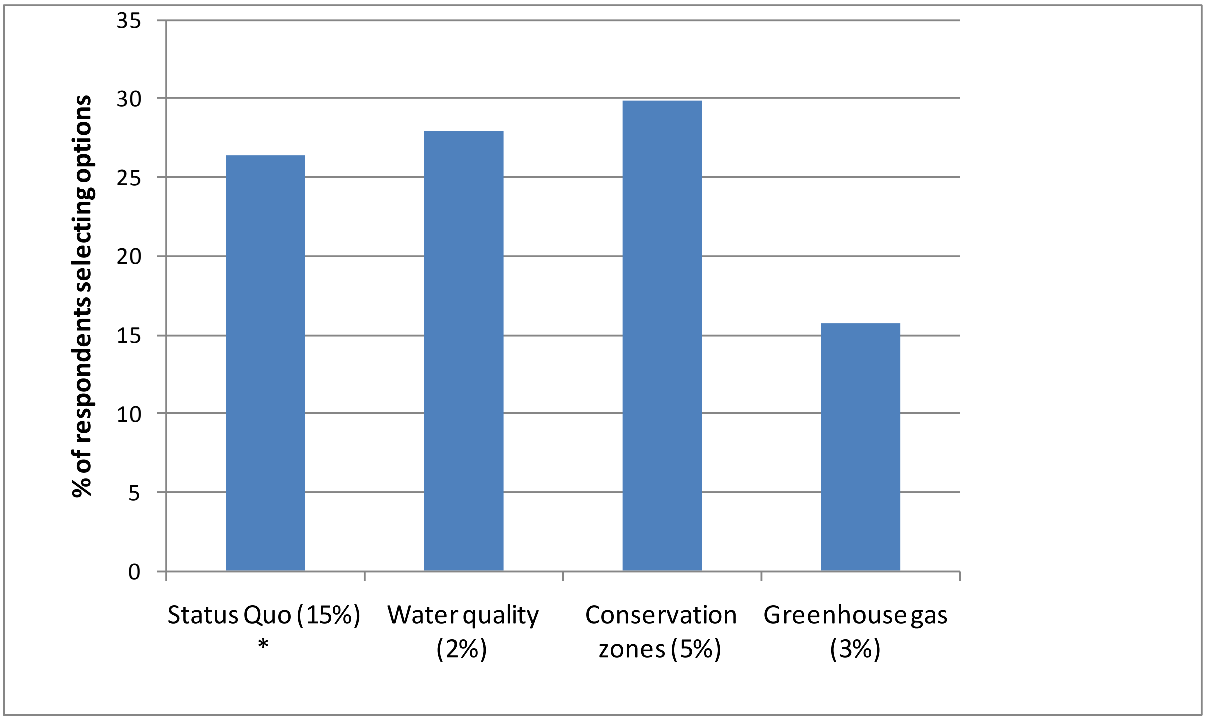
Table 6. The value to the Queensland public of improving the condition of the GBR

	Average household WTP per year	Annual WTP 75% of households	Present value (5 years)	Annual WTP 100% of households	Present value (5 years)
Each one per cent improvement					
Labelled version	$22.47	$25,308,138	$109,570,994	$33,744,184	$146,094,658
Unlabelled version	$14.32	$16,128,729	$69,828,956	$21,504,972	$93,105,274
Each 1000 sq km improvement					
Labelled version	$6.42	$7,230,897	$31,305,998	$9,641,195	$41,741,331
Unlabelled version	$4.21	$4,741,756	$20,529,323	$6,322,342	$27,372,430

4.2 Values associated with different policy management options

Each respondent answered six choice sets, with the pattern of answers summarised in Figure 3. The most frequently selected alternative was *Increasing Conservation Zones* and the least frequently chosen was *Reducing Greenhouse Gas Emissions*.

Figure 3. Management option selection in labelled survey



* Values in parenthesis are percentage of respondents who always selected the option

In the labelled models (Table 4), the three ASC constants associated with each management alternative are all significant and all negative, suggesting that respondents avoided selecting a particular labelled option. These influences were strongest for the greenhouse gas option and weakest for the water quality option.

The bias against selection of the *Reducing Greenhouse Gas Emissions* alternative may be because some people are sceptical about the connection between greenhouse gas emissions and the impact on climate change and the GBR. There has also been resistance from some sections of the community to the increase in conservation zones in the GBR. To further explore the structure of preferences across different management options, models have been developed with all three attributes modelled to each specific label (Table 7). In these models only the GBR CONDITION attributes were randomised.

Table 7. Mixed logit models with attributes specified for each management option

	% values			WTP	Absolute values (1000sq km)			WTP
Variable	Coefficient		S.E.		Coefficient		S.E.	
Random parameters in utility functions								
WQGBR CONDITION	0.2114	***	0.0327	26.01	0.0603	***	0.0094	7.42
CZGBR CONDITION	0.2900	***	0.0582	33.01	0.0828	***	0.0166	9.43
GGGBR CONDITION	0.0392		0.0281	8.72	0.0111		0.0080	2.48
Non Random parameters in utility functions								
AGE	-0.0115		0.0096		-0.0115		0.0096	
GENDER	-0.5880	**	0.2776		-0.5875	**	0.2776	
CHILDREN	-0.1761		0.2399		-0.1759		0.2399	
EDUCATION	-0.3253	**	0.1263		-0.3251	**	0.1263	
INCOME	-0.1E-5	***	0.4E-6		-0.1E-5	***	0..4E-6	
Management option: Improve water quality								
WQASC	-18.5792	***	2.3521		-18.3801	***	2.3280	
WQCOST	-0.0081	***	0.0008		-0.0081	***	0.0008	
WQCERTAINTY	0.0106		0.0117		0.0106		0.0117	
Management option: Increase conservation zones								
CZASC	-26.9426	***	4.0387		-26.6871	***	3.9953	
CZCOST	-0.0088	***	0.0020		-0.0088	***	0.0020	
CZCERTAINTY	0.0537	**	0.0230		0.0538	**	0.0230	
Management option: Reduce greenhouse gases								
GGASC	-7.3523	***	2.5661		-7.2845	***	2.5381	
GGCOST	-0.0045	***	0.0007		-0.0045	***	0.0007	
GGCERTAINTY	-0.0015		0.0077		-0.0015		0.0077	
Derived standard deviations of parameter distributions								
WQGBR CONDITION	0.0369	***	0.0034		0.0107	***	0.0010	
CZGBR CONDITION	0.0339	***	0.0029		0.0098	***	0.0008	
GGGBR CONDITION	0.0365	***	0.0035		0.0106	***	0.0010	
Model statistics								
No of Observations	1500				1500			
Log L	-1556				-1556			
Halton draws	150				150			
Chi Sqrd	1047				1047			
McFaddon R--sqrd	0.2518				0.2517			

*** significant at 1%; ** significant at 5%; * significant at 10%;

There are three important results to note in these models. First, the ASC (constant) values associated with each labelled alternative are much higher than when the attributes are specified generally across alternatives (Table 4). This means that the levels of the different attributes were closely related to the preferences for the different management policy options. It is likely that preferences for GBR CONDITION had the most influence as the strength of avoidance is inversely related to the levels of GBR improvements.

Second, the significance of the main attributes varies with the different labelled options. In all options, COST is a significant influence on choice selection. GBR CONDITION is highly significant for both *Improving Water Quality* and *Increasing Conservation Zones* options, but not significant for the *Reducing Greenhouse Gas Emissions* option. The standard deviations for the random parameter estimates (GBR CONDITION) are highly significant for all three options, indicating the presence of considerable preference heterogeneity. The different coefficient values for GBR CONDITION (modelled in percentage values) indicate that the management options did influence preference selection. Preferences were strongest for improvements in the condition of the GBR achieved by increasing the area of conservation zones. These preferences were 37% stronger than improvements gained from improving water quality and seven times greater than improvements made from reducing greenhouse gas emissions.

Third, the WTP estimates calculated from the models are highest for improvements coming from *Increasing Conservation Zones* and lowest from those coming from *Reducing Greenhouse Gas Emissions* (Table 8). However the range in the confidence intervals is also much higher for the *Increasing Conservation Zones* option, indicating greater variation in preferences and support than for *Improving Water Quality*. The lower bound WTP for *Reducing Greenhouse Gas Emissions* is negative, indicating there were some negative preferences for supporting this option. A Poe et al. (2005) procedure indicates that there was no significant difference in WTP for improvements from *Improving Water Quality* and *Increasing Conservation Zones*, but values for generating improvements from *Increasing Conservation Zones* were significantly higher at the 5% level than those from *Reducing Greenhouse Gas Emissions*.

Table 8 Management differences in WTP for improvement in GBR condition

	Improve water quality		**Increase conservation zones**		**Reduce greenhouse gases**	
	per 1%	*per 1000 sq km*	*per 1%*	*per 1000 sq km*	*per 1%*	*per 1000 sq km*
mean WTP	$26.01	$7.42	$33.01	$9.43	$8.72	$2.48
Lower CI	$17.82	$5.21	$16.02	$5.14	-$4.33	-$1.06
Upper CI	$34.73	$10.14	$70.02	$19.19	$24.37	$6.62

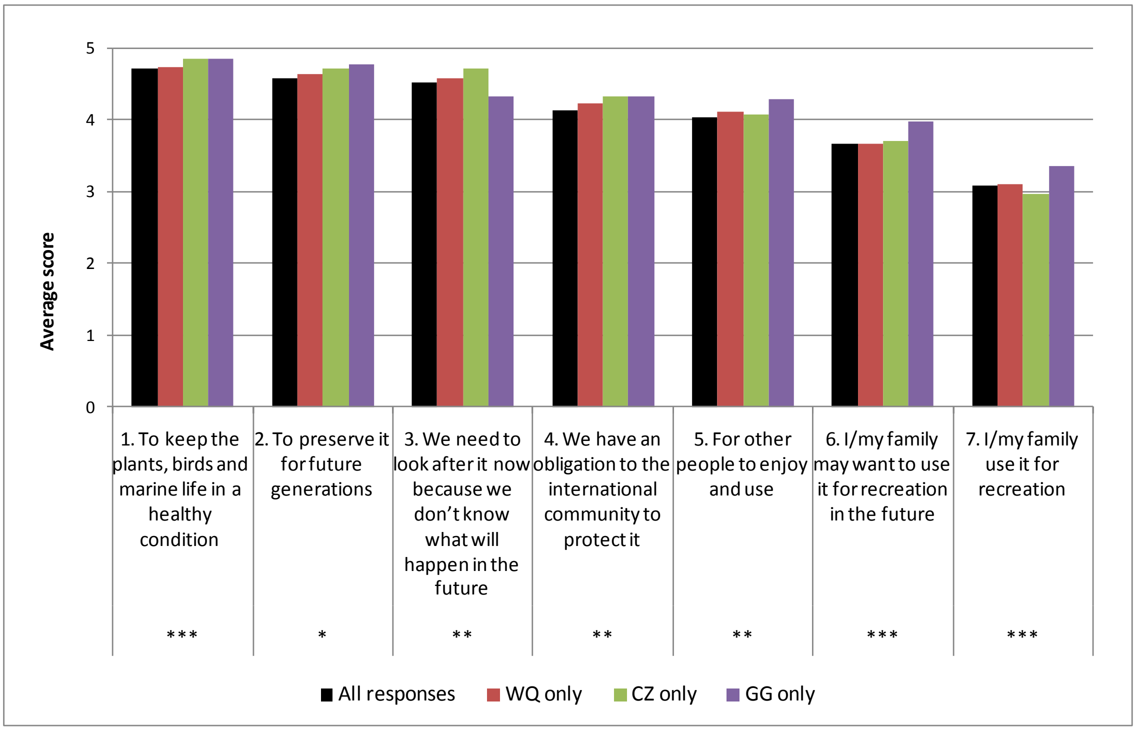
4.3. Prioritising different elements and management options

The simplified approach of the CM experiment does not reveal how respondents might prioritise different characteristics and specific management options for the GBR. To identify further information on how values may be disaggregrated, a series of attitudinal questions in the survey collected information on other preferences. Each question involved respondents rating a series of statements from (**1**) NOT important to (**5**) VERY important, with the results summarised in the figures below. The results are shown in terms of both average scores and averages for those who selected each of the three management options separately. Full details of all scores are presented in Tables A1-A4 in the appendix.

The first group of statements explored the importance of different components of economic value for supporting protection of the GBR (Figure 4). The statements receiving highest support was focused on existence values, bequest values and option values, the core elements of non-use values. The statements receiving lower (but still important) support levels were for current and future recreation use values.

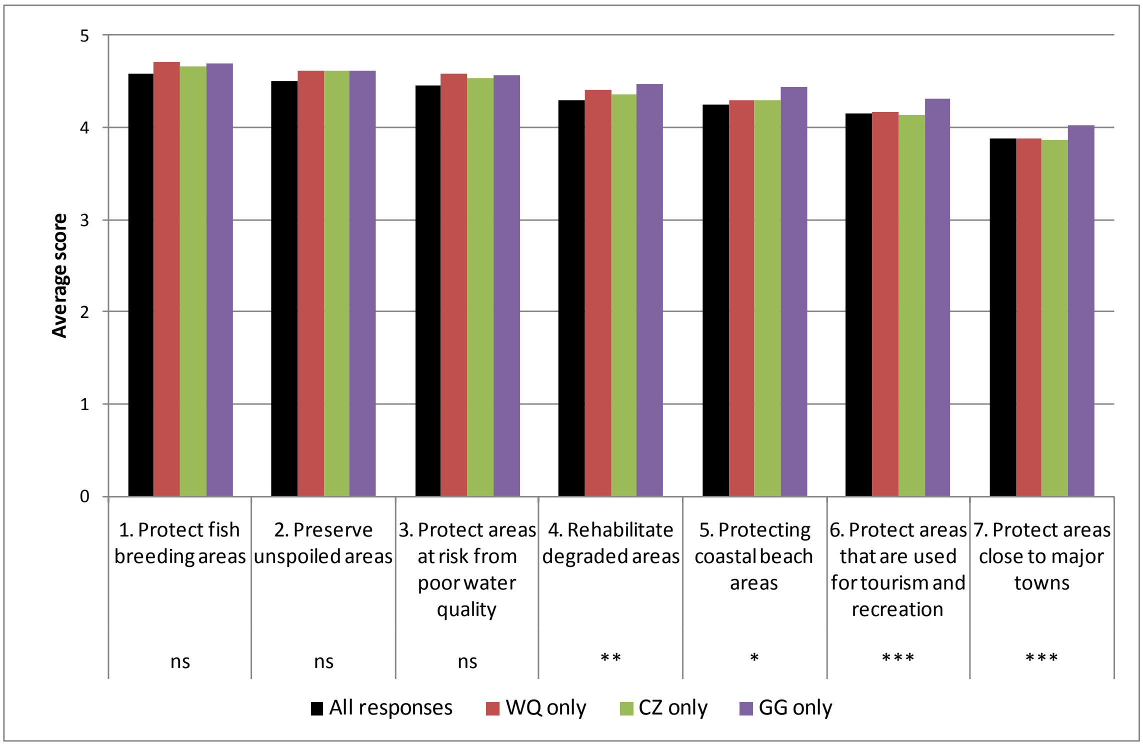
Respondents were also asked to rate statements about the importance of different areas in the GBR (Figure 5).

Figure 4. The relative importance of different reasons to support protection off the GBR



*** significant difference (Pearson chi-squared crosstab) between scores for the three management options at 1%; ** =5% and *=10%; ns= no significant difference

Figure 5. The relative importance of different areas in the GBR to protect

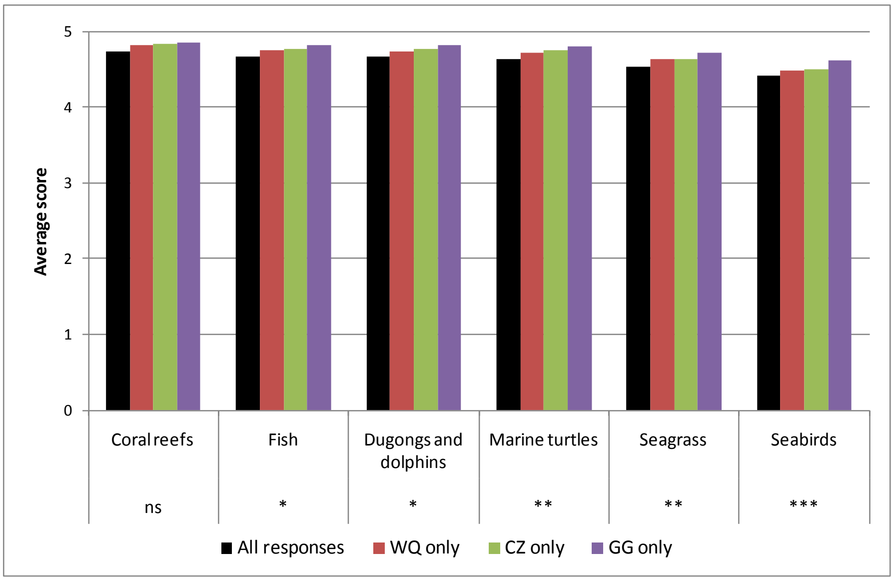


*** significant difference (Pearson chi-squared crosstab) between scores for the three management options at 1%; ** =5% and *=10%; ns= no significant difference

Results show that there was little difference in the categories offered, with fish breeding and unspoilt areas rated most highly, and areas close to major towns and used for recreation and tourism rated of lower importance. This confirms that non-use values appear to be of higher importance than use values in setting protection priorities.

When respondents were asked to prioritise between key groups of plants and animals relating to the GBR, little difference in ratings could be identified (Figure 6). All of the nominated plants and animals received consistently high ratings, with coral reefs receiving slightly higher support.

Figure 6. The relative importance of protecting different plants and animals in the GBR



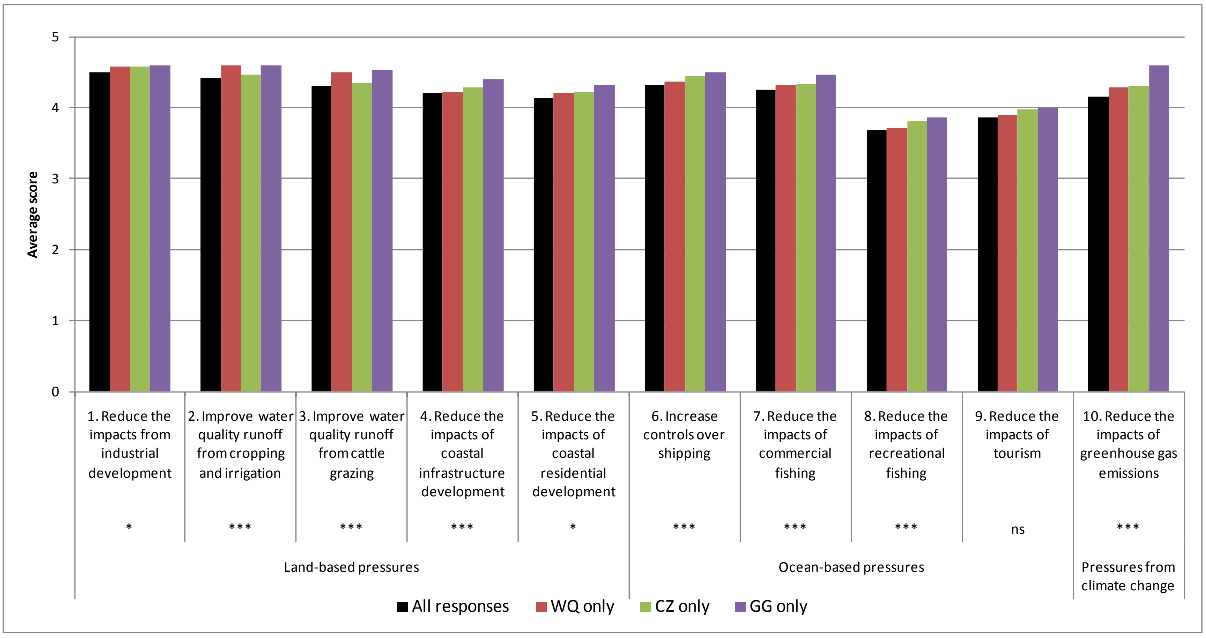
*** significant difference (Pearson chi-squared crosstab) between scores for the three management options at 1%; ** =5% and *=10%; ns= no significant difference

In the last group of questions, the statements focused on potential management actions to reduce pressures on the GBR (Figure 7). The list of actions concentrated on the three main areas of pressure associated with the different management options; land-based pressures, ocean-based pressures and pressure form climate change, (these categories were not shown with the statements). There was very little difference in preferences between different control actions, with the highest scores given for reducing the impacts from industrial developments, improving water quality runoff from cropping and irrigation, and increased controls over shipping. The lowest support was for reducing the impacts of recreational fishing.

As with the other group of questions, respondents choosing the *Reducing Greenhouse Gas Emissions* options in the choice sets generally gave higher scores than those selecting other management options. Otherwise, the selectors of the different management option were generally consistent in their attitudes. The respondents choosing the *Improving Water Quality* options in the choice sets gave high scores for the two water quality actions (no 2 and no 3). All respondents rated improvements in water quality from cropping and irrigation as more important than improvements from cattle grazing. Respondents choosing *Increasing Conservation Zones* in the choice sets had higher rating scores for all the ocean based activities, while those selecting the *Reducing Greenhouse Gas* options gave the highest ratings for action 10 to reduce emissions.

These results suggest that while there are significant values held by Queensland households for the protection of the GBR, they do not distinguish greatly between different elements for protection within the iconic asset.

Figure 7. The relative importance of different actions to reduce pressures on the GBR



*** significant difference (Pearson chi-squared crosstab) between scores for the three management options at 1%; ** =5% and *=10%; ns= no significant difference

5. Discussion and conclusions

The results of the choice modelling application presented in this paper demonstrate that households in the Brisbane population have significant values for protection of the Great Barrier Reef. The average household willingness to pay for each additional 1% of protection is approximately $22.50 when the broad management options to generate improvements were included in the choice sets. These results can be extrapolated to a total value of $110M to $146M per 1% improvement, depending on the assumptions used about the relevant population and survey participation rate. These results fill a significant information gap, and will help policy makers to evaluate the costs of proposed protection programs against the value of potential benefits generated.

There is some indication that information about the management policies used to achieve environmental outcomes may be a significant influence on value estimates. The results of this study demonstrate that including broad management policies as labelled alternatives in the choice sets generated significant coefficients for the alternatives and increased part-worths for the GBR CONDITION attribute by 57%. However, tests indicated there was no significant difference between these estimates.

The labelled format also allowed an insight into how preferences and values varied between the different management options. The value of improvements generated through *Increasing Conservation Zones* was slightly but not significantly higher than those for *Improving Water Quality*. However, there was a much wider range of values associated with *Increasing*

Conservation Zones, indicating greater variation in support for this option. In contrast, the value of improvements through *Reducing Greenhouse Gas Emissions* was significantly lower, as well as generating some opposition from the sample respondents.

The methodology used in this experiment is encouraging for future applications of the CM technique. The use of management policy labels to help make the choice tradeoffs more realistic to respondents had a significant influence on choice processes and subsequent values. Labelling the choice alternatives and providing additional information about management options did not appear to make the choice exercise too difficult (even though attribute levels varied across the different options) and did not appear to distract respondents' attention away from their consideration of the primary attribute values.

The experiments also demonstrate that the certainty of outcomes is a significant influence on choice, with results indicating that there was a value of between $7.42 and $10.39 for each 1% increase in certainty. The part-worths for increasing certainty were lower in the labelled experiment than the unlabelled experiment, indicating that the extra information about the policy options to improve reef protection made respondents more comfortable to select protection options. When certainty was modelled against each management option it was only significant for the conservation zone management option where the certainty values were the highest. The results build on the recent work of Roberts et al. (2008) and Wielgus et al. (2009) to confirm that information about the certainty of outcomes may be an important influence on preferences and values.

Including management policy options as labels in choice experiments comes with some challenges. The application in this experiment involved the addition of a CERTAINTY attribute, the tailoring of attribute levels to choice alternatives in the experimental design, and the addition of other background information. While the results show that these steps have been important in representing the policy situation more accurately in the experiment, further research will be needed to make this a standard framing method in choice experiments.

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Table A1. Importance of reasons to support environmental protection of the GBR

Score from (**1**) NOT important to (**5**) VERY important**.**	**Mean score all respondents (n=415)**	**SQ selected responses**	**WQ selected responses**	**CZ selected responses**	**GG selected responses**	**Sig diff 3 mngt options[1]**
1. To keep the plants, birds and marine life in a healthy condition	**4.71**	4.47	4.73	4.84	4.85	***
2. To preserve it for future generations	**4.57**	4.26	4.63	4.71	4.77	*
3. We need to look after it now because we don't know what will happen in the future	**4.51**	4.14	4.58	4.71	4.32	**
4. We have an obligation to the international community to protect it	**4.13**	3.73	4.23	4.33	4.32	**
5. For other people to enjoy and use	**4.04**	3.81	4.11	4.07	4.28	**
6. I/my family may want to use it for recreation in the future	**3.66**	3.42	3.67	3.70	3.98	***
7. I/my family use it for recreation	**3.08**	3.00	3.10	2.97	3.36	***

[1] significant difference (Pearson chi-squared crosstab) between scores for the three management options at; ***=1%; ** =5% and *=10%

Table A2. Relative importance of different areas in the GBR to protect

Score from (**1**) NOT important to (**5**) VERY important**.**	**Mean score all respondents (n=415)**	**SQ selected responses**	**WQ selected responses**	**CZ selected responses**	**GG selected responses**	**Sig diff 3 mngt options[1]**
1. Protecting fish breeding areas	**4.59**	4.35	4.71	4.66	4.70	
2. Preserving unspoiled areas	**4.51**	4.23	4.62	4.62	4.61	
3. Protecting areas at risk from poor water quality	**4.46**	4.21	4.58	4.54	4.57	
4. Rehabilitating degraded areas	**4.30**	4.02	4.41	4.36	4.47	**
5. Protecting coastal beach areas	**4.25**	4.06	4.30	4.30	4.44	*
6. Protecting areas that are used for tourism and recreation	**4.15**	4.05	4.17	4.14	4.31	***
7. Protecting areas close to major towns	**3.88**	3.80	3.88	3.86	4.02	***

[1] significant difference (Pearson chi-squared crosstab) between scores for the three management options at; ***=1%; ** =5% and *=10%

Table A3. Importance of reasons to support environmental protection of the GBR

Score from (**1**) NOT important to (**5**) VERY important**.**	**Mean score all respondents (n=415)**	**SQ selected responses**	**WQ selected responses**	**CZ selected responses**	**GG selected responses**	**Sig diff 3 mngt options[1]**
Coral reefs	4.74	4.49	4.82	4.84	4.86	
Fish	4.67	4.44	4.75	4.76	4.82	*
Dugongs and dolphins	4.67	4.42	4.74	4.77	4.82	*
Marine turtles	4.64	4.37	4.71	4.75	4.80	**
Seagrass	4.53	4.24	4.63	4.63	4.71	**
Seabirds	4.42	4.14	4.49	4.50	4.62	***

[1] significant difference (Pearson chi-squared crosstab) between scores for the three management options at; ***=1%; ** =5% and *=10%

Table A4. Importance of different management actions to reduce pressures on the GBR

Score from (**1**) NOT important to (**5**) VERY important**.**	**Mean score all respondents (n=415)**	**SQ selected responses**	**WQ selected responses**	**CZ selected responses**	**GG selected responses**	**Sig diff 3 mngt options[1]**
Land-based pressures						
1. Reduce the impacts from industrial development	**4.49**	4.25	4.58	4.58	4.60	*
2. Improve water quality runoff from cropping and irrigation	**4.41**	4.07	4.59	4.46	4.60	***
3. Improve water quality runoff from cattle grazing	**4.30**	3.95	4.49	4.35	4.53	***
4. Reduce the impacts of coastal infrastructure development	**4.20**	3.95	4.22	4.29	4.40	***
5. Reduce the impacts of coastal residential development	**4.14**	3.89	4.20	4.22	4.31	*
Ocean-based pressures						
6. Increase controls over shipping	**4.31**	4.03	4.36	4.45	4.49	***
7. Reduce the impacts of commercial fishing	**4.26**	4.01	4.32	4.33	4.46	***
8. Reduce the impacts of recreational fishing	**3.69**	3.44	3.72	3.82	3.86	***
9. Reduce the impacts of tourism	**3.86**	3.64	3.89	3.98	3.99	
Pressures from climate change						
10. Reduce the impacts of greenhouse gas emissions	**4.16**	3.66	4.28	4.30	4.59	***

[1] significant difference (Pearson chi-squared crosstab) between scores for the three management options at; ***=1%; ** =5% and *=10%