



National Environmental
Research Program

TROPICAL ECOSYSTEMS *hub*

Final Report

The Great Barrier Reef World Heritage Area: its 'value' to residents and tourists, and the effect of world prices on it



Natalie Stoeckl, Marina Farr, Diane Jarvis, Silva Larson, Michelle Esparon, Hana Sakata,
Taha Chaiechi, Hongbo Lui, Jon Brodie, Stephen Lewis, Putu Mustika, Vanessa Adams,
Adriana Chacon, Melissa Bos, Bob Pressey, Ida Kubiszewski and Bob Costanza



Australian Government
Department of the Environment

 Reef &
Rainforest
RESEARCH CENTRE

The Great Barrier Reef World Heritage Area: its 'value' to residents and tourists, and the effect of world prices on it

Final report

Natalie Stoeckl^{1,2}, Marina Farr^{1,2}, Diane Jarvis¹, Silva Larson¹, Michelle Esparon¹, Hana Sakata⁷,
Taha Chaiechi^{1,2}, Hongbo Lui¹, Jon Brodie², Stephen Lewis², Putu Mustika^{1,3}, Vanessa Adams⁸,
Adriana Chacon^{1,6}, Melissa Bos^{6,1}, Bob Pressey⁶, Ida Kubiszewski⁴ and Bob Costanza⁴

¹College of Business, Law and Governance and the Cairns Institute, JCU

²TROPWater, JCU

³School of Earth and Environmental Sciences, JCU

⁴Australian National University

⁵Great Barrier Reef Marine Park Authority

⁶ARC Centre of Excellence in Coral Reef Studies, JCU

⁷Formerly with College of Business, Law and Governance, JCU; now with University of Technology, Sydney

⁸University of Queensland



**Australian
National
University**



**Australian Government
Great Barrier Reef
Marine Park Authority**



Australian Government

Department of the Environment

Supported by the Australian Government's
National Environmental Research Program

Project 10.2 Socioeconomic systems and reef resilience

© JCU

National Library of Australia Cataloguing-in-Publication entry:
978-1-925088-49-6

This report should be cited as:

Stoeckl, N., Farr, M., Jarvis, D., Larson, S., Esparon, M., Sakata, H., Chaiechi, T., Lui, H., Brodie, J., Lewis, S., Mustika, P., Adams, V., Chacon, A., Bos, M., Pressey, B., Kubiszewski, I., Costanza, B. (2014). *The Great Barrier Reef World Heritage Area: its 'value' to residents and tourists Project 10-2 Socioeconomic systems and reef resilience*. Final Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns (68pp.).

Published by the Reef and Rainforest Research Centre on behalf of the Australian Government's National Environmental Research Program (NERP) Tropical Ecosystems (TE) Hub.

The Tropical Ecosystems Hub is part of the Australian Government's Commonwealth National Environmental Research Program. The NERP TE Hub is administered in North Queensland by the Reef and Rainforest Research Centre Limited (RRRC). The NERP Tropical Ecosystem Hub addresses issues of concern for the management, conservation and sustainable use of the World Heritage listed Great Barrier Reef (GBR) and its catchments, tropical rainforests including the Wet Tropics World Heritage Area (WTWHA), and the terrestrial and marine assets underpinning resilient communities in the Torres Strait, through the generation and transfer of world-class research and shared knowledge.

This publication is copyright. The Copyright Act 1968 permits fair dealing for study, research, information or educational purposes subject to inclusion of a sufficient acknowledgement of the source.

The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Australian Government or the Minister for the Environment.

While reasonable effort has been made to ensure that the contents of this publication are factually correct, the Commonwealth does not accept responsibility for the accuracy or completeness of the contents, and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the contents of this publication.

Cover photographs: M. Curnock

This report is available for download from the NERP Tropical Ecosystems Hub website:

<http://www.nerptropical.edu.au/research>

December 2014

Contents

List of Figures	v
List of Tables	vi
Acronyms Used In This Report.....	vii
Abbreviations Used In This Report	vii
Acknowledgements	viii
1 Introduction	1
1.1 Project overview and aims.....	1
1.2 Structure of report.....	2
2 Background to activities A and B	4
2.1 Identifying ‘benefits’ for assessment and appropriate valuation approaches.....	4
2.2 Development of the questionnaires.....	5
2.3 Data collection	8
2.3.1 Tourists	8
2.3.2 Residents.....	8
2.4 Overview of respondents and responses	9
3 Residential ‘values’	10
3.1 How do residents of the GBR catchment ‘benefit’ from the GBRWHA?	10
3.2 The link between resident activities and benefits.....	14
3.3 The total economic value of the GBR.....	17
3.4 The preservation value of the GBRWHA.....	20
3.5 Additional insights.....	22
3.5.1 Resident willingness-to-pay to protect the environment	22
3.5.2 Potential impact, on overall quality of life, of environmental degradation	24
4 Tourist ‘values’	26
4.1 The importance of the GBRWHA for destination competitiveness.....	26
4.2 The potential impact of reef degradation on the tourism industry	31
4.3 The potential impact of climate change on the tourism industry.....	34
4.4 Water clarity, visitor satisfaction and repeat visitation.....	36
4.5 Tourist willingness to pay for improvements in water quality.....	38

4.6	Additional insights.....	41
4.6.1	Visitor willingness to pay to reduce the risk of shipping accidents or to protect top predators	41
5	Do changes in world prices impact the GBRWHA?	44
5.1	Relationship between rainfall and river discharge in the Burdekin River Catchment....	44
5.2	Is there evidence to suggest that prices affect the GBRWHA?.....	45
6	Synthesis	47
7	Concluding remarks and recommendations	56
8	References.....	59
Appendix A: Project outputs		63
	Journal articles	63
	Papers in review.....	63
	Reports.....	63
	Book chapter	64
	Conference Papers.....	64
	Factsheets and presentations.....	64
	Data sets and maps submitted to e-atlas.....	64
Appendix B: Extra insights from research that was associated with this project		66
	Recreational fishing and boating in the Townsville Region	66
	Marine offsets for the GBRWHA	68

List of Figures

Figure 1: Interaction between people, economy and the environment.....	2
Figure 2: Structure of the report.....	3
Figure 3: Stated importance of and satisfaction with 18 community defined benefits associated with the GBRWHA, residents	11
Figure 4: Frequent vs. non-frequent participation in the GBR related activities	15
Figure 5: Resident perceptions of the Importance of 18 different benefits to their overall quality of life	18
Figure 6: Diagrammatic representation of the way in which various community defined benefits contribute to the overall quality of life of residents in the GBR catchment area – using correlation coefficients to group.....	19
Figure 7: Spatial differences across the GBR Natural Resource Management (NRM) regions – preservation effect is stronger in the north	21
Figure 8: Distribution of residents’ responses to questions about willingness to pay for environmental improvements.....	23
Figure 9: Residents’ stated response to hypothetical changes in the GBRWHA.....	25
Figure 10: Mean importance and satisfaction scores compared, tourists	27
Figure 11: Mean length of stay and potential % reduction in days for each respective change across regions.....	30
Figure 12: Visitor expenditure by category of expenditure and visitor segment (mean AUD, per visitor).	32
Figure 13: The potential loss in visitor expenditure from shorter stay (AUD per visitor per trip).33	
Figure 14: The relationship between overall trip satisfaction and average maximum daily temperatures.....	35
Figure 15: Distribution of responses to question about WTP to improve ocean water clarity	39
Figure 16: Importance, perceptions and WTP for water clarity improvement	40
Figure 17: Distribution of visitor responses to questions about willingness to pay (per person per trip) for environmental improvements.....	41
Figure 18: Impact of change in economic structure on values provided by GBRWHA - ‘Simulated’ finding	52
Figure 19: Linkages demonstrated within this report.....	56

List of Tables

Table 1: Community-defined benefits that were selected for assessment – the terms in brackets are the abbreviations used hereafter.....	7
Table 2: Variables used in subsequent analyses – descriptors and abbreviations	12
Table 3: Characteristics of respondents determining importance (IMP) and Index of dissatisfaction (IDS) scores for groups of values tested.....	13
Table 4: Characteristics of most frequent participants in the GBRWHA related outdoor activities	16
Table 5: Determinants of overall satisfaction with life and spatial differences between the regions.....	21
Table 6: Statistically significant relationships between various socio-economic and demographic descriptors of residents and their Willingness to Pay to protect the environment.....	24
Table 7: Additional variables used in subsequent analyses for tourists – descriptors and abbreviations.....	28
Table 8: Characteristics of respondents determining importance scores for groups of values tested using OLS.....	29
Table 9: Characteristics of business and non-business visitors who were likely to spend most ..	33
Table 10: Determinants of WTP to improve water clarity, to reduce the risk of shipping accidents and to protect top predators.....	42
Table 11: Characteristics of residents that had statistically significant relations with importance, satisfaction, reaction to hypothetical change (SUR model); and WTP (To pay or not to pay amount >\$0; and How much to pay (if agreed to pay >\$0) decisions)	53
Table 12: Characteristics of visitors that had statistically significant relations with importance, satisfaction, reaction to hypothetical scenarios (SUR model); and WTP (To pay or not to pay amount >\$0; and How much to pay (if agreed to pay >\$0) decisions)	54
Table 13: Characteristics of boaters, boat-fishers and land-fishers	67

Acronyms Used In This Report

AIMS	Australian Institute of Marine Science
ADF	Augmented Dickey-Fuller
AUS	Australian
AUD	Australian dollars
BOM	Bureau of Meteorology
CATPCA	Categorical Principal Component Analysis
CV	Compensating variation
DERM	Department of Environment and Resource Management
ES	Ecosystem services
EV	Equivalent variation
GBR	Great Barrier Reef
GBRCA	Great Barrier Reef Catchment Area
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
GIS	Geographical information systems
JCU	James Cook University
IDS	Index of Dis-Satisfaction
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LS	Life satisfaction
MTSRF	Marine and Tropical Sciences Research Facility
NERP	National Environmental Research Program
NRM	Natural Resource Management
OLS	Ordinary Least Square
PCA	Principal Component Analysis
PP	Phillips-Peron
SELTMP	Social and economic long term monitoring program
SUR	Seemingly unrelated regressions
QOL	Quality of life
QLD	Queensland
RRRC	Reef and Rainforest Research Centre Limited
TE	Tropical Ecosystems
VAR	Vector autoregression
WC	Water clarity
WTP	Willingness to pay
WTWHA	Wet Tropics World Heritage Area

Abbreviations Used In This Report

b	billion
HH	household
k	thousand
m	million
N	number of groups
nb	"note well"
vs	versus

Acknowledgements

This study was funded by the Tropical Ecosystems (TE) Hub, part of the Australian Government's Commonwealth National Environmental Research Program (NERP). The NERP TE Hub is administered in North Queensland by the Reef and Rainforest Research Centre Limited (RRRC). The NERP Tropical Ecosystem Hub addresses issues of concern for the management, conservation and sustainable use of the World Heritage listed Great Barrier Reef (GBR) and its catchments, tropical rainforests including the Wet Tropics World Heritage Area (WTWHA), and the terrestrial and marine assets underpinning resilient communities in the Torres Strait, through the generation and transfer of world-class research and shared knowledge.

We would like to acknowledge the invaluable contribution of all those who contributed their time to this project – responding to emails, reading through and commenting on questionnaires, participating in workshops, and sharing their knowledge and expertise with us. We would like to say a special thanks to David Barnes, John Bennett, Melissa Bos, Ron Birkett, Chris Briggs, Taha Chaiechi, John Courtenay, Ben Cropp, M C Dunning, Paul Fagg, Natalie Gomez, Margaret Gooch, Tony Ham, Jim Higgs, Katrina Houghton, Christina James, Diane Jarvis, Eddie Jebreen, Brigid Kerrigan, Milena Kim, Chris Kinnaird, Eline Kjoerven, Phil Laycock, Mark Lightowler, Judith Lynne, Joshua Maroske, Michelle Mayhew, Kirrily McInnes, Tim North, Peta Nott, Randal Owens, Deb Packman, Eric Perez, Richard Quincey, Amanda Riches, Doug Ryan, Bill Sawynok, Max Shepherd, Kym Sheridan, Hilary Skeat, Steve Sutta, Stephen Sutton, Amy Thompson, Michelle Thompson, Renae Tobin, Dominic Waddell, Alan Wallish, Sheena Walshaw, Lew Williams, Michelle Winning, and Peter Wood.

We also wish to extend our sincere appreciation to dozens of tourism operators (including airport managers) who helped us distribute the questions and to the thousands of anonymous visitors to the GBRWHA, the focus group participants, interviewees and hundreds of anonymous householders who took the time and effort to complete our survey – without such input the project could not have gone ahead.

Executive Summary

Background

- The project was developed in response to the Great Barrier Reef Marine Park Authority (GBRMPA)'s desire to develop a socio-economic monitoring program. This project is separate but complementary to Project 10.1 (SELTMP), providing additional economic data and modelling/analytical insights.
- There are a vast number of variables (or 'indicators') that could, potentially, be monitored. But monitoring is expensive. The key problem is thus to identify a set of relevant indicators, that are practical to monitor, and that provide one with information which will help meet one's goals/targets.
- The GBRMPA's primary goal is to protect the GBRMP and world heritage area - i.e. to promote reef resilience. So we need to monitor economic indicators that provide information about reef health/resilience. In some situations, it is relatively easy to discern the link between economic indicators and reef resilience, but not always: history abounds with examples of wealthy countries, businesses and individuals who have been environmentally destructive. Knowing that an economy is, or is not 'healthy', does not tell one whether the reef is at risk. To determine that, one needs a better understanding of the interaction between various parts of the economy, and the GBRWHA.

Aims, Objectives and Structure

- This project set out to collect economic data relevant to the GBRWHA and to explore the interaction between economic variables and biophysical variables thought to be related to reef resilience (e.g. indicators of water turbidity). Its overarching aim was to improve our understanding of the way in which the economy and the GBRWHA interact, making it easier to judge (a) which economic variables are most important to monitor, and (b) how to interpret trends in those variables (i.e. whether changes are likely to be 'good' or 'bad' for the reef).
- Operationally, the project comprised three interrelated activities, the specific objectives of which were to improve our understanding of:
 - (a) the 'value' of key ecosystem services (ES) that are provided by the GBRWHA to different groups of residents of the GBR catchment area (GBRCA);
 - (b) the 'value' of key ES that are provided by the GBRWHA to different groups of visitors to the GBRCA;
 - (c) the extent to which variations in beef prices and other socioeconomic variables (in conjunction with biophysical variables) influence water quality and thus (indirectly) reef resilience.

Simplistically, it is as if parts (a) and (b) provide us with information about the way in which the GBRWHA benefits people and the economy, whilst part (c) provides us with information about the way in which the economy affects the GBRWHA. Collectively, the project thus helps us learn more about the way in which the economic system interacts with the biophysical systems of the GBRWHA.

Methods – Activities A and B

- We conducted an extensive literature review, to identify key knowledge gaps. We found that most valuation studies of the GBR and/or the GBRWHA had concentrated on a narrow range of ecosystem services (mostly tourism and fishing), with only a few recent studies that had considered non-use values. No previous studies had explored a comprehensive range of different ecosystem services using a similar method – meaning that comparative information was not readily available. (See section 2.1)
- We ran workshops with a variety of regional stakeholders/managers/decision makers in Cairns, Brisbane and Townsville to (a) identify regionally relevant ‘values’ for assessment, and to (b) learn more about the issues confronting them and about how they hoped to be able to use the information generated from the project. (Section 2.1)
- Insights gleaned from the literature and workshops were used to develop draft questionnaires, which were tested in several different situations. Tourist questionnaires were also translated into Chinese and Japanese, so we were able to elicit the views of the majority of GBR tourists (most of whom are English speaking, with relatively large numbers of Mandarin and Japanese speakers in the Cairns/Port Douglas region). (Section 2.2)
- The questionnaires sought information about ‘values’ associated with the GBR, asking questions in a manner that would allow us to use a variety of different economic valuation techniques including, but not limited to: the contingent valuation method, expenditure and contingent behavior, Larson’s IDS and life/tourist satisfaction approaches. (Section 2.2)
- Questionnaires were mailed out to a geographically stratified random sample of residents of the GBR catchment during late 2012. Questionnaires were also distributed (in person) to tourists as far north as Port Douglas and as far south as Yeppoon at regular intervals between June 2012 and 2013 (to ensure the sample included visitors across all seasons). More than 30 tourism operators also helped distribute questionnaires by making them available (with pre-paid envelopes for return) to their customers. We received more than 1500 completed questionnaires from residents and more than 2700 from tourists. (Section 2.3)
- Data were summarized using descriptive statistics and geographical information systems (GIS). They were analysed using a wide variety of techniques including, but not limited to simple correlational coefficients, factor analysis, categorical principal components analysis, ordinary least squares regression, ordinal regression, geographically weighted regression, seemingly unrelated regressions, tobit, logit, and hurdle models (Section 2.4).

Methods – Activity C

- We undertook this investigation in two parts
 - First we collated rainfall and temperature data from Australia’s Bureau of Meteorology (BOM) and river discharge data from the Department of Environment and Resource Management (DERM) from 1939 to the present day in the Burdekin River catchment. We checked for ‘stationarity’ using the Augmented Dickey-Fuller (ADF) test, the Phillips-Peron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, finding it to be so. We then developed and compared several different time-series models explaining the rainfall-discharge relationships, selecting a model and modelling approach that did the ‘best’ job. (Section 5.1)

- Next we collated data on sediment loads (hind-cast using coral core samples), vegetation and land cover, cattle numbers, beef and gold prices, interest rates, wages, rainfall and extreme events for the Burdekin catchment between 1939 and the present day. The data were combined with data from the BOM and DERM within a Vector Auto Regression (VAR) model, so that we could look for evidence of a price 'signal' in sediment loads, after controlling for other factors (particularly rainfall and extreme events). (Section 5.2)

Key Findings from Activities A and B

- The non-market goods and services provided by the GBR (e.g. having healthy coral reefs, healthy reef fish, clear ocean water, and preserving the reef for future generations) are considered, by residents of the catchment, to be more important to their overall quality of life than recreational values (e.g. being able to go fishing, boating, or spending time at the beach). These recreational values are, themselves, considered to be more important than the jobs and incomes associated with different industries (Larson *et al.*, 2014a, 2014b). (Sections 3.1 & 3.2)
- Environmental and recreational values of the GBR are also considered, by tourists, to have been more important in their decision to visit the coastal area adjacent to the GBRWHA than other market-related 'values' such as good quality accommodation, being able to meet budget, visiting friends and relatives and/or attending to business (Esparon *et al.*, accepted). (Section 4.1)
- Residents and tourists react more negatively to the prospect of degradation of the environment than to the prospect of a 20% increase in prices (Stoeckl *et al.*, 2013; Esparon *et al.*, accepted; Mustika *et al.*, forthcoming). (Sections 2, 4.1 & 4.2)
- As such, our finding that GBR-based environmental values – particularly non-use values – are more important than market values appears consistent across sample groups (residents and tourists) and across methodological approaches (importance, satisfaction, IDS and contingent behavior).
- We generated estimates of several different 'total' values
 - Using novel approaches to control for the problem of inseparable values, we estimate that the collective value of all of the ecosystem services provided by the GBRWHA is likely to be worth at least \$15b per annum – possibly as much as \$20b (Stoeckl *et al.*, 2014). This figure is not implausible. The tourism industry is 'worth' in excess of \$4b per annum to residents of the catchment (Deloitte Access Economics, 2013), and our estimate of 'total' value includes tourism, recreational, cultural and other non-use values (all deemed to be at least, or 'more important' to the overall quality of life of residents than the jobs and incomes associated with reef-based tourism). (Section 3.3)
 - Using other novel approaches, we also generated estimates of the financial value of only non-use values: approximately \$7.5b (Jarvis *et al.*, in review). This is consistent with Stoeckl *et al.*'s (2014) finding that non-use values are worth a minimum of \$4b. (Section 3.4)
 - We found that total expenditure per visitor per trip was higher for non-business visitors than for business visitors (approximately to \$1,760 compared to \$1,290) – largely because they spent more time in the region. More than 60% of expenditure is on accommodation and food (at cafes, restaurants, and other retail outlets). (Mustika *et al.*, forthcoming). (Section 4.2)

- We also generated estimates of several different ‘marginal’ values.
 - We combined responses to our contingent behavior questions with information about tourist expenditure to generate estimates of the potential loss in visitor expenditure that could happen, should various types of environmental degradation occur. Using novel methods to control for hypothetical response bias, we estimate that these amounts could be up to \$300 per visitor, or about 17% of current expenditure (Mustika *et al.*, forthcoming). (Section 4.2)
 - After controlling for factors such as income, gender and length of stay, we found that tourists who experienced clearer water and/or maximum daily temperatures that were close to 29 degrees centigrade while in the region had higher levels of overall trip satisfaction than other tourists (Jarvis, forthcoming; Jarvis *et al.*, in review). We were able to use coefficients from our model with water turbidity, to generate estimates of the potential loss of tourism revenues that could occur if sediment increased by 10% (about \$400,000 annually across the entire GBR catchment area) – Jarvis *et al.*, (in review). (Sections 4.3 & 4.4)
 - We found that residents were willing to pay about \$32 per annum per household to help improve water quality, \$27 to reduce the risk of shipping accidents and \$29 to protect top predators per household per annum. For tourists these figures were \$14.5, \$15.5 and \$9 per person per visit, respectively. The amount people were willing to pay, however, was contingent upon ‘others paying too’ (respondents did not want to be the only person paying). In the case of water quality and tourists, the amount people were willing to pay also depended upon the importance of water quality to the respondent and upon their perceptions (not actual measures) of its quality (Farr *et al.*, 2014a). (Section 4.5)
- Averages aside, our results confirmed that different people ‘value’ things differently, finding consistent patterns across samples (tourists and residents) and methodological approaches. Most notably the relative importance of environmental non-use, recreational, and industry ‘values’ (assessed using importance scores, Larson’s IDS, contingent behavior and Willingness to pay (WTP) questions) differed for people of different gender, education, income (and, in contrast to expectations, this did not always have the same effect as education), ages, industries of association, places of origin/birth, places of residence/region being visited, and (to a lesser extent), marital status.

Key Findings from Activity C

- We found that between 1938 and 1983 (when the Burdekin dam was built), extreme events and cattle numbers had most impact on sediment loads. In this pre-dam model, beef and gold prices had a statistically significant impact on sediment loads, but the magnitude of these impacts was negligible. Wages did not have statistically significant influence on sediment loads. (Section 5.2)
- The full-period model shows more price (cost) sensitivity: in this model lower beef or higher gold prices and/or higher wage costs are all associated with lower sediment loads. Readers are cautioned that these results are an average of responses before and after the dam, so do not provide detailed information about what is likely to happen in the current (post-dam) era. But the fact that the full model (an ‘average’ of pre and post-dam reactions) shows more price sensitivity than the pre-dam model (larger, and more statistically significant

coefficients) indicates that land holders may be becoming more mindful of prices (and costs) over time. (Section 5.2)

Conclusions and recommendations

- Multiple lines of evidence suggest that residents of, and visitors to the GBRCA feel that environmental non-use values are more important, to their overall quality of life or as a 'draw-card' to the region, than recreational or market-based values. As such, developments or changes which degrade those values are likely to be met with some resistance.
- Changes in the environment have a real impact on people and on the decisions of people, which affects the broader economy.
 - Degradation of environmental values are likely to have real financial impacts in the tourism industry, with reductions in tourist satisfaction and hence less repeat visitation, reduced numbers of tourists visiting the region and/or tourists staying for shorter periods of time.
 - It is possible that reductions in aesthetic and/or recreational values could also have a financial impact on non-tourism related businesses (Chen and Rosenthal, 2008). A significant body of literature suggests that workers will trade-off wages for lifestyle, so businesses located within the GBRCA may be enjoying a wage 'discount', largely attributable to the regional environmental amenity and attractive 'lifestyle' offered to workers. Degradation of lifestyle values may mean that businesses need to pay workers higher salaries in compensation. Whether or not this is occurring in the GBR region is an issue worthy of further investigation.
- Multiple lines of evidence also suggest that different groups of people have different 'values'. There are many differences between individuals, but our work suggests that 'on average', those born in QLD, males, those with relatively less education, and those whose primary source of income is the mining and manufacturing industry, are likely to feel that recreation and industry values are relatively more important to their overall quality of life, and that environmental non-use values are relatively less important to their overall quality of life than other people. As such changes to the economic and demographic composition of the population will likely change prevailing values, and this will affect the broader economy as well as the priorities and decisions about future developments.
- More direct links exist: changes in the broader economy such as increases in the price of beef and/or in wages, affect sediment loads (albeit with a lag). Clearly, the economic system is inextricably linked with the environment, with multiple, dynamic feedbacks.
- Monitoring systems should thus keep track of:
 - The demographic composition of the population, and its economic structure.
 - The 'values' of different demographic groups and of those associated with different industries within the region (particularly in regions undergoing rapid economic and or demographic change).
 - Changes in the broader economy (particularly the prices of commodities produced in and around the region).
 - Variables that describe key linkages between the economy and the environment (e.g. water use, pesticide and fertilizer use, land clearing)

- Moreover, our research indicates that:
 - It may not be necessary to require people to 'value' long detailed lists of different ecosystem services. Many of these ecosystem services are viewed, by respondents, as being all but inseparable, suggesting that the 'valuations' could be done at a fairly coarse level (asking people, for example, to assess industry, recreational, cultural and non-use values, and giving broad examples/descriptors of each). That would leave more 'room' within questionnaires (since long ones tend to induce survey fatigue) to elicit other potentially very useful information (about, for example, expenditure, water or chemical use, or other behaviours likely to impact the GBR).
 - Different types of valuation approaches generate quite different types of information (e.g. the dollar value associated with an entire ecosystem, the relative importance of different groups of ecosystems, peoples stated reaction to hypothetical scenarios, or WTP to improve the environment). But in this study, we have found that the methods generate similar information at a 'big picture' level (e.g. that the environment is more important to most people than industry, but that there are recognizable/predictable differences between people). There is often considerable resistance, by respondents, to questions about WTP. Recent decades has seen a substantive growth in the literature about ways to deal with 'protest votes', and (in the related choice modelling literature) 'non attendance to attributes', so those wishing to obtain specific information about WTP can do so. But our research suggests that it might be possible to use more respondent-friendly importance/satisfaction and contingent behavior type questions to monitor values across time and people instead (perhaps comparing findings to those of more traditional valuation approaches at irregular intervals for calibrative / quality-control purposes).

1 Introduction

1.1 Project overview and aims

The National Environmental Research Program (NERP) Tropical Ecosystems (TE) Hub is the largest of the Commonwealth Government's five NERP hubs. The hub involves 38 research projects, divided into three Themes organised around twelve Research Programs.

This particular research project is associated with Theme 3 *Managing for Resilient Tropical Systems*, within the program entitled *Socio-economic value of the GBR goods and services*.

The project was developed in response to the Great Barrier Reef Marine Park Authority (GBRMPA)'s desire to develop a socio-economic monitoring program. This project is separate from and complementary to Project 10.1 (SELTMP), providing additional economic data and modelling/analytical insights.

Our thinking was underpinned by recognition of the fact that there are a vast number of variables (or 'indicators') that could, potentially, be monitored. Indeed, since the 1987 Brundtland report called for 'monitoring' there has been an *indicator explosion* (Riley, 2001). As such, there is little problem with finding an indicator; the key problem is to find an appropriate one. Moreover, because monitoring is not a costless exercise, it is important to ensure that the variables/indicators selected for 'monitoring', are ones which

- provide reliable, relevant information (Parkinns *et al.*, 2001) that is clearly associated with the main goal of the agency desirous of the monitoring program
- are feasible to measure and can be obtained in a cost-effective manner on a regular basis, using a systematic method (Larson and Smajgl, 2006)
- are few in number so that users can become familiar with their presentation and with the 'signal' they give as well as its significance – ideally being linked to formal targets or indicative reference values (Larson and Smajgl, 2006)
- are scientifically credible (Larson and Smajgl, 2006)
- measure interactions between sub-systems – e.g. the economic and biophysical (Gallop, 1997)

The GBRMPA's primary goal is to protect the Great Barrier Reef Marine Park (GBRMP) and world heritage area - i.e. to promote reef resilience. In some situations, it may be relatively easy to discern the link between economic indicators and reef resilience, but the relationship between the 'health' of an economic system and that of a biophysical one can be ambiguous. For example, wealthy people are often more willing (and certainly more able) to pay for environmental goods and services than poor people; they are also likely to have more adaptive capacity. So on the surface, it seems sensible to assume that 'healthy' (wealthy) socio-economic systems are likely to be resilient, adaptive and able to generate, or protect 'healthy' biophysical systems. But 'values' differ significantly across different individuals and some wealthy people may not want to contribute to or participate in programs that protect the reef. Moreover, many income earning activities generate (unintended) negative environmental impacts. Whether the net effect of increases in income (and/or of changes in many other socio-economic indicators) is 'good', 'bad' or indifferent' news for reef resilience is thus an empirical question.

This project set out to collect economic data relevant to the GBRWHA, and to explore the interaction between economic variables and other variables (e.g. indicators of water turbidity) thought to be associated with reef resilience. The conceptual model that underpins the investigation (Figure 1) explicitly recognizes that economic and biophysical systems are interrelated: changes in the economy impact the environment (either positively or negatively),

and environmental changes impact the economy. Simplistically, this project thus set out to improve our understanding of the way in which the environment (the GBRWHA) benefits people and the economy; and also of the way in which the economy affects the environment.

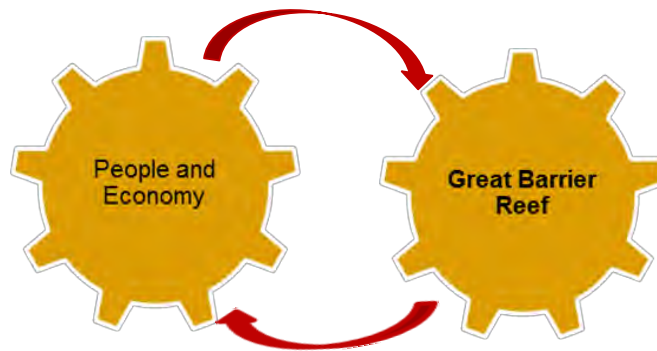


Figure 1: Interaction between people, economy and the environment

Operationally, the project comprised three interrelated activities, the specific objectives of which were to improve our understanding of:

- (a) resident views about the 'value' of key ecosystem services (ES) that are provided by the GBRWHA
- (b) tourist views about the 'value' of key ES that are provided by the GBRWHA
- (c) the extent to which variations in beef prices and other socioeconomic variables (in conjunction with biophysical variables) influence water quality and thus (indirectly) reef resilience.

The project has generated information that is useful by, and of itself (a list of outputs is provided in Appendix A). It has also helped to identify key variables that are likely to be worthy of further monitoring, has developed methods for measuring and analyzing those variables, and has provided a valuable baseline of data for reference in a longer-term socio-economic monitoring program.

1.2 Structure of report

Most of the work undertaken as part of this project has already been published in the peer-reviewed literature, is available on-line (through e-atlas) and/or is under review (see Appendix A for details). This report thus provides a synthesis of findings – presented according to the structure depicted in Figure 2; we encourage interested readers to consult the related documents which provide much more detail.

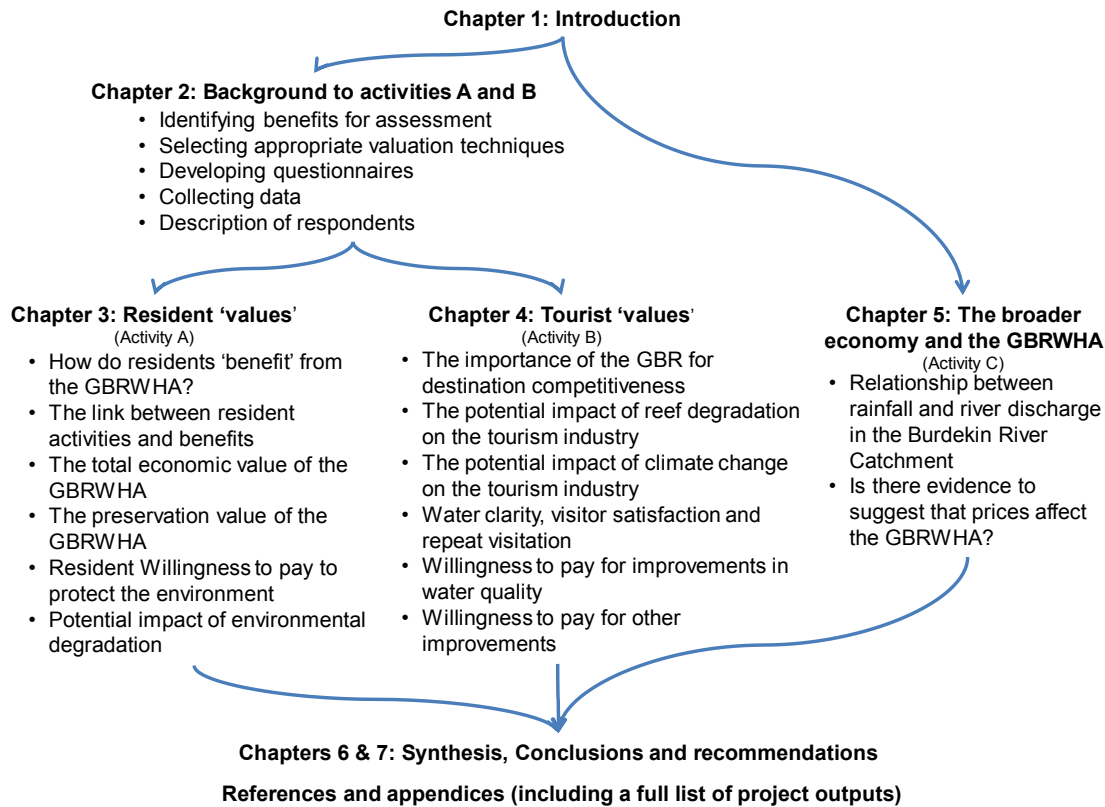


Figure 2: Structure of the report

NB: In 2007, MTSRF provided funding to a team of researchers, led by Bruce Prideaux, to conduct regular visitor exit surveys at Cairns Airport. The TE NERP provided funds for those surveys to continue, through this project. Since 2007, researchers have been visiting Cairns airport at least once a month, collecting data from 8050 departing visitors (although data were not collected during 2010). There have been a consistent set of questions asked of every visitor since 2007, and each year the questionnaires have also sought to investigate a different issue pertinent to the local tourism industry. The long-term Cairns Airport visitor Exit team have already synthesized and reported on their activities and there are several related publications (a book chapter, and three conference papers - Appendix A). We do not report on that material (again) here.

2 Background to activities A and B

The material presented in this section summarises material reported on, in detail, in

Stoeckl, N., Farr, M., & Sakata, H. (2013). *What do residents and tourists 'value' most in the GBRWHA? Project 10-2 Interim report on residential and tourist data collection activities including descriptive data summaries*. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns, pp. 112. Available at: <http://www.nerptropical.edu.au/publication/project-102-technical-report-what-do-residents-and-tourists-'value'-most-gbrwha>

2.1 Identifying 'benefits' for assessment and appropriate valuation approaches

There are different frameworks for thinking about the way in which the environment benefits people all highlighting the fact that:

- the GBRWHA has value far above and beyond that which is reflected in the market place.
- there are likely to be many different ways in which people relate to, interact with and benefit from the GBRWHA – i.e. there are many different types of environmental 'values' (also referred to in this report as ecosystem services).

If interested in the 'value' of the GBRWHA to residents and tourists, it is thus important to begin the process by identifying a set of regionally relevant ecosystem services (ES) for assessment.

First we conducted a substantive literature review. The review revealed that historically, most valuation studies have concentrated on a narrow range of ecosystem services (Stoeckl *et al.*, 2011) such as recreation (Carr and Mendelsohn, 2003; Hundloe *et al.*, 1987; Knapman and Stoeckl, 1995; Kragt *et al.*, 2009) or fishing and boating (Farr *et al.*, 2014b; Prayaga *et al.*, 2010). More recently, researchers have sought to improve our understanding about some of the region's *non-use values* (Rolfe and Windle, 2012a; Rolfe and Windle, 2012b; Windle and Rolfe, 2005), but significant knowledge gaps remain (see also Stoeckl *et al.*, 2014). The review also revealed an absence of comparative information. No assessments existed that simultaneously valued numerous different ecosystem services using the same methodological approach. Different valuation techniques produce different types of estimates (e.g. marginal prices or expenditures) and may not be comparable or additive. If managers are required to make decisions about potentially competing values (e.g. fishing versus tourism versus aesthetic/cultural values), then the lack of comparable information about these different values may stand as a significant knowledge gap.

Second, we conducted workshops with a variety of regional stakeholders/managers/decision makers in Cairns, Brisbane and Townsville. In these workshops we sought to (a) identify a set of regionally relevant community-defined benefits of the GBRWHA which stakeholders required more information about; and (b) learn more about the issues confronting these people and about how they hoped to be able to use the information generated from this project. The workshops highlighted the fact that participants were interested in a broad range of different community benefits (some of which related directly to various ecosystem services provided by the GBRWHA, and some of which related to the economy in general). It also revealed that people wanted to be able to use our research results in a variety of different ways. Some

GBR 'value' to residents and tourists wanted to simply raise public awareness of the importance of the GBRWHA; others wanted to be able to use the results to help them assess the way in which people and/or the economy might be impacted by particular management changes which could impact the reefs ecosystem services (e.g. further reductions in water quality). In other words, some stakeholders were looking for information about (in economic jargon) the 'total' value of the GBRWHA; others wanted information about 'marginal' values (or trade-offs).

Having determined which community benefits to focus on, and that we needed to look at both total and marginal values, our next task was to choose a valuation technique. Over the years, economists have developed many different valuation techniques to estimate the (monetary) value of a variety of different ecosystem services (see, for example, Bateman *et al.*, 2002; Getzner *et al.*, 2005), but only stated preference approaches are capable of assessing a full range of benefits including existence/bequest. Since stakeholders were interested in those benefits, we chose to focus on stated preference approaches.

Choice modelling and contingent valuation are, arguably, the most popular stated preference methods, but there is a substantive body of literature on subjective wellbeing and overall life satisfaction (LS), which offers an alternative way of looking at the 'value' of the environment (see Kristoffesen, 2010). LS studies have been done at both an aggregate level – e.g. using national measures of happiness, indicators of environmental quality and income (Welsch, 2006) – and at an individual level (MacKerron and Mourato, 2009; van Praag and Baarsma, 2005). In most cases, researchers have regressed measures of overall quality of life (QOL) against other potential contributors, to ascertain the relative importance of those contributors. Others have successfully trialed systems that simply ask people to indicate how important various goods and services are to their overall QOL and compared ratings (Larson, 2009; 2011; Larson *et al.*, 2013). It is that general approach, which we used here, although we decided to also include questions that would allow us to use some of the more 'traditional' valuation techniques (i.e., contingent valuation, expenditure and contingent behavior).

More specifically, we decided to develop a questionnaire that would allow us to use

- a) a variation of the life-satisfaction approach to assess
 - i. the 'value' of a wide variety of ecosystem services (benchmarked against some market goods and services);
 - ii. the effect that changes in those ecosystem services would have on overall quality of life (benchmarked against market changes).
- b) the contingent valuation approach to assess marginal changes (i.e. willingness to pay) for three of the key issues identified in (a ii); and
- c) visitor expenditures and contingent behaviour questions to assess the potential financial impact on the tourism industry of changes to the environment.

2.2 Development of the questionnaires

Information gathered from the literature review was combined with information collected during workshops to develop a set of preliminary questionnaires that were pre-tested with peers, during additional stakeholder workshops and at the Cairns airport. We analysed responses to the Cairns airport pilot test, finding that the response rate for some questions was relatively low; people noted that the format of the questionnaire almost reminded them of an examination paper. We thus spent considerable time re-formatting the questionnaires, adding pictures and colours to increase the visual appeal. We tested the revised version of the questionnaire in more face-to-face encounters at the Cairns airport and in a mailout to 200

residents living in 100 different postcodes within the GBR catchment area (GBRCA), finding no need for further changes.

The final version of our **resident questionnaire** included questions about:

- The socio-demographic background of respondents (age, income, education, etc.)
- How often residents go to the GBRWHA, and what they do while there
- The importance of various community benefits associated with the GBRWHA to their overall quality of life and their satisfaction with those benefits (Table 1)
- Satisfaction with their overall quality of life
- People's perceptions about the way in which their overall quality of life would be affected by changes in various community defined benefits and other market factors (e.g. higher prices, reduced water clarity).
- Their willingness to pay for improvements in various community defined benefits

Importantly, respondents have been shown to be highly sensitive to the order in which one presents questions – particularly if asked to evaluate a long list of items (Cai *et al.*, 2011; Lasorsa, 2003). So we produced 24 different versions of the question about the 'importance' of, and 'satisfaction' with, various community defined benefits: all containing the same list of benefits, but presented in a different order.

When developing the **tourist questionnaire**, we sought to keep questions similar (to enable comparisons) but altered the wording of some segments. The final version of visitor questionnaire thus included questions about:

- The socio-demographic background of respondents and background about travel party and origin
- How often visitors had been to the GBRWHA in the past and what they did (or planned to do) while on this particular trip
- The importance of various 'goods and services' to their overall decision to come to the region (Table 1) – in comparison to residents who were asked about importance to overall quality of life
- Their satisfaction with the trip overall (rather than, for residents, life overall)

To ensure that tourist questionnaires were not too long, we decided to use a split sample, approach, asking one half of all tourists to tell us about expenditure while in the area and the way in which their decision to come to the region would have been affected by changes in various environmental and market factors. The other half were instead asked about their WTP for improvements in various community defined benefits (as per residents, although questions were framed as willingness to pay per trip rather than per annum).

Table 1: Community-defined benefits that were selected for assessment – the terms in brackets are the abbreviations used hereafter

Residents	Both	Tourists
Being able to:		
Eat fresh locally caught seafood (Seafood) Go fishing, spear-fishing or crabbing (Fishing) Spend time on the beach, go swimming, diving, etc. (Beach/Swimming) Go boating, sailing or jet-skiing (Boating)		
Having/experiencing/seeing:		
Undeveloped and uncrowded beaches & islands (Undeveloped) Beaches and islands without visible rubbish such as bottles & plastic (No rubbish) Healthy coral reefs (Coral reefs) Healthy reef fish (Reef fish) Healthy habitats for marine plants & animals including whales, dugongs, turtles (Iconic marine species) Clear ocean water with good underwater visibility (Clear ocean) Healthy mangroves and wetlands that clean polluted water from land (Mangroves)		
The Wet Tropics World Heritage rainforest (Wet tropics) Iconic land species: kangaroos, cassowaries, etc (Iconic land species)		
Other:		
Protecting Indigenous traditional and cultural values (Indigenous) "Bragging rights" – being able to say "I live near the GBR" (Bragging)	Experiencing Indigenous traditions and culture (Indigenous) "Bragging rights" – being able to say "I have been to the GBR" (Bragging)	
Preserving the GBRWHA either for its own sake or for future generations (Future generations) Benefiting from low prices associated with cheap shipping transport (Cheap shipping) the jobs and income related to: the reef-based tourism industry (Tourism) the commercial fishing sector (Commercial fishing) the mining and agricultural sectors (Mining/Agriculture)	Sunshine and warmth (Sunshine) Visiting friends and/or relatives (Friends) Attending to business, going to a meeting and/or conference (Business) Visiting a place which is close to where I live (Close) Finding a place where the price matched my budget (Budget) Having good quality accommodation, shops and restaurants (Accommodation)	

(Table adapted from Larson *et al.*, 2014a; Esparon *et al.*, forthcoming)

We had both versions of our tourist questionnaires translated into Chinese and Japanese (and checked, using back-translations).

A copy of (one version) of the resident questionnaire and the two different tourist questionnaires are provided in Appendix 3 and 4, respectively, of Project 10-2's *Interim report* (Stoeckl *et al.*, 2013).

2.3 Data collection

2.3.1 Tourists

When developing sampling strategies, we were mindful of the fact that more than 90% of visitors to the GBRMP go to either the Cairns/Cooktown or the Townsville/Whitsunday management areas (GBRMPA, 2013), thus we decided to concentrate most data-collection effort in those areas.

We sought permission from various airports, ferry/boat operators, caravan-park owners and local governments in Cairns, Port Douglas, Townsville, Bowen, Airlie Beach, Rockhampton and Yeppoon to collect data from visitors at those locations. We collected data at those locations at regular intervals throughout a 12 month period (to control for seasonal differences in type of tourists). The Japanese and Chinese questionnaires were distributed by native speakers of those languages.

We also enlisted the help of a stratified random selection of tourism operators between Cooktown and Gladstone to distribute questionnaires to their customers. When selecting operators, we started by using the yellow-pages and tourism web-sites to compile a list of 673 tourism operators between Cape Tribulation and Gladstone. We divided those operators between the accommodation sector (further subdivided by type – e.g. backpacker hostel, bed and breakfast, 3 4 or 5 star motels), tour operators (marine and terrestrial) and tourism 'attractions' (e.g. museums, information centres, skyrail). We randomly selected two of each group, in each location, and then contacted the operators to see if they would be willing to make our questionnaires (with reply paid envelopes) available to their customers. In total, 36 operators agreed; we sent a random selection of the different versions of our questionnaire to them and received a total of 203 completed questionnaires in the mail from their customers.

In total we collected 2743 tourist questionnaires – 225 from Chinese speaking visitors and 243 from Japanese speaking visitors. Nearly one-half of all respondents had been visiting the Cairns/Cooktown tourism management area when they completed our questionnaire; 40% were visiting the Townsville/Whitsunday management area, while only 8% were recorded in the Mackay/Capricorn. This is very similar to the visitation patterns evident from the GBRMPA Environmental Management Charge data (GBRMPA, 2013). Compared to data collected by Tourism and Events Queensland (2013) and Tourism Research Australia (2013a) our sample is slightly overrepresentative of international visitors (excepting those from Japan and China who may be slightly under-represented), and it under-represents domestic business visitors (Tourism Research Australia, 2013b).

2.3.2 Residents

For the residential sample we aimed for a geographically stratified random sample. We started by identifying postcodes (≈ 100) that lay either partially or entirely within the GBRCA, sending an even number of questionnaires to each ($\approx 48^1$). We estimate that 3977 reached their intended recipient and we received 902 completed questionnaires, giving an overall response rate of 22.7%. Being aware of non-response bias to postal surveys we ensured that when research assistants visited airports, lagoons, ferries etc. to intercept tourists, they also had residential questionnaires, so that we could take advantage of incidental intercepts. We also engaged an Indigenous researcher to help collect data from within Indigenous communities.

¹ We also ensured that the 24 different versions of the questionnaire were sent to each postcode (≈ 2 of each version to each postcode).

GBR 'value' to residents and tourists

These extra activities gave us an additional 663 responses, so in total we received 1592 completed residential surveys.

2.4 Overview of respondents and responses

Our *Interim report* (Stoeckl *et al.*, 2013) provides detailed diagrams and charts with descriptive statistics from our residential and tourist data hence only a short summary is provided here.

Our residential sample has a good geographic representation in comparison to the actual population distribution in the GBR region (Government Statistician, 2013) and is reasonably representative in terms of gender and Indigenous people in the sample. It is overrepresented by participants with a university degree (31% in our sample compare to 16% of population). Just over one quarter of all respondents indicated that their household depends upon the Government, Health or Education sectors for its main source of income while the OESR statistics shows this to be 29% for the GBRC population. The Mining and Manufacturing sectors were slightly overrepresented (20% of our respondents were dependent upon this sector for their income; but only 16% of employed people within the catchment area work within these industries).

In total, 50.3% and 54.9% of residential and tourist respondents, respectively, were female. Approximately 6.6% of residential respondents self-identified as either Aboriginal or Torres Strait islander or both; the figure was higher for tourists (13.5%). More than half of the visitors (53%) who answered the survey were between 20-40 years old while 44% of residents were aged between 40-60 years. About 30% of residents and 50% of tourists had completed a university degree. A slightly larger percent of tourists were in the highest income bracket than were residents. More than one-quarter of both residents and tourists noted that the Government / Health / Education sector was their main source of income. Mining, Agriculture and, to a lesser extent tourism, were much more important sectors (in terms of income dependency) for residents than they were for tourists.

Almost 55% of tourists were international visitors. The majority of international visitors (659 out of 1506) came from Europe. Most domestic visitors were from Queensland (41%). More than one-third of tourists (36.24%) were travelling as a couple; almost 20% were travelling with friends. The median number of nights visitors spent along the coast near the GBRWHA was 5.

Almost 40% of residents had spent about a day on their most recent trip to the GBRWHA; 18% had spent 2-3 nights on their most recent trip, and nearly 22% had spent 4 nights or more. Their most common activity involved spending time on the beach, although the majority of resident respondents (65%) had been involved in more than one recreational activity involving the GBRWHA during the last 12 months.

3 Residential 'values'

3.1 How do residents of the GBR catchment 'benefit' from the GBRWHA?

The material presented in this section summarises material from

Larson, S., Stoeckl, N., Farr, M., & Esparon, M. (2014a). The role Great Barrier Reef plays in resident wellbeing and implications for its management. *AMBIO*, DOI 10.1007/s13280-014-0554-3. Available at <http://link.springer.com/article/10.1007%2Fs13280-014-0554-3>

Abstract

Improvements in human wellbeing are dependent on improving ecosystems. Such considerations are particularly pertinent for regions of high ecological, but also social and cultural importance that are facing rapid change. One such region is the Great Barrier Reef (GBR). Although the GBR has world heritage status for its 'outstanding universal value', little is known about resident perceptions of its values. We surveyed 1545 residents, finding that absence of visible rubbish; healthy reef fish, coral cover, and mangroves; and iconic marine species, are considered to be more important to quality of life than the jobs and incomes associated with industry (most respondents were dissatisfied with the benefits they received from industry). Highly educated females placed more importance on environmental non-use values than other respondents; less educated males and those employed in mining found non-market use-values (i.e. recreational values) relatively more important. Environmental non-use values emerged as the most important management priority for all.

Keywords: Australia, GBRWHA, IDS, Perceptions, Quality of life, Values

Methods and main findings

Using the residential sample, we examined the stated importance, to overall quality of life, of 18 community defined benefits associated with the GBRWHA (Table 1). We identified those which were deemed most/least important and those which people were most/least satisfied with (Figure 3). Having no visible rubbish, healthy reef fish and healthy coral reefs were the three most important factors. Satisfaction was significantly lower than importance for all values except recreational fishing, boating, and bragging rights. Residents were most dissatisfied with their (perceived) benefits from low prices associated with cheap shipping, the mining, agricultural, and commercial fishing sectors, the level of protection of Indigenous traditional and cultural values, and the chances of preserving the GBRWHA either for its own sake or for future generations.

Next we used regression (both ordinary least squares [OLS], and seemingly unrelated regressions [SUR]) to look for statistically significant relationships between various socio-economic and demographic descriptors of people (Table 2) and the importance (IMP); and Index of Dis-Satisfaction (IDS) scores they assigned to different factors (grouped using Principal Component Analysis [PCA]) (Table 3).

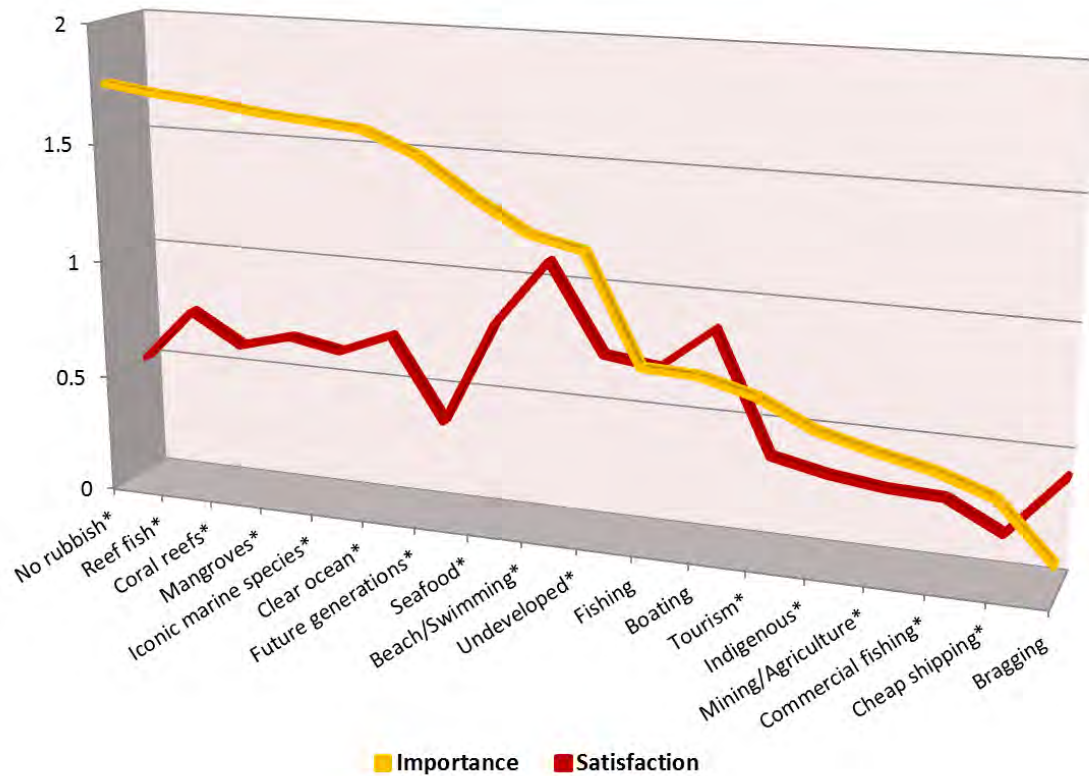


Figure 3: Stated importance of and satisfaction with 18 community defined benefits associated with the GBRWHA, residents

(* indicates a statistically significant difference between the distribution of responses to questions about importance and satisfaction)

(Figure adapted from Larson *et al.*, 2014a)

Highly educated females and people dependent upon the government sector for income allocated more importance and were less satisfied with the current condition of non-use values than other respondents. Relatively less educated males and people whose households were dependent upon the mining and fishing industries placed more importance on non-market use values such as fishing and boating than other participants. People on higher household incomes, with families and with lower levels of education placed more importance on the Industry group of values than their single, better educated, poorer counterparts.

Table 2: Variables used in subsequent analyses – descriptors and abbreviations

Variable of interest	Description	Abbreviations used in this report
Age	Respondent's age	Age
Gender	=1 if respondent is male, 0 otherwise	Male
Marital status	=1 if respondent is single, 0 otherwise	Single
Indigeneity	=1 if respondent i is Indigenous, 0 otherwise	Indigenous
Education	Respondent's highest level of education completed in five different levels ranging from primary school to higher education at university	Education
Household size	Number of people in respondent's household	HH size
Household Income	Respondent's household annual pre-tax income ranging from \$6,500 to \$285,500	Income
Dependence on various sectors for household income		
Tourism	=1 if the main source of respondent's household income is Retail, Accommodation, cafes & restaurants, and Tourism, 0 otherwise	Tourism
Commercial fishing	=1 if the main source of respondent's household income is Fishing, 0 otherwise	Fishing
Mining, manufacturing &/or ports	=1 if the main source of respondent's household income is Mining, Manufacturing and Ports, 0 otherwise	Mining
Government, Health or Education	=1 if the main source of respondent's household income is Government, Health and Education, 0 otherwise	Government
Agriculture	=1 if the main source of respondent's household income is Agriculture and Forestry, 0 otherwise	Agriculture
Place of birth	=1 if resident born in QLD, 0 otherwise	Born QLD
Not prepared to pay unless all GBRWHA users pay too	=1 if not prepared to pay money to protect the GBRWHA unless all GBRWHA users pay too, 0 otherwise	Not prepare to pay unless all users pay too
Only people who live near or visit the GBRWHA should care for it	=1 if strongly agree or agree with the statement that only people who live near or visit the GBRWHA have a responsibility to care for it, 0 otherwise	Only people who live or visit should care
Not prepared to pay unless all Australia pay too	=1 if strongly agree or agree with the statement that if not prepared to pay money to protect the GBRWHA unless all Australia pay too, 0 otherwise	Not prepare to pay unless all Australia pay too
WTP bid range	WTP bid range ranging from \$500 to \$2,000	WTP Bid range

Conclusions

Environmental non-use values such as healthy corals, reef fish and mangroves, absence of visible rubbish and iconic marine species are of highest importance to the quality of life of local residents. Evidently, the GBR is well recognized by local residents for its 'outstanding universal value' and the things that matter most to residents of the GBR region are clearly of a non-monetary nature. Respondents are most dissatisfied with their ability to benefit from various industries along the coast. Non-use values are at the top of the "Action List" for management (derived using the IDS methodology).

That said, people with different levels of education, of different gender, Indigenous status and those dependent upon different industries for income had statistically different 'values'.

Changes in the economic and demographic composition of the population will thus likely see a change in overall social construct of 'values', highlighting the importance of monitoring such changes in the community.

The fastest growing demographic group in the region is of young lesser educated males working in the mining and associated industries receiving relatively high incomes (Deloitte Access Economics, 2013). If this segment of population continues to increase, environmental 'use' (recreation) values and market values could become relatively more important compared to environmental non-use values. Consequently, it might become more difficult to find public support for policies to protect, as required by both international and national statutory obligations, the non-use values of the GBRWHA at the expense of other things.

Table 3: Characteristics of respondents determining importance (IMP) and Index of dissatisfaction (IDS) scores for groups of values tested

Environmental non-use values		Non-market/ Recreation use values		Industry use values		Indigenous culture		Bragging/ Recognition	
IMP	IDS	IMP	IDS	IMP	IDS	IMP	IDS	IMP	IDS
Male (-)	Male(-)	Male (+)	Male(+)			Male (-)	Male(-)	Male (-)	Male(-)
Educa tion(+)	Educa tion(+)	Educa tion(-)	Educa tion(-)	Educa tion(-)					
				Single(-)	Single(-)	Single(+)		Single(+)	Single(+)
						Age(-)	Age(-)	Age(-)	Age(-)
				Income(+)				Income(-)	Income(-)
						Indigenous(+)	Indigenous(+)		
						Born QLD(-)	Born QLD(-)		
Main household income from									
		Mining(+)	Mining(+)		Mining(+)	Mining(-)	Mining(-)		
		Fishing(+)				Fishing(+)			
Govern ment(+)								Govern ment(-)	
								Tourism(+)	

Note: Only significant variables reported. A plus sign (+) indicates that the variable was found to have a positive and statistically significant relationship with the score assigned to the corresponding value; a negative sign (-) indicates negative and statistically significant negative relationship

(Table adapted from Larson *et al.*, 2014a)

3.2 The link between resident activities and benefits

The material presented in this section summarises material from

Larson, S., Farr, M., Stoeckl, N., Chacon, A., & Esparon, M. (2014b). Does Participation in Outdoor Activities Determine Residents' Appreciation of Nature: A Case Study From the Great Barrier Reef, Australia. *Environment and Natural Resources Research*, 4(3), 211-226. Available at

<http://www.ccsenet.org/journal/index.php/enrr/article/viewFile/39015/21817>

Abstract

Different people engage in different activities for different reasons. This paper contributes to literature examining participation in various outdoor activities and its association with the perceived importance of environmental values. Using data from a survey of more than 1500 residents living adjacent to the Great Barrier Reef World Heritage Area (GBRWHA) in Australia, we examine (1) residents' participation and frequency of participation in a number of GBRWHA-related outdoor activities; (2) if a range of socio-economic characteristics played a role in determining participation in these activities; and (3) the linkages between participation in outdoor activities and a range of environmental values related to the GBRWHA. Going to the mainland beaches and swimming were reported as the most frequent activities. Males, residents with higher income, and those with the main household income from fishing and tourism industries, are more likely to participate in outdoor activities than others. There is a link between participation in activities and the perception of values. We found that occasional participation in an activity does not necessarily change perceptions of importance of the GBRWHA values. However, frequent participation in consumptive activities such as fishing was linked to higher appreciation of use values. With the non-consumptive uses, such as beach and island visitation, the association extends to a whole range of use and non-use values. Findings have implications for management as they indicate that those who frequently participate in outdoor recreation place higher importance on environmental values and may therefore stand as stronger environmental stewards than others.

Keywords: ecosystem services, quality of life, recreation, values, wellbeing

Methods and main findings

Using data from our residential sample, we looked at the number of times people participated in different GBRWHA-based recreational activities each year. We found that nearly 65% of local residents were frequent beach users, 37.5% go recreational fishing and 31% go motor boating frequently. Sailing and going on a paid boat were undertaken the least often (Figure 4).

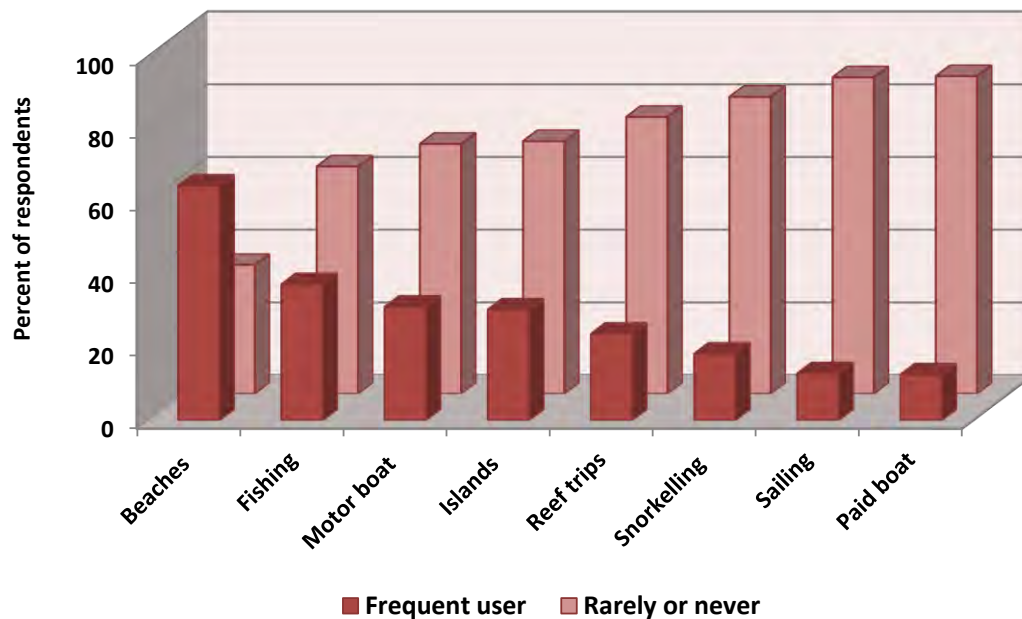


Figure 4: Frequent vs. non-frequent participation in the GBR related activities
(Figure adapted from Larson *et al.*, 2014b)

We used a hurdle model to look for statistically significant relationships between various socio-economic and demographic descriptors of people (Table 2) and the frequency with which they undertook various activities (Table 4). We found that residents with higher household incomes and those who were dependent on tourism and fishing industries were more likely to participate in recreational activities related to the GBR than others. Older people were less likely to go to reefs, islands, snorkelling and to go on a paid boat than their younger counterparts. Indigenous residents and those with small households were more likely to be frequent beach goers than others, and the most frequent recreational fishers were males, single people, those born in QLD, the relatively less educated and those dependent upon the tourism or fishing industries. Those dependent upon the mining industry were less likely to go to the beach, the islands or the reef than those dependent on other industries – i.e. this group of people were generally less 'connected' (recreationally) to the GBRWHA than others.

Table 4: Characteristics of most frequent participants in the GBRWHA related outdoor activities

Activities	Characteristics of most frequent users of the GBR										
Beaches	High Income	Indigenous	Not Males		Small HH size				Not mining	Tourism	
Fishing	High Income		Males	Single		No degree	QLD born			Tourism	Fishing
Motor boat	High Income		Males							Tourism	Fishing
Islands								Young	Not mining		Fishing
Reef trips	High Income								Not mining		
Snorkelling	High Income			Single							Fishing
Sailing	High Income									Tourism	Fishing
Paid boat		Non-Indigenous									Fishing

Note: Only significant variables reported (Table adapted from Larson *et al.*, 2014b)

We also used stepwise OLS regression to look for a relationship between the importance scores and the frequency with which people participated in various activities. We found that residents who frequented beaches were likely to place a higher value on all benefits than their non-beach-going counterparts. Those who went fishing frequently felt that many lifestyle and recreational values (e.g. eating fresh locally caught seafood, fishing, boating, and sailing, in addition to spending time at the beach) were more important than other people. Those who went to the islands frequently were more likely to place a high value on boating, 'bragging', and preserving the reef for future generations.

Conclusions

Frequent participants in outdoor recreation activities place a high importance on environmental values and may therefore stand as strong environmental stewards. As such, frequent island and beach visitors might be the best group to target and mobilise for various environmental activities and actions.

3.3 The total economic value of the GBR

The material presented in this section summarises material from

Stoeckl, N., Farr, M., Larson, S., Adams, V., Kubiszewski, I., Esparon, E., & Costanza, R. (2014). A new approach to the problem of overlapping values: a case study in Australia's Great Barrier Reef. *Ecosystem Services*, 61-78, DOI: 10.1016/j.ecoser.2014.09.005. Available at <http://www.sciencedirect.com/science/article/pii/S2212041614001077>

Abstract

Estimating the value of entire ecosystems in monetary units is difficult because they are complex systems composed of non-linear, interdependent components and the value of the services they produce are interdependent and overlapping. Using the Great Barrier Reef (GBR) as a case study, this paper explores a new 'whole ecosystem' approach to assessing both the importance (to overall quality of life) and the monetary value of various community-defined benefits, some of which align with various ecosystem services. We find that provisioning services are considered, by residents, to be less important to their overall quality of life than other ecosystem services. But our analysis suggests that many community-defined benefits are overlapping. Using statistical techniques to identify and control for these overlapping benefits, we estimate that the collective monetary value of a broad range of services provided by the GBR is likely to be between \$15b and \$20b AUS per annum. We acknowledge the limitations of our methods and estimates but show how they highlight the importance of the problem, and open up promising avenues for further research. With further refinement and development, radically different 'whole ecosystem' valuation approaches like these may eventually become viable alternatives to the more common additive approaches.

Keywords: Great Barrier Reef; Ecosystem Services; Economic Valuation; Total Economic Value

Methods and main findings

Using ideas from a number of different methodological approaches and data from our residential sample (of more than 1500 residents of the GBRCA), we trialed an entirely new way of estimating the 'value' of the GBR, controlling for the perplexing problem of 'separability'. First we looked at how people's stated importance of 18 different community defined benefits (Table 1) contributed to their overall quality of life - Figure 5.

We then used correlation coefficients and the PCA to identify groups of benefits that were likely separable and compared the average importance scores assigned to each group of separable benefits. The analysis is conceptualized in Figure 6. The vertical 'height' of each group of separable benefits indicates mean importance. Arrows show how benefits contribute to overall quality of life – directly (red dotted line from item to quality of life), indirectly (black solid line to another item), or both.

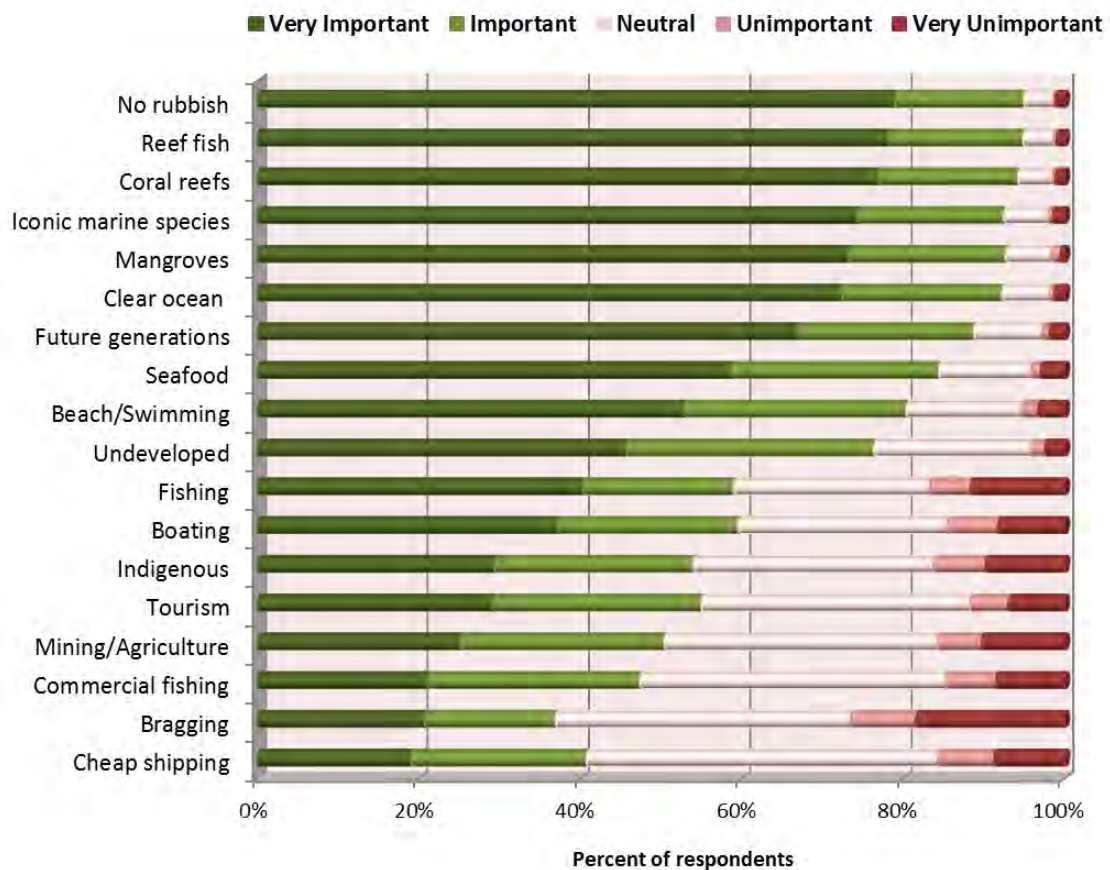


Figure 5: Resident perceptions of the Importance of 18 different benefits to their overall quality of life

(Figure adapted from Stoeckl *et al.*, 2014)

One of the separable benefits relates to the jobs and incomes associated with reef tourism – known to contribute in excess of \$4b to the local economy (Deloitte Access Economics, 2013). In the economics literature, the value of a good is tied to the concepts of compensating and equivalent variation (CV or EV) (Mitchell and Carson, 1989). Formally, CV is the amount of money required to compensate an individual for the loss of a good or service (i.e. to ensure there is no reduction in overall *utility*). If the tourism industry were to collapse, residents would need to be compensated for that loss (i.e. \$4b). By extension, if other benefits, which are deemed more important than the tourism industry, were to also disappear, then we can infer that residents would need to be compensated by more than \$4b for their loss. In other words, the ‘separable’ groups of benefits which are deemed more important to overall quality of life than the tourism industry must also be ‘worth’ more than \$4b.

There may be some ‘overlap’ between the most important group of benefits, which we have termed ‘primary’ benefits, and other groups of benefits which depend upon them (as shown with the dotted lines). But we also collected data from people who have no connection at all to the reef (through culture, lifestyle, or livelihood) and who had never been to the region – so we knew they received no ‘recreational’, ‘indigenous’ or ‘industry’ benefits from the GBRWHA. They still indicated that primary benefits were more important to their overall quality of life than all other listed factors. As such, it seems that these primary benefits do not entirely overlap with other values.

GBR 'value' to residents and tourists

When assessing the collective value of all (separable) groups of community-defined benefits, we assumed that if any group of benefits were deemed to be less important than our market benchmark (here, the tourism industry), then its value was zero (an extremely conservative estimate). If a group of (separable) benefits was deemed more important, then its value was assumed equal to the market benchmark – i.e. \$4b (also conservative). We then counted the number of separable groups (N) that were more important than the market benchmark. The collective value of all separable groups (N) of benefits was thus calculated as $\$4b \times N$. We conclude that the total value of all benefits defined by the community and assessed in this case study will certainly exceed \$16b (even if all primary benefits are deemed to overlap other benefits) and may be closer to \$20b (if no overlap – likely to be a closer representation).

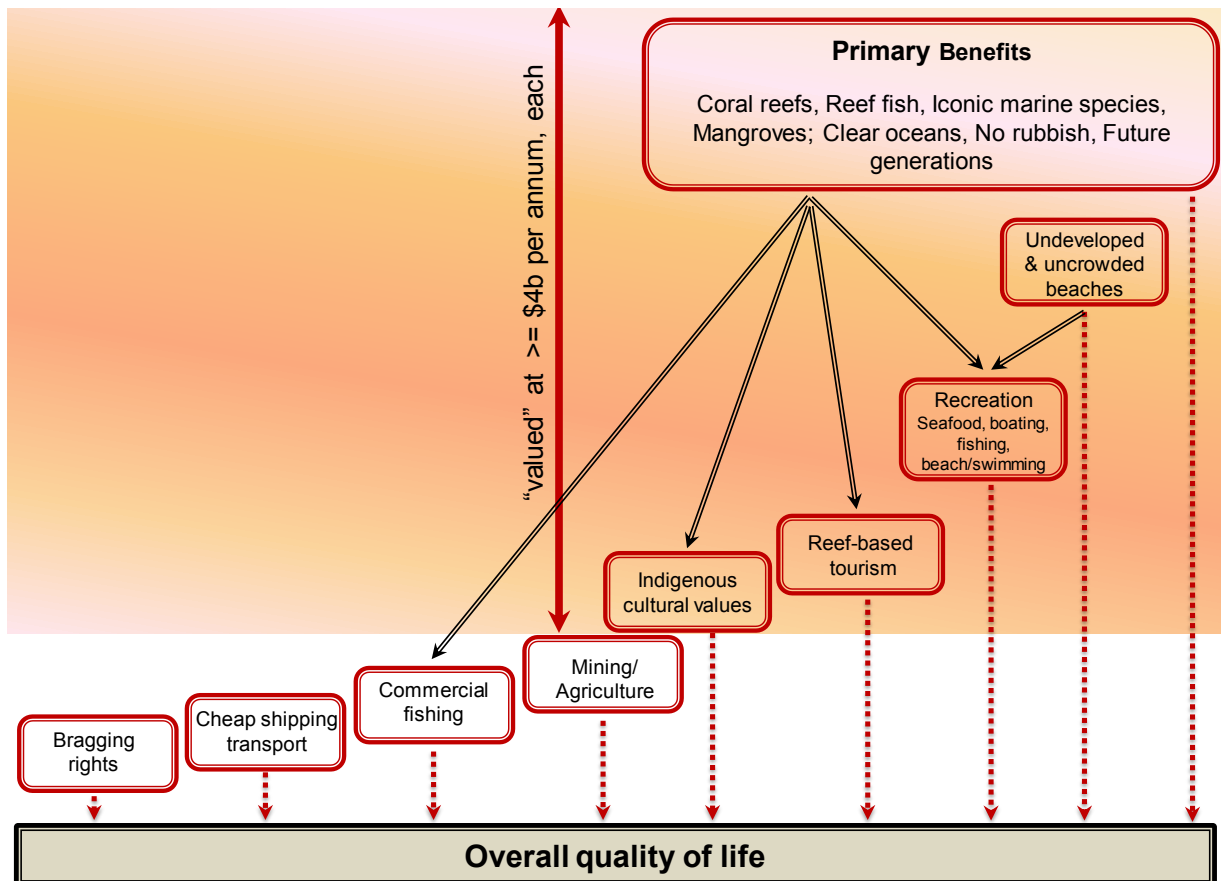


Figure 6: Diagrammatic representation of the way in which various community defined benefits contribute to the overall quality of life of residents in the GBR catchment area – using correlation coefficients to group.

The vertical 'height' of each separable group of benefits indicates mean importance. Arrows show how benefits contribute to the overall quality of life – directly (red dotted line from item to quality of life), indirectly (black solid line to another item), or both.

(Figure adapted from Stoeckl *et al.*, 2014)

Conclusions

The collective value of a wide range of ecosystem services provided by the GBR is likely to be between \$15b and \$20b per annum. Even though the methods and estimates in this study have limitations, our findings highlight the importance of overlapping problem and offer one method of dealing with it. This type of whole-ecosystem valuation method may, with further refinement, offer itself as a viable alternative to the more common additive approaches.

3.4 The preservation value of the GBRWHA

The material presented in this section summarises material from

Jarvis, D., Stoeckl, N., Liu, H. (in review). Can the life satisfaction technique be used to estimate non-use values? A case study of the Great Barrier Reef.

Abstract

There are numerous methods of generating financial estimates of the 'value' of the environment, but these techniques suffer from a range of problems. In this study we consider whether the emerging life-satisfaction (LS) approach offers itself as a viable alternative, testing to see if it can be used to estimate non-use values in the Great Barrier Reef (GBR). We use geographically weighted regression to investigate factors explaining the LS of residents of the GBR catchment area, finding that income is a more important explanatory variable in the south than in the north. We also find that those who feel that the GBR is being 'satisfactorily' preserved for future generations have higher LS scores, after controlling for other factors. We use the model coefficients to draw inferences about how much income would be required, as compensation to keep overall LS constant, should residents become less satisfied that the GBR is being preserved for future generations. This is in the order of \$7.5bn annually. We acknowledge the imperfections of our approach, but feel it demonstrates that with further refinement the LS approach could prove a suitable alternative or supplement to the more common stated preference techniques that seek to measure non-use values.

Keywords: Bequest values; Geographically weighted regression; Life satisfaction approach; Non-use values; Spatial analysis of satisfaction with life; Subjective well-being; Valuing environmental assets.

Methods and main findings

The life-satisfaction approach has been used to 'value' different features of the environment, but to date, has focused on use-values. In this paper we use resident responses to a question about how satisfied they are that the GBRWHA is being preserved for future generations as an admittedly imperfect proxy for non-use values. We test for the statistical significance of its association with overall LS. Our proxy is based on perceptions, rather than on objectively verifiable data. The justification for this relies on previous research indicating that individuals' perceptions of reality are better at explaining their behavior than objective indicators (Cummins, 2000).

Using both OLS and geographically weighted least squares regression, we found that the statistically significant determinants of satisfaction with life overall were: age, gender, marital status, education, income and perceptions about whether the GBRWHA is being 'satisfactorily' preserved. Our results also indicated significant spatial differences, with a very distinct north to south pattern (Table 5 and Figure 7). Age and income effects are stronger in the south; gender, marital status, education and preservation effects are stronger in the north. We were able to use coefficients from these models to estimate how much extra income residents would need to be 'compensated with' to keep life satisfaction constant, if they became less satisfied with the preservation of the reef. This is a very rough estimate of the 'non-use' value of the GBRWHA: about \$7.5 billion per annum. It is consistent with findings from previous paper (section 3.3; Stoeckl et al., 2014) which highlighted that non-use values are considered, by respondents to be more important to their overall quality of life than the jobs and incomes associated with the tourism industry (worth just \$4.2 b to the local region).

Table 5: Determinants of overall satisfaction with life and spatial differences between the regions

Determinants of life satisfaction	Cairns	Townsville	Mackay	Fitzroy
Age (Older=>happier)	Age effect stronger in the south			
Male (males less happy)	Gender effect stronger in the north			
Married (married happier)	Marital effect stronger in the north			
Education level (completed year 12 => happier)	Education effect stronger in the north			
Income (higher income => happier)	Income effect stronger in the south			
The level of satisfaction that the GBRWHA will be preserved for future generations (positive impact on LS)	Preservation effect stronger in the north			

Note: Only significant variables reported (Table adapted from Jarvis *et al.*, in review)



Figure 7: Spatial differences across the GBR Natural Resource Management (NRM) regions – preservation effect is stronger in the north
(Map produced by Diane Jarvis, JCU)

We found that residents of the GBR region who feel that the reef is being satisfactorily preserved for future generations have higher levels of overall LS than those who feel differently. There is also a spatial dimension to this relationship; the further north one goes, the more significant our proxy for non-use values to LS, and the less significant the contribution of income. We estimate that residents non-use values related to the GBRWHA could be about \$7.5 billion per annum. Our research findings thus demonstrate that the LS approach can, in principal, be used to estimate non-use values (although further research is clearly needed to refine methods).

3.5 Additional insights

The material presented in this section is based and builds on data reported in

Stoeckl, N., Farr, M., & Sakata, H. (2013). What do residents and tourists 'value' most in the GBRWHA? Project 10-2 Interim report on residential and tourist data collection activities including descriptive data summaries. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns, pp. 112. Available at: <http://www.nerptropical.edu.au/publication/project-102-technical-report-what-do-residents-and-tourists-'value'-most-gbrwha>

3.5.1 Resident willingness-to-pay to protect the environment

Residents were also asked how much they would be willing to pay each year, to improve water clarity, to reduce the risk of shipping accidents and to protect top predators. Despite the fact that responses to other questions indicated a strong environmental ethic, a relatively large proportion of respondents were not willing to pay anything at all for protection (Figure 8).

We used the hurdle model to look for statistically significant relationships between various socio-economic and demographic descriptors of respondents and their WTP. The hurdle model is appropriate because analysis is done in two steps. First it simply divides respondents into two groups, those who are not willing to pay anything at all, and those who are willing to pay something. It identifies characteristics of respondents that are most/least likely to fall into one of those two categories. Second, it focuses on only those who are willing to pay something, and identifies characteristics of those willing to pay most/least. Results are shown in (Table 6), a key point being that determinants of WTP for all three items are very similar.

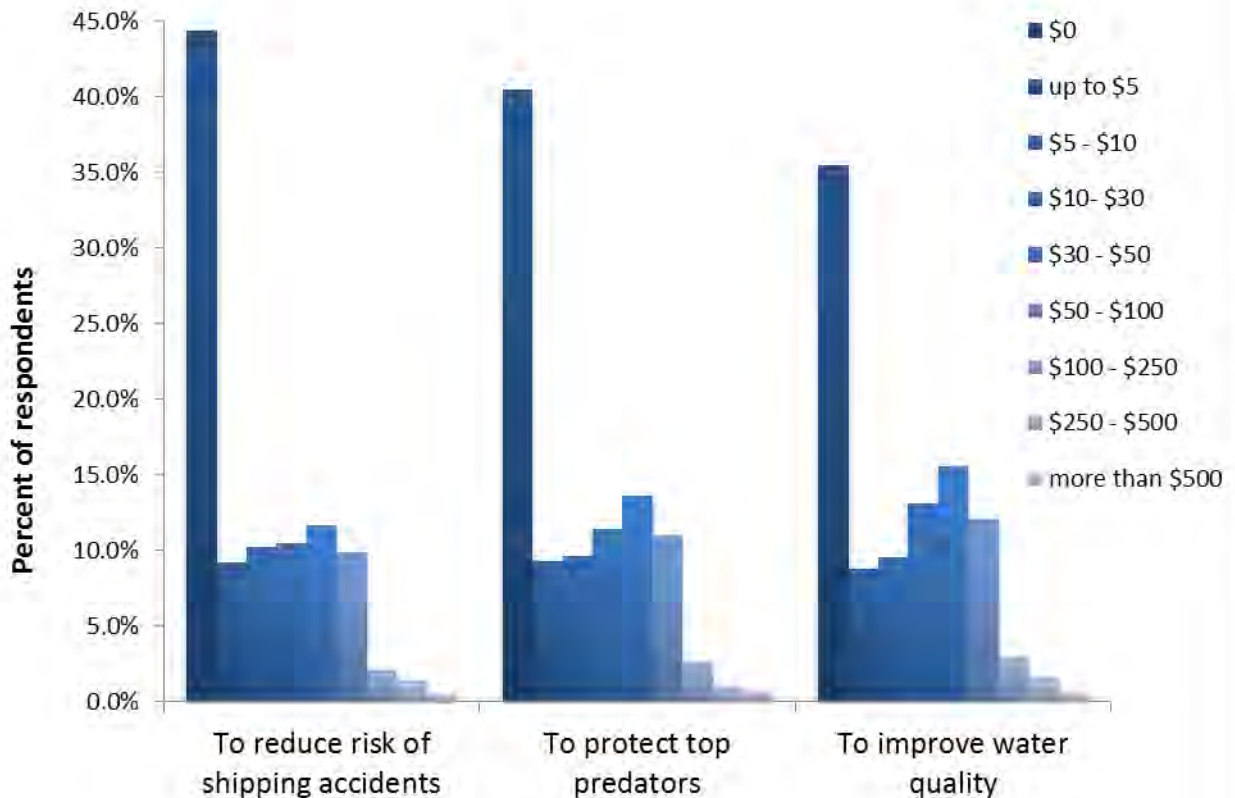


Figure 8: Distribution of residents' responses to questions about willingness to pay for environmental improvements

(Figure adapted from Stoeckl *et al.*, 2013)

In summary, this analysis establishes that residents who are most likely to be willing to pay something to protect the environment were:

- Relatively young
- Females
- Those with a university degree
- The higher income earners
- Those who were employed in Retail; Accommodations, cafes and restaurants; and Tourism-related industries
- Those who were happy to pay to help protect the GBRWHA, providing that other users pay too
- Those given questionnaires with low dollar values on the 'bid card (we generated 24 different versions of the WTP question, presenting the items for assessment – e.g. water quality, shipping, top predators – in four different orders, and presenting 6 different payment cards, each with a different top price. The order in which items were presented made no difference to responses, but the dollar values presented did).

The 'equity' issue seems particularly interesting: evidently people do not mind paying to help protect the environment, as long as they are not the only ones asked to do so.

Table 6: Statistically significant relationships between various socio-economic and demographic descriptors of residents and their Willingness to Pay to protect the environment

Residents					
Water Clarity		Shipping		Predators	
To pay or not to pay amount >\$0	How much to pay (if agreed to pay >\$0)	To pay or not to pay amount >\$0	How much to pay (if agreed to pay >\$0)	To pay or not to pay amount >\$0	How much to pay (if agreed to pay >\$0)
Age (-)		Age (-)		Age (-)	
Male (-)		Male (-)	Male (+)	Male (-)	
Education (+)		Education (+)		Education (+)	
Income (+)	Income (+)	Income (+)	Income (+)	Income (+)	Income (+)
WTP Bid range (-)		WTP Bid range (-)		WTP Bid range (-)	
Tourism (+)	Tourism (-)	Tourism (+)		Tourism (+)	Tourism (-)
Not prepare to pay unless all Australia pay too (+)		Not prepare to pay unless all Australia pay too (+)		Not prepare to pay unless all Australia pay too (+)	
	QLD born (-)		QLD born (-)		QLD born (-)
Estimated WTP = \$32.29		Estimated WTP = \$27.63		Estimated WTP = \$29.68	

Note: Only significant variables reported. A plus sign (+) indicates that the variable was found to have a positive and statistically significant relationship with the score assigned to the corresponding value; a negative sign (-) indicates negative and statistically significant negative relationship

3.5.2 Potential impact, on overall quality of life, of environmental degradation

Residents were asked how a series of eight hypothetical 'changes' (Figure 9) would affect their QOL. Responses support previous messages that environmental factors are very important to QOL. Indeed some forms of environmental degradation (e.g. twice as many oil spills, twice as much rubbish, and reduced ocean water clarity) would have a much stronger impact on overall QOL than a 20% increase in local prices compared to elsewhere in Australia.

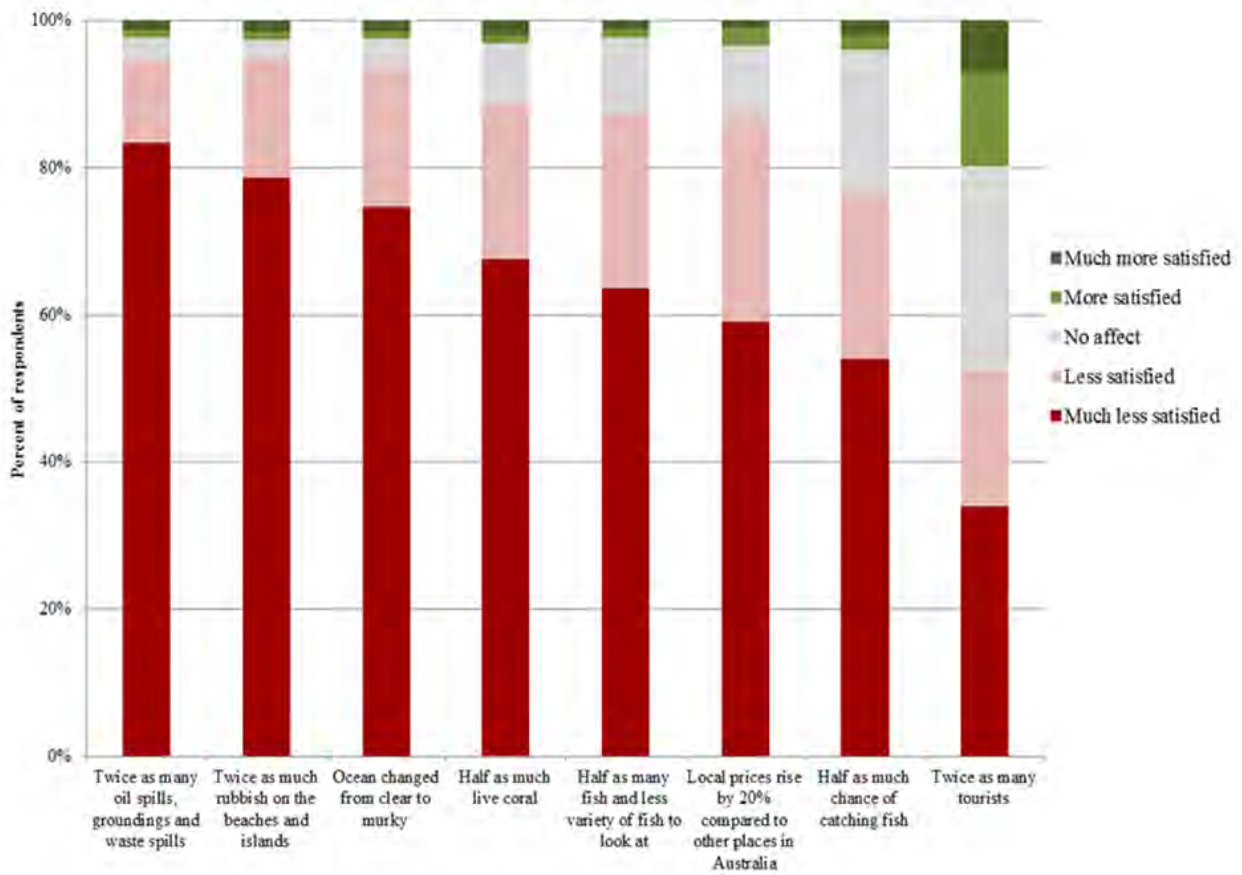


Figure 9: Residents' stated response to hypothetical changes in the GBRWHA

(Figure adapted from Stoeckl *et al.*, 2013)

4 Tourist 'values'

4.1 The importance of the GBRWHA for destination competitiveness

The material presented in this section summarises material from:

Esparon, M., Stoeckl, N., Farr, M., & Larson, S. (forthcoming). The significance of environmental values for destination competitiveness and sustainable tourism strategy making: Insights from the Great Barrier Reef World Heritage Area. *Journal of Sustainable Tourism*.

Abstract

Sustainable destinations must deliver products that perform better than their competitors and at the same time protect key environmental drawcards. This research explores the environmental – economic interface of a major destination, both as a case study in how to approach this complex relationship, and as a contribution to the methodology of tackling the need for understanding competitive pressures as part of sustainable tourism strategy creation. Using the Great Barrier Reef World Heritage Area (GBRWHA) as an example, the paper assesses 21 key environmental values, including indigenous culture, against market-based factors, in terms of their importance for visitors as regional drawcards, satisfaction with them and the way in which changes in them might affect trip numbers and duration across different regions. While the natural values of the GBRWHA are found to be the most important drawcards, satisfaction scores were significantly lower than importance scores for a number of these values. Visitors responded more negatively to the prospect of environmental degradation than to the prospect of a 20% increase in local prices: the detailed impact depends, however, on location and visitor mix. Clear ocean, healthy coral reefs, healthy reef fish and lack of rubbish were the top four most important values.

Keywords: Great Barrier Reef World Heritage Area, destination competitiveness, environmental values, visitor perceptions, importance, satisfaction

Methods and main findings

We used a sub-set of our tourist data (on 996 visitors, all of whom answered all questions about importance, satisfaction, likely response to changes in hypothetical scenarios and demographic descriptors) to learn more about how important various ecosystem services provided by the GBRWHA were as a regional drawcard, and at how satisfied visitors were with those services when here. Clear ocean, healthy coral reefs, healthy reef fish and no visible rubbish were found to be the most important drawcards and were ranked by visitors as the top four (out of 21) most important values. Clearly it is these values that attract tourists to the GBRWHA. When comparing importance and satisfaction scores (see Figure 10), the majority of environmental importance scores were significantly higher than the corresponding satisfaction scores.

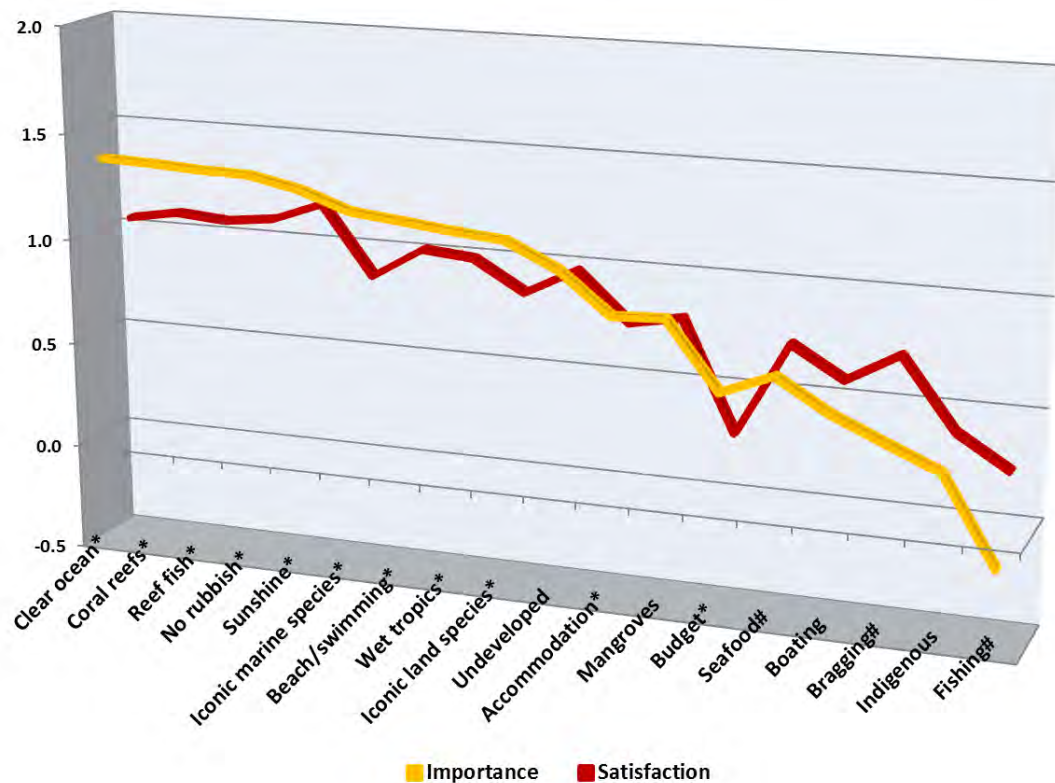


Figure 10: Mean importance and satisfaction scores compared, tourists

* denotes statistically significant differences between the distributions relating to importance and those relating to satisfaction
 # denote statistical significance of the difference between the distributions relating to satisfaction
 (Figure adapted from Esparon *et al.*, forthcoming)

We used Categorical Principal Component Analysis (CATPCA) to identify which importance scores grouped together. The twenty one original items (Table 1, Figure 10) generated three groups of factors:

- 1st group – Nature, culture, seafood and recreation- included all environmental values (e.g. coral reefs, coral fish, clear ocean etc.) as well as sunshine, seafood, indigenous, boating and bragging.
- 2nd group – Business- included values associated with attending to business, going to a meeting and/or conference
- 3rd group – Socialising and value for money – grouped those who preferred to be somewhere close where they live, to suit their budget, to visit their friends and go fishing, and to have a good quality accommodation.

We then used OLS and seemingly unrelated regressions (SUR) to look for statistically significant relationships between the socio-demographic and economic characteristics of visitors (Table 7) and the 'importance' assigned to these grouped factors. The results revealed that different people attach different importance to different things (Table 8).

Table 7: Additional variables used in subsequent analyses for tourists – descriptors and abbreviations

Variable of interest	Description	Abbreviations used in this report
Origin of visitors		
QLD	=1 if visitor from QLD, 0 otherwise	Visitor QLD
Elsewhere in Australia	=1 if visitor from the rest of Australia, 0 otherwise	Visitors AUS (not QLD)
China	=1 if visitor from China, 0 otherwise	China
Japan	=1 if visitor from Japan, 0 otherwise	Japan
International	=1 if international visitor, 0 otherwise	International visitor
Type of travel party		
Couple	=1 if travelling as a couple, 0 otherwise	Couple
Family with children	=1 if travelling as a family with children, 0 otherwise	Family with children
Friends	=1 if travelling with friends, 0 otherwise	Friends
Tour group	=1 if travelling with a tour group, 0 otherwise	Tour group
Visitor to Mackay/Rockhampton area	=1 if visitor to Mackay/Rockhampton area	Visitor Mackay/Rockhampton
Visitor to Townsville/Whitsunday area	=1 if visitor to Townsville/Whitsunday area	Visitor Townsville/Whitsunday
Will return to the GBRWHA	Scale variable =2 if visitor will definitely return to visit the region in the future, = -2 if definitely will not return	Return
Importance	Importance of water clarity- scale variable (=1 if water clarity is very unimportant; =5 if very important)	Importance
Satisfaction	Satisfaction with water clarity- scale variable (=5 if very dissatisfied; =1 if very satisfied)	Satisfaction
Importance and Satisfaction	Importance multiplied by Satisfaction	IS

Males place more importance on coming to do business, but consider nature, culture, seafood and recreation, socialising and value for money as less important reasons to come to the region.

Table 8: Characteristics of respondents determining importance scores for groups of values tested using OLS

Nature, culture, seafood & recreation	Business	Socialising & value for money
Male (-)	Male (+)	Male (-)
Education (-)		Age (+)
	Income (+)	Education (-)
	Visitor QLD (+)	
	Visitor AUS (not QLD) (+)	
	Couple (-)	Couple (+)
	Family with children (-)	Family with children (+)
	Friends (-)	Friends(+)
	Tour group (-)	
		Visitor Mackay/Rockhampton (-)
	Visitor Townsville/Whitsunday (+)	Visitor Townsville/Whitsunday (-)

Note: Only significant variables reported. A plus sign (+) indicates that the variable was found to have a positive and statistically significant relationship with the score assigned to the corresponding value; a negative sign (-) indicates negative and statistically significant negative relationship

(Table adapted from Esparon *et al.*, forthcoming)

We also looked at visitor responses to a range of different hypothetical scenarios. Specifically, we asked visitors to tell us how 8 different 'changes' would have affected their decision to come to the region and/or their decision about how long to stay. Visitors reacted more negatively to the prospect of oil spills, a reduction in water clarity, twice as much rubbish and half as much live corals, than to the prospect of a 20% increase in local prices.

We then used OLS regression and SUR to look for statistically significant relationships between the socio-demographic and economic characteristics of visitors and their stated reaction to these various hypothetical changes. Our findings clearly indicated that different types of tourists would be likely to respond in a different way to environmental changes. We found that environmental deterioration would have a greater negative impact on Indigenous visitors' decision to come to the region than on non-Indigenous visitors. Our results also indicated that Chinese and Japanese tourists were more averse to the prospect of environmental degradation than other tourists. Moreover, and in accordance with findings from the residential sample, we found a clear north-south spatial pattern to responses. Those visiting the Cairns/Port Douglas region reacted more negatively to the prospect of environmental degradation than those in the south, although southern visitors were more sensitive to the prospect of a decline in the chance of catching fish than those in the two northern regions (Figure 11).

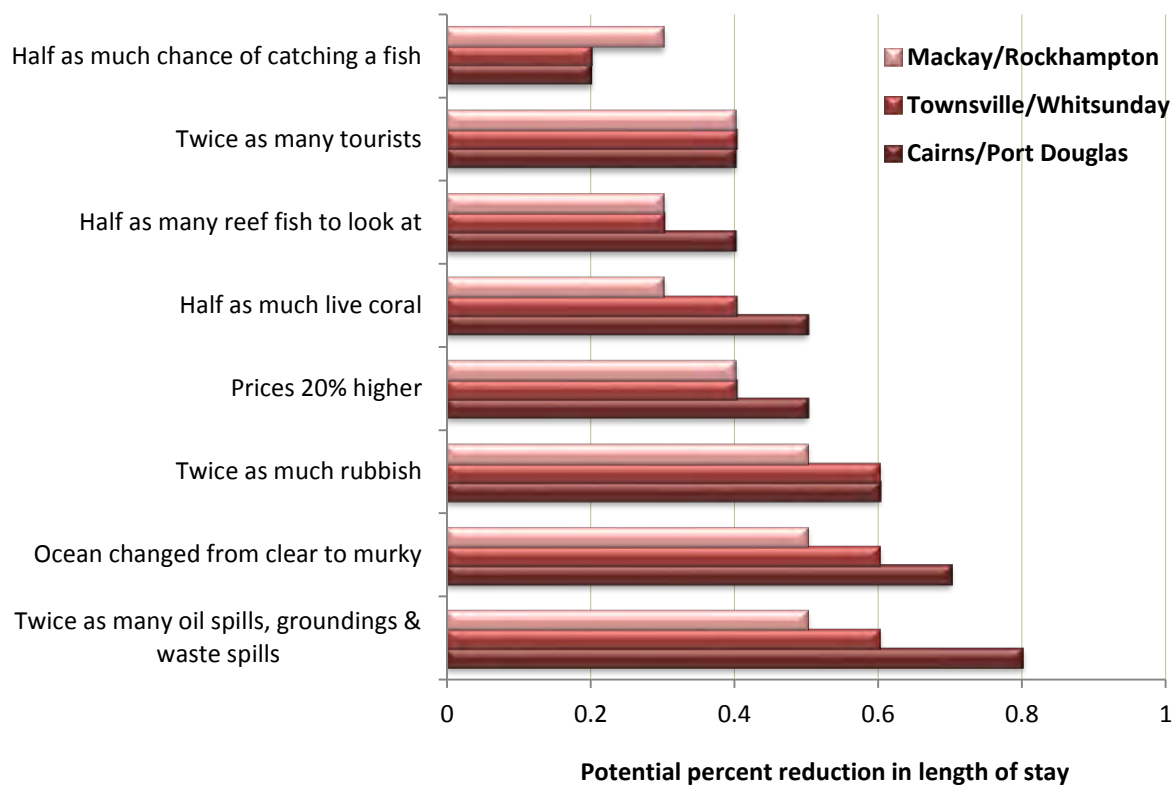


Figure 11: Mean length of stay and potential % reduction in days for each respective change across regions

(Figure adapted from Esparon *et al.*, forthcoming)

Conclusions

Environmental amenity values are more important drawcards to the region than good quality accommodation, and low prices. Most tourists are reasonably satisfied with a range of different ecosystem services provided by the GBRWHA, but similar to residents, the 'gap' between importance and satisfaction scores is largest for environmental non-use values, and respondents seem more averse to the prospect of environmental degradation than to the prospect of prices increasing by 20%. Also similar to our analysis of residents, we find that different types of tourists (e.g. the old, those from QLD or other parts of the world), are motivated by different factors and are likely to react differently to environmental degradation. Moreover, there is a north/south effect with those visiting the north being more environmentally sensitive than those in the south.

4.2 The potential impact of reef degradation on the tourism industry

The material presented in this section summarises material from:

Mustika, P. L. K., Stoeckl, N., & Farr, M. (forthcoming). The potential implications of environmental deterioration on business and non-business visitor expenditures in a natural setting: a case study of Australia's Great Barrier Reef, *Tourism Economics*.

Abstract

Nature based tourism can be an important source of income for regional economies, but relies on a healthy environment. Using data collected from business and non-business visitors to Australia's coast adjacent to the Great Barrier Reef, we generate estimates of the potential financial impact of environmental degradation, demonstrating a novel way of testing and controlling for hypothetical response bias. More than 90% of non-business visitors and 67% of business visitors came to the region for at least one nature related reason. Average daily expenditure was similar for both visitor segments (\$190), but because non business visitors spent longer in the region, they spend more overall. All visitors reacted much more negatively to the prospect of environmental degradation than to a 20% increase in (local) prices, although business visitors were much less responsive than non-business visitors. Adjusting for hypothetical response bias, we estimate that substantial environmental degradation could reduce visitor expenditures (and thus local tourism incomes) by at least 17%.

Keywords: business and non-business visitors, visitor expenditure, Great Barrier Reef, hypothetical response bias, environmental degradation

Methods and main findings

In this paper we used data about visitor expenditure, and responses to questions about the various hypothetical scenarios, to generate estimates of the potential financial impact of environmental degradation – considering both business and non-business visitors.

Total expenditure per visitor per trip was higher for non-business visitors than for business visitors (approximately to \$1,760 compared to \$1,290) – largely because non-business visitors spent a similar amount to business visitors each day, but they stay longer in the region. As show in Figure 12, for each expenditure item, non-business visitors' expenditure was greater than business-visitors expenditure. Nearly 30% of all money was spent on accommodation; with an additional 30% spent on food and beverages at restaurants, cafes and bars or from grocery stores.

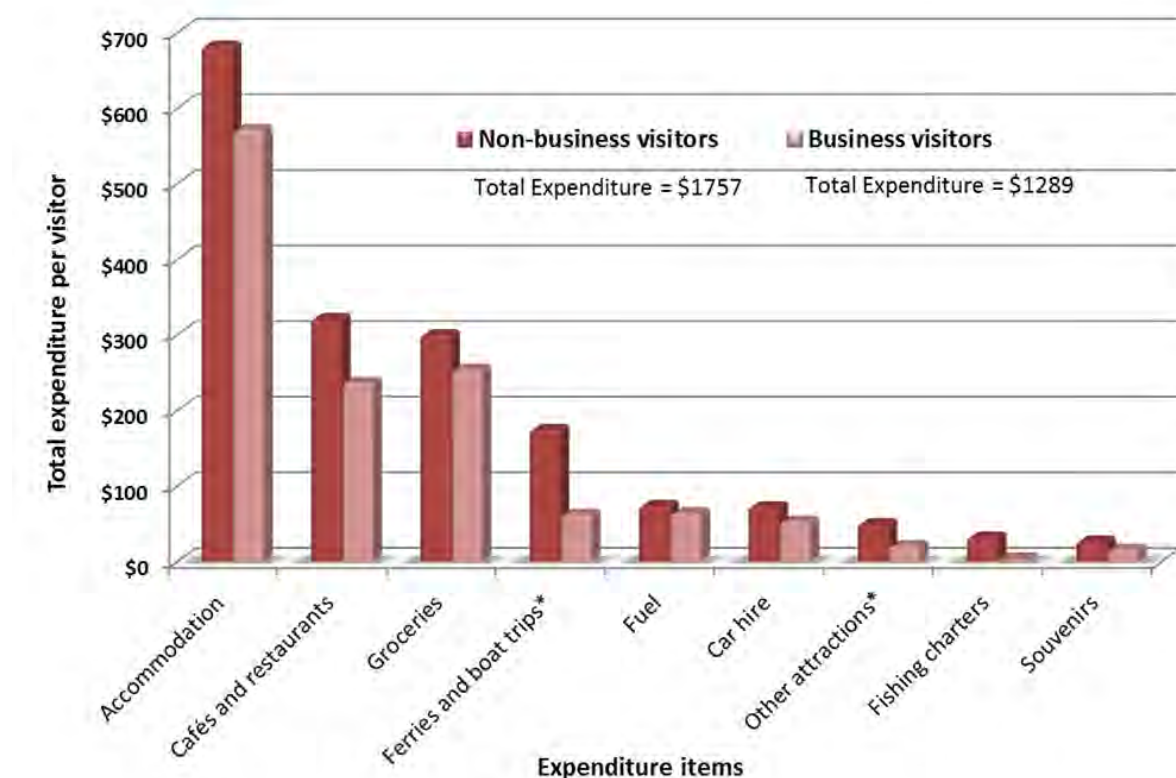


Figure 12: Visitor expenditure by category of expenditure and visitor segment (mean AUD, per visitor).

A '*' indicates statistically significant differences between spending of business and non-business visitors

(Figure adapted from Mustika *et al.*, forthcoming)

We used various types of regression (probit, negative binomial, tobit) to identify statistically significant relationships between socio-economic descriptors of the visitors (Table 7) and total business expenditure². Results are summarized in Table 9. Those business visitors, who spent most, were relatively young and non-nature motivated. This contrasts markedly with non-business visitors: those 'big spenders' were relatively old and highly motivated by nature.

We then looked at responses to our questions about the way in which various hypothetical scenarios would have impacted decisions to come to the region. Both groups of visitors responded negatively to environmental degradation (water clarity, oil spills and reduction in live coral cover) – much more so than to a 20% increase in price. Business visitors were, as expected, much less responsive to all hypothetical changes than non-business visitors.

We adjusted responses for hypothetical bias, and estimated the potential loss of visitor expenditure under each hypothetical change (Figure 13). The results indicate that deterioration of the environment in the GBRWHA could cause much greater financial losses than a 20% increase in regional prices. Economic sectors most affected include those currently receiving the

² We also investigated determinants of expenditure for each expenditure item and the results were consistent with those explaining total expenditure.

most money (Figure 12), namely: the accommodation sector, the café, restaurants and retail sectors, and the operators of boats and ferries.

Table 9: Characteristics of business and non-business visitors who were likely to spend most

Business visitors	Non-business visitors
Australian visitors (excluding those from QLD)	Australian visitors (excluding those from QLD)
Those who stay for long periods of time	Those who stay for long periods of time
Those who spent much time on the beach, and/or who went to an island or the reef spent	Those who spent much time on the beach, and/or who went to an island or the reef spent
Relatively young	Relatively old
Those who were non-nature motivated	Those who highly motivated by nature
	Those on high incomes
	International visitors

Note: Only significant variables reported (Table adapted from Mustika *et al.*, forthcoming)

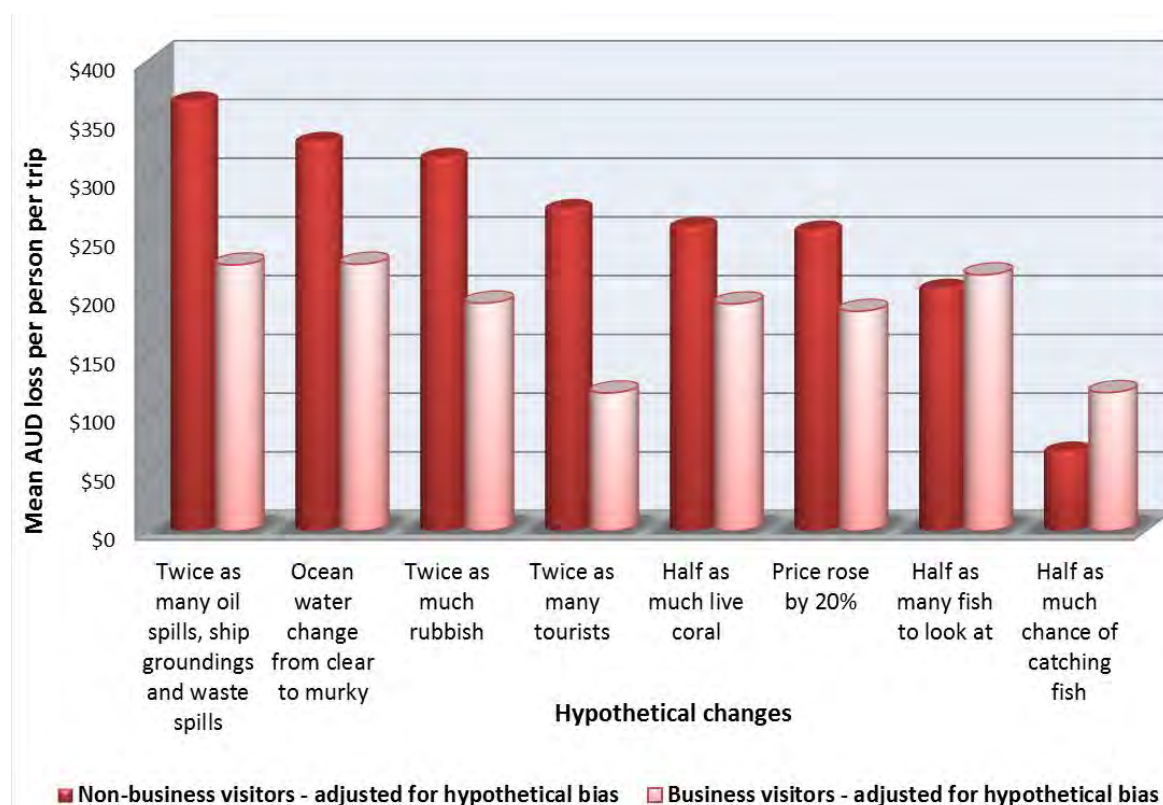


Figure 13: The potential loss in visitor expenditure from shorter stay (AUD per visitor per trip)

(Figure adapted from Mustika *et al.*, forthcoming)

Conclusions

Non business visitors spend more within the GBR catchment than business visitors, primarily because they stay for longer.

Visitors (both business and non-business) who spent a large proportion of their time on a beach, island or at the offshore reefs, spent more than other visitors. Non-business visitors who were strongly motivated by nature also spent more than visitors with other motivations. But nature-motivated business visitors spent less than other business visitors (the nature motivated business visitors stayed for longer – presumably to enjoy nature – but spent significantly less, per night, on accommodation).

Both visitor segments would likely be affected by environmental deterioration. These effects could be more significant than a 20% increase in local prices, suggesting that the tourism industry could lose hundreds of dollar per visitor, if the environment were to deteriorate substantially.

4.3 The potential impact of climate change on the tourism industry

The material presented in this section summarises material from:

Jarvis, D. (accepted paper). Could climate change redistribute global tourism activity by impacting trip satisfaction? Paper to be presented at the 25th Annual CAUTHE Conference, Gold Coast, Queensland, 2-5th Feb 2015.

Abstract

Understanding the elements influencing tourist trip satisfaction is critical if we are to understand the risk tourism faces from climate change. If it affects satisfaction, and thus repeat visitation and/or recommendations to others, it could affect the sustainability of the tourism industry. This case study of tourists visiting the Great Barrier Reef (GBR) catchment investigates the impact of daily maximum temperatures on trip satisfaction. The relationship is found to have an inverted U shape; increased temperatures improve trip satisfaction until a turning point at around 29 degrees centigrade, beyond this point increased temperatures reduce satisfaction. As current temperatures in the region are very close to this turning point, a temperature increase would decrease trip satisfaction, adversely impacting the region's tourism industry. However, currently cooler regions would benefit as increasing temperatures improve the satisfaction of tourists visiting those areas; the net effect being a global redistribution of the tourism activity.

Keywords: trip satisfaction; sustainable tourism; climate change; global warming; maximum daily temperatures; repeat visits

Methods and main findings

We combined data collected from the visitor survey described in section 2 with data from the Bureau of Meteorology (BOM) about the maximum daily temperature experienced by each visitor (i.e. we matched location, and time of visit, to daily temperature data from the BOM). We used both OLS and ordinal regression, to estimate a model describing overall trip satisfaction, as a function of socio-demographic, economic and temperature data. We found that the highest levels of trip satisfaction were associated with tourists who

- Had a high income
- Stayed in the region for a relatively long period
- Believed that a lost wallet and its contents would be returned
- Were satisfied with water quality in the GBR lagoon
- Did not experience maximum daily temperatures that were 'too high', or 'too low'.

More specifically, we found that low average daily temperatures were associated with relatively low levels of trip satisfaction, but that once temperatures rose to about 29.1 or 29.3 degrees centigrade (dependent on whether using ordinal regression or OLS regression models respectively), the relationship reverses; further increases in average daily maximum temperatures reduce the overall level of trip satisfaction. Thus, we have an inverted U shaped relationship between these variables (Figure 14).

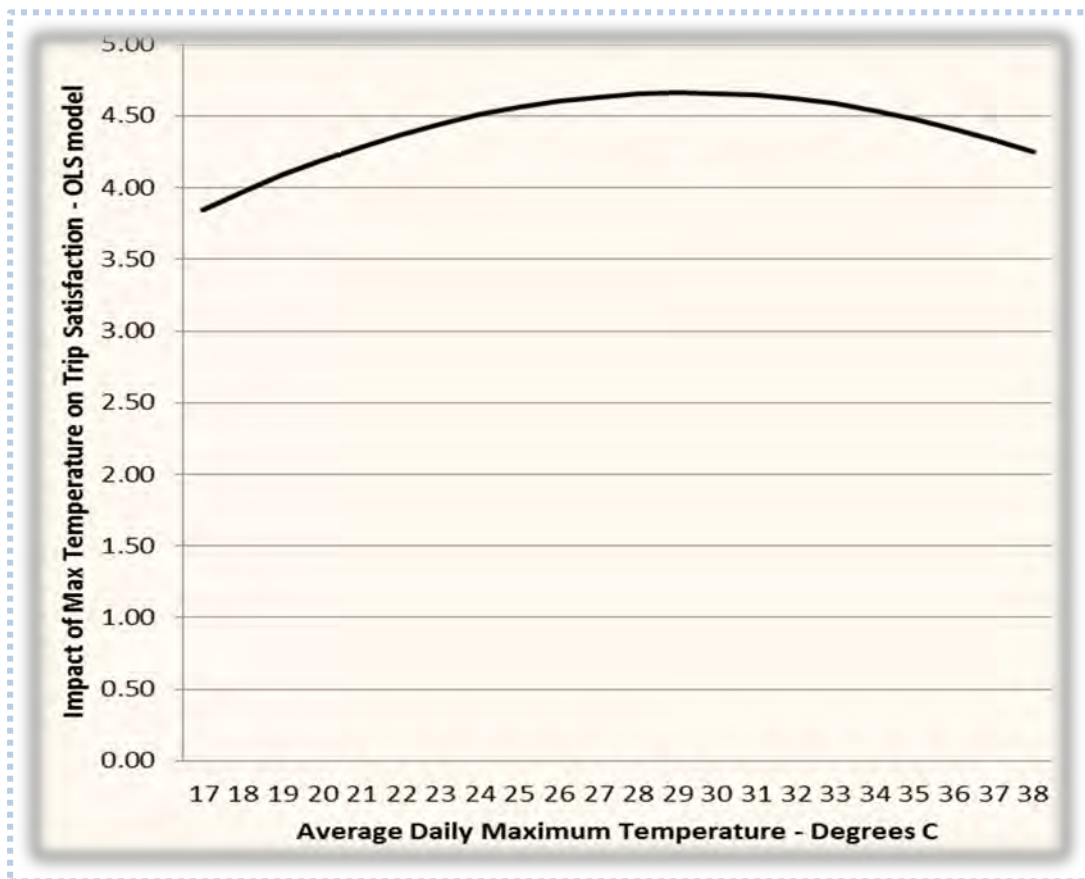


Figure 14: The relationship between overall trip satisfaction and average maximum daily temperatures

(Figure adapted from Jarvis, accepted)

Controlling for other factors, we find there is a non-linear relationship between trip satisfaction and maximum daily temperatures; trip satisfaction improves as temperatures increase to around 29 degrees centigrade, but falls beyond that point. This may have important implications for tourism within the GBR region. With current average maximum temperatures across the region approximately 28 degrees centigrade, and exceeding 29 degrees centigrade in the northern part of the region, any increase in temperature from current levels is likely to result in a decrease in overall trip satisfaction experienced by visitors to the region. Thus a direct consequence of global warming could be a reduction in trip satisfaction, which could seriously impact the sustainability of the tourism industry in the GBR region. However, for locations that are currently cooler than the GBR region, this finding could have positive implications as increasing temperatures would increase the satisfaction of tourists which could significantly boost their tourism industry.

The global implications on tourism from increased temperatures experienced as part of climate change could therefore be a redistribution of tourists between regions, with hotter regions suffering due to the negative relationship between temperatures and trip satisfaction above 29 degrees, whilst currently cooler regions benefit from the positive relationship between maximum temperatures and tourist satisfaction at lower temperatures. Whilst the overall impact on global tourism is unclear, it appears likely that some regions could experience great benefits whilst in other regions tourism may become unsustainable.

4.4 Water clarity, visitor satisfaction and repeat visitation

The material presented in this section summarises the material from

Jarvis, D., Stoeckl, N., & Liu, H. (in review). The impact of economic, social and environmental factors on sustainable tourism.

Abstract

Tourism is vital to the economy of many regions; however visitor numbers are stagnating in some areas. We use tourist survey data supplemented by objective data from secondary sources to develop a model of overall trip satisfaction in the GBRWHA. We also quantify the link between the likelihood of a tourist returning and their overall trip satisfaction.

We find that increased construction work, decreased water clarity and decreased perceptions of tourist safety are all likely to reduce satisfaction, and thus the likelihood of repeat visits. Linking that information to expenditure data, we are able to estimate the potential losses in expenditure / tourism revenue that could occur as a result of reduced repeat visitation, should there be more construction, decreased water clarity, or increased perceptions of crime. We conclude that future development within the region should be evaluated holistically, noting that expansion of one industry, will likely affect others.

Key words: Sustainable tourism, Repeat visitors, Tourist trip satisfaction, Life satisfaction, Triple bottom line impacts on tourism

Methods and main findings

Using data collected from 641 visitors, we first used ordinal regression to explore the link between responses to a question about the likelihood of returning to the GBRWHA, trip satisfaction, and various other socio-demographic factors. Those most likely to return were

- Already repeat visitors (i.e. they had been before)
- Not from North America, Europe or Asia
- Satisfied with their trip

We then supplemented our survey data with data from a variety of other sources (including the Australian Bureau of Statistics, Australian Institute of Marine Science [AIMS]), that described the region in which tourists were visiting when surveyed (e.g. crime rates, construction activity) at the time they were there (e.g. rainfall, water turbidity).

We used ordinal regression to model the relationship between trip satisfaction and these other variables. We found that those most satisfied with their trip were

- On relatively high incomes
- Staying for more than one night
- Of the opinion that a lost wallet would be returned, intact³
- Not in a region with high levels of construction activity
- Visiting a region that had low levels of water turbidity at the time of their visit (we used instrumental variables to control for endogeneity between rainfall, sunshine, turbidity and satisfaction).

We then used coefficients from the models to make quantitative predictions about the way in which (a) higher water turbidity, (b) higher construction activity; (c) higher perceptions of crime would impact firstly overall trip satisfaction and subsequently, the probability that a person would return. We were then able to use predicted reductions in the probability of return, to generate estimates of the likely financial impact of those changes (in terms of lost tourist revenue, with lower numbers of repeat visitors). For example, we were able to estimate that a:

- 10% increase in water turbidity within the GBR lagoon would reduce tourist revenues by approximately \$430,000 per annum
- 10% increase in the level of construction activity within the region would reduce tourist revenues by approximately \$392,000 per annum
- 10% reduction in the number of tourists perceiving that a lost wallet would be returned with contents intact would reduce tourist revenues by approximately \$305,000 per annum

Conclusions

High numbers of repeat visitors help sustain an industry. Visitors most likely to return to the GBRWHA are those who were most satisfied with their most recent visit (controlling for other factors). Satisfaction is influenced by a range of factors – social, economic, and environmental. In this part of the world, there is a statistically significant relationship between tourist satisfaction, perceptions of crime, construction activity, and water turbidity. Increases in any of those three factors could thus impact the tourism industry.

³ Actual crime rates were not correlated with responses to the lost wallet question; neither were they correlated with trip satisfaction.

4.5 Tourist willingness to pay for improvements in water quality

The material presented in this section summarises material from:

Farr, M., Stoeckl, N., Esparon, M., Larson, S., & Jarvis, D. (2014a). The importance of water clarity to tourists in the Great Barrier Reef and their willingness to pay to improve it. *Tourism Economics*. Available at <http://www.ingentaconnect.com/content/ip/tec/pre-prints/content-teft157>

Abstract

Using the Great Barrier Reef as a case study area, we investigate visitors' willingness to pay (WTP) to improve water clarity (WC). We also explore the extent to which people's objective and subjective measures of WC influenced WTP. Our results suggest that people's stated perceptions (importance and satisfaction) and the interaction between them have a significant influence on WTP. Those for whom WC was very important and who were very satisfied with WC were willing to pay more to preserve it. The importance variable interacts with subjective perceptions that drive behaviour. Thus one needs to consider not only satisfaction, but also the importance of the environment rather than using only subjective (or objective) measures when trying to explain behaviour. Further deterioration in WC could adversely affect the tourism industry and the average visitor would be willing to pay up to Aus\$14.5 per visit to help improve it (although this amount is different for different visitors).

Key words: Contingent Valuation; Great Barrier Reef World Heritage Area; hurdle model; Payment card; visitors' willingness to pay; water clarity; objective and subjective measures

Methods and main findings

We asked one-half of our tourist sample to answer questions about willingness to pay for various improvements to the environment (the other half were asked expenditure questions). In this paper we focused on responses to questions about how much visitors were willing to pay (each visit) to contribute to a fund that would seek to improve water clarity in the GBR lagoon; 80 % were willing to pay something, some even more than \$50 (see Figure 15).

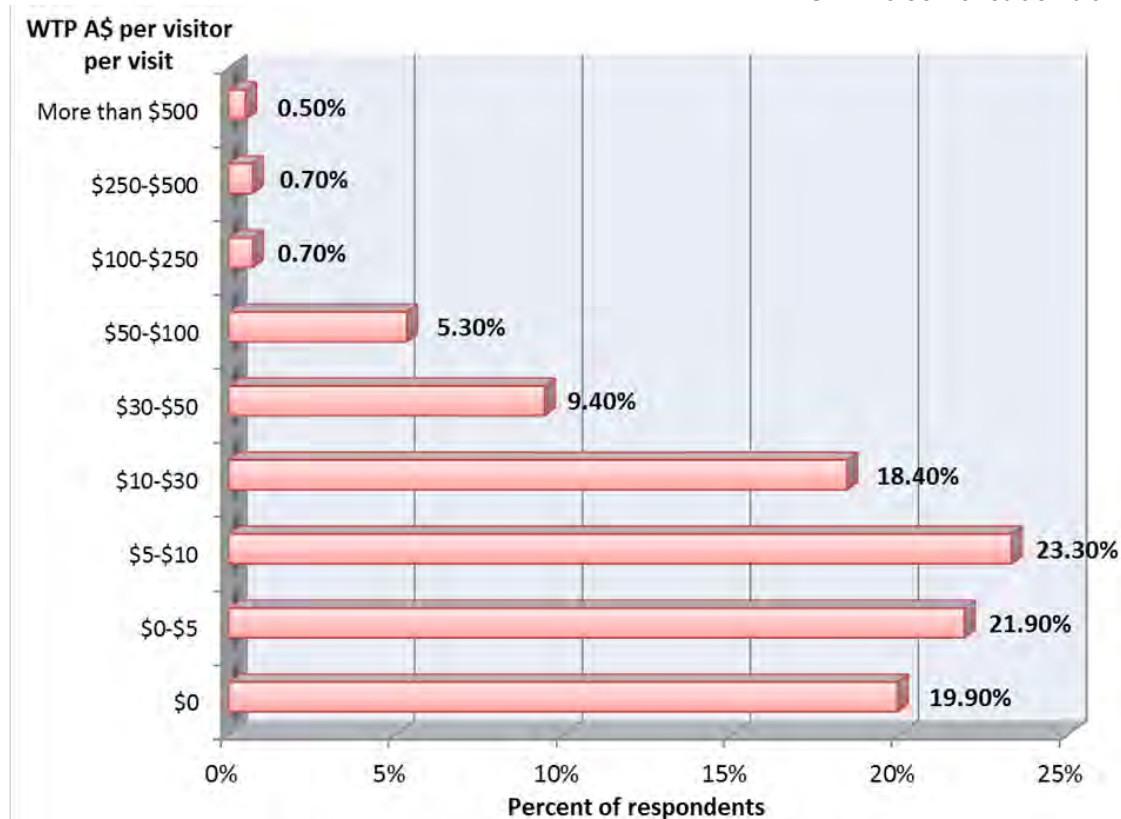


Figure 15: Distribution of responses to question about WTP to improve ocean water clarity

(Figure adapted from Farr *et al.*, 2014a)

We used various types of regression (probit, tobit and Heckman selection) to look for statistically significant relationships between socio-economic and demographic descriptors of visitors (Table 7) and the amount they were willing to pay to improve ocean water clarity. We also included in those regressions, visitor responses to questions about (a) how important water quality was to them when deciding whether to come to the region (b) how satisfied they were with water quality and (c) actual measures of water turbidity – provided to us by the AIMS.

We found that actual water quality (turbidity) was irrelevant. Instead, we found that tourists who are most likely to be willing to pay something to improve WC were:

- Females
- Relatively young
- Highly educated
- Relatively low income earners
- Not employed in tourism-related industries
- Planning to return to the GBRWHA in the future
- Not from China but from Japan
- Happy to pay to help protect the GBRWHA, providing that other users pay too
- Do not believe that only those who live near the GBR should care for it
- Completed a questionnaire with low dollar values on the 'bid card' (see comments about this in section 3.5)
- Of the opinion that WC was important when deciding to visit this part of Australia

Of the 80% of visitors who were willing to pay something, those offering to pay most were visitors who were

- Not from China
- Not from Queensland
- Presented with a questionnaire where high dollar values were part of the 'bid card'
- Very satisfied with water clarity and thought it was very important

The average respondent was willing to pay about \$14.5 per visit for water clarity improvement – although, as shown in Figure 16, that varies significantly according to attitudes about how important water is, and perceptions of water quality.

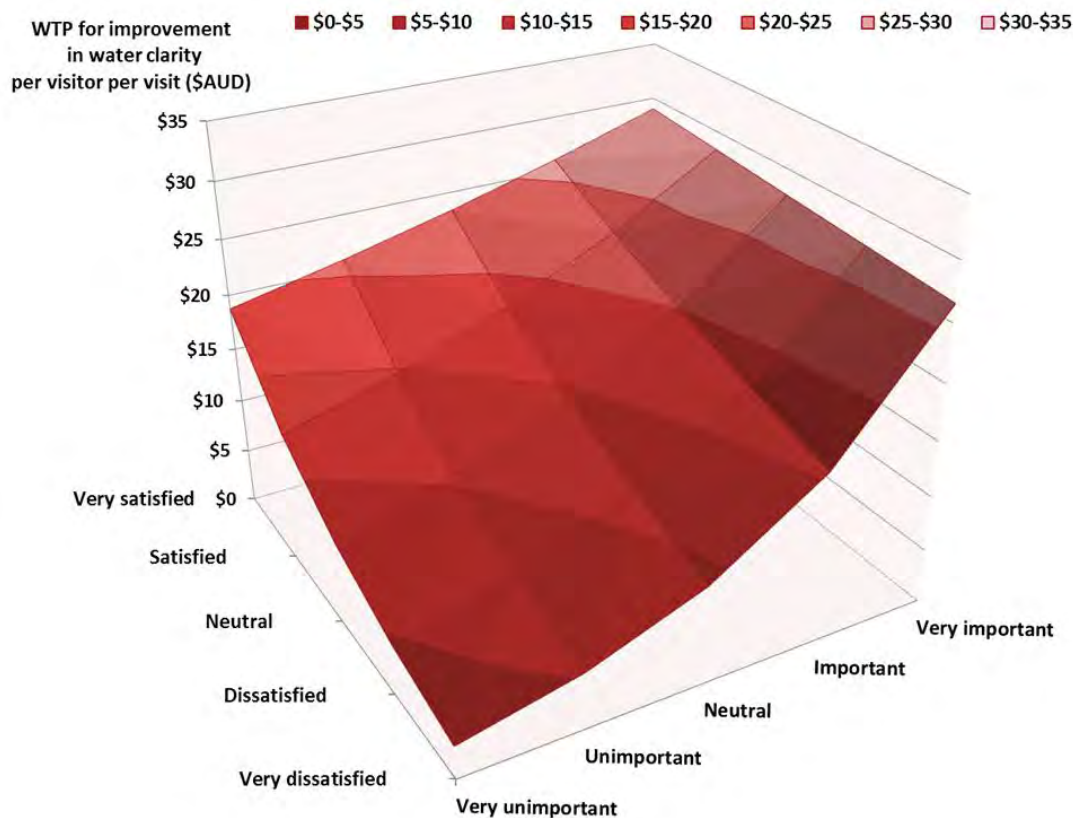


Figure 16: Importance, perceptions and WTP for water clarity improvement

(Figure adapted from Farr et al., 2014a)

Conclusions

Water quality is important to visitors and they state that they are willing to pay, on average, about \$14 each time they visit to help improve water quality – although these amounts differ significantly according to the origin of visitors, their income, and the attitudes and perceptions of water quality. These results indicate that one could, in theory, collect between \$30 million and \$90 million per annum from visitors (depending upon whether the money were collected only from those visiting the reef or from all those visiting the region). We do, however, need to be aware that hypothetical responses do not always translate directly into actual behaviours – as evidenced in the paper described in section 4.2.

4.6 Additional insights

The material presented in this section is based and builds on data reported in

Stoeckl, N., Farr, M., & Sakata, H. (2013). What do residents and tourists 'value' most in the GBRWHA? Project 10-2 Interim report on residential and tourist data collection activities including descriptive data summaries. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns, pp. 112. Available at: <http://www.nerptropical.edu.au/publication/project-102-technical-report-what-do-residents-and-tourists-'value'-most-gbrwha>

4.6.1 Visitor willingness to pay to reduce the risk of shipping accidents or to protect top predators

Tourists were not only asked about their WTP to improve water clarity; they were also asked about their WTP to reduce the risk of shipping accidents and to protect top predators. A relatively large proportion of respondents were not willing to pay anything at all (Figure 17), although these proportions were significantly smaller than for residents (Figure 8).

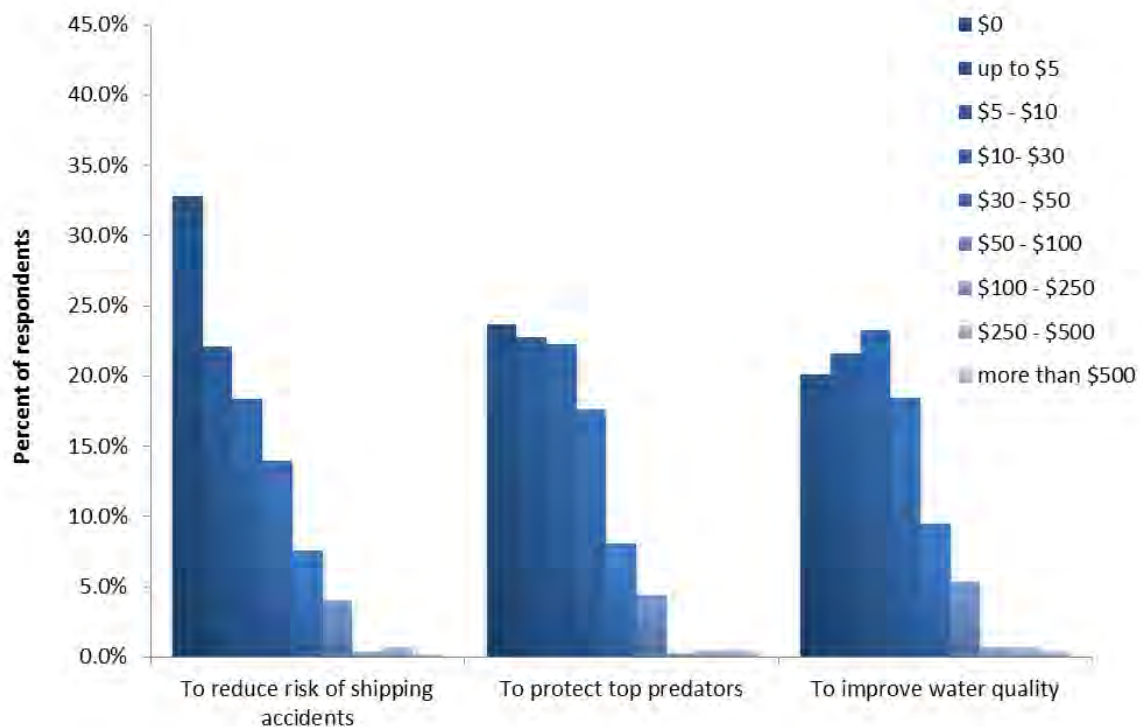


Figure 17: Distribution of visitor responses to questions about willingness to pay (per person per trip) for environmental improvements

(Figure adapted from Stoeckl et al., 2013)

As was done for the residential data, and for the tourist, water quality data, we used the hurdle model to look for statistically significant relationships between various socio-economic and

demographic descriptors of respondents (Table 7) and their WTP. Here again, we found that the determinants were very similar for all three WTP improvements (Table 10).

Table 10: Determinants of WTP to improve water clarity, to reduce the risk of shipping accidents and to protect top predators

Tourists					
Water Clarity		Shipping*		Predators*	
To pay or not to pay amount >\$0	How much to pay (if agreed to pay >\$0)	To pay or not to pay amount >\$0	How much to pay (if agreed to pay >\$0)	To pay or not to pay amount >\$0	How much to pay (if agreed to pay >\$0)
Age (-)		Age (-)	Age (+)	Age (-)	
Only people who live or visit should care (-)		Only people who live or visit should care (-)		Only people who live or visit should care (-)	Only people who live or visit should care (-)
Not prepare to pay unless all users pay too (+)		Not prepare to pay unless all users pay too (+)		Not prepare to pay unless all users pay too (+)	
	Visitor QLD (-)		Visitor QLD (-)	Visitor QLD (-)	Visitor QLD (-)
China (-)	China (-)				
Japan (+)		Japan (+)			
Return (+)		Return (+)	Return (+)	Return (+)	Return (+)
Education (+)				Education (+)	
WTP Bid range (-)	WTP Bid range (+)	WTP Bid range (-)	WTP Bid range (+)		
Income (-)					
Importance (+)					
Male (-)					
Tourism (-)					
	Satisfaction (-)				
	Importance*				
	Satisfaction (+)				
Estimated WTP = \$14.51		Estimated WTP = \$15.53		Estimated WTP = \$8.93	

Note: Only significant variables reported. A plus sign (+) indicates that the variable was found to have a positive and statistically significant relationship with the score assigned to the corresponding value; a negative sign (-) indicates negative and statistically significant negative relationship. * These WTP models did not include 'Importance', 'Satisfaction', and 'IS' explanatory variables.

Several variables are strongly associated with all responses. For example, older people are generally much less likely to be willing to pay anything (or to 'play' the WTP game in our surveys). Similarly, residents of QLD who are visiting the GBRWHA are willing to pay less than other visitors – likely reflecting the fact that the question asked how much people were willing to pay for each visit, and these people visit more often. That said, those who say they are likely to return to the region (irrespective of origin), were generally willing to pay more. As expected, questionnaire design has an impact: high bid ranges deterred people from answering the question, but if they did choose to answer the question, higher bid ranges typically generated higher WTP responses.

Equity issues feature prominently. People feel that caring for the GBRWHA is the responsibility of many and are willing to pay to help protect it, but not unless others are also making a contribution.

It seems that visitors from Japan were more likely to agree to 'play' our Contingent valuation game (and were thus more likely to have a non-zero WTP), but the amount these visitors were willing to pay were not different from the amount visitors that domestic (non QLD) or other overseas visitors were willing to pay. Visitors from China were willing to pay less to protect WC than those from elsewhere; so too were males, those dependent upon the tourism industry for their household income, and those dissatisfied with water quality.

5 Do changes in world prices impact the GBRWHA?

A significant body of research has established that ocean turbidity impacts reef health. There are many plans to reduce sediment loads by encouraging best management practices; there is also interest in the use of market based instruments. But it is exceedingly difficult to assess the potential efficacy of market policies, since that requires one to determine how changes in the socioeconomic system (e.g. price changes) impact the biophysical (e.g. sediment loads). In this exploratory segment of the project, we set out to develop a prototype model that would allow us to use statistical/econometric techniques developed within the (macro)economics literature to explore such issues. Simplistically, the econometric techniques which we tested (time series analysis and vector auto regression models) allow one to model interactive sub-systems simultaneously, to control for seasonality, and to consider the fact that changes in one part of a system may only impact another with lags. As such, they are well suited to complex real-world systems, yet (to the best of our knowledge) untested in this context.

We undertook this investigation in two parts: firstly testing to see if we could use these econometric techniques to adequately model hydrological systems, and then (having established that it was possible to do so), expanding the model to also incorporate economic variables. The sub-sections below summarise key aspects of that investigation.

5.1 Relationship between rainfall and river discharge in the Burdekin River Catchment

The material presented in this section summarises material described in:

Jarvis, D., Stoeckl, N., & Chaiechi, T. (2013). Applying econometric techniques to hydrological problems in a large basin: Quantifying the rainfall–discharge relationship in the Burdekin, Queensland, Australia. *Journal of Hydrology*, 496(0), 107-121. doi: <http://dx.doi.org/10.1016/j.jhydrol.2013.04.043>

Abstract (shortened)

This study seeks to explore the relationship between rainfall and river discharge within a large river basin (the Burdekin) flowing into the waters surrounding the Great Barrier Reef (GBR), and to investigate the best method of measuring the relationship. Modern econometric time series techniques are utilised, and compared with results using an alternate technique developed by researchers from the bio-physical sciences; the widely used Thiessen Polygon method. We find that modern econometric time series techniques provide a viable alternative to other methods, and may thus be useful in data-poor environments.

Keywords: Rainfall–discharge relationship, Thiessen Polygons, Temporal scale, Time series estimation techniques, Stationarity, Unit root testing

Methods and main findings

First we collated rainfall and temperature data from Australia's Bureau of Meteorology (BOM) and river discharge data from the Department of Environment and Resource Management (DERM) from 1939 to the present day in the Burdekin River catchment. We checked for 'stationarity' using the Augmented Dickey-Fuller (ADF) test, the Phillips-Peron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS), finding it to be so (the implication being that climate

GBR 'value' to residents and tourists
change has not had a statistically discernable impact on either river discharge or rainfall in the Burdekin catchment during the research period).

We then tested several different time-series models, specifically trying to determine

- What is the best measure of rainfall that can be used to quantify this relationship including the optimal number of rain stations?
- What is the optimal temporal scale for measuring the relationship (e.g. monthly, quarterly or annual data)?

We found that models which used a small number of rain stations had higher explanatory power and were more robust than models with a larger number of stations for both pre-dam and post-dam periods. We also found that models which used annual time-series data performed better than those using monthly or quarterly data and that the time-series analysis can be easily extended to include other explanatory variables (e.g. as the seasonality index and the temperature measure).

Conclusion

It is possible to model hydrological relationships using econometric techniques; and that when doing so, models with coarser temporal and geographic scale tend to perform best.

5.2 Is there evidence to suggest that prices affect the GBRWHA?

The material presented in this section summarises material reported on, in detail, in

Chaiechi, T., Stoeckl, N., Jarvis, D., Lewis, S., & Brodie, J. (in review). Assessing the impact of price changes and extreme climatic events on sediment loads in a large river catchment near the Great Barrier Reef.

Abstract

Ocean turbidity (associated with sediment from rivers) can significantly impact reef health. In Australia, there are many plans to reduce sediment loads by encouraging best management practices; there is also interest in the use of market based instruments. But it is exceedingly difficult to assess the potential efficacy of market policies, since that requires one to determine how changes in the socioeconomic system (e.g. price changes) impact the biophysical (e.g. sediment loads). We use historical data (from 1938 - 2011) in a Vector Auto Regression to simultaneously model interactions between the economic and biophysical systems in the Burdekin River Catchment adjacent to the Great Barrier Reef lagoon. This allows us to statistically test for the impact of changes in prices and costs on sediment load, while controlling for biophysical influences. We find that changes in rainfall and extreme events have the most impact on sediment loads, but that prices also impact sediment loads, once controlling for these other factors. Evidently market based policies may have the potential to reduce sediment loads. Our empirical results provide useful information for those interested in the Burdekin River Catchment and the Great Barrier Reef; the modelling approach may have wide applicability in a variety of contexts.

Methods and main findings

Our underlying hypothesis was that sediment loads are a function of climate (and extreme events), rainfall & catchment wetness, vegetation & land cover, and cattle numbers, which are a function of input and output prices (e.g. Wages and beef prices) and climate. The modelling challenge, therefore, was to determine if it was possible to detect a 'price signal' after controlling for external factors such as climate and extreme events.

We collated data from a variety of different sources to 'populate' and then build a vector auto regression (VAR) model – developing a separate one for the period from 1938 – 1983 (before the Burdekin dam was built), and one for the entire period (using dummy variables to control for the fact that the dam would have fundamentally altered streamflow-sediment relations).

We found that it was possible to successfully integrate economic and biophysical data within a VAR, and that one could detect a price signal, after controlling for extreme events (and for the construction of the dam, which seems to act as something of a sediment catch). Evidently, higher beef prices will, with one year's lag, increase cattle numbers, which will, with another year's lag, increase sediment loads. There was also evidence to suggest that the system is becoming more price sensitive with time.

Conclusion

Rainfall and extreme events are the two most significant drivers of sediment loads in the Burdekin Catchment, but after controlling for that, it is possible to pick up a price signal. Some argue that 'efforts to encourage land managers to adopt recommended management actions may, alone, be insufficient to achieve more significant improvements in water quality' (Thorburn *et al.*, in The Scientific Consensus (2013)). If so, then our results suggest that market based incentives may offer themselves as a supplementary strategy – how successful they could be in comparison to other policies or strategies, or in other contexts, remains to be investigated.

6 Synthesis

This project set out to collect economic data relevant to the GBRWHA and to explore the interaction between economic variables and biophysical variables known to be related to reef resilience (e.g. indicators of water turbidity). Its overarching aim was to improve our understanding of the way in which the economy and the GBRWHA interact, making it easier to judge (a) which economic variables are most important to monitor, and (b) how to interpret trends in those variables (i.e. whether changes are likely to be 'good' or 'bad' for the reef). Simplistically, we focused on the 'value' of various ES provided by the GBRWHA to residents and tourists, and on the way in which the economy affects those ES (thus explicitly acknowledging the existence of dynamic feedbacks).

To begin we conducted a substantive literature review. The review revealed that most valuation studies have concentrated on a narrow range of ecosystem services (Stoeckl *et al.*, 2011) such as recreation (Carr and Mendelsohn, 2003; Knapman and Stoeckl, 1995; Kragt *et al.*, 2009) or fishing and boating (Farr *et al.*, 2014b; Prayaga *et al.*, 2010). More recent studies have sought to improve our understanding about some of the region's *non-use values* (Rolfe and Windle, 2012a; Rolfe and Windle, 2012b; Windle and Rolfe, 2005), but significant knowledge gaps remain (see also Stoeckl *et al.*, 2014). The literature review also revealed the lack of comparative information. No assessments existed that simultaneously valued numerous different ecosystem services using the same methodological approach. Different valuation techniques produce different types of estimates (e.g. marginal prices or expenditures) and may not be comparable or additive. If policy makers and managers need to make decisions about potentially competing values (e.g. fishing versus tourism versus aesthetic/cultural values), then the lack of comparable information about these different values may stand as a significant knowledge gap.

We also conducted workshops with a variety of regional stakeholders/managers/decision makers in Cairns, Brisbane and Townsville. Not only did we use these workshops to identify a set of regionally relevant 'values' for assessment (as discussed in previous sections), but to learn more about the issues confronting these people and about how they hoped to be able to use the information generated from this project. The workshops highlighted the fact that participants were interested in a broad range of different community benefits (some of which related directly to various ecosystem services provided by the GBRWHA, and some of which related to the economy in general). It also revealed that people wanted to be able to use our research results in a variety of different ways. Some wanted to simply raise public awareness of the importance of the GBRWHA; others wanted to be able use the results to help them assess the way in which people and/or the economy might be impacted by particular management changes which could impact the reefs ecosystem services (e.g. further reductions in water quality). In other words, some stakeholders were looking for information about (in economic jargon) the 'total' value of the GBRWHA; others wanted information about 'marginal' values (or trade-offs).

We thus set out to assess the 'value' of a broad range of ES, using methods that allowed us to generate such information.

We found that:

- The non-market goods and services provided by the GBR (e.g. having healthy coral reefs, healthy reef fish, clear ocean water, and preserving the reef for future generations) are considered, by residents of the catchment, to be more important to their overall quality of life than recreational values (e.g. being able to go fishing, boating, or spending time at the beach). These recreational values are, themselves, considered to be more important than the jobs and incomes associated with different industries (Larson *et al.*, 2014a, 2014b).

- Environmental and recreational values of the GBR are also considered, by tourists, to have been more important in their decision to visit the coastal area adjacent to the GBRWHA than other market-related 'values' such as good quality accommodation, being able to meet budget, visiting friend and relatives and/or attending to business (Esparon *et al.*, forthcoming).
- Residents and tourists react more negatively to the prospect of degradation of the environment than to the prospect of a 20% increase in prices (Stoeckl *et al.*, 2013; Esparon *et al.*, forthcoming; Mustika *et al.*, forthcoming).

Our finding that GBR-based environmental values – particularly non-use values – are more important than market values appears consistent across sample groups (residents and tourists) and across methodological approaches.

As regards estimates of 'total' value

- We used novel approaches to control for the problem of inseparable values, estimating that collective value of all of the ecosystem services provided by the GBRWHA is likely to be worth at least \$15b per annum – possibly as much as \$20b (Stoeckl *et al.*, 2014). This figure is not implausible. The tourism industry is 'worth' in excess of \$4b per annum to residents of the catchment (Deloitte Access Economics, 2013), and our estimate of 'total' value includes tourism, recreational and other non-use values (both deemed to be 'more important' to the overall quality of life of residents than the jobs and incomes associated with reef-based tourism).
- Using other novel approaches, we also generated estimates of the financial value of only non-use values: approximately \$7.5b (Jarvis *et al.*, in review). This is consistent with Stoeckl *et al.*'s (2014) finding that non-use values are worth a minimum of \$4b.
- We found that total expenditure per visitor per trip was higher for non-business visitors than for business visitors (approximately to \$1,760 compared to \$1,290) – largely because non-business visitors spent a similar amount to business visitors each day, but they stayed longer in the region. More than 60% of expenditure is on accommodation and food (at cafes, restaurants, and other retail outlets). (Mustika *et al.*, forthcoming).

We also generated estimates of several different 'marginal' values.

- We combined responses to our contingent behavior questions with information about tourist expenditure to generate estimates of the potential loss in visitor expenditure that could happen, should various types of environmental degradation occur. Using novel methods to control for hypothetical response bias, we estimate that these amounts could be up to \$300 per visitor, or about 17% of current expenditure (Mustika *et al.*, forthcoming).
- After controlling for factors such as income, gender and length of stay, we found that tourists who experienced clearer water and/or maximum daily temperatures that were close to 29 degrees centigrade while in the region had higher levels of overall trip satisfaction than other tourists (Jarvis, forthcoming; Jarvis *et al.*, in review). We were able to use coefficients from our model with water turbidity, to generate estimates of the potential loss of tourism revenues that could occur if sediment increased by 10% (about \$400,000 across the entire GBR catchment area) – Jarvis *et al.* (in review).
- We found that residents were willing to pay about \$32 per annum per household for to help improve water clarity, \$27 to reduce the risk of shipping accidents and \$29 to protect top predators per household per annum (not yet published). For tourists these figures were \$14.5, \$15.5 and \$9 per person per visit, respectively. The amount people

GBR 'value' to residents and tourists were willing to pay, however, was contingent upon 'others paying too' (respondents did not want to be the only person paying). In the case of water quality and tourists, the amount people were willing to pay also depended upon the importance of water quality to the respondent and upon their perceptions (not actual measures) of its quality while in the region (Farr *et al.*, 2014a).

Averages aside, different people 'value' things differently. Our results confirmed this to be true, with patterns that were consistent across samples (tourists and residents) and across methodological approaches – see pages 53 and 54 for a synthesised summary of findings. Most notably,

- Gender matters
 - Both males and females agree that non-use values are more important to their overall quality of life than other values. But males seem to attach less 'value' to non-use environmental values, Indigenous cultural values and 'bragging rights' than females. This is true for 'importance' scores and for Larson's IDS. It is also true for both residents and tourists. Moreover, male residents are not willing to pay as much for improvements in water clarity and to protect top predators as females.
 - Males residents are likely to rate fishing and boating as being (relatively) more important than females – this is true for 'importance' scores and for Larson's IDS. Male residents are also willing to pay more, on average, than females to reduce the risk of shipping accidents.
 - Similarly, male tourists also value fishing and boating more than female tourists and are WTP less for improvements in water quality.
 - Females are generally more satisfied with their life, overall, than males (controlling for other factors).
- Education matters
 - The higher a resident's education, the more 'importance' they are likely to attach to Indigenous cultural values, and the less importance they were likely to attach to boating, fishing, or mining. WTP to improve water quality, to reduce the risk of shipping accidents and to protect top predators was also positively related to education for residents. Those with more education were also likely to be much less satisfied with various environmental factors than their less educated counterparts.
 - The higher a tourist's education, the more important were various environmental values (such as having little rubbish, healthy coral reefs, etc.) as a reason for coming to the region; these tourists were also more likely to be willing to pay at least some small amount to improve water quality or to protect top predators than their less educated counterparts.
- Income matters – and, in contrast to expectations, it does not always have the same effect as education
 - Residents with a relatively high income were more frequent recreational users of the GBRWHA than others, and were likely to place a higher value on mining, seafood, beaches industry and a lower value on 'bragging rights', than residents on lower incomes. Residents on a high income were willing to pay more, on average, to improve water quality than those on lower incomes – most likely because of the strong link between willingness to pay and ability to pay.

- Visitors on a relatively high income were, on average, willing to pay more to improve water clarity than those on lower incomes. They also spent more when in the region, and had higher levels of overall trip satisfaction than their poorer counterparts.
- That said, Indigenous cultural and environmental values were a less important draw-card to visitors on high incomes than they were to those on lower incomes.
- Age matters
 - Elderly residents are generally more satisfied with life as a whole than younger residents. They are also likely to consider Indigenous culture, preservation of the GBR (for its own sake), boating, iconic marine animals, clear oceans and 'bragging rights' to be less important to their overall quality of life than their younger counterparts. Seafood was more important to this group and they were generally willing to pay less to protect the environment than their younger counterparts.
 - Elderly tourists place a higher value on friends/socializing, seafood, and land-based environmental values (seeing the wet tropics rainforest and mangroves/wetlands) than their younger counterparts; boating and spending time at the beach are relatively less important for older tourists than for younger ones.
 - Younger business visitors are likely to spend more money in the region than older business visitors; but for non-business visitors, it is, on average, the older ones who spend more money locally.
- Place of origin / birth matters
 - Residents of the GBRCA who were born in QLD were not willing to pay as much to improve water quality, to reduce the risk of shipping accidents or to protect top predators as those born outside QLD. They were likely to feel that Indigenous culture was less 'valuable' (using just raw importance scores, or Larson's IDS) than those born elsewhere, and were more frequent recreational fishers than others.
 - Visitors from within QLD were not willing to pay as much to improve water clarity, to reduce the risk of shipping accidents or to protect top predators as others. They were more likely to have come to the region for friends/family/socializing, and were less likely to be drawn by environmental values.
 - Domestic visitors (excluding those from within QLD) spent, on average, more within the region than visitors from elsewhere.
 - Tourists from China were generally not willing to pay as much to improve water clarity as visitors from elsewhere.
- Location matters
 - Income is a relatively more important contributor to overall quality of life to residents in the southern parts of the GBR than to residents in the north. Being satisfied that the GBR is being preserved for future generations is less important (to overall quality of life) to those in the southern parts of the GBR than to those in the north.
 - Tourists visiting southern parts of the GBR were less concerned by the prospect of environmental degradation than tourists visiting the north. They were however, relatively more concerned by the prospect of having fewer fish to catch.

- Tourists visiting places with relatively little construction activity, clear water and maximum daily temperatures of approximately 29 degrees centigrade were generally more satisfied with their overall trip (controlling for other factors) than other tourists.
- Marital status matters
 - Single people are generally less satisfied with their life, overall, than those in a long-term relationship (controlling for other factors)
 - Single residents are likely to view industry values as being less important than other values; Indigenous culture and bragging rights are relatively more important to this group.
 - Single residents are more frequent recreational fishers and also more frequent swimmers & snorkelers than their married counterparts.
 - Single travelers are more likely to be in the region for business than others
- Industry of association matters
 - Residents whose household incomes were dependent upon the mining industry felt that recreational (e.g. boating and fishing) and industry values were more important than those dependent on other industries (with the exception of fishing). They also spent less time at the beaches, on islands, or at the reef than others.
 - Residents whose household incomes were dependent upon the commercial fishing industry felt that recreational values were more important than those dependent on other industries (with the exception of mining). They also felt that Indigenous cultural values, clear oceans and undeveloped beaches were more important than those dependent on other industries, and they spent more time engaging in marine-based recreational activities (except spending time at the beach) than those dependent on other industries.
 - Residents whose household incomes were dependent upon the tourism industry felt that 'bragging' rights were more important than those dependent on other industries and they spent more time at the beach, fishing, boating, snorkeling and sailing than those dependent on other industries.

The fastest growing demographic group in the GBRC is of young lesser educated males working in the mining and associated industries receiving relatively high incomes (Deloitte Access Economics, 2013). We used coefficients from our models describing the link between industry of association, other demographics and the 'importance' of different ES to overall quality of life, to compare the current distribution of 'values' with one that could prevail if there was significant growth in either the tourism or the mining/manufacturing sector (Figure 18). Growth in the mining/manufacturing sector would likely mean that recreational values would become more important when compared to other values.

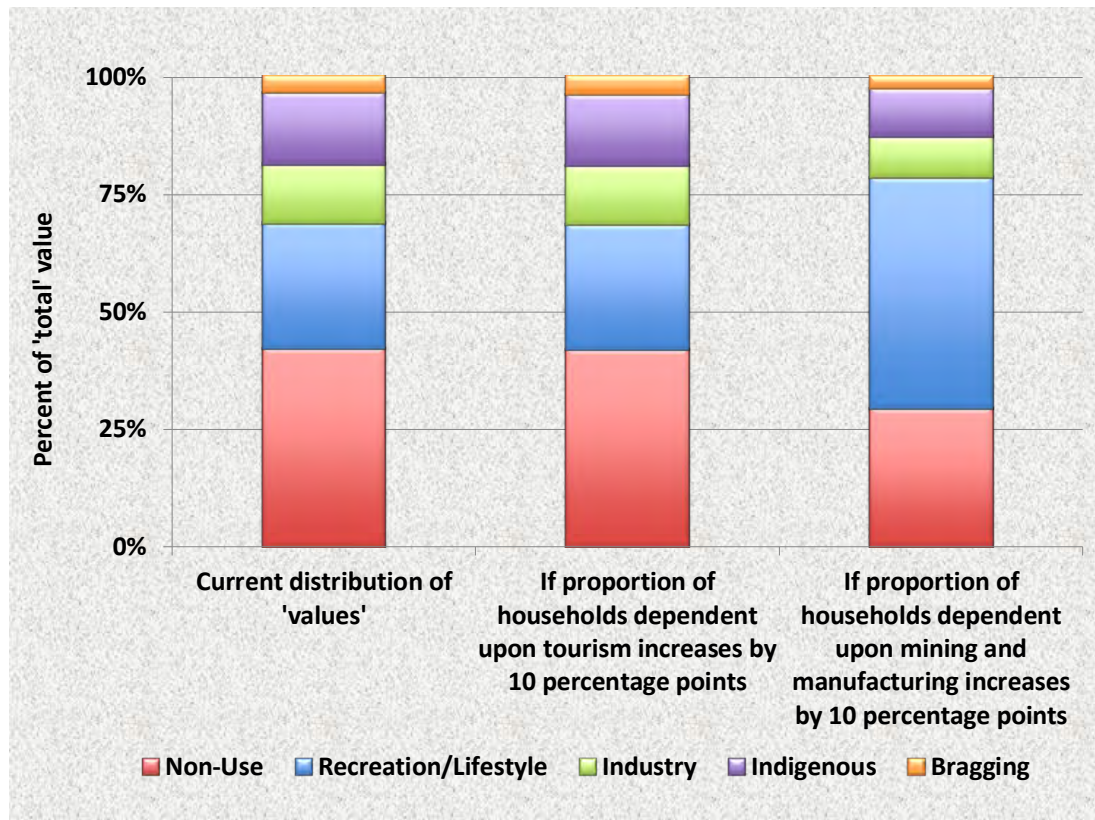


Figure 18: Impact of change in economic structure on values provided by GBRWHA - 'Simulated' finding

Table 11: Characteristics of residents that had statistically significant relations with importance, satisfaction, reaction to hypothetical change (SUR model); and WTP (To pay or not to pay amount >\$0; and How much to pay (if agreed to pay >\$0) decisions)

Variables	Importance (I) and Satisfaction (S)												Importance (I), Satisfaction (S) & Change in environmental quality (C)								WTP		
	Commercial fishing (I,S)	Mining/Agriculture (I,S)	Cheap shipping (I,S)	Future generations (I,S)	Seafood (I,S)	Beach/Swimming (I,S)	Boating (I,S)	Indigenous (I,S)	Bragging (I,S)	Undeveloped (I,S)	Iconic marine species (I,S)	Mangroves (I,S)	No rubbish (I,S,C)	Coral reefs (I,S,C)	Reef fish (I,S,C)	Fishing (I,S,C)	Clean ocean (I,S,C)	Tourists (I,S,C)	Oil spills, groundings & waste spills (C)	Increase in prices (C)	Water Clarity amount >\$0, How much to pay (if agreed to pay >\$0)	Shipping amount >\$0, How much to pay if agreed to pay >\$0)	Top predators amount >\$0, How much to pay (if agreed to pay >\$0)
Male				-	-	-	+	-	-	-	-	-	++	++	-	+	-	++	++	++	-	++	-
Single	-	-		-		+	+	++	+							+							
Age				++	+		-		-		-		--	-	--	--	--	--	--	--	-	-	-
Indigenous		-						+		-	-	+		++	++	--	+	--	--	--			
Education		-	-	-			-	+			-	-		-	+	-			--		+	+	+
Income		++			+	+			-				--		--	--	--	--	--		++	++	++
HH size							+			+	+				+								
Born QLD		+						-					-	--		++	-				-	-	-
Fishing						+	++	+	+	++	+	+	+	+	+	+	++	++					
Mining		++			+	+	++					+			--	++	+						
Tourism		+	++			+			+						--	--					+	+	+
Agriculture															--	--	--	--	--				
Not prepared to pay unless all Australians pay too																					+	+	+

Table 12: Characteristics of visitors that had statistically significant relations with importance, satisfaction, reaction to hypothetical scenarios (SUR model); and WTP (To pay or not to pay amount >\$0; and How much to pay (if agreed to pay >\$0) decisions)

Variables	Importance (I) and Satisfaction (S)																Importance (I), Satisfaction (S) and Change environmental quality (C)								WTP		
	Friends (I,S)	Business (I,S)*	Close (I)	Budget (I,S)	Accommodations (I,S)	Seafood (I,S)	Beach/Swimming (I,S)	Boating (I,S)	Indigenous (I,S)	Sunshine (I,S)	Bragging (I,S)	Undeveloped (I,S)	Iconic marine species	Wet tropics (I,S)	Iconic land species (I,S)	Mangroves (I,S)	No rubbish (I,S,C)	Coral reefs (I,S,C)	Reef fish (I,S,C)	Fishing (I,S,C)	Clean ocean (I,S,C)	Tourists (C)	Oil spills, groundings & waste spills (C)	Increase in prices (C)	Water Clarity amount >\$0, How much to pay (if agreed to pay >\$0)	Shipping amount >\$0, How much to pay (if agreed to pay >\$0)	Top predators amount >\$0, How much to pay (if agreed to pay >\$0)
Male	-	+				-	-		-	-	-	-	-		-		-			+	-				-		
Single		-	+			-						+									+						
Age	+	+	+	-	+	+	-	-			-		-			+		+	+					+	-	-	-
Indigenous	-								+					+	+	+		+	+		+						
Education	-	-	-	-	-		+		+	-		+	+		-		+	+	+		+	-	-	-	+		+
Income				-					-	-	-		-	-	-			-	-						-		
HH size														-													
Visitor QLD	+	+	+	+	+		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-			-	-	-
Visitor AUS (not QLD)		+	+	+	+	+		-	-		-	-	-	-	-	-		-	-	+	-						
China		+	+	+	-	+			+	-	-		+				+			+	+				-		
Japan		+	+	+	-	+	-		-	-	+	-	-	-	-	+	-	-	-	+					+	+	
Couple	-	-		+	+		+		-	+		+	+	+	+	+	+	+	+	+	+						
Family with children		-	+	+	+		+			+		+	+	+	+	+	+	+	+	+	+						
Friends		-		+		+	+	+	-	+	+		+		+	-	+	+	+	+	+						
Tour group	-	-		-											+				+	+	+						
Business Visitor																	+	+	+		+	+	+	+			
Visitor Mackay/ Rockhampton	+	+			-		-	+		-	+			-	-	-				+			+				
Visitor Townsville/ Whitsunday	+	+			-			+		-				-	-	-						+	+				
Only people who live or visit should care																									-	-	-
Not prepare to pay unless users pay too																									+	+	+
Return																									+	+	+
Tourism																									-		
Importance																									+		
Satisfaction																									-		
IS																									+		

* For Satisfaction Friends + Business combined; no Close variable for satisfaction.

(+) indicates the relationship was positive and statistically significant; (-) = negative and statistically significant; a blank field indicates no statistically significant relationship.

7 Concluding remarks and recommendations

Multiple lines of evidence suggest that residents of, and visitors to the GBRCA feel that environmental non-use values are more important, to their overall quality of life or as a 'draw-card' to the region, than recreational or market-based values. As such, developments or changes which degrade those values are likely to be met with some resistance.

Degradation of environmental values is likely to have real financial impacts in the tourism industry, with reductions in tourist satisfaction and hence less repeat visitation, reduced numbers of tourists visiting the region and/or tourists staying for shorter periods of time.

It is possible that reductions in aesthetic and/or recreational values could also have a financial impact on non-tourism related businesses. A significant body of literature suggests that workers will trade-off wages for lifestyle (Chen and Rosenthal, 2008), so businesses located within the GBRCA may be enjoying a wage 'discount', largely attributable to the regional environmental amenity and attractive 'lifestyle' offered to workers. Degradation of lifestyle values may mean that businesses need to pay workers higher salaries in compensation. Whether or not this is occurring in the GBR region is an issue worthy of further investigation.

In short, changes in the environment (light green lines, Figure 19) have a real impact on people and on the decisions of people, which affects the broader economy (dark green lines, Figure 19).

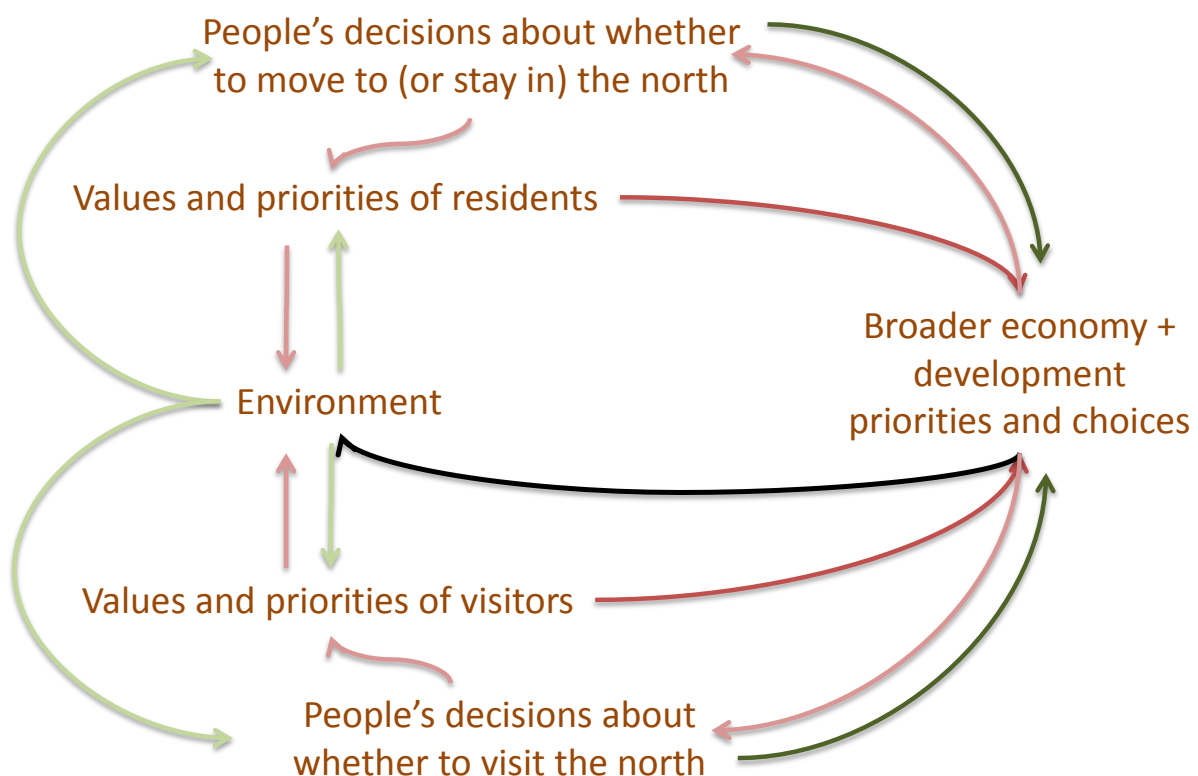


Figure 19: Linkages demonstrated within this report

Multiple lines of evidence also suggest that different groups of people have different values. There are many differences between individuals, but our work suggests that 'on average', those born in QLD, males, those with relatively less education, and those whose primary source of income is the mining and manufacturing industry, are likely to feel that recreational values are relatively more important to their overall quality of life, and that environmental non-use values are relatively less important to their overall quality of life than others. As such changes to the economic and demographic composition of the population will likely change prevailing values (pink lines, Figure 19), and this will affect the broader economy as well as priorities and decisions about future developments (red lines, Figure 19).

More direct links between the economy and the environment also exist: changes in the broader economy such as increases in the price of beef and/or in wages, affect sediment loads (albeit with a lag) – (black line, Figure 19). Clearly, the economic system is inextricably linked to the environment, with multiple, dynamic feedbacks.

Monitoring systems should thus keep track of:

- The demographic composition of the population, and its economic structure.
- The 'values' of different demographic groups and of those associated with different industries (particularly in regions undergoing rapid economic and or demographic change).
- Changes in the broader economy (particularly the prices of commodities produced in and around the region).
- Variables that describe key linkages between the economy and the environment (e.g. water use, pesticide and fertilizer use, land clearing)

Moreover, our research indicates that it may not be necessary to require people to 'value' long detailed lists of different ecosystem services. Many of these ecosystem services are viewed, by respondents, as being all but inseparable, suggesting that the 'valuations' could be done at a fairly coarse level (asking people, for example, to assess industry, recreational, cultural and non-use values, and giving broad examples/descriptors of each). That would leave more 'room' within questionnaires (since long ones tend to induce survey fatigue) to elicit other potentially very useful information (about, for example, expenditure, water or chemical use, or other behaviours likely to impact the GBR).

Finally, it is worth noting that different types of valuation approaches generate quite different types of information (e.g. the dollar value associated with an entire ecosystem, the relative importance of different groups of ecosystems, peoples stated reaction to hypothetical scenarios, or WTP to improve the environment). But in this study, we have found that the methods generate similar information at a 'big picture' level (e.g. that the environment is more important to most people than industry, but that there are recognizable/predictable differences between people). There is often considerable resistance, by respondents, to questions about WTP. Recent decades has seen a substantive growth in the literature about ways to deal with 'protest votes', and (in the related choice modelling literature) 'non attendance to attributes', so those wishing to obtain specific information about WTP can do so. But our research suggests that it might be possible to use more respondent-friendly importance/satisfaction and contingent behavior type questions to monitor values across time and people instead (perhaps comparing findings to those of more traditional valuation approaches at irregular intervals for calibrative / quality-control purposes).

8 References

- Bateman, I., Carson, R., J., Day, B., Hanemann, M., Hanleys, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D., Sugden, R., & Swanson, J.I. (2002). *Economic Valuation with Stated Preference Technique: A Manual*. Cheltenham, Edward Elgar.
- Bos, M., Pressey, B., & Stoeckl, N. (2014). Effective marine offsets for the Great Barrier Reef World Heritage Area, *Environmental science & policy*, 42, 1 – 15.
- Cai, B., Cameron, T., & Gerdes, G.R. (2011). Distal order effects in stated preference surveys. *Ecological economics*, 706, 1101-1108.
- Carr, L., & Mendelsohn, R. (2003). Valuing coral reefs: A travel cost analysis of the Great Barrier Reef. *AMBIO: A Journal of the Human Environment*, 32, 353-357.
- Chaiechi, T., Stoeckl, N., Jarvis, D., Lewis, S., & Brodie, J. (in review). Assessing the impact of price changes and extreme climatic events on sediment loads in a large river catchment near the Great Barrier Reef.
- Chen, Y., & Rosenthal, S. S. (2008). Local amenities and life-cycle migration: Do people move for jobs or fun? *Journal of Urban Economics*, 64(3), 519-537
- Cummins, R. A. (2000). Objective and Subjective Quality of Life: An Interactive Model. *Social Indicators Research*, 52(1), 55-72.
- Deloitte Access Economics. (2013). Economic contribution of the Great Barrier Reef. Townsville: Great Barrier Reef Marine Park Authority.
- Esparon, M., Stoeckl, N., Farr, M., & Larson, S. (forthcoming). The significance of environmental values for destination competitiveness and sustainable tourism strategy making: Insights from the Great Barrier Reef World Heritage Area. *Journal of Sustainable Tourism*.
- Farr, M., Stoeckl, N., Esparon, M., Larson, S., & Jarvis, D. (2014a). The importance of water clarity to tourists in the Great Barrier Reef and their willingness to pay to improve it. *Tourism Economics*. Available at <http://www.ingentaconnect.com/content/ip/tec/pre-prints/content-teft157>
- Farr, M., Stoeckl, N., & Sutton, S. (2014b). Recreational fishing and boating: Are the determinants the same? *Marine Policy*, 47(0), 126-137.
- Gallopin, G. C. (1997). Indicators and their use: Information for decision-making, in Moldan, B., Billharz, S., and Matravers, R., (Editors) *Scope 58 Sustainability Indicators: A report on the project on indicators of sustainable development*, John Wiley and Sons, France.
- Getzner, M., Spash, C., & Stagl, S. (2005). *Alternatives for Environmental Valuation*. New York: Routledge.
- Government Statistician. (2013). Queensland Regional Profiles: Resident Profile for the SLA4s and one SLA3 that lie within the GBRCa Region, Queensland Treasury and Trade.
- Great Barrier Reef Marine Park Authority. (2013). *Great Barrier Reef Tourist Numbers*.

Hundloe, T., Vanclay, F., & Carter, M. (1987). *Economic and socio economic impacts of crown of thorns starfish on the Great Barrier Reef*. Institute of Applied Environmental Research, Griffith University.

Jarvis, D. (accepted paper). Could climate change redistribute global tourism activity by impacting trip satisfaction? Paper to be presented at the 25th Annual CAUTHE Conference, Gold Coast, Queensland, 2-5th Feb 2015.

Jarvis, D., Stoeckl, N., Liu, H-B. (in review). Can the life satisfaction technique be used to estimate non-use values? A case study of the Great Barrier Reef.

Jarvis, D., Stoeckl, N., & Liu, H-B. (in review). The impact of economic, social and environmental factors on sustainable tourism.

Jarvis, D., Stoeckl, N., & Chaiechi, T. (2013). Applying econometric techniques to hydrological problems in a large basin: Quantifying the rainfall–discharge relationship in the Burdekin, Queensland, Australia. *Journal of Hydrology*, 496(0), 107-121. doi: <http://dx.doi.org/10.1016/j.jhydrol.2013.04.043>

Knapman, B., & Stoeckl, N. (1995). Recreation user fees: An Australian empirical investigation. *Tourism Economics*, 1, 5-15.

Kragt, M. E., Roebeling, P. C., & Ruijs, A. (2009). Effects of Great Barrier Reef degradation on recreational reef trip demand: a contingent behaviour approach. *Australian Journal of Agricultural and Resource Economics*, 53(2), 213-229.

Kristoffersen, I. (2010). The metrics of subjective wellbeing: Cardinality, neutrality and additivity. *Economic Record*, 86(272), 98-123.

Larson, S. (2009). Communicating stakeholder priorities in the Great Barrier Reef region. *Society and Natural Resources*, 22, 650-664.

Larson, S. (2011). From individual wellbeing to regional priorities: Concepts and measures to assist policy makers. Cambridge Scholars Publishing, Newcastle upon Tyne, UK, 180p.

Larson, S., & Smajgl, A. (2006). Conceptual framework for the water use benefit index in the Great Barrier Reef region. *International Journal of Sustainable Planning and Development*, 1(2), 1-13.

Larson, S., Stoeckl, N., Neil, B., & Welters, R. (2013). Using resident perceptions of values associated with the Australian Tropical Rivers to identify policy and management priorities. *Ecological Economics*, 94, 9-18. <http://dx.doi.org/10.1016/j.ecolecon.2013.07.005>

Larson, S., Stoeckl, N., Farr, M., & Esparon, M. (2014a). The role Great Barrier Reef plays in resident wellbeing and implications for its management. *AMBIO*, DOI 10.1007/s13280-014-0554-3. Available at <http://link.springer.com/article/10.1007%2Fs13280-014-0554-3>

Larson, S., Farr, M., Stoeckl, N., Chacon, A., & Esparon, M. (2014b). Does Participation in Outdoor Activities Determine Residents' Appreciation of Nature: A Case Study From the Great Barrier Reef, Australia. *Environment and Natural Resources Research*, 4(3), 211-226. Available at <http://www.ccsenet.org/journal/index.php/enrr/article/viewFile/39015/21817>

- Lasorsa, D.L. (2003). Question-order effects in surveys: The case of political interest, news attention, and knowledge. *Journalism & mass communication quarterly*, 80(3), 499-512.
- MacKerron, G., & Mourato, S. (2009). Life satisfaction and air quality in London. *Ecological economics*, 68(5), 1441-1453.
- Mustika, P. L. K., Stoeckl, N., & Farr, M. (forthcoming). The potential implications of environmental deterioration on business and non-business visitor expenditures in a natural setting: a case study of Australia's Great Barrier Reef, *Tourism Economics*.
- Mitchell, R., & Carson, R. (1989). *Using Surveys to Value Public Goods*. John Hopkins University, Baltimore.
- Parkins, J. R., Stedman, R. C., & Varghese, J. (2001). Moving towards local-level indicators of sustainability in forest-based communities: a mixed-method approach. *Social Indicators Research*, 56, 43 – 72.
- Prayaga, P., Rolfe, J., & Stoeckl, N. (2010). The value of recreational fishing in the Great Barrier Reef, Australia: a pooled revealed preference and contingent behaviour model. *Marine Policy*, 34(2), 244-251.
- Riley, J. (2001). The indicator explosion: local needs and international challenges. *Agriculture, Ecosystems & Environment*, 87(2), 119-120.
- Rolfe, J., & Windle, J. (2012a). Testing benefit transfer of reef protection values between local case studies: The Great Barrier Reef in Australia. *Ecological economics*, 81, 60-69.
- Rolfe, J., & Windle, J. (2012b). Distance decay functions for iconic assets: assessing national values to protect the health of the Great Barrier Reef in Australia. *Environmental and Resource Economics*, 53(3), 347-365.
- Stoeckl, N., Hicks, C., Mills, M., Fabricius, K., Esparon, M., Kroon, F., Kaur, K., & Costanza, R. (2011). The economic value of ecosystem services in the Great Barrier Reef: State of knowledge and information gaps in "Ecological Economics Reviews" Robert Costanza, Karin Limburg & Ida Kubiszewski, Eds. *The Annals of the New York Academy of Sciences*, 1219, 113–133.
- Stoeckl, N., Farr, M., & Sakata, H. (2013). *What do residents and tourists 'value' most in the GBRWHA? Project 10-2 Interim report on residential and tourist data collection activities including descriptive data summaries*. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns, pp. 112. Available at: <http://www.nerptropical.edu.au/publication/project-102-technical-report-what-do-residents-and-tourists-value-most-gbrwha> (accessed 6 November 2014)
- Stoeckl, N., Farr, M., Larson, S., Adams, V., Kubiszewski, I., Esparon, E., & Costanza, R. (2014). A new approach to the problem of overlapping values: a case study in Australia's Great Barrier Reef. *Ecosystem Services*, 61-78, DOI: 10.1016/j.ecoser.2014.09.005. Available at <http://www.sciencedirect.com/science/article/pii/S2212041614001077> (accessed 16 November 2014).
- Thorburn, P., Rolfe, J., Wilkinson, S., Silburn, M., Blake, J., Gongora, M., . . . Carroll, C. (2013). 2013 Scientific Consensus Statement Chapter 5 The water quality and economic benefits of agricultural management practices: Reef Water Quality Protection Plan Secretariat.
- Tourism and Events Queensland. (2013). Tourism Economic Key Facts. Available at http://www.tq.com.au/fms/tq_corporate/research%20%28NEW%29/Destination%20Visitor%2

[0Data/QLD%20Tourism%20Economic%20Key%20Facts%20July%202013.pdf](#) (accessed 5 February 2014)

Tourism Research Australia. (2013a). International Visitors in Australia: March 2012 – Quarterly results of the International visitor survey, Tourism Research Australia, Canberra. Available at (<http://www.ret.gov.au/tourism/Documents/tra/International%20Visitor%20Survey/IVSMarch2012.pdf>) (accessed 14 November 2013).

Tourism Research Australia. (2013b). Tourism Research Australia Regional Overview , Tourism Research Australia. Available at <http://www.tra.gov.au/statistics/Regional-overview.html> (accessed 1 July 2014)

van Praag, B. M. S., & Baarsma, B. E. (2005). Using happiness surveys to value intangibles: The case of airport noise. *The Economic Journal*, 115(500), 224-246.

Welsch, H. (2006). Environment and happiness: Valuation of air pollution using life satisfaction data. *Ecological Economics*, 58(4), 801-813.

Windle, J., & Rolfe, J. (2005). Assessing non-use values for environmental protection of an estuary in a Great Barrier Reef catchment. *Australasian Journal of Environmental Management*, 12(3), 147-155.

Appendix A: Project outputs

Journal articles

Stoeckl, N., Farr, M., Larson, S., Adams, V., Kubiszewski, I., Esparon, E., & Costanza, R. (2014). A new approach to the problem of overlapping values: a case study in Australia's Great Barrier Reef. *Ecosystem Services*, 61-78, DOI: 10.1016/j.ecoser.2014.09.005.

Farr, M., Stoeckl, N., Esparon, M., Larson, S., & Jarvis, D. (2014a). The importance of water clarity to tourists in the Great Barrier Reef and their willingness to pay to improve it. *Tourism Economics*. Available at <http://www.ingentaconnect.com/content/ip/tec/pre-prints/content-teft157>

Larson, S., Stoeckl, N., Farr, M., & Esparon, M. (2014a). The role Great Barrier Reef plays in resident wellbeing and implications for its management. *AMBIO*, DOI 10.1007/s13280-014-0554-3.

Larson, S., Farr, M., Stoeckl, N., Chacon, A., & Esparon, M. (2014b). Does Participation in Outdoor Activities Determine Residents' Appreciation of Nature: A Case Study From the Great Barrier Reef, Australia. *Environment and Natural Resources Research*, 4(3), 211-226.

Jarvis, D., Stoeckl, N., & Chaiechi, T. (2013). Applying econometric techniques to hydrological problems in a large basin: Quantifying the rainfall–discharge relationship in the Burdekin, Queensland, Australia. *Journal of Hydrology*, 496(0), 107-121. doi: <http://dx.doi.org/10.1016/j.jhydrol.2013.04.043>

Bos, M., Pressey, B., & Stoeckl, N. (2014). Effective marine offsets for the Great Barrier Reef World Heritage Area, *Environmental science & policy*, 42, 1 – 15.

Farr, M., Stoeckl, N., & Sutton, S. (2014b). Recreational Fishing and Boating: are the determinants the same? *Marine Policy*, 47, 126-137

Mustika, P. L. K., Stoeckl, N., & Farr, M. (forthcoming). The potential implications of environmental deterioration on business and non-business visitor expenditures in a natural setting: a case study of Australia's Great Barrier Reef, *Tourism Economics*.

Esparon, M., Stoeckl, N., Farr, M., & Larson, S. (forthcoming). The significance of environmental values for destination competitiveness and sustainable tourism strategy making: Insights from the Great Barrier Reef World Heritage Area. *Journal of Sustainable Tourism*.

Papers in review

Jarvis, D., Stoeckl, N., Liu, H-B. (in review). Can the life satisfaction technique be used to estimate non-use values? A case study of the Great Barrier Reef.

Jarvis, D., Stoeckl, N., & Liu, H-B. (in review). The impact of economic, social and environmental factors on sustainable tourism.

Chaiechi, T., Stoeckl, N., Jarvis, D., Lewis, S., & Brodie, J. (in review). Assessing the impact of price changes and extreme climatic events on sediment loads in a large river catchment near the Great Barrier Reef

Reports

Stoeckl, N., Farr, M., & Sakata, H. (2013). *What do residents and tourists 'value' most in the GBRWHA? Project 10-2 Interim report on residential and tourist data collection activities*

Stoeckl, et al

including descriptive data summaries. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns, pp. 112, available at: <http://www.nerptropical.edu.au/publication/project-102-technical-report-what-do-residents-and-tourists-value-most-gbrwha>

Prideaux, B., Sakata, H., & Thompson, M. (2013). *Tourist Exit Survey Report: February – September 2012*. Annual Patterns of Reef and Rainforest Tourism in North Queensland from Exit Surveys Conducted at Cairns Domestic Airport. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns.

Book chapter

Jamal, T., Prideaux, B., Thompson, M., & Sakata, H. (forthcoming). A micro-macro assessment of climate change and visitors to the Great Barrier Reef, Australia. In V.J. Reddy & K. Wilkes (Eds.), *Tourism in the Green Economy*. Routledge.

Conference Papers

Jamal, T., Prideaux, B., Thompson, M., & Sakata, H. (2014). A preliminary exploration of tourists as a key stakeholder in climate change impact management. Referred paper presented at the meeting of the CAUTHE national conference Tourism and hospitality in the contemporary world: trends, change and complexity, Brisbane, 10-13TH February, 2014.

Prideaux, B., Lee, L., & Thompson, M. (2014). Tourists' perspectives on protecting Australia's Great Barrier Reef: Concerns, challenges and possible policy responses. Paper presented at the meeting of the Global Tourism and Hospitality Conference and Asia Tourism Forum Charting the new path: innovations in tourism and hospitality, Hong Kong, 18-20th May, 2014.

Jarvis, D. (accepted paper). Could climate change redistribute global tourism activity by impacting trip satisfaction? Paper to be presented at the 25th Annual CAUTHE Conference, Gold Coast, Queensland, 2-5th Feb 2015.

Factsheets and presentations

(available at <http://e-atlas.org.au/nerp-te/gbr-jcu-socio-economic-reef-resilience-10-2>)

An overview with interim results (largely for DOE) – April 2014

Tourism factsheets, developed for the industry

One of each region (Cairns/Port Douglas; Townsville/Whitsundays; Mackay/Rockhampton); One for Chinese visitors, one for Japanese visitors

Series focusing on Domestic visitors (at request of TTNQ);

Series on specialist issues – drive tourists, food tourists etc.

Data sets and maps submitted to e-atlas

Residential and Tourist data summaries; LT visitor exit survey data submitted to e-atlas; Maps summarising responses to most questions in residential survey, by postcode – available in e-atlas.

Appendix B: Extra insights from research that was associated with this project

(but which did not use the data collected in activities (a), (b) and (c))

Recreational fishing and boating in the Townsville Region

The material presented in this section summarises material reported on, in detail, in

Farr, M., Stoeckl, N., & Sutton, S. (2014b). Recreational Fishing and Boating: are the determinants the same? *Marine Policy*, 47, 126-137. Available at <http://www.sciencedirect.com/science/article/pii/S0308597X14000529>

Abstract

The research uses household survey data collected from 656 people in Townsville** (adjacent to the Great Barrier Reef, Australia) within a hurdle model to investigate key factors influencing both the probability of participating and the frequency of (a) boating trips which involve fishing; (b) boating trips which do not involve fishing; and (c) land-based fishing trips. The findings suggest that there are differences in determinants, highlighting the importance of disaggregating the fishing/boating and boat/land-based experience (an uncommon practice in the literature) if wishing to obtain information for use in the design of monitoring programs, policy and/or for developing monitoring and enforcement strategies relating to fishing and boating.

Keywords: Determinants of the demand, Great Barrier Reef, Hurdle model, Negative binomial, Recreational boating and fishing

** The data used here is separate to that collected in the main survey described in section 0.

Methods and main findings

Most previous studies have assumed that fishing and boating are an inseparable activity. In this study, we did not – deliberately setting out to see if there was a difference between the characteristics of those who go boating frequently, and those who fish frequently.

First we looked at the characteristics of those who did, and did not have a boat. We found that males and those who live a long distance from the boat ramps were more likely to have a boat than others.

Second, we divided people into those who had or had not gone on a fishing and/or boating trip in the last two years. Then we used a probit regression to look at the characteristics of people who had gone fishing or boating at least once (left side of Table 13). Not surprisingly, boat owners were more likely to have gone boating at least once. Those who had moved to the Townsville region in the last 10 years were more likely to have tried boating or boat-fishing at least once, as were single people, or those who live close to the boat ramp. Next we used zero truncated negative binomial regression, to look at the characteristics of those who went fishing or boating most frequently (right side, Table 13). Long term residents take more boating (fishing and no fishing) and boat-based fishing trips. Single people take fewer boating trips, as do people earning less than \$100,000 per annum. Those who live on the outskirts of town (away from the boat ramps) are the most frequent boat-fishers. Older people are more frequent land-fishers than the young.

Table 13: Characteristics of boaters, boat-fishers and land-fishers

Characteristics of people who went fishing or boating at least once in the last two years			Characteristics of people who went fishing or boating most frequently in the last two years (ignoring those who didn't go at all)		
a boating trip (fishing and no fishing)	a boat-based fishing trip	a land-based fishing trip	a boating trip (fishing and no fishing)	a boat-based fishing trip	a land-based fishing trip
Own a boat	Own a boat				
Young	Young	Young		Not employed as a clerical or administrative worker	Older
Moved to Townsville region in the last 10 years	Moved to Townsville region in the last 10 years		Long term resident of Townsville (> 10 years)	Long term resident of Townsville (> 10 years)	
Single	Single		Not single	Not single	
Live close to boat ramp	Live close to boat ramp			Live far away from boat ramp	
	Household income is less than \$100,000 per annum		Household income is less than \$100,000 per annum		

Note: only significant determinants reported

(Table adapted from *Farr et al.*, 2014b)

Conclusion

Boat ownership is clearly a pre-requisite for boating, but not all people who own a boat use it frequently. Income, age and length of residence are key determinants of fishing and boating activity, suggesting that changes in the demographic composition of the population will be associated with changes in demand for fishing and boating facilities, and with changed pressures to fishing stocks. New arrivals to the region are apt to try boating and fishing at least once in their first few years of residence, but the most frequent boaters and boat-fishers are those who have lived here longest. Married people with household incomes less than \$100,000 are more likely to go boating (without fishing) than others. Age is strongly associated with land-based fishing activity suggesting that an aging population could increase land-based fishing but decrease boating and boat-based fishing activities.

Marine offsets for the GBRWHA

Bos, M., Pressey, B., & Stoeckl, N. (2014). Effective marine offsets for the Great Barrier Reef World Heritage Area, *Environmental science & policy*, 42, 1 – 15.

Abstract

Biodiversity offsets are a prevalent mechanism to compensate for development impacts to natural resources, but the appropriateness and efficacy of offsets remain the subjects of research and debate. Effective offsets for impacts to marine resources present even more challenges than those for terrestrial impacts. The Great Barrier Reef World Heritage Area is globally valuable for both biodiversity and heritage, but coastal development is undermining these values, and more effective offsets are needed to compensate for the damage. To improve the effectiveness of marine offsets for the Great Barrier Reef, we recommend that: (1) proponents be required to follow and document their adherence to the mitigation hierarchy, which considers offsets only as a last resort after avoidance and mitigation, (2) proponents and regulators consider the risk of offsetability prior to offset design, (3) the Australian government require offsets to achieve additional, measurable net benefits, relative to the counterfactual baseline, for all affected values, (4) specialist third parties (not government or proponents) design and implement marine offsets, (5) offsets are direct and specific to the affected values, with very minimal investment into research, (6) offsets are consolidated into strategic implementation sites, with long-term legal protection, that are consistent with the zoning of the Great Barrier Reef Marine Park and adjacent coastal land uses, (7) the time between impact and net benefit should be minimized, and net benefits should be maintained in perpetuity, (8) proponents pay the full cost of offset implementation, monitoring and evaluation, and cost is agreed upon before the development is approved, and (9) monitoring of the efficacy of offsets is separate to but coordinated with regional monitoring programs for ecosystem health, and monitoring data are made publically available. Within this context, and with careful and rigorous methods as described herein, offsets can contribute to maintaining the Outstanding Universal Value of the multiple-use World Heritage Area.

Keywords: Great Barrier Reef World Heritage Area Biodiversity Offsets Mitigation Compensation