Farr, Marina (2013) ***Estimating the demand for and economic value of 'fish' in the recreational fishing and tourism sectors: general methodological issues and empirical findings relevant to the Great Barrier Reef*****. PhD Thesis, James Cook University.**

Estimating the demand for and economic value of ‘fish’ in the recreational fishing and tourism sectors: general methodological issues and empirical findings relevant to the Great Barrier Reef

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August 2013

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Statement of Contribution of Others

Research Funding

James Cook University Postgraduate Research Scholarship (stipend for 3.5 years) $84,000
Faculty of Law Business and Creative Arts Graduate Research Scheme award $3,000

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Editorial Support

Prof Natalie Stoeckl
Dr Stephen Sutton
Dr Simone Marsiglio
Anonymous reviewers for my published chapter

Permits and Ethics

Research associated with this thesis complies the current laws of Australia and all permits necessary for the project were obtained (JCU Human Ethics H4079)

Acknowledgements

This dissertation would not have been possible without the support of many people. First and foremost I would like to thank my supervisor Natalie Stoeckl for her advice, enthusiasm, unconditional support and faith in my ability throughout my undergraduate, honours and PhD years. I appreciate all her contributions of time and ideas, her patience, her motivations, her encouragement and immense knowledge. The joy and enthusiasm she has for the research was contagious and inspirational for me. Her guidance helped me in all the time of research and writing of this thesis. It has been an honour to be her student.

I would especially like to thank Owen Stanley who converted me to ‘economics’ and without whom I would never have considered and never have started on this journey.

My sincere thanks also go to the rest of my thesis committee Steve Sutton and Simone Marsiglio, who offered guidance and support. I also would like to thank Rabi Beg who was always willing and available to provide statistical guidance.

I would like to extend my thanks to James Cook University, the Australian Government's Marine and Tropical Sciences Research Facility and the Australian Government’s National Environmental Research Program (the Terrestrial Ecosystem’s Hub) for their institutional support (in particular Robyn Yesberg for her help and support with paper work) and funding which supported the data collection that I have used within the analysis.

I also would like to say very special thanks to Townsville residents who were willing to participate in my household survey and who were happy to share their experiences and opinions. Special thanks go also to my recreational boaters and fishers who were so pleasant, helpful and supportive of my research and willing to share their concerns and experiences.

I would like acknowledge Alastair Birtles and his team (including Matt Curnock, Susan Sobtzick, Arnold Mangott and Peter Valentine) for the data which were used in Chapter 5 as well as the managers, owners of the dive operations, the crews and all passengers who kindly agreed to share their experiences and thoughts.

I would like to thank my parents Valentina and Boris and my daughter Anastasia who were always supporting and encouraging me with their best wishes. Finally, I would like to say very special thank my husband Michael who was always there cheering me up and stood by me through the good and bad times during all these years.

My research would not have been possible without ALL these inspirational people.

Abstract

Around the world, natural resource management policies attempt to find ways of sustainably managing terrestrial, freshwater and marine natural resources. Marine areas are traditionally common property resources thus they are often subject to overuse. Each multiple user (e.g. commercial fishers, recreational fishers, tourists, and tourism operators) puts pressure on the marine environment. One of the biggest challenges facing marine resource managers, is thus being to determine how to allocate resources across them. Those charged with managing conflicts between different user groups could benefit thus from information about 'value' (formally, the net marginal benefits) of these resources to each competing user.

There is much publically available data and research relating to commercial fishers, and for this sector, market price can often be used as a guide when assessing marginal values (MVs). So the research 'gap' associated with the commercial sector is, arguably, not as significant as it is for others. Much research has also been done on tourism. But whilst many studies have sought to estimate the total value of tourism as an entire industry or the total value of a trip/experience, few researchers have attempted to assess the MV of a 'fish' or of a single species to tourists. The studies that have been done, were, for the most part, conducted in various parts of the United States or Europe.

Compared to the commercial and tourism sectors, there is relatively little information available about recreational fishing, and existing studies do not differentiate between: the boating and fishing experience; and the characteristics of those who are most likely to keep or release a fish and the characteristics of those who keep most fish (those who place greatest strain on the resource). Moreover, most recreational fishing studies use historical or actual catch - *ex post* measures - rather than anticipated (*ex ante*) catch when estimating MVs. As such, relatively little is known about the 'value' of fish to this sector.

The primary aim of my thesis, was therefore to help fill those research gaps – specifically: improving methodological approaches for estimating the demand for and economic values of ‘fish’ in the recreational fishing and tourism sectors whilst also providing regionally relevant empirical information. The area selected for study was the Great Barrier Reef Marine Park (GBRMP) which offers itself as an ideal case study area – not only because it has multiple, relevant, users, but also because there are significant empirical gaps in this region. As such, choice of this area as a case-study provided an opportunity to ensure that my thesis generated empirical and policy insights (in addition to methodological ones).

The first aim of my thesis was to learn more about the importance (or otherwise) of disaggregating the fishing/boating experience. More specifically, I sought to determine if the factors influencing the probability of participating in fishing/boating activities and the factors influencing the intensity of boating, boat-based and land-based fishing trips were similar or different. In addition I also aimed to provide information to managers of the GBR about the characteristics of boaters, boat-fishers and land-based fishers.

The second aim of my thesis was to learn more about Catch and Release (C&R) in recreational fishing. I set out to provide an empirical demonstration of a model that allows one to differentiate between factors that influence the keep/release decision and those that influence the total annual keep decision and to compare the determinants of the keep/release decision with determinants of the total number of fish kept annually. I also sought to generate information for fisheries managers in the GBR about the characteristics of anglers who are likely to keep most fish annually (and who are thus likely to contribute most to fishing pressure in this part of the world).

The third aim of my thesis was to learn more about the MV of a ‘fish’ for recreational fishers. I differentiated between expected and actual recreational catch so as to: learn more about the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch; to estimate and compare the MV of fish using *ex post* and *ex ante* measures of recreational catch; and to provide information about MV of a recreational fish to the GBR managers.

The fourth aim of my thesis was to learn more about the MV of a species for tourists. In this investigation, I was also interested in exploring the sensitivity of final WTP estimates to various methodological issues (e.g. bid-end values, bid presentation orders, the 'menu' of species presented for evaluation, and the analytical approaches taken – sophisticated econometrics or simple mid-points), and in providing information to managers of the GBR about the non-consumptive 'value' of key species for tourists.

I addressed aim one in Chapter 2. I used survey data collected from 656 householders in the Townsville region and a (two-step) 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.

To meet aim 2 (Chapter 3) I used data collected in that same household survey within a Zero Inflated Negative Binomial model (another two step approach) to identify and to compare the determinants of total annual keep with those of the probability of keeping fish on a particular trip. I found that the determinants are different: age and activity commitment influence the probability of keeping fish; boat ownership, income, consumptive orientation, fishing experience, number of annual trips and retirement status are the main determinants of total annual keep. Evidently, those wishing to use C&R as a fishery management tool may need to ensure that their background studies consider total annual keep rather than only focusing on the probability of keeping a fish. In this case study region, failure to do so would mean that managers could be duped into monitoring factors such as age and commitment, and misinterpret consumptive orientation, rather than other factors such as boat ownership, income and retirement status.

To address aim 3 (Chapter 4) I used data from a survey of 404 anglers from the Townsville region in a Tobit Model to estimate and compare the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch. I also used a Hedonic Price Model (Instrumental Variable Tobit) to estimate and compare the MV of fish, using *ex post* and *ex ante* measures of recreational catch . The results indicate that the determinants of *ex ante* and *ex post* recreational catch are different. Expectations are largely driven by motivations (e.g. importance of fishing for fun and for eating) but personal variables – such as consumptive orientation, years fishing and gender – have a greater influence on outcomes (*ex post* catch). Evidently, those interested in predicting behaviours may need to pay greater attention to motivations, and somewhat less attention to socio-demographics. I also found that the marginal, *ex ante* estimates of 'value' were much lower than *ex post* 'values': $7.38 versus $22.83 AUS, respectively. Differences are likely to be attributable to differences in expectations and actual catches.

Finally, to address aim 4 (Chapter 5) I used the Kristrom Spike Model to analyse contingent valuation (payment card) data collected from 2180 domestic and international visitors taking reef trips to the Northern section of the GBR. I found that final estimates were particularly sensitive to questionnaire design, but that the ranking of species (from most to least 'valued') were robust across a range of methodological specifications. The most valued groups of species were (in order): whales and dolphins; sharks and rays; 'variety'; marine turtles; and finally large fish. Evidently, whale watching is not the only potentially lucrative source of tourism revenue; other marine species may be similarly appealing. These potential revenues need to be considered when making decisions about whether or not to conserve marine species.

For those who are in charge with management and allocation of 'fish' my thesis highlights the importance of differentiating between boating and fishing, boat fishing and land-based fishing, recreational catch and recreational keep, and the probability of keeping/releasing and the total number of fish kept annually. My thesis demonstrates techniques that can be used to facilitate this differentiation, with results clearly indicating that a two-step approach is likely to generate better quality information about those placing greatest pressure on fishing stocks than simpler one-step analyses that fail to differentiate these groups.

That said, my thesis also demonstrates that one should not get too bogged down in econometric detail: as demonstrated in both chapters 4 and 5, final estimates can be more sensitive to differences in survey design (e.g. use of *ex ante* or *ex post* constructs; bid range, and 'menu') than to analytical techniques (e.g. simple means versus sophisticated Spike models). Researchers may thus need to devote every bit as much time and energy into survey design and data collection as they do into data analysis.

Clearly value estimates are not 'precise' – they are sensitive to a range of methodological issues. Thus natural resource managers should be cautious of using just single estimates when considering the allocation of 'fish' (or indeed any scarce resource) across competing using groups. Instead of using just single point-estimates, a constructed range could be more useful – if only because it clearly demonstrates the uncertainties associated with such estimates.

Henry and Lyle, (2003, p. 23) note that without detailed information about MVs, debates about which sector should have more or less fish are basically unsolvable. My research has not 'solved' the problem. But it has made a significant contribution –

providing more information about MVs for recreational fishing and tourism in the GBR and more information about techniques for trying to estimate and better understand those values.

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Publications during PhD

As first author – already published

Farr, M., Stoeckl, N., & Beg, A. R. (in press). The non-consumptive (tourism) 'value' of marine species in the Northern section of the Great Barrier Reef. *Marine Policy*.

http://dx.doi.org/10.1016/j.marpol.2013.05.002

Farr, M., Stoeckl, N., & Beg, R. A. (2012). *On Relative Values of Marine Species in the Great Barrier Reef.* Conference Paper was presented on the 56th AARES Annual Conference, 7-10 February 2012, Fremantle WA.

Farr, M., Stoeckl, N., & Beg, R. A. (2011). The efficiency of the Environmental Management Charge in the Cairns management area of the Great Barrier Reef Marine Park, *The Australian Journal of Agricultural and Resource Economics, 55*, 322-341

As first author – in review

Farr, M., Stoeckl, N., & Sutton, S. Catch and Release in Recreational Fishing: identifying those who place most stress on fish resources. (in review in *Fisheries Research*).

Farr, M., Stoeckl, N., & Sutton, S. The Marginal Value of fish to recreational anglers: ex ante and ex post estimates ARE different (in review in *The American Journal of Agricultural Economics*)

As Contributing author

Stoeckl, N., Esparon, M., **Farr, M.,** Delisle, A., & Stanley, O. (2013).Economy, Society and Water: An investigation into some of the distributional and consumptive water demand consequences of development in Northern Australia. *Australasian Journal of Regional Studies* (forthcoming)

Stoeckl, N., Esparon, M., **Farr, M.,** Delisle, A., & Stanley, O. (2013) The great asymmetric divide: An empirical investigation of the link between Indigenous and non-Indigenous economic systems in Northern Australia. *Papers in Regional Science* (forthcoming).

Stoeckl, N., Esparon, M., Stanley, O., **Farr, M.,** Delisle, A., & Altai, Z. (2011). *Socio-Economic Activity and Water Use in Australia's Tropical Rivers: A Case Study in the Mitchell and Daly River Catchments*, Final Report for The Tropical Rivers and Coastal Knowledge Research Consortium, February 2011.

Stoeckl, N., Birtles, A., **Farr, M.,** Mangott, A., Curnock, M. & Valentine, P. (2010). Live-aboard dive boats in the Great Barrier Reef: their regional economic impact and the relative values of their target marine species, *Tourism Economics, 16*(4), 995-1018.

Stoeckl, N., Birtles, A., Valentine, P., **Farr, M.,** Curnock, M., Mangott, A., & Sobtzick, S. (2010). *Understanding the social and economic values of key marine species in the Great Barrier Reef*. Final Report to the Reef and Rainforest Research Centre,14th June 2010, Townsville, QLD.

1 General Introduction

Abstract/Chapter overview

Around the world, there is increasing conflict between fishers and non-fishers in marine environments. But determining how best to manage and allocate 'fish' between fishers, recreationists and tourists is a non-trivial and potentially contentious task. Moreover, there are numerous methodological and empirical gaps that make this task more difficult. In this chapter I outline some of those gaps, identify the aims of my thesis (to help fill some of those gaps) and describe its structure.

1.1 Introduction

Natural resource management (NRM) policies attempt to find ways of sustainably managing terrestrial, freshwater and marine natural resources (The Western Balkan Countries INCO-NET, 2013; USGS, 2013; Terrain, NRM 2013; Regional NRM Policy, Department of Environment and Resource Management, 2011; Toronto and Region Conservation Authority, 2013; GAO U.S. Government Accountability Office, 2013). When designing and implementing these policies, natural resource managers must confront many issues including land use change, alterations to wetlands and waterways, ecosystems health and water quality. As such, much of their time and energy must deal with 'the impact of human activities on natural resource values, such as the impact of recreational activities and household behaviour …and the impacts of industrial and commercial activities (e.g. forestry, tourism, fisheries, aquaculture and agriculture)' (NRM South, 2010, p. 5).

Although terrestrial, freshwater and marine managers face many similar problems, marine areas are distinguished by the fact that they are traditionally common property resources – sometimes, but not always – being open-access (Hess, 2006; Newkirk, Baird, & McAllister, 2013). Common property resources are thus often subject to overuse (Ostrom, 1990), and frequently 'subject to contestation among multiple users' (Adams, Brockington, Dyson, & Bhaskar, 2002, p.1), arguing over perceptions of unfair use and over the allocation of the resources (Newkirk et al., 2013).

As outlined by the Marine Biodiversity Decline Working Group (2008), common users of marine areas include:

- Commercial fishers
- Recreational fishers

- Commercial marine tourism operators
- Tourists
- Residents – for general recreation (e.g. boating, yachting, snorkelling, diving, water skiing)
- Traditional users
- Ports and ships
- Scientific researchers
- Defence groups (e.g. conducting training activities)

These users each put pressure on the marine environment and one of the biggest challenges facing marine resource managers is to determine how to allocate resources across them (Marine Biodiversity Decline Working Group, 2008; Dulvy, Jennings, Rogers, & Maxwell, 2006). This PhD is focused on the challenge of managing and allocating one type of marine resource (fish) across a subset of those users (fishers, recreationists, and tourists).

Around the world, there is increasing conflict between fishers and non-fishers in marine environments (Jones, 2001; Caddy & Seijo, 2005), particularly tourists and fishers. Even though many recreational boaters and fishers would derive pleasure from seeing several of the marine species that interest tourists recreational divers and eco-tourists 'typically seek to remove or minimize effects of fishing on environmental aesthetics …[and] … growing ecosystem conservation imperatives often appear incompatible with fishery harvests' (Mapstone et al., 2008, p. 315). Yet even between fishers, different sectors seek different, often non-compatible, outcomes from fishery managers. For example, '[recreational] fishing expectations (e.g., catching trophy fish) often conflict with [the expectations] of commercial fisheries (e.g., maximum sustainable yield, economic returns to businesses, or maximum gross national economic benefit)' (Mapstone et al., 2008, pp. 315-316). As such, determining how best to manage, and allocate 'fish' between fishers, recreationists and tourists is a non-trivial, and potentially contentious task.

Economic theory suggests that the optimal allocation of fish resources between two competing sectors is one that maximises the net social value where marginal net benefits to competing users are equal (see point Q* Figure 1.1). If one is able to establish a (working) 'market' for Total Allowable Catch (TAC) (e.g. a tradeable permit system that includes both commercial and recreational fishers), then regulators need not concern themselves with the allocation problem – competing sectors will 'bid' for access as long as the marginal value (MV) of the fish is greater than the marginal cost. However, if it is not possible to establish a 'market' for TAC, then regulators may need to confront the allocation problem.

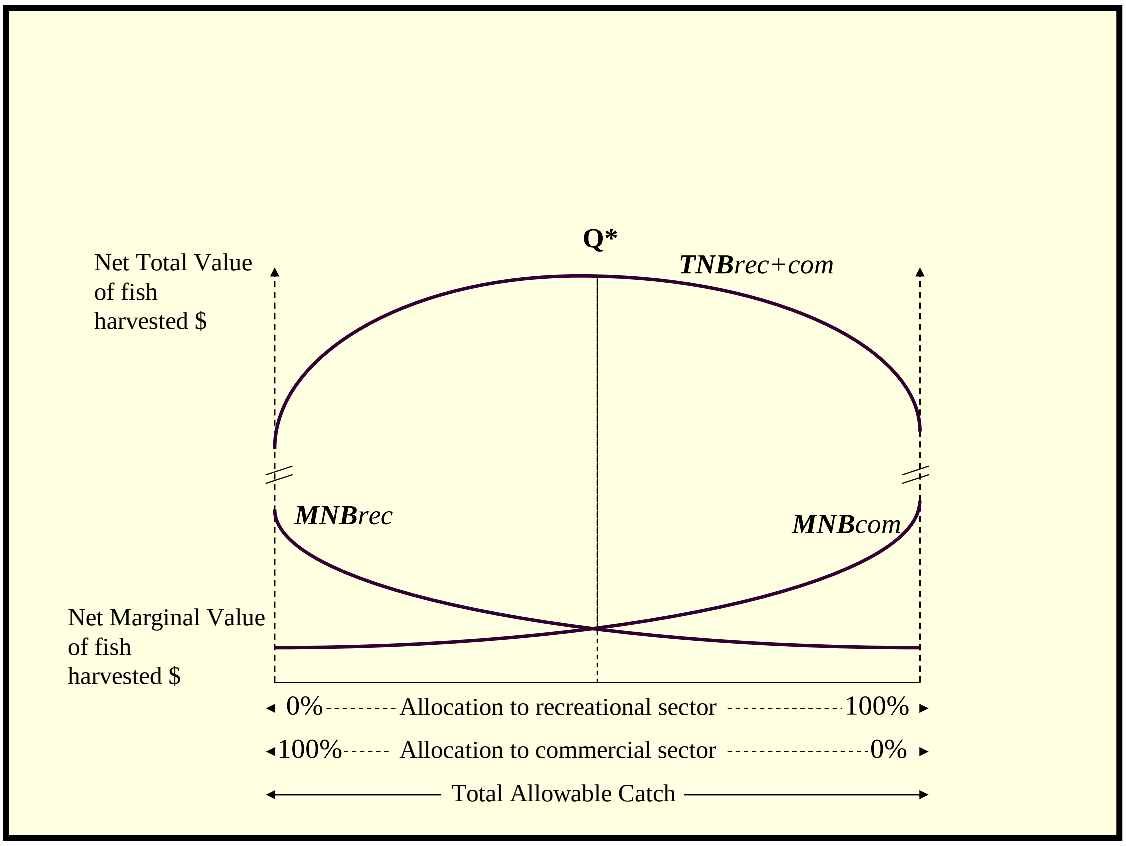

Figure 1.1 Efficient allocation of fish stock between two competing sectors (Source: Lal et al., 1992)

If seeking maximise the net social benefit of a fishery, regulators should reallocate fish resources away from sectors with low MVs to those with high MVs, and they should continue this reallocation process until the net MVs for both sectors are equal (Blamey, 2002; Holland, 2002; Galeano et al., 2004). As such, those charged with managing conflicts between different user groups could benefit from information about marginal benefits.

There is much publically available data and research relating to commercial fishers (Thurman & Easley, 1992; Bjørndal, Conrad, & Salvanes, 1993; Mackinson, Sumaila, & Pitcher, 1997; Laukkanen, 2001; Lange, 2003; Independent Economic Analysis Board, 2005; Maroto & Moran, 2008; ABARE, 2009; Claro, de Mitcheson, Lindeman, & García-Cagide, 2009; Harry et al., 2011; Price, Gayeski, & Stanford, 2013) (see also Table 1.1) and for this sector, market price can often be used as a guide when assessing MVs. So the research 'gap' associated with the commercial sector is, arguably, not as significant as it is for other sectors.

Much research has also been done on tourism. But whilst many studies have sought to estimate the total value of tourism (see Appendix 1, Figure A1.2) as an entire industry (Driml, 1987a; Driml, 1999; KPMG, 2000; Access Economics, 2005; Access Economics, 2007) or the total value of a trip/experience (Kragt, Roebeling, & Ruijs, 2009; Rolfe, Gregg, & Tucker, 2011)(see also Table 1.1), few researchers have attempted to assess the MV of a 'fish' or of a single species. Those that have, were, for the most part, conducted in various parts of the United States (Hageman, 1985; Samples & Hollyer, 1989; Olsen, Richards, & Scott, 1991; Loomis & Larson,1994) or Europe (Ressurreiçãoa et al. 2011; Stithou, 2009).

Table 1.1 Studies in the GBR

Commercial Fishing	Recreational Fishing	Recreational Boating only	Charter Fishing	Indigenous Fishing & Hunting	Tourism
Management studies					
Brodie and Waterhouse (2012)	Brodie and Waterhouse (2012)		Brodie and Waterhouse (2012)	Brodie and Waterhouse (2012)	Brodie and Waterhouse (2012)
McCook et al. (2010)	McCook et al. (2010)		McCook et al. (2010)	McCook et al. (2010)	McCook et al. (2010)
Russell (2003)	Russell (2003)		Russell (2003)	Russell (2003)	Russell (2003)
Mapstone et al. (2004)	Mapstone et al. (2004)		Mapstone et al. (2004)		
Welch, Mapstone, and Begg (2008)	De Freitas, Sutton, Moloney, Ledee, and Tobin (2013)			Robinson, Ross, and Hockings (2006)	
Ledee, Sutton, Tobin, and De Freitas (2012)	Craik (1990)			Marsh (2007)	
Miller, Cheal, Emslie, Logan, and Sweatman (2012)	Craik (1993)			Smith (1989)	
Tobin, Currey, and Simpfendorfer (2013)				Benzaken, Smith, and Williams (1997)	
Pears, Choat, Mapstone, and Begg (2006)				Nursey-Bray (2011)	
Craik (1978)	Craik (1978)			Smith and Marsh (1990)	
Little et al. (2007)				Gibbs (2003)	
Cadwallader et al. (2000)				Dobbs (2007)	
Impact assessment/Economic contribution studies (Expenditure, Financial and Economic values etc.)					
Access Economics (2005)	Access Economics (2005)				Access Economics (2005)
Access Economics (2007)	Access Economics (2007)				Access Economics (2007)
Access Economics (2008)	Access Economics (2008)				Access Economics (2008)
Driml (1987a)	Driml (1987a)		Driml (1987a)		
Hundloe (1985)	Hundloe (1985)		Hundloe (1985)		
Driml (1994)	Driml (1994)				Driml (1994)
KPMG (2000)	KPMG (2000)				KPMG (2000)
Driml (1999)	Driml (1999)				Driml (1999)
Bishop (1992)	Murphy (2003)				
Oxford Economics (2009)	Oxford Economics (2009)				Oxford Economics (2009)
GBRMPA (2003b)	GBRMPA (2003b)				
Hundloe, Driml, Lack, and McDonald (1980)	Hundloe, Driml, Lack, and McDonald (1980)				
Productivity Commission (2003)	Productivity Commission (2003)				
Harriott (2001)	Hand (2003)				Driml & Common

					(1995)
Fenton & Marshall (2001)	Hunt (2005)				Stoeckl et al. (2010a)
Watson, Coles and Long (1993)	Murphy (2002a)				Driml (1987b)
Daley, Griggs and Marsh (2008)	Murphy (2002b)				Driml and Common (1996)
Fenton, Kelly, Vella, & Innes. (2007)	Fenton, Kelly, Vella, & Innes. (2007)				Fenton, Kelly, Vella, & Innes. (2007)
Bureau of Rural Sciences (2003)					Chadwick (2003)
	PDP Australia (2003)				Stoeckl, Greiner, and Mayocchi (2006)
					Sutton and Bushnell (2007)
	Peachey (1998)				Peachey (1998)
Non-market valuation studies					
	Rolfe, Gregg, and Tucker (2011)				Carr and Mendelsohn (2003)
	Prayaga, Rolfe, and Stoeckl (2010)				Kragt, Roebeling, and Ruijs (2009)
	Blamey (1991)				Knapman and Stoeckl (1995)
					Hundloe, Vanclay, and Carter (1987)
					Farr, Stoeckl, and Beg .(2011)
Descriptive studies					
Benzaken and Aston (1997)	Benzaken and Aston (1997)		Benzaken and Aston (1997)	Benzaken and Aston (1997)	Benzaken and Aston (1997)
Lawrence, van Putten, and Fernbach (2010)	Lawrence, van Putten, and Fernbach (2010)		Lawrence, van Putten, and Fernbach (2010)	Lawrence, van Putten, and Fernbach (2010)	Lawrence, van Putten, and Fernbach (2010)
Starck (2005)		Economic Associates (2011a)		Nursey-Bray (2009)	
		Economic Associates (2011b)		Smith (1989)	
Quantitative studies					
Asafu-Adjaye et al. (2005)	Asafu-Adjaye et al. (2005)				Asafu-Adjaye et al. (2005)
Reid and Campbell (1998)	Sutton (2007)				Miller (2006)
Sutton and Tobin (2012)	Lynch, Sutton, and Simpfendorfer (2010)				
Harry et al. (2011)	Sutton (2005)				
Gribble (2003)					
Little et al. (2009)					
Robertson (2003)					
Attitudinal studies					
	Higgs and McInnes (2003)				Inglis, Johnson, and Ponte (1999)
	Jennings (1998)				Wynveen, Kyle, and Sutton (2010)
	Ormsby (1999)				

	Ormsby (2004)	
	Roy Morgan Research (1999)	
	Sutton (2006)	
	Smith, Kyle, and Sutton (2010)	
	Sutton (2008)	
	Young and Temperton (2007)	
	Wachenfeld, Oliver and Morrissey (1998)	
Catch and effort		
Leigh et al. (2006)	Leigh et al. (2006)	Leigh et al. (2006)
Campbell, Mapstone, and Smith (2001)	Campbell, Mapstone, and Smith (2001)	Campbell, Mapstone, and Smith (2001)
Mapstone et al. (2008)	Mapstone et al. (2008)	Mapstone et al. (2008)
Mapstone et al. (2004)	Mapstone et al. (2004)	Mapstone et al. (2004)
Harry et al. (2011)	Frisch et al. (2008)	
Little et al. (2010)	Blamey and Hundloe (1993)	
Heupel et al. (2009)	Platten, Sawynok, and Parsons (2007a)	
Hill and Wassenberg (2000)	Platten, Sawynok, and Parsons (2007b)	
Welch et al. (2008)		
Little et al. (2008)		
Williams (2002)		

The relevant value for a recreational angler is that of the marginal fish: specifically, 'the amount a fisher would be willing to forgo in order to increase the catch per trip by one fish' (Lal et al., 1992, p. 38) (see Appendix 1 for details). However, few researchers have sought to estimate such value, perhaps at least partially because of the costs and difficulties of collecting relevant data given the 'non-market nature of the benefits from recreational fishing' (Lal et al., 1992, p. 38). As such, when compared to the commercial and tourism sectors, there is relatively little information available about recreational fishing, and existing studies do not differentiate between

- the boating and fishing experience (KPMG, 2000; Asafu-Adjaye, Brown, & Straton, 2005; Prayaga, Rolfe, & Stoeckl, 2010) (see also Table 1.1); and

- the characteristics of those who are most likely to keep or release a fish, rather than on the characteristics of those who keep most fish (those who place greatest strain on the resource) (Grambsch & Fisher, 1991; Sutton & Ditton, 2001; Sutton, 2001, 2003; Wallmo & Gentner, 2008).

Moreover, most recreational fishing studies use historical or actual catch - *ex post* measures - rather than anticipated (*ex ante*)[1] catch when estimating MVs (Whitehead & Haab, 1999; Zhang, Hertzler, & Burton, 2003; Besedin, Mazzotta, Cacela, & Tudor, 2004; Carter & Liese, 2010). As such, there are numerous important research gaps for this sector, discussed in more detail below.

1.2 Thesis aims and study area

The primary aim of my thesis is to help fill those research gaps – specifically: improving methodological approaches for estimating the demand for and economic values of 'fish' in the recreational fishing and tourism sectors whilst also providing empirically relevant information.

The area selected for study is the Great Barrier Reef (GBR) – 'an integral part of the Australian national identity' (Great Barrier Reef Marine Park Authority [GBRMPA], 2009a, p. 2). It 'is the world's largest World Heritage Area, covering about 35 million hectares' (Australian State of the Environment Committee, 2001, p. 26) and includes nearly 3000 individual reefs in total (GBRMPA, 2009a) (see Figure 2.2). The Great Barrier Reef Marine Park (GBRMP) is a multiple use area and it supports significant commercial industries including tourism, shipping and fishing (commercial, recreational,

[1] *Ex ante* (Latin): literally, from (what might lie) ahead. *Ex ante* is based on anticipated changes or activity in an economy and means 'before the event'. *Ex post* (Latin): from (what lies behind). *Ex post* is based on the analysis of past performance and means 'after the fact' (Dictionary.com, 2013).

Indigenous and charter[2]. As such the GBR offers itself as an ideal case study area – not only because it has multiple, relevant, users, but also because it provides an opportunity to ensure that the thesis provides empirical and policy insights to the GBRMPA and fisheries management (in addition to methodological ones).

To briefly describe the case study area (further details are provided in subsequent chapters): the land area of eastern Queensland (QLD) that is adjacent to the GBRMP (termed the GBR catchment area) includes the cities of Townsville, Cairns, Bowen, Mackay, Rockhampton, and Gladstone (Productivity Commission, 2003). This area is covers approximately 423,000 km^2 (Hutchings, Haynes, Goudkamp, & McCook, 2005) and is home to approximately 1.2 million residents (GBRMPA, 2009a).

Indigenous and charter fishing activities account 'for a relatively small component of the overall fisheries take' (GBRMPA, 2009a, p. 68; CRC Reef Research Centre, 2002; Aslin & Byron, 2003; Cadwallader, Russell , Cameron, Bishop, & Tanner, 2000; Tanzer, 1998), but the commercial fishing sector covers the entire GBR (GBRMPA, 2009a), and is 'the largest extractive activity' in the Marine Park (Ledee, Sutton, Tobin, & De Freitas, 2012, p. 227). Licences (to fish and/or to own and operate a boat) and permits are required for commercial fishers. In addition, all commercial fishermen and harvesters must provide data about each day's catch, time spent fishing and fishing location. It is a legal obligation to record this data in a daily logbook. The data is used for fisheries and individual species assessment (Department of Employment, Economic Development and Innovation, 2010; CRC Reef Research Centre, 2002).

'Recreational use of the [GBR] marine environment tends to be concentrated around major regional centres' along the QLD coast (Marine Biodiversity Decline Working Group 2008,

[2] GBRMPA, 2009a; Mapstone et al., 2008; Ledee et al., 2012

p.25). An important type of recreational use in this region, relates to recreational fishing. Formally, the recreational fishing sector comprises enterprises and individuals involved in recreational, sport or subsistence fishing activities that do not involve selling the products of these activities (FRDC, 2000). For many years, recreational fishing on the GBR has been an important cultural and leisure time activity for Queensland coastal residents and inter-state and international visitors (GBRMPA, 2009a; CRC Reef Research Centre, 2002). In 2008, more than one half of visitors to the GBR went fishing (GBRMPA, 2009a). This fishery is open access, and is mostly focused in inshore areas and targeted reef fish. Fish size and possession limits, gear restrictions, boat limit and area closures are used to regulate recreational catch (Australian State of the Environment Committee, 2001; GBRMPA, 2009a; Prayaga, 2011; ABARE, 2009). However, unlike the commercial sector, detailed information 'about the volume and type of catch' for recreational sector is limited 'because there are no licensing or reporting requirements for recreational fishers'(CRC Reef Research Centre 2002, p. 4) – although the Queensland Department of Primary Industries conducts regular surveys of recreational fishers to collect information about place of residence, their participation in recreational fishing, where they fish and what they catch (Taylor, Webley, & McInnes, 2012).

Each year, the GBR catchment area hosts an estimated 1.6 million tourists, associated with $5.2 billion in value added (Deloitte Access Economics, 2013). Tourism activities (diving, snorkelling, boating etc.) within the GBRMP are managed by zoning plans and 'through a system of permits and licences, accreditation and self-regulation through Best Environmental Practice Guidelines for some activities' (Australian State of the Environment Committee, 2001, p.46). The GBRMPA uses an environmental management charge (EMC) to monitor tourists visits to the GBRMP (Fernbach , 2008) and to collect revenues used to contribute to the GBRMPA's overall running costs (Farr, Stoeckl, & Beg, 2011). ‘All licensed tourism operators are subject’ to the EMC (Australian State of the Environment Committee 2001, p. 46). The GBRMPA also monitors independent tourists by monitoring the number of registered recreational boats (STIG 2006; Fernbach, 2008).

1.3 Specific research gaps and associated aims

Gap 1

The sustainable management of marine resources requires managers and policy makers to understand (a) the way in which recreational boaters and fishers make decisions about their participation and the frequency of using the marine resources and (b) the factors that impact their behaviour, choices and welfare. However, the relative scarcity of regionally relevant recreational boating and fishing data increases the challenges facing policy makers and resource managers who have to balance sustainable use with protection of the environment while maintaining high quality recreational experiences (Smallwood & Beckley, 2009).

As noted above, most published studies on the value of recreational fishing and boating have been done in the USA, Canada and Europe (Bilgic & Florkowski, 2007; Carson, Hanemann, & Wegge, 2009; Connelly, Brown, & Brown, 2007; Tseng et al., 2009), although some have also been done in New Zealand (Wheeler & Damania, 2001; Kerr & Greer, 2004), in different parts of Australia (Sant, 1990; Raguragavana, Hailua, & Burtona, 2010; Smallwood, Beckley, Moore, & Kobryn, 2011; Yamazaki, Rust, Jennings, Lyle, & Frijlink , 2011) and on the GBR (Blamey & Hundloe, 1993; Prayaga et al., 2010; Rolfe, Gregg & Tucker, 2011) (see Table 1.1).

That said, existing recreational fishing studies do not always differentiate between the boating and fishing experience and look at boating and fishing as if it were a single, homogenous, good (Blamey & Hundloe, 1993; Morey, Shaw, & Rowe, 1991; KPMG, 2000; Asafu-Adjaye et al., 2005; Bilgic & Florkowski, 2007; Prayaga et al., 2010; Rolfe et al., 2011). As such, they do not necessarily generate information that is unambiguously about those who place greatest pressure on fish stocks (the fishers). But if interested in assessing the pressure on fish stocks, one needs to look at the demand for fishing which may be different from the demand for boating. Moreover some policy implementations and monitoring programs require information about boating and fishing to be considered separately (e.g. policies about boat-ramps and coast-guards versus policies about fishing limits). As such, there is a need for dissagregated information about the demand for boating, and the demand for fishing. In addition, many researchers have treated boat and land-based fishing as similar (Greene, Moss, & Spreen, 1997; Jones & Lupi, 1999; Parsons, Plantinga, & Boyle, 2000; Hauber & Parsons, 2000; Shrestha, Seidl, & Moraes, 2002; Ojumu, Hite, & Fields, 2009) – but these activities require different inputs, affect different fish stocks, and are thus likely to be viewed as quite different 'goods', by both fishers and fish managers alike. As such, there is a need to differentiate between drivers of boat and land-based fishing.

Aim 1:

To disaggregate the fishing/boating experience, specifically seeking to

- provide information to managers of the GBR about the characteristics of boaters, boat-fishers and land-based fishers;
- determine if the factors which influence the probability of participating in boating activities are the same as those which influence the probability of participating in fishing activities; and
- determine if the factors which influence the intensity of boating, boat-based fishing, and land-based fishing are similar or different.

Gap 2

Declining fish stocks in some areas of the world and for some species are at least partially attributable to fishing activities (commercial and recreational) and are a major concern for fisheries managers. Catch-and-release (C&R) has come to light as a viable management tool for reducing recreational fishing pressure. Even though C&R can cause fish mortality (Taylor, Webleya, & Mayer, 2011), and may have a negative physiological effect on fish, nowadays, it is 'generally accepted as an important, even critical, aspect of modern recreational fishing management' (Policansky, 2002, p. 82).

The popularity of C&R practices among recreational fishers has generated much research interest; investigating biological, social and psychological aspects of the phenomena (Grambsch & Fisher, 1991; Wallmo & Gentner, 2008). But historically, C&R studies have tended to focus on specific biological aspects of the practice (e.g. hooking mortality, sub lethal impact) for a particular species. It is only relatively recently that researchers from the social sciences have focused their attention on C&R, seeking to understand 'anglers who practice C&R and why they choose to do so' (Arlinghaus et al., 2007, p. 99).

The early studies on C&R have been useful when 'identifying which segments [of the angling population were] more receptive to the C&R philosophy' (Arlinghaus et al., 2007, p. 100), but they may not provide information that allows one to identify segments of the population that are putting most/least strain of total fish stocks. This is because most previous studies into recreational C&R fisheries have sought to identify the characteristics of those who are most, or least, likely to keep/release (Grambsch & Fisher, 1991; Sutton & Ditton, 2001; Sutton, 2001, 2003; Wallmo & Gentner, 2008). They have not sought to identify the characteristics of those who keep most fish. This is a potential problem because information about the probability of releasing fish on a particular trip does not necessarily provide information that is useful for fisheries managers. A fisher may not keep many fish on any given trip (and may thus be deemed 'non-threatening' if looking only at probabilities), but if they fish daily, their annual keep – a proxy for fishing pressure (GBRMPA, 2010a) – could be substantial. As such, it is the factors associated with annual keep (as opposed to the factors associated with the probability of keeping a particular fish) that are likely to be of most use to fisheries managers.

Aim 2:

To look at Catch versus Release and to

- provide an empirical demonstration of a model that allows one to differentiate between factors that influence the keep/release decision and those that influence the total annual keep.
- compare the determinants of the keep/release decision with determinants of the total number of fish kept annually; and
- provide information to managers of the GBR about the characteristics of anglers who are likely to keep most fish annually (and who are thus likely to contribute to fishing pressure in this part of the world).

Gap 3

As noted earlier, conflict and competition between the commercial and recreational fishing sectors is increasing globally (Aas, 2007) and it is one of the most important management issues in many fisheries around the world (McPhee & Hundloe, 2004; Arlinghaus, 2005). With growing populations, 'fishing pressure from both commercial and recreational sectors increases' (Crowe, Longson, & Joll, 2013, p. 201) and questions about the 'optimal' allocation of fish resources between those two sectors become more and more important (Tobin, 2010; Lindner & McLeod, 2011; Crowe et al., 2013). When market based solutions, such as allocating a TAC to be distributed between ALL users, are not feasible (perhaps because it is expensive to monitor and enforce the recreational sector catches) information about the net MVs of fish to each sector is thus critical to those charged with making the allocation decision (Galeano, Langenkamp, Levantis, Shafron, & Redmond, 2004).

There is a large body of literature that attempts to assess MVs in the recreational fishing sector but when estimating demand for fishing trips (Morey, Breffle, Rowe, & Waldman, 2002; Zhang et al., 2003; Hunt & Moore, 2006; Bingham et al., 2011; Gao & Hailu, 2012) and/or when estimating the 'value' of fish, most researchers have used historical/actual catch as a variable in their models (Whitehead & Haab, 1999; Whitehead & Aiken, 2000; Hicks, 2002; Morey et al., 2002; Zhang et al., 2003; Besedin et al., 2004; Carter & Liese, 2010). This may be problematic. In the 1930s Myrdal (1939) introduced the concepts of *ex-ante* and *ex-post* to economics. He suggested that 'an important distinction exists between prospective and retrospective methods of calculating economic quantities such as incomes, savings, and investments; and … a corresponding distinction of great theoretical importance must be drawn between' those two (Myrdal, 1939, pp. 46–47, cited in Gnos, 2004, p. 335).

Insights from social psychology suggests that there are good reasons for believing that there may be significant differences in *ex post* and *ex ante* constructs, primarily because individuals tend to revise their expectations after an event has happen. But economic studies of *ex ante* and *ex post* constructs in fisheries are extremely rare. Moreover, there is very little previous research that can be used to determine if recreational fishing studies that have used *ex post* measures are, or are not, able to generate final estimates of demand, or of 'value' that approximate estimates that would obtain if *ex ante* measures were used instead.

Aim 3:

To learn more about the MV of a 'fish' to recreational fishers, specifically:

- to differentiate between expected and actual recreational catch and to investigate the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch; and
- to estimate and compare the MV of fish, using *ex post* and *ex ante* measures of recreational catch
- to provide information about MV of a recreational fish to the GBR management

Gap 4

There is a long history of using marine species for consumptive purposes, but the demand for non-consumptive uses of wildlife – particularly for recreational activities – has been also growing rapidly, worldwide (Wilson & Tisdell, 2011). Some researchers have found that various species are 'highly sought after and preferred by visitors, and that visitors are usually willing to pay greater amounts of money to see these' (Miller, 2006, p.18) than other species. Yet despite the fact that many researchers around the world have estimated the use and/or non-use 'value' (see Appendix 1, Figure A1.2) of different species, most studies valuing marine species have been undertaken in different parts of the United States (Hageman, 1985; Samples & Hollyer, 1989; Olsen et al., 1991; Loomis & Larson,1994).

This is not to say that little research has been done on the GBR: indeed, there have been more than a dozen published studies that have investigated economic and financial 'values' associated with the tourism and recreational activities in the GBR (see Table 1.1). But only one study has attempted to estimate the value of an individual species on the GBR: Stoeckl et al. (2010a). All other studies have, instead, valued activities (which may or may not be associated with individual species). That said, Stoeckl et al. (2010a) primarily focused on valuing an activity (specifically dive tourism) and included only a preliminary, descriptive analysis of data that focused in on particular species encountered whilst diving. As such, relatively little is known about the value of particular marine species in the GBR (as opposed to the value of an activity that is associated with a variety of species). Moreover, in the past, most research effort seems to have focused on econometric issues, with relatively little attention given over to the task of differentiating between the sensitivity of estimates to other issues (such as questionnaire design) in comparison to econometric ones.

Aim 4:

To learn more about the MV of species for non-consumptive (tourist) users. Specifically:

- to investigate the extent to which variations in methodological approaches (e.g. bid-end values, bid presentation orders, the 'menu' of species presented for evaluation, and the analytical approaches taken – sophisticated econometrics or simple mid-points) affected final willingness to pay (WTP) estimates; and
- to provide information to managers of the GBR about the importance (or 'value') of key species for non-consumptive uses

1.4 Thesis outline

This thesis is presented as a series of chapters formatted for publication in peer-reviewed journals. It comprises four case studies each focusing on one of the aims above. Authorship of chapters for publication (Chapters 2-6) is shared with members of my thesis committee Natalie Stoeckl (Chapters 2-6) and Steve Sutton (Chapters 2-4, 6) as well as a contributing co-author Rabiul Alam Beg (Chapter 5).

Data used in Chapter 5 were collected during a project that was funded by the Australian Government's Marine and Tropical Sciences Research Facility (led by Alastair Birtles) and supported by funding from the Australian Government's National Environmental Research Program (the Terrestrial Ecosystem's Hub) and I have identified it within the relevant chapter. Tables and Figures are presented throughout the text and additional information about supporting methods, tables and figures are provided in the appendices.

Chapter 1 (this chapter) provides an introduction to methodological and empirical gaps identified during the literature review

Chapter 2 uses the Townsville region near the GBR as a case-study area, and analyses data that I collected from 656 householders via mail out survey in a hurdle model to identify important determinants of recreational boating and fishing. It looks at factors which influence both the probability of participating in boating and fishing activities and also at factors influencing the intensity of boating and fishing trips.

I conducted the analysis and wrote the chapter. Natalie Stoeckl and Steve Sutton assisted with the survey design, model interpretation and editing.

Publication:

Farr, M., Stoeckl, N., & Sutton, S. Recreational Fishing and Boating: are the determinants the same? (about to be submitted to *Journal of Environmental Management*)

Chapter 3 uses the dataset from Chapter 1 to provide an empirical demonstration of a model (the Zero Inflated Negative Binomial) that allows one to differentiate between factors that influence the keep/release decision and those that influence the total keep.

It compares determinants of the keep/release decision with determinants of the total number of fish kept annually; and it describes the characteristics of anglers who are likely to keep most fish annually (and who are thus likely to contribute to fishing pressure in this part of the world).

I conducted the analysis and wrote the chapter, and Natalie Stoeckl and Steve Sutton assisted with survey design, model interpretation and editing.

Publication:

Farr, M., Stoeckl, N., & Sutton, S. Catch and Release in Recreational Fishing: identifying those who place most stress on fish resources. (in review in *Fisheries Research*).

Chapter 4 uses a Tobit Model, to investigate the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch. It also uses a Hedonic Price Model (see Appendix 1 for details) to compare the MV of fish, using *ex post* and *ex ante* measures of recreational catch. I collected the data from a survey of 404 anglers from Townsville. All were intercepted before going fishing (at boat ramps, while preparing to leave on their trip) to capture true *ex ante* expectations; follow-up telephone interviews were conducted to collect *ex post* measures of catch and background socio-demographic information.

I conducted the analysis and wrote the chapter, and Natalie Stoeckl and Steve Sutton assisted with the survey design, model interpretation and editing.

Publication:

Farr, M., Stoeckl, N., & Sutton, S. The Marginal Value of fish to recreational anglers: ex ante and ex post estimates ARE different (in review in *The American Journal of Agricultural Economics*)

Chapter 5 uses the Kristrom (logit) Spike Model to analyse contingent valuation (payment card) data from a study of 2180 domestic and international visitors taking reef trips to the Northern section of the GBR. It estimates the non-consumptive value of several broad groups of species including: whales and dolphins; sharks and rays; large fish; marine turtles; and a 'wide variety of wild life' (this last item is clearly not a species, but was included for reference, and for simplicity, referred to as if it were a 'species' in this chapter; hereafter termed 'variety'). It determines which species were of most/least 'value' to different types of visitors and investigates the extent to which variations in methodological approaches (e.g. bid-end values, bid presentation orders, the 'menu' of species , & the analytical approaches taken – sophisticated econometrics or simple mid-points) affected final WTP estimates.

Data used in this chapter were collected during a project that was funded by the Australian Government's Marine and Tropical Sciences Research Facility (led by Alastair Birtles) and supported by funding from the Australian Government's National Environmental Research Program (the Terrestrial Ecosystem's Hub). The survey design was developed by Natalie Stoeckl.

I conducted the analysis and wrote the chapter, and Natalie Stoeckl assisted with model interpretation and editing, and Rabiul Alam Beg assisted with the Spike model.

Publications:

Farr, M., Stoeckl, N., & Beg, A. R. (in press). The non-consumptive (tourism) ‘value’ of marine species in the Northern section of the Great Barrier Reef. *Marine Policy*.

Farr, M., Stoeckl, N., & Beg, R. A. (2012). *On Relative Values of Marine Species in the Great Barrier Ree.* Conference paper and presentation on the 56th AARES Annual Conference, 7-10 February 2012, Fremantle WA.

Chapter 6

This final chapter summarises key findings from previous chapters. It also discusses the empirical and policy contributions relevant to the GBR and the methodological contributions relevant more broadly. In this chapter I also discuss the limitations of my study and provide some suggestions for future research.

Publication:

Farr, M., Stoeckl, N., & Sutton, S. (2013). *Taking a closer look at Boating, Fishing and Fish in the GBR.* (accepted for presentation at QLD Coastal Conference 2-4 October 2013 in Townsville, QLD)

2 Recreational Fishing and Boating: are the determinants the same?

Abstract

The sustainable management of marine resources needs to understand the way in which recreational anglers and boaters make their decisions about participation, the frequency of using the marine resources and the factors influencing their behaviour, choices and welfare. Most existing studies do not differentiate between the boating and fishing experience and look at boating and fishing as if it is a homogenous good. As such, they do not necessarily generate information about those who place greatest pressure on fish stocks (the fishers). But some policy implementations and monitoring programs require information about boating and fishing to be considered separately.

In this chapter I use household survey data collected from 656 people in Townsville (adjacent to the GBR, 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. My 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.

2.1 Introduction

It is increasingly recognized that the sustainable management of marine resources requires managers and policy makers to understand (a) the way in which recreational boaters and fishers make decisions about their participation and the frequency of using the marine resources and (b) the factors that impact their behaviour, choices and welfare. However, the relative scarcity of regionally relevant recreational boating and fishing[3] data increases the challenges facing policy makers and resource managers who have to balance sustainable use with protection of the environment while maintaining high quality recreational experiences (Smallwood & Beckley, 2009).

Most published studies on the value of recreational fishing[4] and boating[5] have been done in the USA, Canada and Europe, although some have also been done in New Zealand (Wheeler & Damania, 2001; Kerr & Greer, 2004), in different parts of Australia (Sant, 1990; Raguragavana, Hailua, & Burtona, 2010; Smallwood, Beckley, Moore, & Kobryn, 2011; Yamazaki, Rust, Jennings, Lyle, & Frijlink, 2011) and on the Great Barrier Reef (GBR) (Blamey & Hundloe, 1993; Prayaga, Rolfe, & Stoeckl, 2010; Rolfe, Gregg & Tucker, 2011). But – most pertinent here – the vast majority of these studies have looked at boating and fishing as if it were a single, homogenous, good[6]. Others have treated boat and land-based fishing as similar[7]. There are only a limited number of studies that have looked at fishing by itself – that of Zhang et al. (2003); Rolfe and Prayaga (2007) and Loret et al. (2008). The first study looked at land-based fishing, whilst the other two

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1 Recreational boats in this study are those that used for the purposes of recreation and not for any type of business, trade or commerce (MSQ, 2007).'Recreational fishing' is used in accordance with definition by FRDC (2000). The recreational fishing sector comprises enterprises and individuals involved in recreational, sport or subsistence fishing activities that do not involve selling the products of these activities.

[4] Berrens, Bergland, & Adams, 1993; Curtis, 2002; Bilgic & Florkowski, 2007; Carson, Hanemann, & Wegge, 2009; Lloret, Zaragoza, Caballero, & Riera, 2008

[5] Gurmu & Trivedi, 1996; Siderelis & Moore, 1998; Connelly, Brown, & Brown, 2007; Tseng et al., 2009

[6] Blamey & Hundloe, 1993; Morey, Shaw, & Rowe, 1991; KPMG, 2000; Asafu-Adjaye, Brown, & Straton, 2005; Bilgic & Florkowski, 2007; Prayaga et al., 2010; Rolfe et al., 2011

[7] Greene, Moss, & Spreen, 1997; Jones & Lupi, 1999; Parsons, Plantinga, & Boyle, 2000; Hauber & Parsons, 2000; Shrestha, Seidl, & Moraes, 2002; Ojumu, Hite, & Fields, 2009

looked at boat fishing. To the best of my knowledge no previous study has comprehensively investigated and compared different types of fishing (land and boat-based) with non-fishing related boating activities.

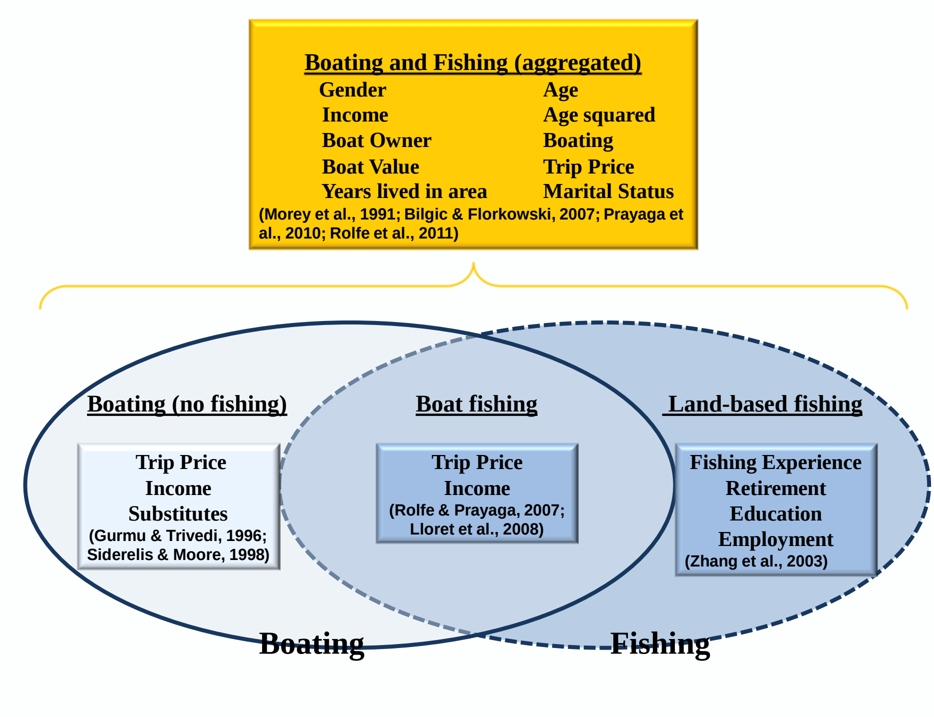

Figure 2.1 Determinants of recreational boating and fishing – summary from the literature

This may be problematic, since treating fishing and boating as a single, aggregated 'good' is equivalent to assuming that the drivers for boating and fishing and for boat and land-based fishing are the same. But they may not be. As such, key indicators of recreational boating and fishing activities that have been identified by previous research (see Figure 2.1) may apply to either boating, or fishing, or to boat fishing, or to land-based fishing but not necessarily all. This may reduce the usefulness of some information to resource managers, since some policy implementations and monitoring programs require information about boating and fishing to be considered separately (e.g. policies about boat-ramps and coast-guards versus policies about fishing limits). Hence, there is a need to disaggregate the fishing and boating experience as well as boat fishing and land-based fishing.

The research described in this chapter helps to redress that problem by demonstrating that it is indeed possible to look at boating and fishing separately. I use the Townsville region near the GBR as a case-study area, and analyse data collected from 656 householders in a hurdle model to identify important determinants of recreational boating and fishing. I look at factors which influence both the probability of participating in boating and fishing activities and also at factors influencing the intensity of boating and fishing trips[8]. As such, this chapter allows me to address the following research question:

- Are the main drivers for boating and fishing and for boat and land-based fishing similar or different?

2.2 Study area

The GBR is the largest coral reef system in the world. The marine park area extends more than 2000 km north-south on the continental shelf off Queensland and covers 348 700 km^2. The GBR is unique in its size, diversity of plants and marine species. In 1975 it was declared a marine park by the Australian Government and in 1981 it was declared a World Heritage Area (GBRMPA, 2010b). The Great Barrier Reef Marine Park Authority

[8] Despite the fact on-site surveys are 'cheaper and practical way to obtain data on visits to sites' (Martinez-Espineira, Loomis, Amoako-Tuffour, & Hilbe, 2008, p. 568) I use household survey to get information about recreation in Townsviile region from people who go boating/fishing and who are not. On-site survey are not only subject to truncation but also endogenous stratification when users are 'over-represented by on-site sampling' (Martinez-Espineira et al., 2008, p. 568; Loomis, 2003; Parson, 2003; González-Sepúlveda & Loomis, 2010) and where 'frequent visitors are more likely to be sampled' (p. 572). Loomis (2003) found that the consumer surplus estimates derived from on-site survey were significantly larger than the estimates derived from household survey. González-Sepúlveda and Loomis (2010) finding also confirmed that 'using on-site samples of visitors overstates visitor willingness to pay (WTP) estimates relative to a household sample of visitors, and substantially overstates the unconditional population values' (p. 561). The household survey avoids those problems.

(GBRMPA) is responsible for management (including fisheries) within the Great Barrier Reef Marine Park (GBRMP). It is challenged with conservation of fish resources and sustainability of the environment for the future (GBRMPA, 2012b).

The land area of eastern QLD adjacent to the GBRMP (termed the GBR catchment area) includes the cities of Townsville, Cairns, Bowen, Mackay, Rockhampton, and Gladstone (Productivity Commission, 2003) (see Figure 2.2). The current population is approx. 1.2 million and expected to increase by 40 per cent by 2026 (Office of Economic and Statistical Research, 2008).

The increasing number of people living adjacent to the GBR leads to an increase of use of the marine park area and an increase in the number of recreational vessels within the catchment (GBRMPA, 2009a; Fernbach, 2008). In December 2011, there were almost 90,000 registered recreational vessels in the GBR catchment area (GBRMPA, 2012b). The growing popularity of recreational boating in QLD is increasing congestion and pollution pressures on coastal waterways and rivers, where most recreational vessels are used (MSQ, 2006). 'This has driven an increased demand for boating facilities such as marinas, moorings and boat ramps, often located within the GBR region or adjacent coastal habitats' (GBRMPA, 2009a, p.101; Economic Associates, 2011a). Indeed researchers have estimated that between 63 and 90 per cent of all registered vessels in the GBR catchment are used solely for recreational boating and fishing (Blamey & Hundloe, 1993; Innes & Gorman, 2002; GBRMPA, 2003a; Fernbach, 2008). Evidently, the increase in population and in the number of recreational boats has the potential to increase fishing activity (both off-shore and land-based) putting even more pressure on infrastructure and on the fish stock.

Figure 2.2 The GBR and the survey area (Source: Stoeckl et al., 2012)

Townsville is the largest town within the catchment, is one of the high growth coastal regions in QLD (Australian Bureau of Statistics [ABS], 2010). It has the second highest number of (registered) recreational boats (GBRMPA, 2012b) (see Figure 2.3). Economic Associates (2011a) predict that it will have the largest increase in boat registrations of any GBR area in the next 20 years, and it also falls in the area with highest probability of recreational fishing usage (GBRMPA, 2010a). As such the region offers itself as an ideal case study, since results are likely to be of use to regional policy makers.

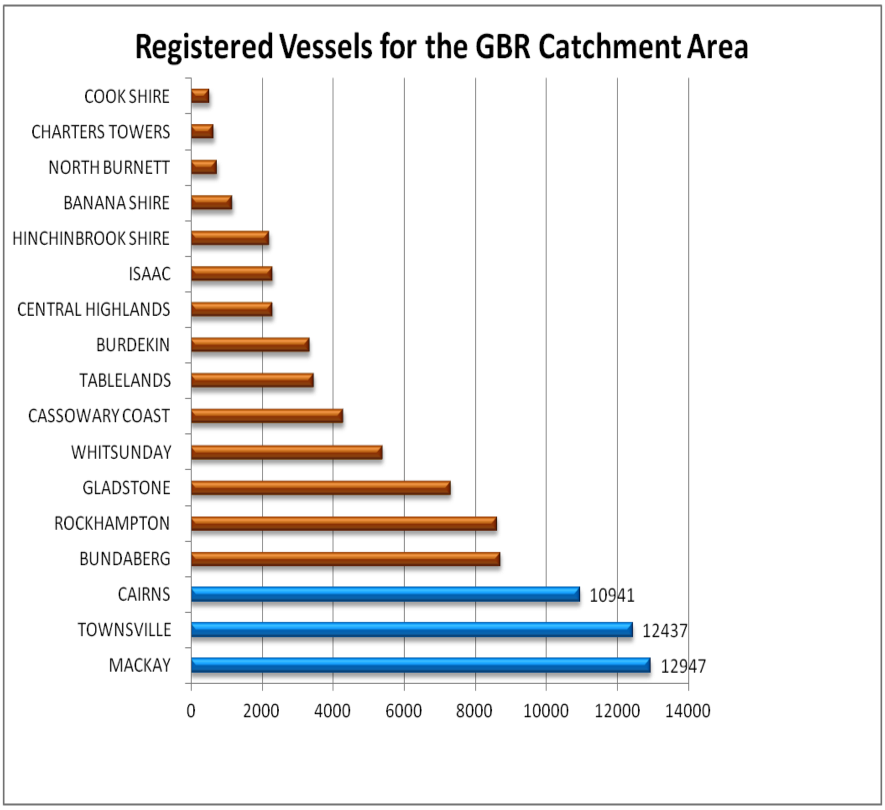

Figure 2.3 Registered vessels for the GBR catchment area December 2011 (Source: GBRMPA, 2012b)

2.3 Survey (Data)

Most previous recreational fishing studies have collected data from fishers at for example boat ramps. This particular study is different, in that I collected data via a mail out survey of randomly selected households in the Townsville region. As such I collected data from both participants and non- participants. It should be noted that it is also different from previous studies with regard to the nature of data: I did not ask about a single trip/experience but rather about the (average) number of trips per annum each respondent took and about the characteristics of their 'average' trip. In addition, the questionnaire was designed to collect data on a wide range of social and demographic factors which previous researchers had found to influence boating and fishing including: fishing and boating participation, fishing preferences, consumptive orientation, occupation and education, age and gender, migration and household income.

The survey sample was selected by consulting the Townsville 2010/2011 telephone directory and randomly selecting 10 names from each of the 212 pages of the book. Data were collected in a household mail-out survey using the procedure developed by Don Dillman (1978, 2000). Dillman's data collection method recommends four separate mailings but I used only two. On 15 August 2011, an introductory letter (with a detailed explanation of the purpose of the research) and questionnaire was mailed to the 2120 selected residents (see Appendix 2 for introductory letter and the questionnaire). A reminder letter (see Appendix 2) and replacement survey was mailed four weeks later to those who had not responded to the first letter. Out of the 2120 initially mailed, 656 valid responses were received; 173 letters were returned due to incorrect address or person moving away or deceased. The overall response rate was thus 33.7%.

Forty four per cent of respondents were male. The average age was about 54 years and 18.4% of the respondents were born and had lived all their life in Townsville. The majority of people (35%) who moved to Townsville were from Brisbane or other parts of QLD. Twenty one per cent of the respondents had never been fishing as an adult and 56.3% had not been fishing during the previous two years. This is consistent with Rolfe et al. (2011)

who collected their data from QLD coastal cities between Cairns (North QLD) and Bundaberg using household survey and found that 42% of respondents went fishing/boating over the last two years.

The majority of respondents preferred outdoor to indoor recreational activities and indicated that camping could be a substitute for recreational boating and/or fishing. The number of times respondents went fishing (on average) was greater than the number of times they went boat-fishing justifying my decision to look at the demand for both boat-based and land-based fishing trips separately.

Compared to demographic data from the ABS Census 2006 (ABS, 2011) for the Townsville region, my sample slightly underrepresents males but over represents people who are more than 33 years of age. This is in accordance with other household surveys (e.g. Rolfe et al., 2011): females and older people are more likely to complete questionnaires than their younger, male counterparts. My sample also over represents professionals, people with university degrees and those on relatively high household incomes – an observation which is also typical for household surveys. My sample may also be subject to self-selection bias because those who are interested in outdoor activities may have been more likely to respond to a survey on outdoor activities than those who have no interest. Thus, motivation can be overrepresented. This suspicion is partially substantiated by the fact that fishing participation in my sample is 42% but Taylor et al.(2012) estimated fishing participation rate at 20% in the Northern region (covering Townsville and Ingham). Thus my sample seems to be overrepresented by fishers – although more than half of the sample (56.3%) have not been fishing so it is still possible to use the data to compare the characteristics of those who do fish, with those who do not.The average size of household was smaller (2.4) in this sample compared to 2.5-3 for Townsville region ABS Census

2006 data. One should, therefore, be careful not to naively extrapolate observations from this sample to the population as a whole.

2.4 The model

2.4.1 Modelling Issues

It can be assumed that the decision to participate and the decision about trip frequency can be influenced by different factors. These decisions can be modelled by two separate models 'to reflect the reality that people first choose if they will engage in the activity' and then decide 'the frequency of use' (Rolfe et al., 2011, p.5). Mullahy (1986) suggested using modified count data models where these two processes are not constrained to be the same and where a binomial probability manages the binary outcome (whether a count is zero or positive). If it is positive, the hurdle is crossed and the conditional distribution of positive outcomes is managed by a truncated (at zero) count data model (Gurmu & Trivedi, 1996).

The decision to participate and the decision about trip frequency are thus estimated in a two stage process: the first stage models people's choices about whether or not to participate; the second stage explores decisions about the quantity of recreational trips (given the choice to participate in this activity). It is this two-stage decision process (hurdle approach) that I used here.

Following Gurmu and Trivedi (1996) and Bilgic and Florkowski (2007) let y_{ij}, j=0, 1, 2,...n be the number of trips for i^{th} individual. Let $\theta_{1i} = \exp(x_{1i}^{'}\beta_1)$ be the negative binomial model 2 (NB2) mean parameter for the case of zero counts and $\theta_{2i} = \exp(x_{2i}^{'}\beta_2)$ for the case of positive counts. Where x_{1i} and x_{2i} are $(k \times 1)$ covariate vectors of the explanatory variables to be used in to be used in the first and second hurdle stages, respectively and β_1 and β_2 are k – dimensional vectors of unknown parameters associated with the first and second hurdle stages respectively. Further define the indicator function $I_i = 1$ if $y_{ij} > 0$ and $I_i = 0$ if $y_{ij} = 0$ and α is a dispersion parameter.

For the negative binomial distribution with k = 0 the following probabilities can be obtained:

$$P_1(y_{ij} = 0 \mid x_{1i}) = (1 + \alpha_1\theta_{1i})^{-1/\alpha_1},\ j = 0 \qquad (2.1)$$

$$1 - P_1(y_{ij} = 0 \mid x_{1i}) = 1 - (1 + \alpha_1\theta_{1i})^{-1/\alpha_1} \qquad (2.2)$$

$$P_2(y_{ij} \mid x_{2i}, y_{ij} > 0) = \frac{\Gamma(y_{ij} + \alpha_2^{-1})}{\Gamma(\alpha_2^{-1})\Gamma(y_{ij} + 1)}\left(\frac{1}{(1 + \alpha_2\theta_{2i})^{1/\alpha_2} - 1}\right) \times \left(\frac{\theta_{2i}}{\theta_{2i} + \alpha_2^{-1}}\right)^{y_{ij}} \qquad (2.3)$$

The density function for the observations is

$$[P_1(y_{ij} = 0 \mid x_{1i})]^{1-I_i} \times [(1 - P_1(y_{ij} = 0 \mid x_{1i}))P_2(y_{ij} \mid x_{2i}, y_{ij} > 0)]^{I_i} \qquad (2.4)$$

and its related log-likelihood is

$$LnL_{h1}(\beta_1, \alpha_1) = \sum_{i=1}(1 - I_i) \times \ln[P_1(y_{ij} = 0 \mid x_{1i})] + I_i \times \ln[(1 - P_1(y_{ij} = 0 \mid x_{1i}))] \qquad (2.5)$$

$$LnL_{h2}(\beta_2, \alpha_2) = \sum_{i=1} I_i \times \ln[P_2(y_{ij} \mid x_{2i}, y_{ij} > 0)] \qquad (2.6)$$

As noted by Bilgic and Florkowski (2007, p.480)

- L_{h1} can be considered as ‘a log-likelihood function for the binary (zero/positive) outcome, e.g., logit, and L_{h2} is a log-likelihood function for a truncated-at-zero model of a positive number’ of trips

- The decision to take boating or fishing trip is the first hurdle which is a binary probability distribution and while the second hurdle 'truncates non-zero counts in the underlying negative binomial distribution'
- 'The maximum likelihood estimates of β_1 and β_2 can be obtained separately from L_{h1} and L_{h2}'

To simplify the estimation, I followed the lead of Gurmu and Trivedi (1996) and used $\alpha_1 = 1$, which is equivalent to the use of a logit model' (2.3) at the first stage.

2.4.2 Variables

According to economic theory, demand is a function of several variables including price, consumer income, population, age, the price of substitutes etc.

$$D = f\left(P, Inc, Pop, Age...etc\right) \qquad (2.7)$$

A normal demand curve can be estimated using the quantity demanded as the dependent variable and price, income, age, etc. as independent variables (Walsh, John, McKean, & Hof, 1992), and this concept can be applied to estimate the visitation equation for the recreational fishing and boating activities. In this case, the number of fishing/boating trips V_i is the dependent variable that represents demand and it is a function of various explanatory variables including a surrogate for price P_i (i.e., distance), and socio-economic descriptives of recreationalists X_i such as age, household/individual income, education, gender, family size, boat owner, experience etc. and site characteristics and measures of substitutes Z_i (Gilling, Ozuna, & Griffin, 2000; Zhang, Hertzler, & Burton, 2003)

$$V_i = f(P_i, X_i, Z_i) \qquad (2.8)$$

2.4.2.1 Identifying variables to include in the models

Dependent variable

In the first, participation model, the dependent variable is binary, so a Probit model was used to perform the analysis. In the second, consumption model, the dependent variable is the number of boating/fishing trips and is, therefore, a non-negative integer (Wang, Little, & Yang, 2009). Discrete non-negative dependent variables can be modelled using either the simple Poisson or Negative Binomial count models, however, the Poisson distribution assumes that the conditional mean of the dependent variable equals its conditional variance. This assumption is not realistic when modelling recreational number of trips. In fact, the conditional variance is often greater than the conditional mean implying overdispersion (Cameron & Trivedi, 1986; Wang et al., 2009) – a problem which can be handled using either the negative binomial or a truncated negative binomial, if the sample is truncated (Prayaga et al., 2010). Preliminary results show that for this data set, the conditional variances are greater than the means (see Table 2.1) implying overdispersion. Therefore I used a zero truncated negative binomial specification to perform the analysis.

Explanatory variables

Many empirical studies have used the same set of economic and non-economic factors to investigate and explain both the participation and the consumption decision processes (Keelan, Henchion, & Newman, 2009). At least some of this may be due to the fact that economic theory provides no definitive guidance (except noting that price is likely to be important) and in many cases, the selection of other independent variables appears to be arbitrary (Newman, Henchion, & Matthews, 2003; Moffatt, 2005). Below I explain how I measured ‘price’; after that I discuss the selection of other variables used in the models..

Price

Although price is generally assumed to influence demand, there are no definitive 'rules' about the best way to estimate or calculate the price of a trip or travel costs (TC). Some researchers have used self-reported costs (Kennedy, 2004; Prayaga et al., 2010). Others have estimated TC as a function of distance [and the average cost of operating a vehicle per mile or km (Carpio, Wohlgenant, & Boonsaeng, 2008; Fleming & Cook, 2008) and the opportunity cost of time (Cesario, 1976; Coupal, Bastian, May, & Taylor, 2001; Bin, Landry, Ellis, & Vogelsong, 2005)]; others have included on-site costs of food (Chen et al., 2004; Herath & Kennedy, 2004); length of trip (Poor & Smith, 2004), or entry fees (Prayaga, Rolfe, & Sinden, 2006). Stoeckl (2003) used Monte-Carlo simulations to investigate the accuracy of welfare estimates generated from TCs studies and found that researchers may be able to estimate a visitation equation using just price of distance as a regressor (instead of TC) and then (if required) scale final welfare estimates for a range of 'plausible' TC equal to a simple function of distance (Stoeckl, 2003, p. 325). It is that approach which I have adopted here.

Specifically, the one-way distance between the respondents' residence (based on the postcode) to the boat ramp was calculated with the 'great circle distance' formula:

$$D_i = 1.852*60*ARCOS\ (SIN(L1)*SIN(L2) + COS(L1)*COS(L2)*COS(XG)) \quad (2.9)$$

where L1, latitude of the survey site (degrees); L2, latitude of the respondents' place of origin (degrees); G1, longitude of the survey site (degrees); G2, longitude of the respondents' place of origin (degrees); XG, longitude of the second point minus longitude of the first point (degrees). For each observation, latitude and longitude were determined by noting the latitude and longitude of each of the ABS's Census Population 2006 postcodes and the boat ramps[9] (Geoscience Australia, 2009)[10]. Using distance in this manner, is equivalent to assuming that the price of distance is one; varying the per-unit cost of travel scales the variable and thus the parameter estimates but will not alter t-ratios or the parameters associated with other variables.

Other explanatory variables

In this study, the choice of other variables for the first and second stage equations was done through a lengthy selection procedure that involved trying out many different combinations of variables from a list of 'potential' explanatory variables – developed by identifying key determinants from previous studies (see Figure 2.1).

In the first instance I used non-parametric Mann-Witney, Kruskal-Wallis and Kolmogorov-Smirnov tests to simply identify variables that had a statistically significant (bivariate) relationship with the dependent variable. A large number of variables were identified as potential determinants; however, there was high correlation between some variables, clearly indicating that inclusion of all would be sub-optimal. The next step was, therefore, to investigate the entire set of characteristics and explore if they collectively influenced choice. The final set of explanatory variables used in the models (Table 2.1) was obtained after a series of estimations, starting from a specification that used all variables and gradually dropping the insignificant ones based on Likelihood Ratio (LR) tests. The

[9] I could have used RACQ, Google maps etc. but it is unlikely that final results would be different since this would simply have given men me higher distances for <u>every</u> observation (rather than changing relativities).

[10] I also estimated self-reported price of the trip as a function of distance and other variables to check if distance is significant. The data from boat ramp survey which I collected at the same time and at the same study region was used to investigate the relationship. Distance was insignificant thus confirming my suspicions that expenditure is unlikely to be significant thus expenditure was irrelevant.

distance to the boat ramp was irrelevant to the land-based fishing and was not, therefore, used as an explanatory variable in these models[11].

[11] I did not ask the respondents where they fished if they went on land-based fishing trips. Thus I was not able to include distance to land-based trips models

Table 2.1 Variables used in the empirical models

Variable	Description	Mean	Std. dev
Boating	1 if the respondent participated in recreational boating in the last 12 months, 0 otherwise	0.36	0.481
TimesBoating	Number of boating trips in the last 12 months	9.28	11.46
Fishing	1 if the respondent participated in recreational fishing, 0 otherwise	0.43	0.496
TimesFishing	Number of times fishing in the last 12 months	12.55	18.74
BoatFishing	1 if the respondent participated in recreational boat fishing in the last 12 months, 0 otherwise	0.31	0.462
TimesBoatFishing	Number of times boat fishing in the last 12 months	8.22	10.29
LandFishing	1 if the respondent participated in land-based fishing in the last 12 months, 0 otherwise	0.33	0.46
TimesLandFishing	Number of times land-based fishing in the last 12 months	8.74	18.70
<u>Explanatory variables</u>			
Boat Owner	1 if boat owner, 0 otherwise	0.23	0.421
Activity Commitment	1 if highly committed to boating or fishing, 0 otherwise	0.16	0.365
Clerical worker	1 if the respondent is clerical and administration worker, 0 otherwise	0.10	0.296
Migrant	1 if the respondent moved to Townsville within the last 10 years, 0 otherwise	0.28	0.451
Age	Age of the respondent	54.43	14.736
Income > $100,000	1 if respondent's *i* annual household income per annum is $100, 000 and above, 0 otherwise	0.29	0.457
Single	1 if Single, 0 otherwise	0.18	0.381
Distance to boat ramp	Distance to the boat ramp for the respondent *i* based on the postcode	6.71	4.470
Male	1 if male, 0 otherwise	0.44	0.497

I also conducted several checks to test for multicollinearity for all explanatory variables in all models. For these models 'tolerance' values ranged between 0.69 and 0.90 and the VIFs ranged between 1.06 and 1.49. There were also no significant differences in Eigenvalues and Condition Indexes for each dimension in the 'Collinearity Diagnostics' table. Evidently multicollinearity is not an issue in this instance (UCLA Statistical Consulting Group, 2013a)[12].

I suspected that endogeneity might also be an issue – particularly given the likely association between the decisions about boating/fishing trips, trip frequency and boat

[12] 'Tolerance', the 'variance inflation factor' (VIF) and 'Collinearity Diagnostics' have been used to examine the presence of multicollinearity. Menard (1995) suggested if a tolerance value is less than 0.1 it 'almost certainly indicates a serious collinearity problem' (Field, 2009, p.297) and that a value that is less than 0.2 could also be a concern. There is no particular rule about which value of the VIF should be a subject of concern but Myers (1990) suggested that a VIF value greater than 10 should be cause of worry (UCLA Statistical Consulting Group, 2013).

ownership. So I conducted an augmented regression test (Durbin–Wu–Hausman test) for endogeneity suggested by Davidson and MacKinnon (1993). The null hypothesis that boat ownership is exogenous was rejected at the 1% levels for both stages, indicating that instrumental variables should be used to estimate boat ownership functions.

Since Boat Ownership is a binary variable, I used a Probit model to regress Boat Ownership against several other exogenous explanatory variables from the final model (specifically: Gender, Clerical worker, Migrant, Age, Income > $100,000, Single and Distance to boat ramp) [13] and kept the predicted values. I then used predicted values of 'Boat Owner' in the participation and trip frequency models.

2.5 Results

2.5.1 Participation equations

Results from the Probit model describing Boat Ownership are presented in Table 2.2[14][15]. The Wald chi-square statistic is highly significant indicating good model fit. Being male and living a longer distance from the most popular boat ramps (all of which are located in the middle of the city) positively influence boat ownership. This positive relation between the distance and boat ownership almost certainly reflects the (much) higher property prices in the city and the smaller property sizes (e. g. apartments) with less room to keep boats. In

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[13] These instruments were chosen based on the significance of the coefficients using Stepwise LR methods

[14] The majority of previous studies have not differentiated between participation (yes/no) and frequency of trips. They also treated boat ownership as exogenous variable (e.g. Rolfe et al., 2011). However, boat ownership is likely to be endogenous and it is what I have found in my model. Thus I have included boat ownership 'correctly' in my models. Specifically, I estimated it as a function of other exogenous explanatory variables (checking first to rule out potential problems associated with multicollinearity). I then used the predicted values of boat ownership in the model, thus formally controlling for endogeneity.

[15] As regards all four participation models were tested for weak instruments and overidentification using IV Probit and the Conditional Likelihood-Ratio (CLR) test, Anderson–Rubin (AR) statistics (Anderson & Rubin, 1949), Kleibergen–Moreira Lagrange multiplier (LM) test (Moreira, 2003; Kleibergen, 2007), a combination of the LM and overidentification J (LM-J) and Wald tests. The statistics for all tests were significant at 1% and 5% level thus I rejected the null of weak instruments and overidentification.

other words people who own boats are more likely to live outside in outer- city suburbs. Single people are less likely to be boat owners.

Table 2.2 Probit model for Boat Owner (endogenous variable)

Instrumental Variables	**Instrumented variable Boat Owner**
Constant	-0.7359**
	(0.371)
Male	0.5584***
	(0.132)
Clerical worker	-0.2726
	(0.256)
Migrant	-0.1767
	(0.153)
Age	-0.0074
	(0.005)
Income > $100,000	0.0935
	(0.152)
Single	-0.3645*
	(0.190)
Distance to boat ramp	0.0339**
	(0.014)
N	479
Log pseudolikelihood	-247.93
Wald chi2	40.54***
AIC	1.069
BIC	-2410.995

*** significant at 1% level
** significant at 5% level
* significant at 10% level

The results from models describing participation decisions are shown in Table 2.3. Note that these results are those generated from STATA's Probit routine with robust standard errors and thus control for heteroskedasticity (Pitts, Thacher, Champ, & Berrens, 2012).

Table 2.3 Binary Probit models for participation decision and Zero Truncated Negative Binomial for frequency of trip decision

Variables	**Boating (fishing and no fishing)**		**Boat Fishing**		**Land-based Fishing**	
	Participation	Consumption	Participation	Consumption	Participation	Consumption
	Coeff (RSE)	Coeff (RSE)	Coeff (RSE)	Coeff (RSE)	Coeff (RSE)	Coeff (RSE)
Constant	-0.9968** (0.401)	2.1669*** (0.722)	-1.0174** (0.410)	1.9331** (0.778)	-0.3136 (0.399)	-0.6409 (1.196)
Boat Owner (predicted values)	5.1574*** (0.743)	1.4814 (1.196)	5.8683*** (0.777)	0.3032 (1.465)	2.8985*** (0.609)	0.5280 (1.572)
Clerical worker	0.2111 (0.251)	-0.3260 (0.382)	0.4269* (0.252)	-0.8675** (0.401)	0.4831** (0.219)	-0.3508 (0.543)
Migrant	0.3327** (0.155)	-0.5161** (0.248)	0.2863* (0.160)	-0.5017* (0.290)	0.0207 (0.148)	0.6401 (0.446)
Age	-0.0096* (0.005)	-0.0089 (0.009)	-0.0138*** (0.005)	-0.0075 (0.010)	-0.0166*** (0.005)	0.0284** (0.014)
Income > $100,000	-0.1379 (0.150)	-0.5055** (0.225)	-0.3844** (0.156)	-0.3020 (0.249)	-0.2204 (0.143)	-0.2437 (0.353)
Single	0.6454*** (0.183)	-0.7331** (0.308)	0.4520** (0.192)	-0.4524 (0.342)	0.2498 (0.184)	0.6698 (0.437)
Distance to boat ramp^	-0.0440*** (0.016)	0.0299 (0.025)	-0.0452*** (0.016)	0.0572* (0.030)		
N	477	170	477	149	477	160
Log likelihood/ pseudolikelihood	-275.17	-521.32	-252.86	-435.95	-280.72	-459.98
Wald chi2	75.69***	24.85***	82.17***	17.77**	47.05***	8.78**
AIC	1.187	6.239	1.094	5.973	1.206	
BIC	-2342.20	215.79	-2386.82	171.36	-2337.29	
LR chi2		19.23***		14.27**		13.53**
Alpha		1.984		1.911		6.152
LR alpha=0		1044.7***		715.10***		1787.89***
Marginal effects						
Boat Owner PVs	1.9167***	9.2709	2.0022***	1.6307	1.0353***	1.5791
Occupation CA	0.0806	-2.0400	0.1572*	-4.6658**	0.1841**	-1.0492
Migrant	0.1261**	-3.2297**	0.1005*	-2.6985*	0.0074	1.9141
Age	-0.0035*	-0.0562	-0.0047***	-0.0403	-0.0059***	0.0850*
Income	-0.0507	-3.1637**	-0.1255***	-1.6241	-0.0771	-0.7287
Single	0.2498***	-4.5879**	0.1647**	-2.4335	0.0922	2.0030
Distance	-0.0163***	0.1876	-0.0154***	0.3078*		

*** significant at 1% level
** significant at 5% level
* significant at 10% level
^ Distance to the boat ramp was irrelevant for Land-based fishing therefore were excluded from the analysis
Note: alpha is the same for ZTNB regression with the robust errors. LRchi2 and LR of alpha=0 are for ZTNB with standard errors but cannot be performed for RSE model.

The Wald chi-square statistics for both models are highly significant indicating good model fits. The Pearson goodness-of-fit test and a model specification link test were conducted for all four participation models. The results indicate that all four models fit reasonably well and the link test confirmed that the models do not have specification errors.

The models show that those who own a boat are more likely to have taken a boating or fishing trip in the last 12 months. Age coefficients are highly significant and have a negative sign for all activities: a result that is consistent with previous research (Floyd, Nicholas, Lee, Lee, & Scott, 2006; Bilgic & Florlowski, 2007). Younger people are more likely to take either boat, boat-fishing or land-based fishing trips. As expected the coefficient on Distance to boat ramp (a proxy for price) is negative and highly significant for the Boating (fishing and no fishing) and Boat fishing models. The further the distance to travel between 'home' and the inner city boat ramps the lower the probability that a person will participate in boating and fishing. Being single or being a recent migrant increases the probability of going boating (with fishing and no fishing) as well as the probability of participating in boat fishing.

The probability of participating in a recent boat fishing trip is lower for those on high incomes than for those with household incomes below $100,000 per annum. This is consistent with the findings of other researchers: Floyd et al. (2006) suggest that recreational fishers are mostly belonging to the middle income group; Bilgic and Florlowski (2007, p. 482) found 'the participation rate declines for those with the income exceeding $75 000'. People employed as a clerical or administrative workers were more likely to have participated in a boat or land-based fishing trip within the last 12 months.

2.5.2 Consumption equations

The second stage of the analysis modelled the frequency of trips - results are presented in Table 2.3. The estimates of the dispersion parameter (alpha) and the LR test for alpha = 0 (equivalent to a Zero-Truncated Poisson model) for all four models indicate that the data are overdispersed and that the Zero-Truncated Negative Binomial (ZTNB) models are thus preferable to a zero-truncated Poisson model (UCLA Statistical Consulting Group, 2013b). The likelihood ratio (LR) chi-square test suggests that a high level of model fit for all four models is being achieved.

The results indicate that recent migrants, single people and individuals with annual household incomes which exceed $100 000 per annum went boating less often than others. This later finding confirms results from other studies (Gilling et al., 2000). Recent migrants and people who were employed as a clerical or administrative workers, went boat-fishing less frequently than others. The positive relationship between the frequency of boat fishing trips and distance can perhaps be explained by the fact that frequent boat-fishers are those that own boats (part one of the modelling relationship) and these people mostly live in outer-city suburbs, thus needing to travel longer distances to get to the boat ramps (which are located in the inner city). The positive coefficient on Age for land-based fishing support previous research (Walsh et al., 1992; Bilgic & Florkowski, 2007). Boat ownership is insignificant for all types of activities[16].

2.6 Discussion

The boat ownership equations simply show the characteristics of those who are most likely to own a boat. The participation equations show how likely it is that someone will participate in the activity at least once. The consumption equations show how frequently

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[16] I also estimated participation and consumption models using predicted values of both 'Activity Commitment ' and 'Boat Owner' (see Appendix 2, Table A 2.1 Model 1) and using only 'Activity Commitment' instead of 'Boat Owner' (see Appendix 2, Table A 2.1 Model 2) . First I tested Activity Commitment for endogeneity and found it to be endogenous. The instruments for 'Activity Commitment' equation (for obtaining predicted values for Model 2) were Male and the same set of exogenous explanatory variables from the final model that were used to obtain predicted values for 'Boat Owner' (see Appendix 2, Table A 2.2). However, based on the model performance I reported only models that include 'Boat Owner' instrumented variable.

someone will participate in the activity given that he/she owns a boat. This modelling approach is important because these decisions are different and combining those decisions into a single model would lead to missing some important subtle effects.

I found that married people who live a long way from the boat ramps are more likely to have a boat. This could perhaps be due to the fact that these people live in the outer suburbs so they are able to keep their boats in the backyards. These people are also more likely to go boating frequently. . Single people who live near the boat ramp are more likely to have gone fishing at least once in the last two years –perhaps joining other people on their boat trips.

Recent migrants are less likely to own a boat but they are more likely to have joined someone else on a boating and/or boat fishing trip at least once during the last two years than longer term residents. Interestingly, although they have been at least once recently, they do not do so on a regular basis. This could be something to do with the novelty of having just moved to the region and wanting to try a new experience, but not necessarily wanting to adopt the activity as a frequent hobby.

Participation in land-based fishing decreases with age. Moreover, it seems that when people get older, they are less likely to have been boating, boat or land-based fishing even once in the last two years. This is probably because they have an established life style and do not want to start something new. However, the frequency of land-based fishing trips increases with age. Evidently, keen fishers want to keep fishing, even as they grow older: they might not be able to manage a boat or may find boat maintenance too costly but if they still love to go fishing then fishing from the shore is a viable option for this group of people.

To summarise, the key determinants of the participation decision and of the frequency-of-trip equations are summarised in Table 2.4 and 2.5, respectively. Boat ownership and age are the main drivers of the **participation decision** for all types of activities. Others determinants vary depending on types of activities. Likewise, it seems that length of residence is a key determinant of the frequency of boating and boat-fishing trips (longer residents take more trips), but that other determinants vary across activities.

Table 2.4 Determinants that increase the probability of participation in boating and fishing trips

a boating trip (fishing and no fishing)	a boat-based fishing trip	a land-based fishing trip
Boat ownership (+)	Boat ownership (+)	Boat ownership (+)
Age (-)	Age (-)	Age (-)
	Clerical worker (+)	Clerical worker (+)
Migrant to Townsville region in the last 10 years (+)	Migrant to Townsville region in the last 10 years (+)	
Single (+)	Single (+)	
Distance to boat ramp (-)	Distance to boat ramp (-)	
	Income > $100,000 (-)	

Table 2.5 Factors associated with many boating or fishing trips

Boating trips (which may or may not involve fishing)	Boat-based fishing trips	Land-based fishing trips
Migrant to Townsville region in the last 10 years (-)	Migrant to Townsville region in the last 10 years (-)	
Single (-)		
	Clerical worker (-)	
Income > $100,000 (-)		
	Distance to boat ramp (+)	
		Age (+)

That determinants differ depending on the activity, highlights the importance of disaggregating the fishing/boating experience. Specifically, factors that influenced the participation decision (Table 2.4) show that what distinguishes someone who

1) goes boating (on a trip that may or may not involve fishing) from someone who goes boat-fishing is (a) whether or not they are employed as clerical or administrative workers (those who are employed as clerical or administrative worker are more likely to go boat fishing); and (b) household income (those on higher household incomes are less likely to go boat fishing)
2) goes boat-fishing from someone who goes land-fishing is (a) migration to Townsville region in the last 10 years (recent migrants are less likely to fish) (b) whether or not they are single.

Factors that influenced the frequency of participation (Table 2.5) shows that what distinguishes someone who is more likely to take frequent

1) boating trips from someone who takes frequent boat-fishing trips is: (a) their marital status; (b) whether or not they are on a high income; (c) whether or not they are employed as a clerical or administrative worker; and (d) the distance that they have to travel to boat ramp
2) boat-fishing trips from someone who takes frequent land-fishing trips is age, employment as a clerical or administrative worker and migration (10 years ago or less): older people are more likely to fish from shore.

2.7 Conclusion

The popularity of recreational boating and fishing in the GBR Marine Park, coupled with the rapidly rising population in this area, encouraged this investigation into factors that influence decisions about participation and the frequency of boating, boat-fishing, or land-fishing trips. To the best of my knowledge, this is the first study which has attempted to disaggregate the boating and fishing experience (most previous research considers boating and boat-fishing as a single, composite, good), and my results clearly indicate that there are different drivers for these activities.

The key drivers of decisions surrounding boating (fishing and no fishing) are income, migration and marital status. However, there are a small, but nonetheless significant number of boaters that either do not fish at all or for whom fishing is only a part of other recreational activities while out on a boat. My results indicate that whether or not people fish whilst on the boat (and the frequency of their fishing activity), depends upon income and marital status. Thus it seems that it might also be useful for the GBRMPA to monitor some of these other variables (particularly household incomes): changes in these might also affect participation rates and/or frequency of boat-trips, signalling a potential need to monitor boat-related infrastructures and policies in the region (e.g. those relating to boat ramps, sewage, pollution and marine crowding). I understand that the GBRMPA is currently working with scientists from the Commonwealth Scientific and Industrial Research Organisation to develop such a monitoring program and my results support the need for it.

Migration and employment determine frequency of boat fishing trips. The GBRMPA already monitors boat registrations – using them as an indicator of demand for both boat-fishing and boating and as an indicator of fishing pressure. However, the results from my study suggest that boat ownership determines only participation in boating, boat and land-based fishing activities; not the frequencies of boating or fishing trips. My research suggests that recent migrants tend to fish less often than longer term residents; a finding that is consistent with previous research showing a decline in participation rates over recent years (Taylor, Webley, & McInnes, 2012). Similarly, as people grow older they are inclined to reduce their number of boat and boat- fishing trips. It thus seems that an aging population may decrease boating and boat-fishing activities but this may not have much impact on land-based fishing. These indicators are important when making decisions about fishing pressures and resource allocation, requirement for coast and marine guards, fishing facilities, planning, monitoring and enforcement of fishing activities.

That there are different drivers for boating, boat fishing and land-based fishing, implies that one should consider these activities as related, but nonetheless separate – certainly in this study area, and probably also elsewhere. Clearly more research is needed to investigate these issues further and it would be valuable to use insights from research such as this to make predictions about the potential longer-term impact of population growth, aging population, migration and change in household composition on the demand for fishing and boating. Better still would be research that could extend such investigations to draw inferences about the potential impact of such demographic changes on the fish stock. That said, the results of my study are a useful step in the right direction. They help to improve our knowledge about anglers and boaters and about the drivers of boating, boat-fishing, and land-fishing activities. There are differences; and knowing of their existence is important when formulating marketing strategies, marine park policies or making other management decisions relating to fishing and boating.

Whether or not more frequent fishing trips (be they land or boat based) directly translates into more pressure on fish stocks, remains to be seen – since not everyone who goes fishing catches a fish, and not everyone who catches a fish, chooses to keep it. It is on that important topic that the next chapter focuses.

3 Catch and Release in Recreational Fishing: identifying those who place most stress on fish resources

Abstract

Declining fish stocks in some areas of the world and for some species are at least partially attributable to fishing activities (commercial and recreational) and are major concern for fisheries managers. Catch-and-release has come to light as one way of reducing recreational fishing pressure and much biological and social research has been done on the phenomena. Most previous social science studies have looked at factors affecting the probability that a fisher will keep a particular fish on a particular trip. But this does not necessarily provide information that is useful for fisheries managers: a fisher may not keep many fish on any given trip, but if he/she fishes daily, the annual keep – a proxy for fishing pressure - could be substantial.

Using data from a survey of more than 650 householders in Townsville, Queensland, I compare the determinants of total annual keep with those of the probability of keeping fish on a particular trip. I find that the determinants are different: age and activity commitment influence the probability of keeping fish; boat ownership, income, consumptive orientation, fishing experience, number of annual trips and retirement status are the main determinants of total annual keep. Evidently, those wishing to use Catch-and-Release as a fishery management tool, may need to ensure that their background studies consider total annual keep rather than only focusing on the probability of keeping a fish. In this case study region, failure to do so would mean that managers could be duped into monitoring factors such as age and commitment, rather than other factors such as boat ownership, income and retirement status.

3.1 Introduction

The 'exploitation of fishery resources has become a major conservation issue on a global scale' (Cooke & Cowx, 2004, p. 857). For centuries, fish stocks around the world have been affected by climate, pollution and harvesting – but harvesting pressures 'grew enormously' in the 20th century (Hilborn et al., 2003, p. 368). The Food and Agriculture Organization (FAO) of the United Nations (2000) estimated that 75% of fisheries in the world were fully or overexploited and the FAO (2012) reports that not only are most inland waters overfished but that 'the declining global marine catch over the last few years together with the increased percentage of overexploited fish stocks and the decreased proportion of non-fully exploited species around the world convey the strong message that the state of world marine fisheries is worsening' (p.12).

Even though the global situation is of substantive concern, several countries such as the USA, New Zealand and Australia have made a good progress 'in reducing exploitation rates and restoring overexploited fish stocks and marine ecosystems through effective management actions in some areas' (FAO, 2012, p. 13). For example, in 2002, the National Marine Fishing Survey estimated that 33% of fish stocks in the USA were overfished or depleted. However, ten years later, the FAO (2012) reported that only 17% of all fish stock in the US were still overexploited. In Australia in 2009 only 12% of the fish stock was reported as overfished.

Even though the commercial fishing sector has often been 'blamed for the worldwide declines in fish populations' (Cooke & Cowx, 2004, p. 857), Henry and Lyle (2003), Cooke and Cowx (2004) and Coggins et al. (2007) argue that the recreational fishing sector is also a significant contributor to the problem. Recreational fishing is a popular activity around the world (Post et al., 2002) and it is a substantial industry in terms of the number of participants and fish catch (FAO of the United Nations, 2012). Indeed, Cooke and Cowx

(2004) estimate that approximately 47 billion fish or 12 % of the global harvest is attributable to the recreational fishing sector. There are also records of ‘the detrimental effects of recreational fisheries, such as spear fishing on individual species of gropers along the coasts of the Mediterranean and Australia and in the eastern Red Sea’ (FAO of the United Nations, 2012, p. 122). Some species-specialised recreational fisheries ‘target highly iconic species’ (e.g. marlins, sailfish, swordfish) ‘in particular areas and seasons, contributing significantly to the total catch’ (FAO of the United Nations, 2012, p. 123).

Importantly, many big game fishing clubs and associations actively encourage recreational fishers to release all fish caught (North, 2002; Arlinghaus & Mehner, 2003; Cramer, 2004; FAO of the United Nations, 2012). Termed “Catch-and-Release” (C&R) this practice is often described as a process of catching fish using hooks or lines and ‘then releasing live fish back to the waters where they were captured, presumably to survive unharmed’ (Arlinghaus et al., 2007, p. 77). C&R is not a new phenomenon – but it is only relatively recently that fisheries authorities have identified the practice as a critical aspect of modern recreational fishing management for reducing fishing pressures and for promoting the sustainable use of fish resources (Policansky, 2002; Cooke & Sneddon, 2007; Quinn, 1996; Barnhart, 1989). However, G&R practice relies on people doing it voluntarily and thus, a key management question is ‘How do we encourage more people to participate in C&R fishing and who needs to be targeted in education and encouragement programs?’

C&R was first used in the US in freshwater fisheries and soon after in marine recreational fisheries (Policansky, 2008; Radonski, 2002). Nowadays C&R angling is practiced by many recreational anglers around the world (Policansky, 2008; Aas, Thailing, & Ditton, 2002).

Even though C&R can cause fish mortality (Taylor, Webleya, & Mayer, 2011), and may have a negative physiological effect on fish, nowadays, it is 'generally accepted as an important, even critical, aspect of modern recreational fishing management' (Policansky, 2002, p. 82). The larger the number of fish released, the less will be the impact of recreational fishing on fish stocks (Muoneke & Childress, 1994; Policansky, 2008; Arlinghaus et al., 2007; Barnhart, 1989) and Cooke and Cowx (2004) suggest that each year more than 30 billion fish are released worldwide. In Queensland, Australia, the Department of Primary Industries and Fisheries estimates that the majority of the recreational catch is released – about 60% for some species (Higgs, 2001; DAFF, 2012a).

The popularity of C&R practices among recreational fishers has generated much research interest; investigating biological, social and psychological aspects of the phenomena (Grambsch & Fisher, 1991; Wallmo & Gentner, 2008). Historically, C&R studies tended to focus on specific biological aspects of the practice (e.g. hooking mortality, sub lethal impact) for a particular species (see Arlinghaus et al., 2007 for literature review). It is only relatively recently that researchers from the social sciences have focused their attention on C&R, seeking to understand 'anglers who practice C&R and why they choose to do so' (Arlinghaus et al., 2007, p. 99). Indeed, the first studies focusing on human dimensions of C&R did not appear until the 1990's (Grambsch & Fisher, 1991; Graefe & Ditton, 1997; Fedler, 2000) and most of these were either theoretical or descriptive (Arlinghaus et al., 2007). These studies investigated, for example, various populations of recreational fishers and sought to understand individuals' behaviour towards C&R regulations and participation (Quinn, 1996; Salz & Loomis, 2005).

While these early studies have been useful when 'identifying which segments [of the angling population were] more receptive to the C&R philosophy' (Arlinghaus et al., 2007, p. 100), they may not provide information that allows one to identify segments of the population that are putting most/least strain of total fish stocks. This is because most previous studies (see Table 3.1) have used binary logistic regression to investigate the keep/ release decision (Grambsch & Fisher, 1991; Sutton & Ditton, 2001; Sutton, 2001, 2003; Wallmo & Gentner, 2008). Their aim has been to identify factors that make it more/less likely for an angler to decide to release. There have been a few studies that have attempted to estimate daily and annual recreational catches (Kirchner & Beyer, 1999; O'Neill & Faddy, 2003) and/or harvesting rates (Hunt, Haider, & Armstrong, 2002) but all of these studies have focused on the keep/release probability. This is a potential problem because information about the probability of releasing fish on a particular trip does not necessarily provide information that is useful for fisheries managers. A fisher may not keep many fish on any given trip (and may thus be deemed 'non-threatening' if looking only at probabilities), but if they fish daily, their annual keep – a proxy for fishing pressure (GBRMPA, 2010a) – could be substantial. As such, it is the factors associated with annual keep (as opposed to the factors associated with the probability of keeping a particular fish) that are likely to be of most use to fisheries managers if wanted to encourage/incentivise people to participate in C&R fishing.

It is on this information gap that this chapter focuses. Using data from a household survey of more than 650 householders in Townsville, QLD, this chapter

- Provides an empirical demonstration of a model that allows one to differentiate between factors that influence the keep/release decision and those that influence the total keep;
- compares determinants of the keep/release decision with determinants of the total number of fish kept annually; and
- describes the characteristics of anglers who are likely to keep most fish annually (and who are thus likely to contribute to fishing pressure in this part of the world).

3.2 Literature review

Previous studies have found that recreational catch is often associated with factors such as familiarity with fishing sites, fishing effort, age, number of anglers in a group, seasons, types of day (weekday or weekends), fishing mode (shore-fishing or boat-fishing), tidal situation, temperature and water quality, stock available (e.g. historical catch as a proxy), target species, types of bait used, motivations, hours or years fished, (see Table 3.1). Hours fished is often used as a proxy for fishing effort and it is assumed that the longer people fish the greater the probability of catching a fish (McConnell, Strand, & Blake-Hedges, 1995; O'Neill & Faddy, 2002). The number of years fished (a proxy for experience or skills) and the numbers of fishing lines used are also expected to increase the probability of catching fish (O'Neill & Faddy, 2002).

Also important, is *commitment to fishing* (sometimes referred to as *affective attachment*). According to Buchanan (1985) there are two components to affective attachment that 'influence the degree to which an individual becomes' attached to an activity (Sutton & Ditton, 2001, p.51). The first component is 'the persistence of goal-directed behaviour over time' implying 'a willingness to devote time and effort to the activity' (Sutton & Ditton, 2001, p.51). This leads to consistent participation in recreational fishing and these fishers are apt to be more interested in the condition of the fishing stock and its management (Hammit & McDonald, 1983). Moreover, experienced anglers have a more complicated vision of fishing activity than less experienced anglers: they look for a wider variety of rewards from fishing and have different expectations, preferences, beliefs and attitudes towards recreational fishing (Sutton & Ditton; 2001).

The second component of effective attachment described by Buchanan (1985) is associated with behavioural patterns, objectives and values (Sutton & Ditton, 2001). An increase in ‘affective attachment’ or commitment to an activity leads to an increase in the importance of ‘how anglers view themselves and how they would like to be viewed by others’ (Sutton & Ditton, 2001, p. 52). More experienced and more committed anglers are expected to get more information about the state of and management of fishing resources, and also of fishing outcomes. They are, therefore, expected to be ‘more receptive to the catch-and-release philosophy’ and more involved in highly specialised fishing…where non-catch-related motives for fishing tend to be more important (Sutton & Ditton, 2001, p. 52) and where the principles of catch-and-release and the desire to protect fish stocks are assumed to be solidly established (Bryan, 1979). Sutton and Ditton (2001) found that the more committed anglers were more likely to release all the fish they caught and to have a positive attitude towards C&R fishing.

Consumptive orientation is also strongly associated with catch and release behaviour (Aas & Kaltenborn, 1995; Sutton & Ditton, 2001; Sutton, 2003). Sutton and Ditton (2001) described consumptive orientation as ‘the degree to which an angler values the catch-related outcomes of the angling experience’ (p. 52) and it is considered to be an important determinant of keep or release decision: recreational fishers who are less consumptively orientated are more likely to practice C&R (Quinn, 1996; Arlinghaus & Mehner, 2003; Salz & Loomis, 2005; Sutton, 2001). Sutton (2001) also developed a theoretical framework to highlight the fact that choices about whether to release or to keep depend on the norms, attitudes, values, knowledge and beliefs of individual’s; and these variables are influenced by an individual’s level of commitment or attachment to fishing activity (discussed above) and also by his or her consumptive orientation (Arlinghaus et al., 2007).

Affective attachment and *consumptive orientation* are not the only important variables to consider when analysing C & R decisions. Different anglers have different motives for fishing, and they also ‘probably utilize different strategies for attaining preferred outcomes’ (Aas & Kaltenborn, 1995, p. 752). Fisher (1997) found that different groups of anglers have different experience needs and wants and, therefore, they put more or less stress on fishery resources. Anderson et al (2007) and Fedler and Ditton (1986) argued that understanding fishers' attitudes to the specific fishing experience and the relationship between consumptive orientation and individual's catch level 'could add further insight into the impacts of fishery management decisions on recreational fishing experiences' (Fedler & Ditton, 1986, p.226). Some years later Sutton (2003) demonstrated that it was important to include other personal factors (e.g. preferred species, importance of keeping fish, importance of catching a trophy) and also situational factors (e.g. size of fish, species caught, caught preferred species) when analysing the keep or release decisions. That study showed that the importance of keeping fish, species caught and size of species have a significant impact on C&R choice while commitment to fishing, fishing experience and importance placed on number of fish caught and on catching 'something' had no significant impact.

Hunt et al. (2002) found that the number of fish caught and attitudes towards the fishing experience were vital determinants of the decision to retain fish. A more recent study by Wallmo and Gentner (2008) estimated conservation release as a function of angler's characteristics, species caught, demographic variables (education) and three angler's orientation measures: the importance of using caught fish for food, attitudes towards regulations and C&R fishing practices. They found all that all of the anglers' characteristics were statistically significant determinants, highlighting the importance of understanding the population of recreational fishers in order to 'predict future C&R behaviour' (Wallmo & Gentner 2008, p. 1459). They also found that species had significant impact on release decision. Evidently, those interested in understanding the catch and release decision need to ensure that their research considers standard concepts drawn from the field of human dimensions research such as substitution, motivation, and association with different social groups and other socio-demographic factors (Hunt et al., 2002).

Table 3.1 A selection of studies on human dimensions of C&R – examples of analytical techniques and variables used

Source	Species	Estimated model	Dependent variable	Explanatory variables
Grambsch and Fisher (1991)	Black bass and trout	Descriptive study	Participation rate in C&R	Household income Education Fishing frequency Number of fish caught in a 1 year
Graefe and Ditton (1997)	Billfish	Logistic regression and OLS analysis	Releasing all fish caught	Number of billfish fishing trips taken over the 12 months Number of tournaments entered over a 12-month period Income
Kirchner and Beyer (1999)	Silver kob	The ratio of means; the mean of ratios	Daily and annual catch	Total number of anglers Number of hours in a fishing day Catch rate
Sutton (2001)	Billfish Freshwater (bass, crappie, and catfish) anglers	Logistic regression	Release or keep	Consumptive orientation Activity commitment Fishing experience
Sutton and Ditton (2001)	Bluefin tuna	Logistic regression	Release or keep	Activity commitment: Centrality to lifestyle Previous experience Importance of keeping fish Fishing party size Hours fished Number of tuna caught Substitute fish species
Sutton (2003)	Freshwater bass, crappie, and catfish	Logistic regression	Release or keep	Number of days fished last year Size of fish caught Preferred species caught Size caught × species caught Size caught × caught preferred species Species caught × caught preferred species Size caught ×importance placed on catching a trophy Fishing experience Activity commitment (Centrality to lifestyle) Importance placed on # of fish caught Importance placed on catching ‘something’
Hunt et al. (2002)	Northern pike and smallmouth bass	Analysis of Covariance (ANCOVA) models	Harvesting rate	Number caught per day Number of days fishing Fishing groups Motivational items Substitute fish species
O’Neill and Faddy (2003)	Yellowfin bream, dusky flathead and summer whiting	Logistic regression Zero truncated negative binomial	Zero/non-zero catch Number of fish kept	Season Day type Boat fishing Shore fishing Hours fished Number of fishers Number of fishing lines
Wallmo and Gentner (2008)	Striped bass, bluefish, summer flounder, black sea bass, Atlantic cod, weakfish, tautog	Stated preference model	Release or keep	Number of days fishing from beach in the past 2 months Number of days fishing from a boat in the past 2 months Education Species dummies 3 categories of angler’s orientation

3.3 Methods

3.3.1 Study area

As mentioned earlier the case study area is the Townsville region (see Figure 2.2 and Chapter 2 Section 2.2 for more details). Despite the fact that there has been a decrease in recreational fishing participation rates since 2000, it is still a very popular outdoor activity in QLD, Australia (DAFF, 2012b). Approximately 700,000 people (17% of QLD's population aged 5 years and older) went recreational fishing, crabbing or prawning in the 12 months prior to July 2010 (DAFF, 2012b).

The GBRMP is currently regulated with a variety of tools including limits on fish size, total fish take (bag limits), gear restrictions and area closures (Australian State of the Environment Committee, 2001; GBRMPA, 2009a; ABARE, 2009). C&R is an existing component of fisheries management in Australia (Cooke & Sneddon, 2007) and is a common practice among recreational anglers but it is not required action in the GBRMP.

3.3.2 The data

As I mentioned early in this chapter I used a household survey of more than 650 householders in Townsville, QLD. The survey sample, survey details and the response rate were discussed in Chapter 2 Section 2.3 (see also Appendix 2 for introductory and reminder letters and questionnaire).

One quarter of respondents were professionals and nearly one third had an annual household income $100,000 and above. The average household had 2.6 people. Nearly ninety per cent of fishers were employed full time. Approximately one third of respondents had moved to the region within the last 10 years.

The majority of respondents (79%) had been fishing at least once in their life and 54.2% had been fishing within the previous two years. Of those who had been fishing within the last two years, 63.3% were males and 45.4% were boat owners. Approximately 73% of respondents had been recreational boating in the last 12 months. Nearly 23% of recreational anglers had a trade certificate or apprenticeship and 20.4% had completed university.

Thirty three per cent of anglers said that fishing was part of their culture or family tradition and 34% said that fishing was their most important recreational activity (see Figure 3.1). Males preferred to fish with friends; females preferred to fish with family. The majority (62.8%) were relatively infrequent fishers; only 7.8% went fishing at least once each week during the previous two years (see Figure 3.2). The most targeted species were coral trout, barramundi and mackerel.

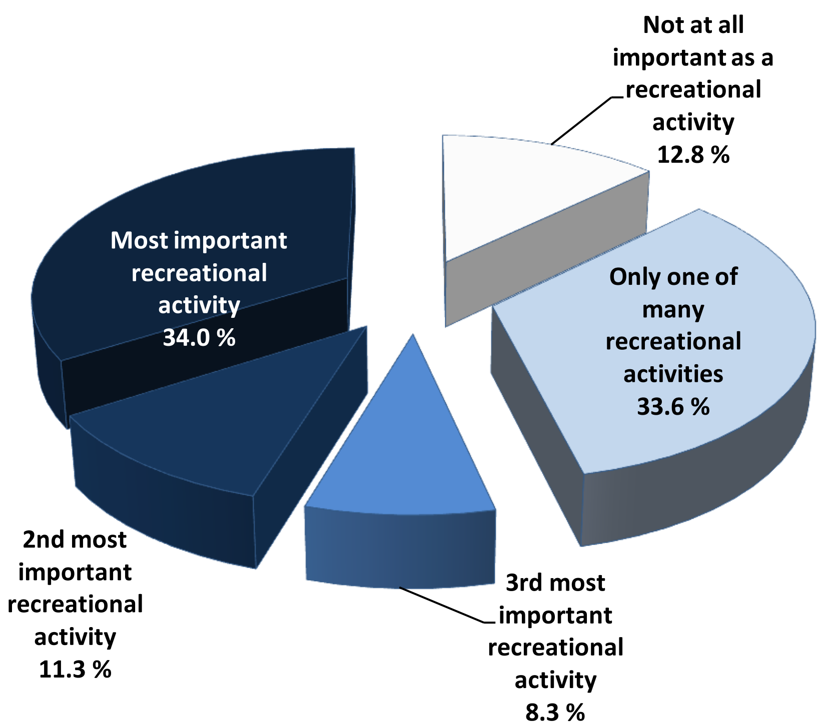

Figure 3.1 Proportion of respondents by level of commitment to recreational fishing

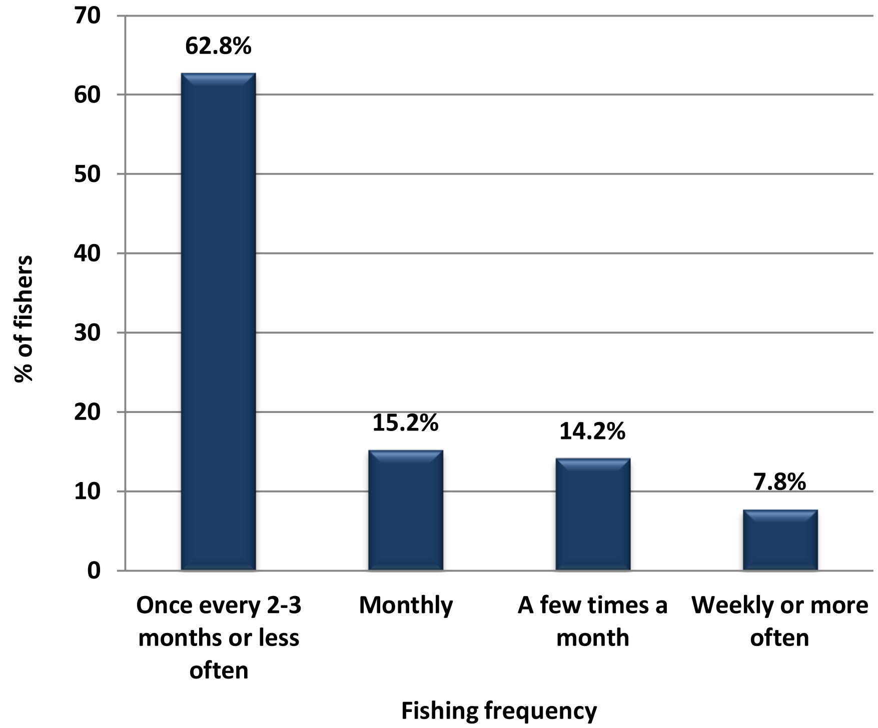

Figure 3.2 Proportion of respondents by frequency of fishing trips

3.3.3 Modelling

As mentioned in the introduction, most previous C&R studies have investigated the keep/release decision using logistic regression and a yes or no (binary) dependent variable (see Table 3.1). However, if one wishes to identify the characteristics of recreational fishers that are likely to place more or less pressure on fish stocks, information on factors influencing total recreational catch/keep is needed. As such, one needs to use (a) a different dependent variable; and (b) a different modelling approach.

From a statistical modelling perspective, it is important to note that measures of the total number of fish caught/kept will be discrete and non-negative in nature. As such, neither logistic nor ordinary least squares regression are appropriate modelling choices. Moreover, recreational catch distributions are generally highly positively skewed or zero-inflated (Hoyle & Cameron, 2003; Cunningham & Lindenmayer, 2005; Webley, Mayer, &

Taylor, 2011): in recreational fisheries a small proportion of fishers often catch most of the fish and the majority of anglers catch no fish at all (Jones et al., 1995; Henry & Lyle, 2003; O'Neill & Faddy, 2003). As a result, recreational catch data is likely to be dominated by large numbers of zeroes (Taylor et al., 2011). The 'excess-zero [or zero inflation problem] is often of interest because zero counts frequently have special meaning' (Martinez-Espineira, 2007, p. 343): to ignore the zeros, would be to ignore vital information. So one needs to select a modelling approach that can cope with a non-normally distributed, discrete, truncated, dependent variable.

Several are available. The Poisson distribution assumes that the conditional mean of the dependent variable equals its conditional variance, whereas the negative binomial or zero inflated negative binomial (data with access zeros) specifications have the advantage of handling the over-dispersion problem when this assumption is violated (Cameron & Trivedi, 1998; Maundera & Punt, 2004; Jung et al., 2005; Prayaga et al., 2010; Akyuz & Armstrong, 2011). Details of those models are provided below.

Negative Binomial (NB)

The Negative Binomial model extends Poisson model (Potts & Elith, 2006) as it is characterised by two parameters. A dispersion parameter α is additionally applied to the mean μ and the probability of obtaining a number of events y (the NB distribution) is given by the formula:

$$P(y) = \left(\frac{\alpha + y - 1}{\alpha - 1}\right)\left(\frac{\mu}{\alpha + \mu}\right)^{y}\left(\frac{\alpha}{\alpha + \mu}\right)^{\alpha} \quad \text{(A3.1)}$$

Where $\mu(1 + \mu / \alpha)$ is the variance (Cameron & Trivedi, 1998; Maundera & Punt, 2004; Lewin, Freyhof, Huckstorf, Mehner, & Wolter, 2010)

NB specification accounts for overdispersion but does not explicitly account for overdispersion caused by zero inflated data (Potts & Elith, 2006; Minami et al., 2007). The NB models do not obtain information about the participation decision from the zeros in the data (Martinez-Espineira, 2007) but 'simply treat the zeros as being generated by the same process that generates positive observations' (Englin, Holmes, & Sills, 2003, p. 350). In the presence of zero inflation hurdle (Mullahy, 1986) or zero-inflated count data models are preferable (Cunningham & Lindenmayer, 2005; Lewin et al., 2010).

Zero-inflated Negative Binomial (ZINB)

Zero inflation occurs because 'the data generating process adds an additional mass at zero, inflating the probability of observing a zero above that which is consistent with the specified distribution. It may therefore be a misspecification to assume that the zero and non-zero observations come from the same source' (Potts & Elith, 2006, p.154).

The ZINB model allows zeros to be generated by two different processes (Cameron & Trivedi, 1998; Minami et al., 2007). The ZINB distribution of a number of events *y* can be written as

$$P(y=0)=\phi+(1-\phi)\left(\frac{\alpha}{\mu+\alpha}\right)^{\alpha} \quad \text{(A3.2)}$$

$$P(Y=y)=(1-\phi)\frac{\Gamma(y+\alpha)}{\Gamma(\alpha)\Gamma(y+1)}\left(\frac{\alpha}{\mu+\alpha}\right)^{\alpha}\left(1-\frac{\alpha}{\mu+\alpha}\right)^{y} \quad y = 1, 2, 3,\ldots n \quad \text{(A3.3)}$$

Where ϕ is the probability of excess zero responses and where $0<\phi<1$, μ is the mean and *α* is a dispersion parameter of the underlying NB distribution. The mean and the variance of the ZINB are given by:

$$E(Y)=(1-\phi)\mu \quad \text{(A3.4)}$$

$$Var(Y) = (1-\phi)\left(1+\frac{\mu}{\alpha}+\phi\mu\right)\mu \qquad \text{(A3.5)}$$

As $\alpha \to 0$ and $Var(Y) \to (1-\phi)(1+\phi\mu)\mu$ the ZINB distribution converges to Zero-Inflated Poisson (Moghimbeigi, Eshraghian, Mohammad, & Mcardle, 2008; Mwalili, Lesaffre, & Declerck., 2007; Martinez-Espineira, 2007).

The dependent variable and estimation technique

Two different models were investigated, each with a different dependent variable. The first looked at the total number of fish caught by each respondent over an entire year; the second at the total number of fish kept. These dependent variables were estimated by combining responses to two separate questions in the survey. Respondents had been asked how many times in the last 12 months they had been fishing. They were also asked how many fish (on average) were caught on each trip, and how many were kept. Total catch (keep) per year per person was estimated by multiplying the average number caught (kept) per trip by the number of trips in the previous year[17]. For this data set, the conditional variances associated with the dependent variables were greater than the means (see Table 3.2) implying "over-dispersion" (Cameron & Trivedi, 1998; Maundera & Punt, 2004; Jung, Jhun, & Lee, 2005; Prayaga, Rolfe, & Stoeckl, 2010; Akyuz & Armstrong, 2011). From Figure 3.3 it is evident that the data relating to total number of fish kept were also 'zero-inflated' (Potts & Elith, 2006) – in accordance with expectations since in most recreational fisheries it is only a small proportion of fishers who catch most of the fish and the majority of anglers catch no fish at all (Jones, Robson,

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[17] Using the average number of fish caught and kept per fishing trip to estimate the total number of fish caught/kept per annum does not give an absolutely accurate measure of total catch and keep. Individuals' catch will vary on every fishing trip depending on many different things. However, the information about catch and keep on each fishing trip during the last 12 months would be costly to collect and it was not available to me.

Lakkis, & Kressel, 1995; Henry & Lyle, 2003; O'Neill & Faddy, 2003). In other words, there were substantially more zeros in this data set than would be expected from standard statistical distributions for count data (Tu, 2002; Martinez-Espineira, 2007).

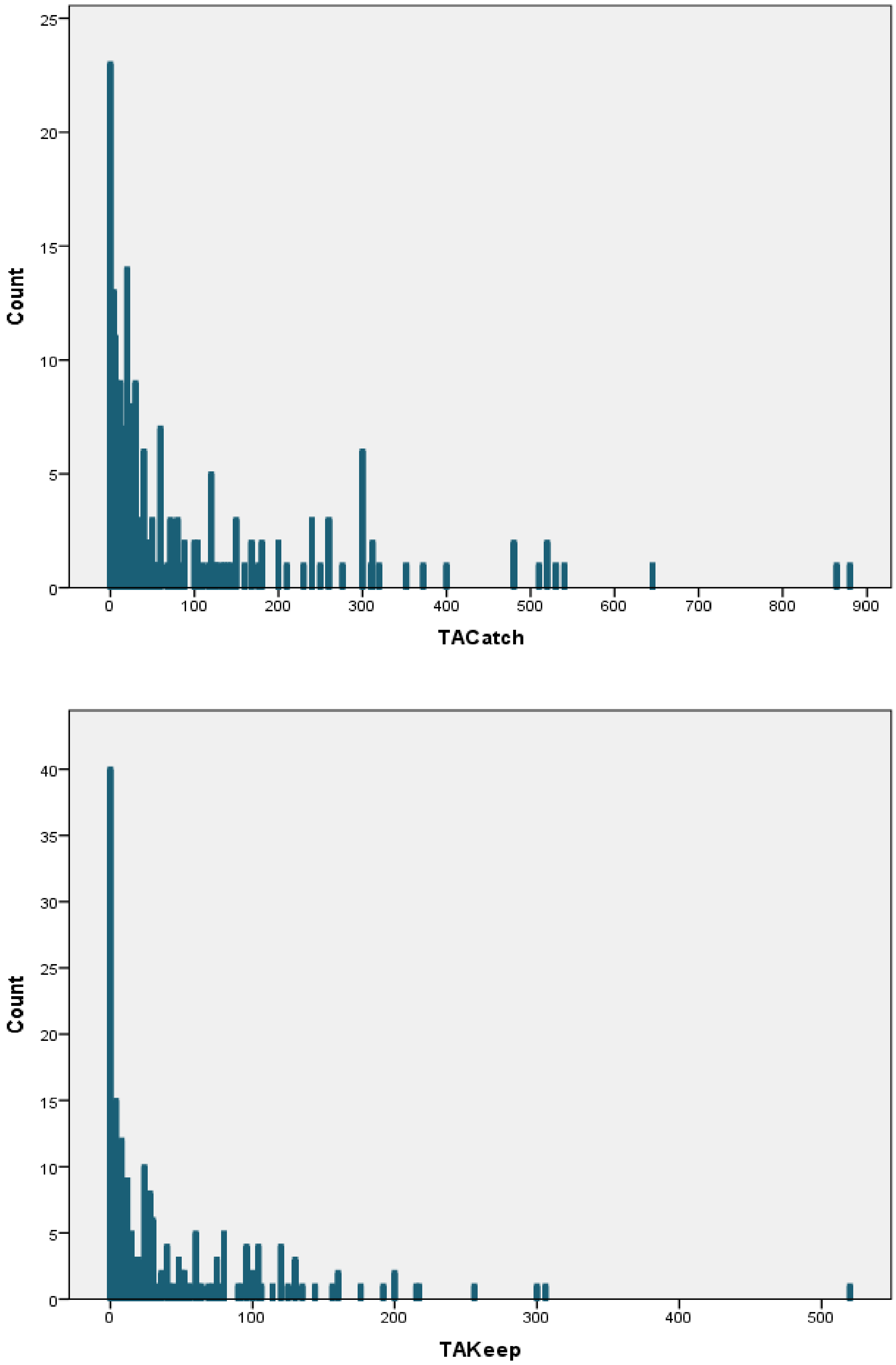

Figure 3.3 Frequency distribution of zero and non-zero total catches and keeps

The analysis was therefore performed using a ZINB model when examining the total number of fish kept per year and a standard NB model when examining total catch per year. The ZINB model comprises two parts. In this case:

- part one (modelled using logistic regression) gives information about the probability that an individual will choose to keep a fish (or not)
- part two (modelled using a negative binomial distribution) focuses on all individuals who choose to keep at least one fish, and then looks at factors which influence the total number of fish kept (Minami, Lennert-Cody, Gaoc, & Roman-Verdesoto, 2007, p. 211)

Explanatory variables

The explanatory variables used in the analysis are summarised in Table 3.2 and were selected because they had been shown to be important determinants of catch and of C & R behaviours in previous studies (see Table 3.1).

To measure consumptive orientation, I used 6 items adapted from a scale that was first developed by Graefe (1980) and subsequently extended scale (Fedler & Ditton, 1986; Sutton & Ditton, 2001). The level of agreement for each item was measured on a 5-point Likert scale. Elicited responses ranged from 'strongly disagree'(1) to 'strongly agree'(5). A 'being neutral'(3) option was also provided (Sutton & Ditton, 2001; Sutton, 2003; Fedler & Ditton, 1986). The six statements were used to measure the importance that each respondent placed on: catching something (1 item); the number of fish caught (1 item); catching a trophy fish (2 items); and keeping fish (2 items) (Sutton, 2003; Kyle, Norman, Jodice, Graefe, & Marsinko, 2007; Anderson, Ditton, & Hunt, 2007).

Table 3.2 Variables used in the empirical model

Variable	Description	Mean	Std. dev
Number of fish caught	Mean number of fish caught by a respondent *i* per year	81.05	137.98
Number of fish kept	Mean number of fish kept by a respondent *i* per year	39.50	63.02
Explanatory variables			
Gender (Male)	1 if male, 0 otherwise	0.65	0.47
BoatOwner	1 if boat owner, 0 otherwise	0.51	0.50
Age	Age of the respondent	47.97	12.87
Age sq	Age of the respondent squared	2466.94	1271.94
Number of years fishing	Number of years fishing of a respondent *i*	20.67	16.15
TimesFishingSalt*	Number of times a respondent *i* fish in salt water	10.33	11.13
TimesFishingFresh	Number of times a respondent *i* fish in fresh water	1.05	3.01
Activity Commitment	Scale variable	3.28	1.48
Activity Commitment squared		12.93	9.69
Consumptive Orientation	Scale variable (=1 if consumptive orientation is low; =2 if medium; =3 if high)	1.69	0.56
LnIncome	Household annual income	1.38	0.48
Years in Townsville	Number of years lived in Townsville region	22.90	17.01
Years in Townsville squared		812.59	1088.24
FishSaltOnly	1 if in the last 12 months a respondent fished in salt water only, 0 otherwise	0.71	0.45
FishFreshOnly	1 if in the last 12 months a respondent fished in fresh water only, 0 otherwise	0.04	0.21
Retired	1 if retired, 0 otherwise	0.17	0.38
Child	1 if a respondent went fishing as a child, 0 otherwise	0.95	0.21

*Number of times a respondent *i* fish in salt water was estimated as a sum of number of times a respondent fished on reefs, shoals, offshore islands, bays, creek in the last 12 months

A reliability test (item-total correlation and Cronbach's alpha) was conducted calculated for the summated scale that included all 6 items[18]. The Cronbach alpha of 0.745 (see Table 3.3) indicated 'good consistency within and between items' (Fedler & Ditton, 1986, p. 223; Cronbach, 1951; Aas & Kaltenborn, 1995) and thus all 6 items were used to estimate a consumptive orientation score for each recreational angler. A summated score was estimated from the responses to 6 original items, and thus ranged from a minimum at 6

[18] The total correlation for the first item was low and alpha reliability was 0.745 (See Table 3.3) . It showed that the first item did not improve the scale significantly. Exclusion of the first item improved Cronbach alpha (0.759) only by 0.014 but in this case the dimension of 'catching something' would be missing.

(1+1+1+1+1+1) to a maximum at 30 (5+5+5+5+5+5) (Aas & Kaltenborn, 1995; Fedler & Ditton, 1986). Following the lead of Fedler and Ditton (1986), I grouped recreational anglers into three consumptive orientation categories: low (with scores from 6 to 14), mid (from 15 to 22) and high (22 to 30). Figure 3.4 shows the proportion of the respondents in each category; most (56%) had a mid-consumptive orientation and only 5% were highly consumptively orientated.

Table 3.3 Reliability Analysis for the Four Consumptive Orientation Dimensions

Dimensions and Items*	**Item – Total correlation**	**α if item deleted**
Catching something		
A fishing trip can be successful even if no fish are caught**	0.27	0.77
Number of fish caught		
The more fish I catch, the happier I am	0.67	0.65
Catching a trophy		
The bigger the fish I catch, the better the fishing trip	0.63	0.67
I like to fish where I know I have a chance to catch a big fish	0.51	0.70
Keeping fish		
I want to keep all the fish I catch	0.46	0.72
I'm happier if I release some of the fish I catch**	0.39	0.74
Cranbach's α (α = 0.745)		
Cranbach's α based on standardized items (α = 0.744)		

*Measured on a 5-point scale with response categories ranging from (1) strongly disagree to (5) strongly agree
** Item responses reversed for scale calculation and reliability analysis

Activity commitment (specifically the importance of fishing and/or boating compared to other recreational activities) was measured with response categories ranging from 'not at all important'(1) to 'most important recreational activity'(5).

Dummy variables for fishing in salt or fresh water only were included for the model stability because some recreational anglers fished in fresh or salt water only.

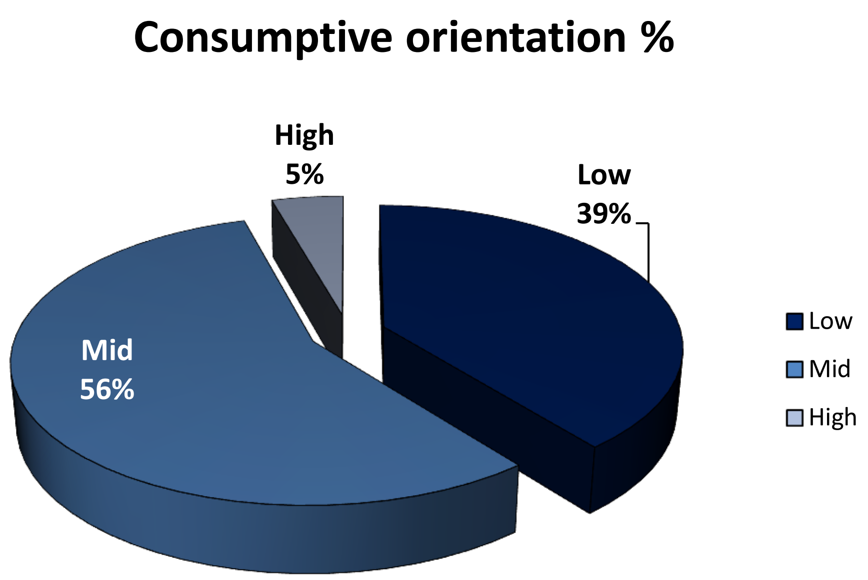

Figure 3.4 The proportion of the respondents in each category

3.4 Results

The modelling results for the two separate investigations of (1) the number of fish caught per year (NB) and (2) the total annual number of fish kept per year (ZINB) regressions are presented in Table 3.4. It should be noted here that individuals with zero catch were excluded from the 'number of fish kept' analysis.

The likelihood ratio (LR) test for the NB model indicates that the data is, as anticipated, overdispersed and that the standard NB that was used here is indeed preferable to a Poisson model. The LR test for the ZINB model also indicates that this specification is more appropriate than its alternative (a zero inflated Poisson – see Akyuz & Armstrong 2011; Long & Freese 2003). The Vuong (1989) test adapted by Greene (1994) was used to test if the ZINB was more appropriate than an ordinary NB model (a significant z-test = 4.48). Results indicated that the ZINB is a significant improvement over an ordinary NB specification (Martinez-Espineira, 2007; Akyuz & Armstrong, 2011). The likelihood ratio (LR) chi-square test suggests a high level of model fit for both.

For the model describing total annual catch, the coefficients associated with gender, boat ownership and consumptive orientation were positive and highly significant at 1% and 5% level. Evidently, males, those who own a boat and those with a high consumptive orientation are more likely to catch more fish than others. Those who are highly committed to fishing and who went fishing as children are also likely to catch more fish than others. The quadratic relationship between the annual number of fish caught and activity commitment shows that highly committed fishers are likely to catch more fish up to a certain point; after that, the number of fish caught will decline as commitment rises. The coefficients associated with the number of times each respondent went fishing in (a) saltwater and (b) freshwater areas have the expected positive signs and are statistically significant at the 1% and 5% levels respectively; the more often one goes fishing, the more fish one is likely to catch. The quadratic relationship between the number of years lived in the Townsville region and the annual number of fish caught suggests that initially, increases in the length of residency are associated with increases in catch; but those who have lived in Townsville for longer periods of time, catch less (perhaps when the novelty of fishing wears off).

Table 3.4 Mean number of fish caught and kept per year per person

Variable	**Negative Binomial** Dependent variable measures Total number of fish caught Coeff (SE)	**ZINB** Logistic part Dependent variable captures The probability of keeping a fish Coeff (SE)	 NB part Dependent variable measures The annual number of fish kept Coeff (SE)
Intercept	-0.9012 (1.060)	17.9462*** (6.249)	0.3321 (1.284)
Consumptive orientation	0.5936*** (0.115)	-1.9431*** (0.652)	0.5708*** (0.129)
Gender (Male)	0.3243** (0.141)	0.1868 (0.579)	0.1955 (0.152)
BoatOwner	0.4449*** (0.153)	0.1865 (0.759)	0.3509** (0.159)
Activity Commitment	0.5320* (0.291)	-2.6569** (1.245)	0.2395 (0.372)
Activity Commitment squared	-0.0336 (0.043)	0.3423* (0.191)	0.0039 (0.054)
TimesFishingSalt	0.0814*** (0.007)	-0.0490 (0.026)	0.0623*** (0.007)
TimesFishingFresh	0.0711** (0.029)	0.0665 (0.098)	0.0473 (0.039)
Years in Townsville	0.0297*** (0.011)	0.0772 (0.069)	0.0041 (0.012)
Years in Townsville sq	-0.0004** (0.0001)	-0.0006 (0.001)	0.00001 (0.0002)
Child	0.8008*** (0.305)	-1.9729 (1.491)	0.6436 (0.413)
Age	-0.0183 (0.035)	-0.4305** (0.202)	0.0017 (0.042)
Age sq	0.0002 (0.0003)	0.0039* (0.002)	0.0001 (0.0004)
Number of years fishing	0.00002 (0.004)	-0.0669 (0.043)	-0.0172*** (0.005)
LnIncome	0.0482 (0.165)	-0.2985 (0.673)	-0.4376** (0.194)
FishSaltOnly	0.0270 (0.171)	0.9684 (0.762)	-0.2293 (0.201)
FishFreshOnly	0.1243 (0.395)	1.5611 (1.415)	0.1994 (0.498)
Retired	-0.2526 (0.215)	-0.3304 (1.035)	-0.4894** (0.234)
Log likelihood	-887.38	-715.80	
LR chi2	254.78***	165.23***	
Likelihood-ratio test of alpha=0: Chi bar sq	5204.87***	2261.33***	
Vuong test of zinb vs. standard negative binomial: z-value		4.48***	
Number of observations	192	193	

*** significant at 1% level
** significant at 5% level
* Significant at 10% level

The results of the ZINB model (looking at the fish kept, as distinct from fish caught) is presented in two parts (right hand side of Table 3.4)[19]. The first, logit, part allows one to differentiate between respondents who had not kept any fish at all during the previous year, and those that kept at least one. Statistically significant factors here include: age, commitment to fishing and consumptive orientation (see column 2 of Figure 3.5). Contrary to expectations, the coefficient on consumptive orientation is negative and statistically significant at 1% level, indicating that those with a low consumptive orientation are more likely to have kept at least one fish than their more 'consumptive' counterparts (perhaps these are the first-time, 'novelty' fishers). There is a quadratic relationship for both age and activity commitment. Evidently, the relatively young and the relatively old are more likely to have kept at least one fish during the previous year than the 'middle aged'. Similarly, those with very little commitment and those with very high commitment were more likely to have kept at least one fish than those who were 'moderately' committed.

The second part of the ZINB model highlights factors associated with total annual keep (far right hand column, Table 3.4). As expected, the results indicate that boat owners tend to keep more fish than non-boat owners. Those who taken frequent trips to fish in marine environments also tend to keep more fish than those who fish less often (interestingly the same cannot be said of those who fish frequently in freshwater environments). The coefficient on income is negative and significant at 5% level implying that low income earners tend to keep more fish than their richer counterparts. Similarly, retirees tend to

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[19] The majority of previous studies have not differentiated between the probability of keeping at least one fish and the total number of fish kept (harvested). My approach allows me to differentiate between the factors that influence two separate decisions: to keep or not to keep and if to keep how many to keep. Thus, I was looking first at the probability of keeping at least one fish and then given the decision of keeping I looked at total number of fish harvested. This type of modeling is important because if one looks only at the probability of keeping at least one fish (keep/no keep decision) one would miss these subtle but important effects of income, fishing experience and retirement status which are influencing total harvest decision only.

keep less fish than others. The coefficient associated with the number of years fishing is negative and highly significant at 5% - indicating that more experienced fishers tend to keep fewer fish.

3.5 Discussion and Conclusion

Declining fish stocks in some areas of the world and for some species are a major concern for fisheries managers and have been at least partially attributed to some fishing activities (commercial and recreational). Using C&R as a management tool has become a feasible option for managing recreational fisheries and 'there is a little doubt' (Policansky, 2008, p. 203) about its effectiveness (Cooke & Sneddon, 2007; Quinn, 1996; Barnhart, 1989). C&R changes not only the impact of fishing on the fish stock but it has also changed the way in which fishers and management authorities 'view fishing by changing the incentives and disincentives associated with it' (Policansky 2002, p.74). Research that helps to: (a) improve our understanding of C&R behaviour; (b) provides information about who is likely to practice C&R; and (c) identifies factors that influence anglers' decisions to C & R, will thus help fisheries managers 'as it provides an alternative to harvesting and thus can facilitate conservation' and 'recovery efforts' (Wallmo & Gentner, 2008, p. 1459).

But most previous research investigating C & R behaviours has sought to identify factors influencing the decision to keep or release. This does not necessarily provide information that is useful for fisheries managers: a fisher may not keep many fish on any given trip, but if he/she fishes daily, the annual keep – a proxy for fishing pressure - could be substantial. The aim of the research described in this chapter was, therefore, to identify and compare determinants of the keep/release decision; with determinants of the total number of fish kept annually.

I also sought to identify the characteristics of anglers in the case-study region (Townsville, Australia) who are likely to keep the greatest number of fish annually, thus providing useful information to those charged with managing the recreational fishery in this region (the Great Barrier Reef lagoon), should they decide to promote C & R practices. C&R is not currently in GBRMPA's bag of regulatory 'tools'. However C&R programs were successful in some countries and some fisheries around the world (North, 2002; Arlinghaus & Mehner, 2003; Cramer, 2004; FAO of the United Nations, 2012) and therefore, the MPA could consider adding C&R as a management tool or just consider actively campaigning for it.

Both personal and demographic variables were found to explain and predict C&R behaviour. Not surprisingly, those who own boats, who fish frequently in marine environments, and who have a high consumptive orientation are more likely to catch – and keep – large quantities of fish each year than others. With coastal population growth and an increasing number of recreational boats, the Great Barrier Reef Marine Park Authority which is responsible for fishery management within the GBRMP, is probably right in monitoring the number of registered boats and using that number as an indicator of fishing effort along the GBR coast. Monitoring boat ownership is easier and is more cost effective than monitoring annual fishing effort.

But there are differences between the characteristics of anglers who catch large quantities of fish each year and those who keep large quantities (see Figure 3.5 which summarises key findings from this chapter). The big ‘catchers’ are more likely to be male, to have gone fishing as a child, to fish in fresh water and to be a long term resident (although the quadratic relationship indicates that they do it up to the point and then their catch is declined). In contrast, the big ‘keepers’ are relatively low income earners, are not retiree, and are less experienced recreational anglers. Moreover, there are differences between the factors that distinguish those who keep at least one fish each year from those who keep nothing, and the factors which are associated with a large annual keep. Indeed the research findings indicate that they have nothing in common.

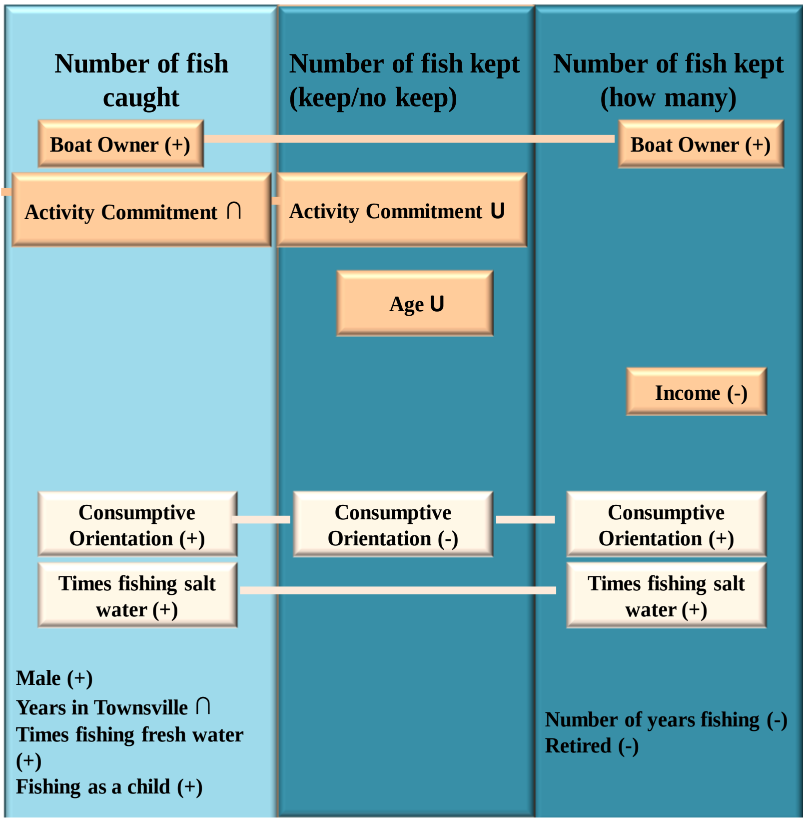

Figure 3.5 Determinant of total recreational catch and keep per year
∩ - coefficients +/-
∪ - coefficients -/+

Factors differentiating those "who keep at least one fish" each year from those "who keep nothing" include consumptive orientation, level of commitment to recreational fishing and age. The quadratic relationship between age and the probability of keeping fish indicates that the young and old anglers are more likely to release fish than their "middle-aged" counterparts. The negative relationship between consumptive orientation and the probability of keeping fish could be explained based on Sutton and Ditton (2001), Aas and Kaltenborn (1995) and Fedler and Ditton (1986) who suggest that low consumptive orientated anglers put a low value on catching fish but value the fishing experience while highly consumptive orientated anglers put a greater value on number of fish caught, size and type of species. As such highly consumptive orientated anglers might wish to keep a particular species only (species that they target) and release other fish or they might want to keep fish of a particular size. Moreover, Arlinghaus et al. (2007) argued that low consumptive orientated anglers 'will not necessarily harvest fewer fish than anglers classified as high consumptive' (p.103). Highly committed anglers are more likely to release fish an observation which is consistent with Sutton and Ditton (2001) hypothesis that these angler most satisfaction from catching fish and keeping them is relatively unimportant.

The big 'keepers' are likely to be non-retired, boat owners, highly consumptively orientated, with a relatively low household income, less experienced and frequent salt water anglers. This is consistent with other studies. Graefe and Ditton (1997) found that higher income earners were less likely to keep caught fish. Arlinghaus et al. (2007) suggested that more experienced and, therefore, more specialised recreational anglers will shift their focus from fish consumption to fish preservation or from 'the fish to the experience of fishing' (p. 99). As a result of that they might be 'more supportive of C&R policies to maintain healthy fish populations' (Arlinghaus et al., 2007, p.99). The results also suggest that in this particular region salt water species are preferable to freshwater species and the pressure on fish stock is likely to be an issue for saltwater fishing.

The main message here therefore, is that if policy makers are seeking to reduce total catch, and only consider factors influencing the decision to keep or release (a common practice in C&R literature), then they may target the wrong group of recreational anglers (e.g. missing the boat ownership and fishing experience, misinterpreting consumptive orientation, and focusing on activity commitment and age when these characteristics are not all that important).

4 The Marginal Value of fish to recreational anglers: *ex ante* and *ex post* estimates ARE different

Abstract

The results from previous chapters suggest that the frequent boaters differ from frequent fishers, and frequent fishers and the big 'catchers' are not necessarily the big 'keepers'. But previous results have not yet provided information about whether it is 'valuable' to catch or to keep those fish, hence the focus of this chapter.

Most demand and valuation studies of recreational fishing have used *ex post* (actual or historic) measures of catch as a proxy or as a dependent variable to estimate the *ex ante* measure: expected catch. But it is not clear if such proxies are appropriate. Using data from a survey of 404 anglers from Townsville, the research described in this chapter compares the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch. It also uses a Hedonic Trip Price Model to compare the marginal value of fish, using *ex post* and *ex ante* measures of recreational catch. Results indicate that the determinants of *ex ante* and *ex post* recreational catch are different. Expectations are largely driven by motivations (e.g. importance of fishing for fun and for eating) but personal variables – such as consumptive orientation, years fishing and gender – have a greater influence on outcomes (*ex post* catch). Moreover, the marginal , *ex ante* 'value' estimates were much lower than *ex post* 'values': $7.38 versus $22.83 AUS, respectively. Differences are likely to be attributable to differences in expectations and actual catches. Consequently, those using *ex post* constructs to approximate *ex ante* values may be – perhaps seriously – misled about the key factors influencing choices whether to go fishing or not. Both the economics and the psychology literature agrees that one should use *ex ante* constructs if

trying to predict behaviours, so this observed difference should send warning to those who use *ex post* constructs in this manner.

4.1 Introduction

Conflict and competition between the commercial and recreational fishing sectors is increasing globally (Aas, 2007) and it is one of the most important management issues in many fisheries around the world (Ruello & Henry, 1977; Gartside, 1986; Green, 1994; Kearney, 2002a; Kearney, 2002b; Sumaila, 2002; McPhee & Hundloe, 2004; Arlinghaus, 2005). Competition and conflict between the two industries is predictable because both sectors are often fishing in the same area and/or targeting the same species (Ramsay, 1995; Scialabba, 1998; McPhee, Leadbitter, & Skilleter, 2002; Arlinghaus, 2005; Ngoc & Flaatenaaten, 2010; Lindner & McLeod, 2011). With growing populations, 'fishing pressure from both commercial and recreational sectors increases' (Crowe, Longson, & Joll, 2013, p. 201) and questions about the 'optimal' allocation of fish resources between those two sectors become more and more important (Tobin, 2010; Lindner & McLeod, 2011; Crowe et al., 2013).

Economic theory suggests that the optimal allocation of fish resources between two competing sectors is one that maximises the net social value – where the marginal net benefits of competing users are equal (Lindner & McLeod, 2011). If one is able to establish a (working) 'market' for Total Allowable Catch (TAC) (e.g. a tradeable permit system that includes both commercial and recreational fishers), then regulators need not concern themselves with trying to measure these marginal net benefits – competing sectors will 'bid' for access as long as the marginal value (MV) of the fish is greater than the marginal cost. However, if it is not possible to establish a 'market' for TAC, then regulators may need to confront the allocation problem. If seeking to maximise the net social benefit of a fishery, regulators should reallocate fish resources away from sectors with low MVs to those with high MVs, and they should continue this reallocation process until the net MVs for both sectors are equal (Blamey, 2002; Holland, 2002; Galeano, Langenkamp, Levantis, Shafron, & Redmond, 2004; Ngoc & Flaatenaaten, 2010). When market based solutions are not feasible (too expensive to monitor and enforce the recreational sector catches) information about the net MVs of fish to each sector is thus critical to those charged with making the allocation decision (Galeano et al., 2004).

There are two common methodological approaches to estimating demand and MVs for recreational fishing: stated preference (e.g. Contingent Valuation Method, Contingent Behaviour Method) and/or revealed preference (Travel Cost Method, Hedonic Price, Hedonic Travel Cost, Random Utility Model) techniques. The difference between them is based on how information is obtained from consumers (Gautam & Hicks, 1999).

When estimating demand or MVs of recreational fishing, most researchers have found that expected catch is a critical factor influencing the demand for, or quality of a fishing trip (Morey & Waldman, 1998; Haab, Whitehead, & McConnell, 2000); it is generally assumed that individuals will take more trips to sites or pay more for fishing trips where expected catch is high (Morey & Waldman, 1998; Hunt, Boxall, Englin, & Haider, 2005a; Hunt, Boxall, Englin, & Haider, 2005b). This is not at all surprising since economic theory suggests that demand for a particular good or service will be influenced by price and a variety of other non-price factors – the most pertinent of which (to this study) being expectations (Layton, Robinson, & Tucker, 2005; Gans, King, Stonecash, & Mankiw, 2005). Expectations or views of the future may affect the demand for good or service in the present (Layton et al., 2005) and 'every decision about the use of resources is based finally on the expectations' (Heyne, Boettke, & Prychitko, 2006, p. 270).

Researchers have used historical or actual catch per trip (an *ex post* measure) to estimate the demand for fishing trips[20] and to estimate a variety of economic values (EV) such as

- the total economic value of recreational fishing (Greene, Moss, & Spreen, 1997; Whitehead & Haab, 1999),
- the economic value of fishing sites and harvest (Haab, Hicks, &. Whitehead, 2005),
- the value of improvements in catch (Schuhmann, 1998),
- the value/cost of bag limit changes (Whitehead, 2006),
- user-day values (Lupi, Hoehn, Chen, & Tomasi, 1998)
- the value of a fishing trip (Hailu et al., 2011),
- site access values (Zhang, Hertzler, & Burton, 2003; Raguragavan, Hailua, & Burtona, 2010; Hailu et al., 2011),
- the welfare losses to recreational anglers from impingement and entrainment (Besedin, Mazzotta, Cacela, & Tudor, 2004), for site closures (Scrogin, Hofler, Boyle, & Milon, 2010), and oil spill Alvarez, Larkin, Whitehead, & Haab, 2012),
- the direct economic benefit of new fishing sites (Bingham et al., 2011),
- WTP for changes in policy (Haab et al., 2005; Whitehead, 2006)
- WTP for an additional fish caught (Haab, Hicks, Schnier, & Whitehead, 2008),
- the consumer surplus associated with changes in species availability (Morey et al., 1991) and catch improvement (Schuhmann & Easley, 2000)
- and the MV of fish (Whitehead & Haab, 1999; Whitehead & Aiken, 2000; Hicks, 2002; Morey, Breffle, Rowe, & Waldman, 2002; Zhang et al., 2003; Besedin et al., 2004; Carter & Liese, 2010)

[20] Morey, Shaw, & Rowe, 1991; Kaoru, Smith, & Liu, 1995; Berman, Haley, & Kim, 1997; Greene et al., 1997; Lupi et al., 1998; Morey & Waldman, 1998; Breffle & Morey, 2000; Schuhmann & Easley, 2000; Morey et al., 2002; Zhang et al., 2003; Hunt & Moore, 2006; Bingham et al., 2011; Gao & Hailu, 2012

In many cases, historical or actual catch per trip has been used as a proxy for expected catch (Bockstael, McConnell, & Strand, 1989). In other words, researchers have used an *ex post* measure of actual outcomes to approximate an *ex ante* measure of anticipated outcomes. This may be problematic. In the 1930s Myrdal (1939) introduced the concepts of *ex-ante* and *ex-post* to economics. He suggested that 'an important distinction exists between prospective and retrospective methods of calculating economic quantities such as incomes, savings, and investments; and … a corresponding distinction of great theoretical importance must be drawn between' those two (Myrdal, 1939, pp. 46–47, cited in Gnos, 2004, p. 335).

Insights from the social psychology literature suggests that there are good reasons for believing that there may be significant differences in *ex post* and *ex ante* constructs, primarily because individuals tend to revise their expectations or motivations after an event has happen. Indeed Manning (1999) and Todd, Anderson, Young, and Anderson (2002) argue that the timing and circumstances under which experience expectations are collected and measured are essential because peoples stated expectations and motivations change over time[21] . Moreover, it seems that the longer the period of time between pre and post measures, the more likely that 'extraneous effects of history' and 'maturation…could be biasing results' (Todd et al., 2002, p. 129).

Economic studies of *ex ante* and *ex post* constructs in fisheries are extremely rare (with one or two exceptions discussed below), but in the broader environmental / resource economics literature researchers have used a several different methods to estimate *ex ante* and *ex post* marginal values (e.g. WTP). It is common for researchers to find that the

[21] Ewert (1993), for example, found that the stated motivations of mountain climbers changed depending on whether or not climbers reached the summit. White and Pennington-Gray's (2002) and Todd et al. (2002) also find evidence for changes in pre and post-trip participants' motivations – even over a short period of time.

estimates differ. Park and MacLachlan (2013) argue that the difference between the *ex-post* and *ex-ante* estimates 'depends upon the degree of uncertainty' (p. 39). If an individual has considerable experience in a market, then certainty is reduced (Hanley, Kristrom, & Shogren, 2009). As such, 'one would expect little difference between *ex ante* and *ex post* measures of WTP for standard and frequently used goods, because consumers have already considerable experiences with the amount of benefit that they can expect from those goods' (Park & MacLachlan, 2013, p. 39). For new products or goods that are not traded in the market – such as recreational fishing – one might expect a significant difference between *ex ante* and *ex post* WTP values (Park & MacLachlan, 2013).

Given that there are likely to be differences in measures, the key problem is, therefore, to determine which measure is most appropriate. In the finance literature, Oulton (2007) states that 'investment decisions are usually made 'in advance of knowing all the relevant facts' and thus the investors need to base 'their decisions on expected, not actual, capital gains and losses' (p. 296). Moreover, Freeman (1989) demonstrates that *ex post* 'measures of the value of risk reduction and risk prevention are likely to be poor and unreliable proxies for the desired ex ante willingness to pay' (p. 316), so reasoning that risk reduction values based on *ex post* measures 'are not likely to be useful, and could be seriously misleading as guides for risk management decisions (p.315). Evidently, one should use *ex ante* measures if wishing to assess WTP to reduce risk.

But the question of whether it is 'best' to use *ex ante* or *ex post* measures in the context of recreational fishing is not so straightforward. Schuhmann and Easley (2000, p. 439) argue that expected and actual catch 'are fundamentally different in their construction and purpose' – so these constructs are likely to be associated with, and reveal, quite different behaviours and values, and choices about whether to use *ex ante* or *ex post* measures thus depend upon what one is trying to measure. The social psychology literature, for example, suggests that motivations should be measured (a) immediately prior to a recreational activity if the aim is determine experience preferences; (b) immediately after a recreational activity to if the aim is to determine the attainment of experiences, and (c) some months after a recreational activity if the aim is to determine enduring experiences (Manfredo et al. 1996, cited in Manning 1999, p.173). Analogously, Bockstael et al. (1989) and McConnell (1988) argue that decisions about demand, choice of fishing site and site quality are *ex ante*. It thus seems that those interested in describing or making predictions about whether individuals will or will not chose to go fishing on a particular day, or interested in investigating (future orientated) *option values*, are likely to be best informed by models that use *ex ante* measures. Those interested in describing characterising a completed fishing experience might instead find models which use *ex post* constructs more informative.

Yet despite the fact that there are good reasons for believing that there are likely to be differences between *ex ante* and *ex post*, and that there are reasons for believing that in many situations *ex ante* measures may provide better information, most recreational fishing studies have used *ex post* measures – either actual or historical catch. Indeed, to the best of my knowledge only one study (van Bueren, 1999) has used *ex ante* expectations when assessing economic values in a recreational fishery – perhaps at least partially because of the difficulty and cost of intercepting anglers before fishing trips (Bockstael et al., 1989). In van Bueren's (1999) study, estimates of marginal values were found to differ[22], depending upon whether actual or expected catch rates were used. But

[22] van Bueren (1999) found that catch rate was 'sensitive to the type of proxy used' (p.12). Coefficients from perceptions catch model were substantially higher than from objective models which supports the idea that fishers' place 'more weight on perceived catch rates relative to objective measures of this attribute' when making a choice between fishing sites (p.13). Individuals are 'more responsive to changes in perceived catch rates than changes in objective catch rates (van Bueren, 1999, p. 13) which has an important

in his study pre-trip catch expectations were only recorded (in self-completed log books) – so one cannot ensure that all reports of expectations were actually captured before the trip was taken. Moreover, expectations were only recorded for one of 6 regions, and these expectations were used to approximate expectations in other regions, so the majority of *ex ante* measures were inferred as opposed to directly measured. Also, respondents were asked about their expected catch 'conditional upon catching at least one fish' and thus zero catch expectations were excluded from the analysis.

More recently, Bennet, Provencher, and Bishop (2004) estimated and compared trip decision models using expected trip outcomes and realised trip outcomes (again finding statistically significant differences across models)[23], but participants were asked about their expectations after the fishing trip – the measures used were thus *ex post* approximations of *ex ante* variables. Both the economics and social psychology literature suggests these may not be particularly good approximations; it would be more theoretically appropriate to use an angler's own expectations measured before a fishing trip (van Bueren, 1999).

In sum, there is very little previous research that can be used to determine if recreational fishing studies that have used *ex post* measures are, or are not, able to generate final estimates of demand, or of 'value' that approximate estimates that would obtain if *ex ante*

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impact on estimated values (e.g. value of fish, access values, total value of fishing resources). van Bueren (1999) found that the perceptions model produced significantly larger access values and Mvs of different types of fish and for a recreational fish in general than the objective specification of catch.

[23] They found that 'valuations implicit in the retrospective responses' differed from 'those implied by *ex ante* trip decisions' and 'in monetary terms, ceteris paribus, these results indicate that the expected valuations implicit in retrospective decisions' are significantly larger (on average) 'than those implicit in trip decisions' (p.18). They suggested that the reason for the differences between estimated values might be explained by 'misspecification of the *ex ante* expected catch variable' (p.21). They suggested that it is somehow consistent with 'the perspective that the researcher-constructed value for angler expectations of catch… is not adequately capturing how anglers evaluate fish catch in their ex ante decisions' (p. 21). Bennet et al. (2004) argued that a participant's values of environmental goods and services 'can vary significantly depending on the context and timing of the observed choice or elicited response' (p.23) which raises a question 'which valuation is correct for welfare analysis?' (p.24).

measures were used instead. And evidence from other studies suggests that one may not be able to make such a determination *a priori*: it seems that *ex post* measures may be greater than, approximately equal to or less than *ex ante* measures (see Table 4.1). Evidently, the significance of potential differences needs to be assessed on a case-by-case basis.

The research described in this chapter thus helps to fill an important gap – comparing models that describe the demand for and value of recreational fishing trips using (a) *ex ante* measures of expected catch; and (b) measures of actual catch (*ex post*). To be more specific, I analyse data that were collected from a survey of 404 anglers from Townsville. All were intercepted before going fishing (at boat ramps, while preparing to leave on their trip) to capture true *ex ante* expectations, follow-up interviews were conducted to collect *ex post* measure of catch and background socio-demographic information. The data were used within

- a Tobit model, to investigate the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch; and
- an Hedonic Trip Price Model (adapted form Hunt et al. (2005a;b) and Carter & Liese (2010) to compare the marginal value of fish, using *ex post* and *ex ante* measures of recreational catch .

Table 4.1 Selected studies that compared *ex ante* with *ex post* estimates

Study	**Economic measure**
Studies where *ex ante* estimates are greater than *ex post*	
van Bueren (1999)	MV of recreational fish
Haq et al. (2001)	Cost
Harrington, Morgenstern, and Nelson (2000)	Costs
Bedate, Herrero, and Sanz (2012)	WTP (museum for residents)
Studies where *ex ante* estimates are greater than or equal to *ex post*	
Farrow and Scott (2011)	Risk of flood
Bedate, et al. (2012)	WTP (museum for visitors)
Studies where *ex ante* estimates are approximately equal to *ex post*	
Brock, Lange, and Ozbay (2013)	Payoffs without risk
Whitehead and Cherry (2004)	WTP (green energy)
Whitehead and Todd (2007)	WTP (green energy)
Brock et al. (2013)	Payoffs with risk
Studies where *ex ante* estimates are less than *ex post*	
Oulton (2007)	Growth rates and contribution of capital (aggregated)
Brathen and Hervik (1997)	Social surpluses
Pinto-Prades, Farreras, and Fernandez de Bobadilla (2006)	WTP (health)
Cho-Min-Naing, Lertmaharit, Kamol-Ratanakul, and Saul (2000)	WTP (health)
Uzochukwu, Onwujekwe, Uguru, Ughasoro, and Ezeoke (2010)	WTP (health)
Heyne, Maennig, and Süssmuth (2007)	WTP (soccer)
Süssmuth, Heyne, and Maennig (2009)	WTP (soccer)
Johannesson, Liljas, and Johansson (1998)	WTP (chocolate)

As such my analysis sheds light on differences between *ex ante* and *ex post* measures in when predicting demand and when attempting to 'value' a fish. This is, I believe, the first time that has been done. Moreover, this study case is also somewhat unique in that it estimates the MV of a fish rather than a MV of a fishing trip (i.e. it does not divide the trip value by the number of fish caught to get the value of fish, as is common in the literature).

4.2 Methods

4.2.1 Study area

Recreational fishing is one of the most popular leisure activities in Queensland (QLD), Australia. As was previously mentioned approximately 17 % of the QLD population aged 5 years and older went fishing, crabbing or prawning in the 12 months prior to July 2010 (Taylor, Webley, & McInnes, 2012). Townsville – a city of approximately 174,000 - (Beumer, Sully, & Couchman, 2012, p. 8) provides access to a variety of fish species in marine and freshwater environments (DAFF, 2010) (see Figure 2.2 and Section 2.2 and Section 3.3 for more details). According to the DAFF (2010) residents of Townsville region mainly fish in coastal waters, boat fishing is more popular than shore fishing and most fishing occurs in marine waters.

4.2.2 The data

The data used in this chapter were collected between April 2011 and March 2012 during on-site interviews at two the most popular public boat ramps in the Townsville region. More specifically, data were collected during 29 visits which occurred at different times of the day - varying from 3 am to 9 pm - during week days, weekends, public and school holidays, so as to ensure good variety of respondents.

When visiting the boat ramps, individuals who were preparing to launch their boats were randomly selected and asked if they would be willing to participate in the survey. This was done to ensure that expectations were genuine *ex ante* measures. Willing respondents were asked ten short questions prior to getting underway; they were also asked about their willingness to participate in a follow-up survey. This was conducted by telephone later (one, two or three days after the trip).

In the pre-fishing (boat ramp) survey (see Appendix 3), I collected information about the planned trip including: primary reason for going on the trip (motivations), expected duration and destination, species targeted, expected catch and keep, familiarity with fishing sites, cost of the trip, boat ownership, boat quality (assessed by researcher) and number of people on the boat. In the follow-up survey (see Appendix 3), I sought additional information about actual duration and destination of the trip, the number and species of fish caught and kept, age, gender, fishing experience and frequency, consumptive orientation and commitment to fishing, level of education, occupation, employment status and household income. They were also asked how many times they had fished on reefs, shoals, offshore islands, bays, estuaries, creeks and freshwater in the last 12 months.

In total 428 people were asked to participate in the boat ramp survey. 404 agreed to participate to the pre-trip survey; 366 also participated in the follow-up. The response rate was thus 94% for the 1st part of the survey was and 91% for the follow-up.

The overall sample was dominated by males (82.4%). Approximately 3% of participants had not been fishing in the last two years while 28.8% went fishing fairly regularly (once every 2 or 3 months), 31% went fishing at least once a month, nearly 23% went fishing a few times each month and 13.8% were very frequent fishers - weekly or more often (see Figure 4.1). Of those who had been fishing within the last two years 71.8% were boat owners and half were targeting a particular species (e.g. Barramundi, or Mackerel).

The participants were intercepted at the boat ramps before going fishing (while launching their boats) to capture true expectations the number of legal sized fish they thought they would be likely to catch on their trip. In the follow up interview, they were asked how many fish were actually caught. When calculating actual catch/keep – I divided the total number of fish caught by number of people that were reported to have shared the catch/keep with the participant for example, 2 passengers kept a single fish to share. Figure 4.2 shows expectations and actual catch responses.

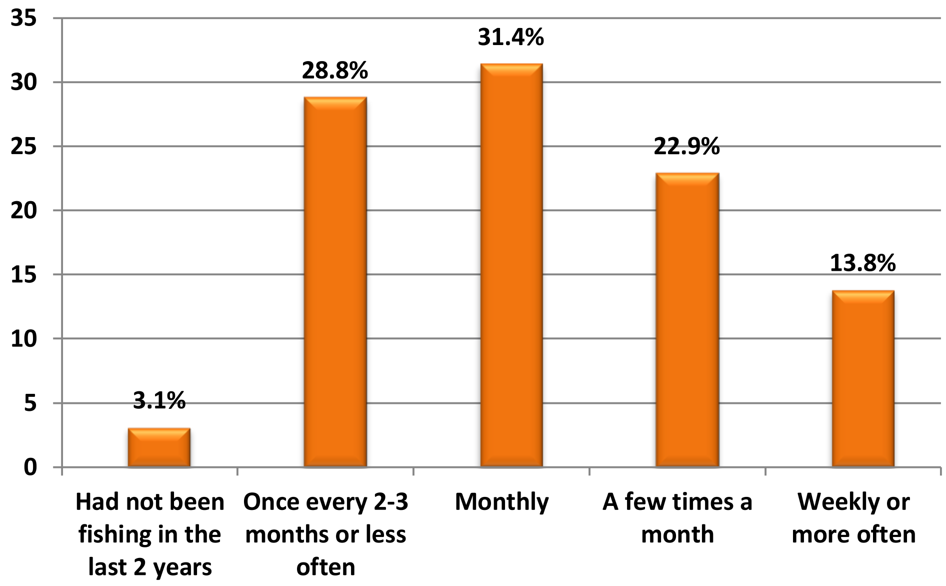

Figure 4.1 The distribution of the frequency of fishing trips

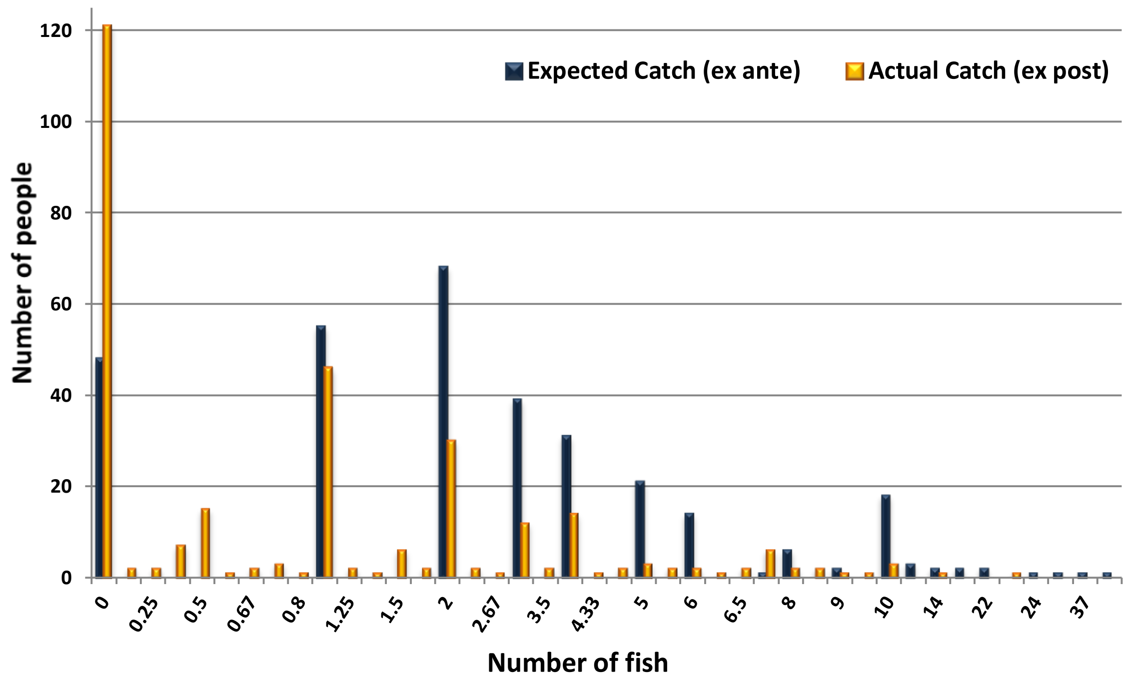

Figure 4.2 *Ex ante* and *ex post* catches

15.2% of recreational anglers expected their catch to be zero and 20.6% of anglers expected not to keep any fish at all on this particular trip. Just over 40% of all anglers reported zero catches during this trip. Clearly expected and actual catch differ so we expect differences in MVs from these different constructs[24].

4.2.3 Ex ante vs. Ex post catch and keep models

The first part of this chapter sought to identify the potential drivers of the expected (*ex-ante*) and actual (*ex-post*) catch – the primary aim being to determine if drivers are similar or different. Individuals who took fishing trips of more than 24 hours duration were excluded from the analysis (it would be difficult to allocate the price of the trip to fishing activities for 2-3 days trip in duration) as well as who were targeting just crabs, prawns and Cray fish etc. together with fish were excluded from the analysis, since catching these animals is an inherently different fishing experience than angling, and (we felt) best treated separately. The discussion below describes both the variables used and the modelling approach.

Dependent variable

Two different dependent variables: expected catch (*ex-ante*) and actual catch (*ex-post*) per person (see Table 4.2[25]) were used in the first part of this chapter. These dependent

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[24] Considering two simple versions of the model in which price of the trip (Y) is regressed on the number of fish caught (EC for expected catch and AC for actual catch) and the set of other explanatory variables X that are the same in both models.

$$Y = a_0 + a_1 EC + a_2 X + e_1$$ for the Expected Catch model

$$Y = b_0 + b_1 AC + b_2 X + e_2$$ for the Actual Catch model

And where $E\overline{C} > A\overline{C}$. Taking expectations after estimations

$$E(Y) = \hat{a}_0 + \hat{a}_1 EC + \hat{a}_2 X$$

$$E(Y) = \hat{b}_0 + \hat{b}_1 AC + \hat{b}_2 X$$

Since $E\overline{C} > A\overline{C}$, the MV of fish with $\hat{b}_1$ will be greater than the MV with $\hat{a}_1$

[25] I also asked about expected keep and actual keep, constructing a 'parallel' set of dependent variables.

variables included a significant number of zeros, but they were not all integers, so the Tobit model (censored at 0) was used[26].

Explanatory variables

Recreational catch is often assumed to be a function of several variables, including those relating to the motivations for fishing and other personal characteristics (see Appendix 3). The explanatory variables used in this study were selected from previous findings in the literature (i.e. my aim being to include variables that had been hypothesised, or found, to influence recreational catch). Variables from social science studies such as measures of consumptive orientation and motivations for fishing were also included (see Appendix 3 and Chapter 3 Section 3.2 for more details). The final set of explanatory variables (obtained by firstly running a model that used all variables which could potentially influence catch, and then gradually dropping insignificant ones) is shown in Table 4.2.

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[26] I also estimated expected catch functions (which did not contain non-integers) using a negative binomial specification but the results were similar in terms of significance of the coefficients so I have not reported them here. Results are available on request.

Table 4.2 Variables used in the empirical (Expected Catch and Actual Catch) models

Variable	Description	Mean	Std. dev	Min	Max
Expected Catch	Expected total catch of legal size fish on this trip	3.65	4.94	0	45
Actual Catch	Actual total number of legal size fish caught on this trip	1.57	2.56	0	23
Explanatory variables					
Male	1 if male, 0 otherwise	0.82	0.38	0	1
Number of years fishing	The number of years fishing	18.15	14.57	0.5	65
Number of years fishing squared	The number of years fishing squared	541.22	742.69	0.25	4225
Consumptive Orientation*	Consumptive orientation of angler calculated as a score	16.40	4.15	6	25
Expected hours	Expected number of hours angler planned to spend fishing	5.35	3.02	0.5	24
Actual hours	Total number of hours angler spent fishing	5.82	2.91	0.2	24
Full moon	1 if a current trip was during full moon phase, 0 otherwise	0.16	0.36	0	1
Targeting Species (expected)	1 if angler was planning to targeting a particular species on the trip, 0 otherwise	0.51	0.50	0	1
Targeted Species caught (actual)	1 if angler caught at least 1 legal sized fish of their targeted species, 0 otherwise	0.23	0.42	0	1
Bait	1 if angler used bait, 0 otherwise	0.85	0.35	0	1
Importance of catching fish for eating**	Importance of catching fish for eating measured on a 5-point scale	3.02	1.46	1	5
Importance of fishing for fun**	Importance of fishing for fun measured on a 5-point scale	4.01	1.42	1	5
Temperature	Temperature at the time of the survey	21.96	6.48	12	30

* To measure consumptive orientation we used 6 items adapted from a scale developed by Graefe (1980) and from a further extended scale (Fedler & Ditton, 1986; Sutton & Ditton, 2001) (see Chapter 3 Section 3.3 for more details on how it was calculated). The Cronbach alpha was 0.58.

**'Importance of catching fish for eating' and 'Importance of fishing for fun' on this particular trip (scale variables) were measured in this study with response categories ranging from 'not at all important'(1) to 'very important'(5).

The same set of variables were used for *ex ante* and *ex post* models but in *ex ante* models the researchers used expected number of hours fishing and expected species targeted. In *ex post* models expected number of hours fishing was replaced by actual number of hours spent fishing and expected species targeted was replaced by targeted species caught.

4.2.4 Hedonic Trip Price Model (HTPM)

The second part of my analysis involved the use of a Hedonic Trip Price Model (HTPM) (adapted from Hunt et al., 2005a, b; and Carter & Liese 2010). This was used to estimate the MV of an extra fish (expected or actual), the primary aim being to look at how MVs vary across *ex ante* and *ex post* approaches.

The Hedonic Price Model (HPM) has its origins in Lancaster's (1966) Theory of Characteristics or consumer theory – which focuses on the fact that most goods and services are multi-attributed, and that the amount a person is willing to pay for a good, depends upon that good's attributes (Rosen, 1974). Thus the demand or value of particular attributes will be reflected in the price that consumers are willing to pay for a (complex) goods or service (Garrod & Willis, 1992).

The HPM has been used to value attributes of amenities such as lakes, beaches and parks or disamenities such as railroads and noise pollutions (Pendleton, Sohngen, Mendelsohn, & Holmes, 1998; Strand & Vagnes, 2001; Crompton, 2001; Loomis & Feldman, 2003; Gopalakrishnan, Smith, Slott, & Murray, 2011). It has also been used to value hunting leases and permits (Livengood, 1983; Taylor & Marsh, 2003; Little & Berrens, 2008; Rhyne, Munn, & Hussain, 2009) and to estimate marginal implicit prices 'for the risk of natural disasters' (Mueller & Loomis, 2008, p. 214) such as wildfire (Donovan, Champ, &. Butry, 2007; Loomis, 2004), floods (Chivers & Flores, 2002; Bin & Polasky, 2004) or earthquakes (Beron, Murdoch, Thayer, & Vijverberg, 1997).

But despite the fact that there are good reasons for believing that Hedonic analysis could be a useful way of uncovering 'anglers' underlying preferences for fishing trips (Pitts, Thacher, Champ, & Berrens, 2012, p. 448; see also Taylor, 2003), there are relatively few examples of its application in the recreational fishing literature. Notable exceptions include the investigation of Carter and Liese (2010) who used a special case of the hedonic onsite model first put forward by Landry and McConnell (2007) to estimate a charter fee hedonic model and derived the marginal value of a fish and the MV of sport fishing harvest, and that of Pitts et al. (2012) who used the HPM to estimate marginal implicit prices for a trout fishing trip characteristics.

Like other goods, fishing trips are characterised by a variety of different trip attributes such as expected catch, duration of the trip, species availability, species targeted, boat quality, fishing sites, people, weather and so on. Here, I assume that the amount which a recreational angler has spent on their fishing trip (i.e. trip price) – something which must be paid in advance – will reflect their expected satisfaction with their up-coming trip, and that anglers will be willing to pay more for relatively more valued attributes (Carter & Liese, 2010, p. 393). More formally: following Hunt et al. (2005b) and Carter and Leise (2010) the hypothesis underlying this investigation, is that differences in trip prices (in this case, trip costs) can be explained by differences in fishing trip attributes and can be defined as a hedonic price function:

$$P_t = f(S_i, \ldots\ldots, S_n) \quad (4.1)$$

Where:

P is the price (cost) of trip at time *t*, and

S is a vector of environmental and quality attributes (i = 1, 2, 3,…n) that jointly determines the ;value' of the trip (Asche & Guillen, 2012; Hunt et al., 2005a).

This hedonic price function thus 'allows a test of the values of each attribute' holding all other attributes constant (Asche & Guillen, 2012, p. 366) and can be used to estimate the marginal values of attributes, using partial derivatives (Anderson , 2000, p. 293).

Dependent variable

Several studies have used trip prices as a dependent variable in HTPMs that have looked at fishing. Sinclair, Clewer, and Pack (1990), Sard, Aguiló, and Alegre (2002), Espinet, Saez, Coenders, and Fluvià (2003), Papatheodorou (2003) and Thrane (2005) used the price of package tours; Tien (2012) used the per-person price of a one-day island boat trip; Hunt et al. (2005b) used the price per person for week-long sport fishing trips; and Hunt et al. (2005a) used 'the weekly fishing package prices charged to one guest at a fishing site' by fly-in remote tourism enterprises (p. 102). But these previous studies differ from mine in that theirs focused on commercial fishing trips with an explicit market price/cost of the carter. In this chapter, I am interested in private fishing trips – without directly observable prices. So instead of using the cost of charter I used self-reported costs of private fishing trip – elicited during the pre-fishing part of the survey with an instrument that included a series of questions designed to help the respondent recall a variety of expenditures they may have incurred when preparing for the trip (asking how much they had spent on fuel, ice, bait etc.[27]). I added all those costs to estimate the price they paid for that trip, and this estimated price of the trip was used as a dependent variable in the HTPM. It is important to note that my approach does not strictly match the hedonic price approach which assumes that the price is formed in some sort of competitive market – but it is similar, in that the costs (prices) that comprise total trip price were formed in a competitive market.

There were a number of people who had not spent any money (they were simply invited to join others at no cost) so had a zero price for their trip. As such, the dependent variable

[27] Importantly these costs did not include capital costs, so reflect a marginal (rather than a total) cost, including the cost of items purchased and consumed on the particular fishing trip assessed. Moreover, I also excluded the cost of getting to the boat ramp – it was relatively small because I did not consider people from other regions: the maximum distance was 15 km. The highest petrol price in Townsville during the survey period was $1.52 (ORIMA Research, 2012). Even if using as much as 20 litres per 100 kms, then those travelling to the boat ramp still only used about 4 litres of fuel, so the cost of fuel would be $6 or less. As such, those costs are ignored

(trip price) was continuous, non-integer and censored at zero. Consequently, the Tobit model censored at zero (Bauer & Sinning, 2006) was considered to be an appropriate estimation technique.

Explanatory variables

There is no theoretical guidance on which specific set of explanatory variables to include in HPMs, with Anderson (2000) arguing that 'the results of earlier studies should be used…for selecting which variables to test…for their subsequent acceptance or rejection' (p. 293). In accordance with other researchers (Carter & Leise, 2010; Pitts et al., 2012) the choice of explanatory variables used in the model was thus based on previous research studies and availability of data (see Table 4.3).

Table 4.3 Variables used in the Hedonic Trip Price Models

Variable	**Description**	**Mean**	**Std. dev**	**Min**	**Max**
Trip Price	Total self-reported cost of this trip	63.40	72.36	0	846
Explanatory variables					
Male	1 if male, 0 otherwise	0.82	0.38	0	1
Expected hours	Expected number of hours angler planned to spend fishing	5.35	3.02	0.5	24
Actual hours	Total number of hours angler spent fishing	5.82	2.91	0.2	24
Targeting Species (expected)	1 if angler was planning to targeting a particular species on the trip, 0 otherwise	0.51	0.50	0	1
Targeted Species caught (actual)	1 if angler caught at least 1 legal sized fish of their targeted species, 0 otherwise	0.23	0.42	0	1
Importance of catching fish for eating	Importance of catching fish for eating measured on a 5-point scale	3.02	1.46	1	5
Importance of fishing for fun	Importance of fishing for fun measured on a 5-point scale	4.01	1.42	1	5
Temperature	Temperature at the time of the survey	21.96	6.48	12	30
Expected Catch	Expected total catch of legal size fish	3.65	4.94	0	45
Actual Catch	Actual total catch of legal size fish	1.57	2.56	0	23
Incomescale*	Angler's annual household income	4.69	1.43	1	6
Boatlength	Length of the boat in meters	4.98	1.02	2.5	9.7

***'Income scale' variable was measured with response categories ranging from 'under $20,000' (1) to '$100,000 and above' (6).

Expected and Actual Catch – instrumented variables

I suspected that endogeneity might be an issue – particularly given the likely association between expected catch and other the other variables highlighted in Table 4.3 (likely to also influence the amount anglers are prepared to pay for any given fishing trip). So I conducted the augmented regression test (Durbin–Wu–Hausman test) for endogeneity suggested by Davidson and MacKinnon (1993). The null hypothesis (that catch variables were exogenous) was rejected at the 5 and 10% levels, respectively, indicating that the instrumental variables (IV) Tobit specification[28] should be used (Gopalakrishnan et al., 2011) – see Appendix 3 for details. The instruments for these models were chosen from those found to be significant determinants in both the expected and actual catch functions discussed in the preceding section (see Table 4.4).

Both HTPMs were tested for weak instruments and overidentification using the Conditional Likelihood-Ratio (CLR) test, Anderson–Rubin (AR) statistics (Anderson & Rubin, 1949), Kleibergen–Moreira Lagrange multiplier (LM) test (Moreira, 2003; Kleibergen, 2007), a combination of the LM and overidentification J (LM-J) and Wald tests. I also estimated confidence intervals based on the CLR, AR, LM, LM-J and Wald tests. The statistics for all tests were significant at 5% level thus we rejected the null of weak instruments and overidentification. The confidence intervals derived from weak instrument robust tests were narrower than the Wald confidence intervals for both models implying that the instruments are strong and that my point estimates are not biased (Finlay & Magnusson, 2009). To allow for heteroskedasticity (Pitts et al., 2012) I then proceeded to estimate the IV Tobit with robust standard errors (SE) [29]. The coefficients and their

[28] I also estimated expected and actual catch models using IV2SLS, IVLIML and IVGMM but tests indicated that the models suffered from weak instruments &/or misspecification.

[29] I could not test models with robust SEs for weak instruments or overidentification because rivtest (stata command) requires an assumption of homoscedasticity

significance for both specifications remained the same – so only the results from IV Tobit Robust models are reported.

4.3 Results

4.3.1 Ex-ante and ex-post catch results

Table 4.4 shows the results from the Tobit regressions exploring the expected and actual catch equations[30]. The likelihood ratio chi-square of 44.76 and 83.75 values are significant at 1% level indicating that each model as a whole fits significantly better than a model without predictors. Although Actual/Expected hours fishing; the desire to target a particular species, and the importance of catching fish for eating were significant determinants in both models, there were – as expected differences between the models. The 'Importance of fishing for fun', Temperature and Bait were only significant in the *ex ante* model (highlighted cells), while consumptive orientation, years fishing, gender and full moon were only significant in the *ex post* model.

[30] I also estimated expected and actual keep models. The results from Tobit regression (censored at 0) are presented in Appendix 3, Table A 3.1.

Table 4.4 **Results for Tobit models censored at lower level (0)** **Variable**	**Expected Catch** Coefficient (SE)	**Actual Catch** Coefficient (SE)
Intercept	-8.3234*** (2.543)	-3.7871** (1.680)
Actual/Expected hours	0.2493** (0.121)	0.3029*** (0.084)
Targeting Species/Targeted Species caught	1.9282*** (0.663)	3.1479*** (0.504)
Consumptive orientation	-0.0532 (0.080)	-0.1424*** (0.052)
Years fishing	0.0043 (0.073)	-0.0734 (0.047)
Years fishing squared	0.0003 (0.001)	0.0020** (0.0009)
Male	0.9909 (0.904)	1.4610** (0.606)
Full moon	1.1070 (0.890)	1.4255** (0.564)
Importance of catching fish for eating for this particular trip	0.4425* (0.253)	0.1464 (0.166)
Importance of fishing for fun for this particular trip	1.1943*** (0.354)	0.3573 (0.227)
Temperature	0.1044** (0.052)	0.0444 (0.034)
Bait	0.0802 (0.946)	-0.3284 (0.626)
Log likelihood	-770.42	-499.78
LR chi2	44.76***	83.75***
AIC	5.59	3.65
BIC	36.35	-511.50
Number of observations	280	281

* significant at 10% level
** significant at 5% level
*** significant at 1% level

4.3.2 HTPM results

Results from IV Tobit Robust models are reported in Table 4.5. The Wald test statistic of the exogeneity of the instrumental variables for the HTPM with Expected Catch (/alpha=0): chi2(1) = 5.92 and p-value (0.02) for the test indicated endogeneity at 5% level, confirming that the IV Tobit is preferable to Tobit specification. Likewise, the Wald test statistic of the exogeneity of the instrumental variables (/alpha=0): chi2(1) = 4.21 and p-value (0.040) for HTPM with Actual Catch indicated endogeneity at 5% level, again confirming the appropriateness of the IV Tobit. The Wald chi-square statistics for both models are highly significant indicating good model fits.

In the 1st stage of the IV Tobit model (shown in the bottom half of Table 4.5) the dependent variables are Expected Catch and Actual Catch and they are regressed on the instrumental variables. Targeting Species/Targeted Species caught, Expected/Actual Hours to fish and Temperature were all found to have a positive effect on both Expected and Actual catch – and they were significant at the 1 % and 5% levels. The importance of fishing for fun has a positive and significant (at 10% level) influence on Expected Catch but not on Actual Catch.

In the Trip Price Model (2^{nd} stage of the IV Tobit model) with an instrumented Expected Catch variable, all coefficients of the explanatory variables were highly significant at the 1% and 5% level. Expected Catch, Income and Boat Length were found to have a positive effect on trip-price/cost which is consistent with economic theory and with other studies: Carter and Leise (2010) also found that vessel length and average number of fish harvested per angler per hour (KPUE) are positively associated with the price of fishing trips. But Targeting Species had a negative impact on trip price. Similarly in the Trip Price Model with instrumented Actual Catch, all coefficients were significant at the 1%, 5% or 10% level. Actual Catch, Income and Boat Length were found to positive influence trip-price/cost while Targeted Species caught had a negative influence.

This last, apparently anomalous result can be explained as follows. The variables 'Targeting species' and 'targeted species caught' were significant and positive in both the expected and actual catch models and in the 1^{st} stage of the HTPM indicating that expected and actual catch were higher for those who wanted particular species. These people can be very keen fishers, more experienced, more familiar with fishing sites and mainly fishing mostly for consumptive purposes. Interestingly, all of the fishers in my sample who targeted species, were targeting species that are primarily valuable for food such as barramundi, mackerel, coral trout, red emperor etc. As such, they seem to have been fishing mainly for consumptive purposes, rather than primarily for ‘fun’. It is possible that those who fish primarily for ‘fun’ are willing to pay more for that experience – if fishing primarily for food, one would rationally limit expenditure to ensure that one does not end up paying more for own-caught fish than for fish purchased from a shop. Hence the reason that the targeting species variables are negative in the 2nd stage of the HTPM.

Table 4.5 Hedonic Trip Price models using Expected Catch and Actual Catch

Instrumental Variables Tobit Trip Price Models (IV Tobit) using Expected Catch and Actual Catch			
Variables	Coefficient (SE)	Variables	Coefficient (SE)
Trip Price Model (dependent variable Trip Price)			
Intercept	-137.80*** (40.20)	Intercept	-210.55*** (73.15)
Expected Catch	13.5028** (5.740)	Actual Catch	46.2809** (21.76)
Income	11.9218*** (4.298)	Income	19.0888** (8.972)
Boat length	22.6420*** (6.418)	Boat length	27.6380*** (7.619)
Targeting Species	-29.7842** (14.401)	Targeted Species caught	-86.7085* (48.488)
1st stage Expected Catch Model (*ex ante*) (dependent variable Expected Catch)		1st stage Actual Catch Model (*ex post*) (dependent variable Actual Catch)	
Intercept	-3.3188 (2.212)	Intercept	0.6869 (1.373)
Income	-0.2204 (0.199)	Income	-0.2428 (0.179)
Boat Length	0.1224 (0.326)	Boat Length	-0.0480 (0.124)
Targeting Species	1.9648*** (0.632)	Targeted Species caught	1.8755*** (0.398)
Expected Hours	0.2238** (0.090)	Actual Hours	0.0756** (0.030)
Temperature	0.1207*** (0.041)	Temperature	0.0405** (0.017)
Importance fish for eating	0.1855 (0.177)	Importance fish for eating	0.0646 (0.075)
Importance of fishing for fun	0.4948* (0.261)	Importance of fishing for fun	0.0496 (0.141)
Log likelihood	-2065.66		-1974.27
Wald chi2 (model fit)	32.69***		17.48***
N of observations	241		252
Wald test of exogeneity (alpha = 0): chi2	5.21**		4.21**
MV of a fish $AUD	7.38**		22.83**
95% C.I.	[1.2397 13.5172]		[1.28 44.37]
Marginal Effect of Income	6.51***		9.42**
Marginal Effect of Boat Length	12.37***		13.63***
Marginal Effect of Species	-16.09**		-38.30**
LM-J test for overidentification	Ho rejected at 5% level [0.2914 22.3826]		Ho rejected at 5% level
CLR test	5.78** [1.15773 19.3505]		3.13* [-0.9921 33.8406]
AR chi2	13.68** [2.45721 17.1847]		16.80***
J chi2	9.44**		14.99***
Wald chi2	6.09** [2.7820 24.2236]		4.88** [5.2279 87.3338]

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

Note: I estimated various models with additional motivations (including ‘Importance to be with family and friends’, ‘Importance for relaxation’, ‘Importance for enjoying nature’); socio-economic variables (age, gender, marital and retirement status, employment, education, number of years lived in Townsville region); different destinations (reef, shoals and offshore islands, bays, estuaries, creeks, beaches, breakwaters), attitude variables (consumptive orientation, activity commitment) and Total number of people in the trip. All these variables found to be insignificant for all models. Results reported for CLR, AR, LM, J, LM-J and Wald tests are for IV Tobit models

The marginal effects of all explanatory variables in the HTPMs were also estimated using STATA software and are presented in Table 4.5[31]. As was expected the MVs of *ex ante* and *ex post* catches differed: they were $7.38 and $22.83 AUS respectively[32].

4.4 Discussion and Conclusion

The values that recreational fishers receive from fishing activities are 'determined in a major way by catch rates and the influence of those catch rates on demand and utility' (Morey & Waldman, 1998, p. 262; Karou et al., 1995). Most demand and valuation studies of recreational fishing have used *ex post* (actual or historic) measures of catch, but as noted by Deyak and Smith (1978, pp.78-79, cited in Schuhmann & Schwabe, 2004, p. 445), "it is [an] individual's anticipations which are relevant to his decision to participate"; it may thus be more appropriate to look at *ex ante* measures in many instances.

The purpose of my research was, therefore, to assess the degree to which models that used *ex ante* and *ex post* catch data differed. My results indicate that (at least in this part of the GBR and for this particular sample) the determinants of *ex ante* and *ex post* recreational catch are different. Consequently, those using *ex post* constructs to approximate *ex ante* values may be – perhaps seriously – misled about the key factors influencing choices on whether to go fishing or not. Both the economics and the psychology literature seems to agree that one should use *ex ante* constructs if trying to predict behaviours, so this

[31] Average Marginal effect (MV) of each variable in the model is calculated at the means of the independent variables dy/dx using post-estimation command mfx in Stata 13

[32] I also estimated HTPM using Expected Keep and compare the results with HTPM using Expected Catch but the differences were neither particularly large nor particularly interesting, thus only Expected and Actual Catch models were reported. HTPM using Actual Keep was also estimated but performed poorly. Wald chi-square statistic for model fit was insignificant at any % level and all coefficients in the model were insignificant.

observed difference should send warning to those who use *ex post* constructs in this manner.

In my case study, it is clear that expectations are largely driven by motivations (e.g. the importance of fishing for fun and for eating) but that personal variables – such as consumptive orientation, years fishing and gender – have greater influence on outcomes (*ex post* catch). Evidently, those interested in predicting behaviours may need to pay greater attention to motivations, and somewhat less attention to socio-demographics.

As regards 'value' estimates: the literature provides much less guidance here about whether one should be using *ex post* or *ex ante* constructs. My research however highlights that these constructs yield different value estimates, which is consistent with other research findings (see Table 4.1). In my study, *ex ante* 'value' estimates were much lower than than *ex post* 'values': ($7 versus $22). This differs from van Bueren's (1999) finding that *ex ante* MVs were larger than *ex post* values. At least some of these differences are likely to be due to differences in the time and method of reporting expectations. In van Bueren's study, recreational anglers were provided with the logbooks and asked to complete them both before and after each fishing trip but the expectations were 'only collected for the region at which individuals intended to visit' (p. 8) and then they were used to draw inferences about expectations to other regions. In contrast, this chapter elicited all expectations consistently - in an interview immediately before the angler embarked on their trip. My measures are thus likely to be more accurate because people were asked about their expectations of catching and keeping fish just some minutes before the fishing trip.

In this chapter expected catch was approximately 2.32 times greater than actual catch and the MV of fish (using actual catch[33]) is \$17.59/\$7.38 $\approx$ 2.38 greater than MV of expected fish. This equivalence of ratios is as expected – what was unknown beforehand is the size of those ratios.

As noted in the introduction, there has been increasing conflict between different fishing sectors around the world (Aas 2007) with associated debates about who is putting most pressure on fish stocks and who should have ‘more’. When market based solution are not feasible, those charged with making the allocation decision need information about marginal values (Galeano et al., 2004). This case study demonstrates that estimates of the MV of ‘a fish’ differ depending upon whether an *ex ante* or *ex post* approach is used; policy makers should be aware of this problem when making allocation decisions. Instead of using just single estimates it might thus be preferable to construct a range of estimates, and my investigation indicates that MVs can be *Post Hoc* estimated but then simply scaled (according to the ratio of expectations versus actuality) to get *ex ante* values. This could considerably simplify the estimation process, while still providing policy makers with a realistic range of estimates (as opposed to a single, possibly imprecise figure).

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[33] For this ratio we estimated Trip Price Model (with all ex ante variables in the model) but replaced Expected Catch by Actual Catch and derive marginal value of a fish

5 The non-consumptive (tourism) 'value' of marine species in the Northern section of the Great Barrier Reef

Abstract

The information about the value of a fish for recreational fishers is useful and one can simply use prices to get the value of a fish for commercial fishers which would be comparable, but what is value of fish or different species for tourist? This chapter is focuses on that problem.

In this chapter I use the Kristrom (logit) Spike Model to analyse contingent valuation (payment card) data from a study of 2180 domestic and international visitors taking reef trips to the Northern section of the Great Barrier Reef. I investigate (a) their willingness to pay for a "100% guaranteed sighting" of several different marine species; and (b) the sensitivity of final estimates to various methodological issues. I found that final estimates are particularly sensitive to questionnaire design, but that the ranking of species (from most to least 'valued') is robust across a range of methodological specifications. The most valued groups of species were (in order): whales and dolphins; sharks and rays; 'variety'; marine turtles; and finally large fish. Evidently, whale watching is not the only potentially lucrative source of tourism revenue; other marine species may be similarly appealing. These potential revenues need to be considered when making decisions about whether or not to conserve marine species.

5.1 Introduction

The Great Barrier Reef Marine Park (GBRMP) is one of the world's largest and most diverse ecosystems and is home to thousands of marine animals including populations of dugongs, snubfin and hump-backed dolphins, humpback whales and dwarf minke whales, sea snakes, six of the world's seven species of marine turtles and a variety of sharks (Great Barrier Reef Marine Park Authority [GBRMPA], 2009a,b).

Since European settlement, development along the coast adjacent to the GBRMP has been associated with extensive agricultural and some urban development which has led to the removal of the buffering and filtering function of the landscape. Suspended sediment loads have been estimated at up to five times pre-European loads in some rivers (McKergow, Prosser, Hughes, & Brodie, 2005), some nitrate loads are up six times higher than 150 years ago and considerable quantities of pesticides are now discharged from rivers which would have been completely absent prior to the 1950's (Furnas, 2003).

These increased sediment, nutrient and pesticides loads to the GBR lagoon have been linked to coastal ecosystem degradation in the GBR (Fabricius, 2005; Furnas, 2003), and perhaps at least partially because of that – and partially also because of more direct threats such as fishing (for some species only) and other impacts related to climate change – there are now twenty-seven ecologically important marine species in the GBR that have declined significantly and are, therefore, listed as 'critically endangered' under Australian and Queensland Government legislation (GBRMPA, 2009b). This list includes six marine mammals, some shark species (e.g. whale shark, great white shark, grey nurse shark)[34], all marine turtles[35] and eight birds (GBRMPA, 2009a,b).

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[34] There are 182 species of sharks and 125 ray species occurring in Australian waters and 134 species of sharks and rays are recorded in the GBR. Sharks and rays have been under significant threat in the GBR area because of some commercial and recreational fishing activities (e.g. targeted fishing, bycatch or illegal

Not only is this of concern because the species are important by, and of, themselves and for biodiversity in general, but these species are of value for a variety of economic reasons (Jakobsson & Dragun, 2001; Pearce & Moran, 1994). Traditionally, the Total Economic Value Framework groups these values into use and non-use values[36] although if interested in addressing conservation-type questions it is also useful to further distinguish between consumptive and non-consumptive values, giving the following broad categories:

(a) Use values

i. Consumptive use values – those which 'relate to the … goods produced by the ecosystem that can be consumed and used by people' (Geoscience Australia, 2011). A relevant example here, is when sharks are used for food.

ii. Non-consumptive use values – those which generate use-benefits for humans but which do not require one to consume the good or service (Campbell & Smith, 2006; Loomis & White, 1996). Corals and marine species such as sea turtles, sharks, and whales 'have non-consumptive use values to divers based on their active enjoyment of diving with these species' (White, 2008, p.7; Wilson & Tisdell, 2011)

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fishing) or from shark control activities (to provide swimmer protection at popular beaches) GBRMPA (2009a,b).

[35] All marine turtles in the GBR are 'recognised internationally as species of conservation concern' (Department of Sustainability, Environment, Water, Population and Communities, 2011). The main threats are pollution, habitat loss, interaction with fisheries, over-harvesting of eggs and meat for body oil and beautiful shells, illegal hunting and predation of eggs by feral pigs, foxes, dogs and goannas (White, 2008; Wilson & Tisdell, 2011).

[36] Although use-values are often subdivided into 'direct' and 'indirect' use values, and there is some disagreement as to whether option values should be categorised as use of non-use values.

(b) Non-use values – those which do not require one to ‘use’ an environment or ecosystem - such as existence and bequest values. Existence values arise from knowledge of presence while bequest values arise from wanting to preserve something for future generations (Jakobsson & Dragun, 2001; Loomis & White, 1996).

There is a long history of using marine species for consumptive purposes, but the demand for non-consumptive uses of wildlife – particularly for recreational activities – has been also growing rapidly, worldwide (Wilson & Tisdell, 2011; Semeniuk, Haider, Beadmore, & Rothley, 2009). The story is no different in Australia where visitors/tourists regularly expect to interact with different types of wildlife such as

- Whales and Dolphins in and around the coast (Corkeron, 1995; Mühlhäusler & Peace, 2001)
- Dingoes on Fraser Island (Burns & Howard, 2003; Peace, 2001).
- Whale sharks in Ningaloo Marine Park, Western Australia (Davis, 1998; Catlin & Jones, 2010)
- Penguins at Kangaroo Island (Mühlhäusler & Peace, 2001) and Phillip Island (Head, 2000).
- Saltwater crocodiles in the Northern Territory (Tremblay, 2002)
- Turtles at the Mon Repos Conservation Park in Queensland (Wilson & Tisdell, 2011)

Numerous recreational studies have reported the importance of seeing wildlife, signs of wildlife, and ‘the psychological benefits of expecting to see wildlife during the activity’ (Catlin & Jones, 2010; Head, 2000). Some researchers have found that various species are ‘highly sought after and preferred by visitors, and that visitors are usually willing to pay greater amounts of money to see these’ (Miller, 2006, p.18). than other species. Yet despite the fact that many researchers around the world (White, Gregory, Lindley, & Richards, 1997; Hoyt, 2001; Parson, Warburton, Woods-Ballard, Hughes, & Johnston, 2003; Bosetti & Pearce, 2003; Bandara & Tisdell, 2005; Stanley, 2005; Togridou, Hovardas, & Pantis, 2006; Jianjun, Zhishi, & Xuemin, 2008; Ninan, 2007; Loureiro & Ojea, 2008; Nabangchang, 2008; Ojea & Loureiro, 2010) have estimated the use and/or non-use 'value' of different species, most studies have been undertaken in different parts of the United States. A selection of some of those studies (differentiated according to whether the researcher was estimating non-consumptive use values or non-use values) is presented in Table 5.1.

This is not to say that little research has been done on the GBR: indeed, there have been more than a dozen published studies that have investigated economic and financial 'values' associated with the tourism and recreational activities in the GBR Stoeckl et al. (2011) (see Table 5.2).

But, only one study has attempted to estimate the value of an individual species on the GBR: Stoeckl et al. (2010a); all other studies have, instead, valued activities (which may or may not be associated with individual species). That said, Stoeckl et al.'s (2010a) study was, like others, primarily focused on valuing an activity (specifically dive tourism) and included only a preliminary, descriptive analysis of data that focused in on particular species encountered whilst diving. As such, relatively little is known about the value of particular marine species (as opposed to the value of an activity that is associated with a variety of species).

This could be an important omission. A well-managed fisher will not put at risk the species it seeks to earn money from. But consumptive uses (e.g. fishing) will generally reduce stocks below that which would prevail in the absence of fishing, and there is evidence to suggest that this may affect non-consumptive uses (e.g. tourism values)

(Reynolds & Braithwaite, 2001). Kragt et al. (2009), for example, found that reef-trips in the northern section of the GBR could fall by as much as 80 % in response to a decrease in coral and fish biodiversity; Anderson and Waheed (2001) reported a decline in the dive-tourism sector in the Maldives – attributing at least part of this to the removal of reef shark populations by fishers; and Miller (2006) argues that if the ‘ attributes of dive sites [that are] significant to scuba divers’ are damaged …there might be a downward shift in the demand and visitation to a site’ (p. 25).

Table 5.1 Selected studies on non-consumptive use and non-use values of rare or endangered species

Source	**Region**	**Species**	**Non-consumptive Use Value US$**	**Non-use Value US$ or €**
Hageman (1985)	California, USA	Sea otter Blue or grey whales Bottlenose dolphins Northern elephant seals	$7.20	$13.62 $25 $18 $18
Samples and Hollyer (1989)	Hawaii, USA	Humpback whale		$172.92
Olsen, Richards, and Scott (1991)	Columbia River Basin, USA and Canada	Salmon and steelhead fish	$47.64	$26.52
Duffield and Patterson (1992)	USA	Cutthroat Trout		$13.02
Whitehead (1991; 1992)	North Carolina, USA	Sea turtle		$12.99
Cummings, Ganderton, and McGuckin (1994)	New Mexico, USA	Squawfish		$8.42
Loomis and Larson (1994)	California, USA	Grey whale		$17.15-$ 31.51
Lupton (2008)	Tofo beach, Mozambique	Manta ray Whale shark	$57 (divers) $50 (divers) $69 (snorkelers)	$14 (divers) $58 (snorkelers)
White (2008)	USA	Sharks Sea turtle Corals	$35.36 $29.63 $55.35	
Hageman (1985)	California, USA	Blue and Grey Whales Bottlenose Dolphins California Sea Otters Northern Elephant Seals		$2.34-$17.15 $2.21-$12.20 $2.49-$13.62 $1.16-$13.50
Ressurreiçãoa et al. (2011)	Pico and Faial Islands, Portugal	 Algae Fish Mammals All marine species Algae Fish Mammals All marine species		<u>Visitors</u> 66 € - 77 86 €- 100€ 85 €- 99 € 581 € - 665 € <u>Residents</u> 45€ - 51 € 58 €- 66 € 58 €- 66 € 405 € - 463€
Stithou (2009)	Zakynthos Island, Greece	Sea Turtle Monk Seal Sea Turtle Monk Seal		<u>Visitors</u> 13€ - 19 € 13€ - 18 € <u>Residents</u> 29.60€ - 32 € 30€ - 40 €

Table 5.2 Selected valuation studies on the GBR

Source	Type of activity	Method used	Economic measure	Estimated values
Hundloe, Vanclay, and Carter (1987)	Recreation	TCM, CVM	CS, WTP	CS for domestic & international visitors = AUS $144 million/year for visits to the GBR; CS for reef visits only = AUS $106 million/year. WTP for reef visits = AUS $8/person.
Driml (1999)	Tourism	Productivity change	Gross financial value	AUS $759 million in 1996
Knapman and Stoeckl (1995)	Recreation	TCM	CS, Price elasticity	Price elasticity of demand 0.0005 to 0.0025
KPMG (2000)	Recreational boating & fishing	Productivity change	Gross financial value	Changed from AUS$112 million in 1993-94 to AUS$107 million in 1997-99
PDP Australia (2003)	Recreational fishing	Expenditure	Total recreational fishing expenditure	Was estimated to be between AUS $80.7 and $200 million a year.
Carr and Mendelsohn (2003)	Recreation	TCM	Total value	Total recreational value of the GBR between US $700 million & US $1.6 billion per year. Domestic value of recreation = US $400 million.
Access Economics (2005)	Recreational activities	Input-output tables	Total value added	For Australia AUS $548 million for 2004-05
Asafu-Adjaye, Brown, and Straton (2005)	Recreational boating & fishing	Productivity change	CS	CS = AUS $127.7 million per year
Access Economics (2007)	Recreational activities	Input-output tables	Total value added	For GBRMCA AUS $3,669 million For QLD $4,450 million For Australia $5, 712 in 2005-06
Access Economics (2008)	Recreational activities	Input-output tables	Total value added	For GBRMCA AUS $3 558 million For QLD $3 951 million For Australia $5 409 in 2006-07
Kragt, Roebeling, and Ruijs (2009)	Recreational trips	CBM	CS	CS = AUS $185 /person/trip.
Windle & Rolfe [59]		Choice experiment	Benefits and costs of improving water quality	Annual total benefits AUS $ 19.9 - $23.6 million Annual total costs AUS $8.92
Rolfe and Windle (2010)		Choice modelling experiment	Use and non-use values to protect the health of the GBR	The total national value for a 1% improvement in the health of the GBR ranges from between AUS $433.6 million to a high of AUS $811.3 million
Prayaga, Rolfe, and Stoeckl (2010)	Recreational fishing and beach activities	CVM, TCM	CS	The total annual CS for recreational fishing = AUS $5.53million.
Rolfe, Gregg, and Tucker (2011)	Recreational activities	TCM	Recreational use values	Average values per person per trip per day were estimated at AUS $35 for beaches, $331 for Islands, and $183 for fishing, boating and sailing activities
Stoeckl, Birtles, Farr, Mangott, Curnock, and Valentine (2010)	Tourism	Expenditure	Generated income	Between AUS $16.06 million and $27.6 million per annum to the Cairns/Port Douglas region

Those charged with managing potential conflicts between different uses (and/or user groups) may thus find it useful to have information about both consumptive and non-consumptive values. Moreover, visitors are likely to have different preferences with regard to the species that are most important to view and it could be useful 'to gear marketing strategies towards the availability of such species to accommodate and maximize tourist interest' (Okello, Manka, and D'Amour, 2008, p.752). Species-level studies may also be useful if seeking to target monitoring activities – expending resources on species that are considered 'important' to tourists (in addition to those considered important by scientists).

This chapter thus helps to fill an existing, and potentially problematic, research gap. I used the Kristrom, logit, spike model, to analyse contingent valuation (CV) data collected from more than 2000 visitors to the Northern section of the GBR. The CV data related to the non-consumptive value of several broad groups of species including: whales and dolphins; sharks and rays; large fish; marine turtles; and a 'wide variety of wild life' (this last item is clearly not a species, but was included for reference, and for simplicity, referred to as if it were a 'species' in this chapter; hereafter termed 'variety').

I used payment cards (PC) to elicit visitor willingness to pay (WTP) for a "100% guarantee" of sighting different species while on their trip. Methodological details (and an associated discussion of relevant research) are provided in Appendix 4, but to summarise here, the experimental design allowed me to not only determine which species were of most/least 'value' to different types of visitors, but to also investigate the extent to which variations in methodological approaches (e.g. bid-end values, bid presentation orders, and the 'menu' of species presented for evaluation) affected final WTP estimates. Results (about which species were 'most' or 'least' important) were robust across methodological specifications, thus giving confidence in the reliability of the observations.

5.2 The survey

5.2.1 Study area and data collection

Many reef trips are typically involve viewing of multiple species, but in the Northern section of the GBR (the focal region of this study) some species are only available to tourists at certain times of year and/or at certain locations. As such, those interested in ascertaining the relative value of a range of different species need to (a) survey a range of different trips, taken at different times of the year, and (b) make allowances for the multi-species nature of most trips. The study described in this chapter thus collected data (via self-administered questionnaires) from visitors who undertook one of five different boat trips to different parts of the region between 2007 and 2009 – see Figure 5.1.

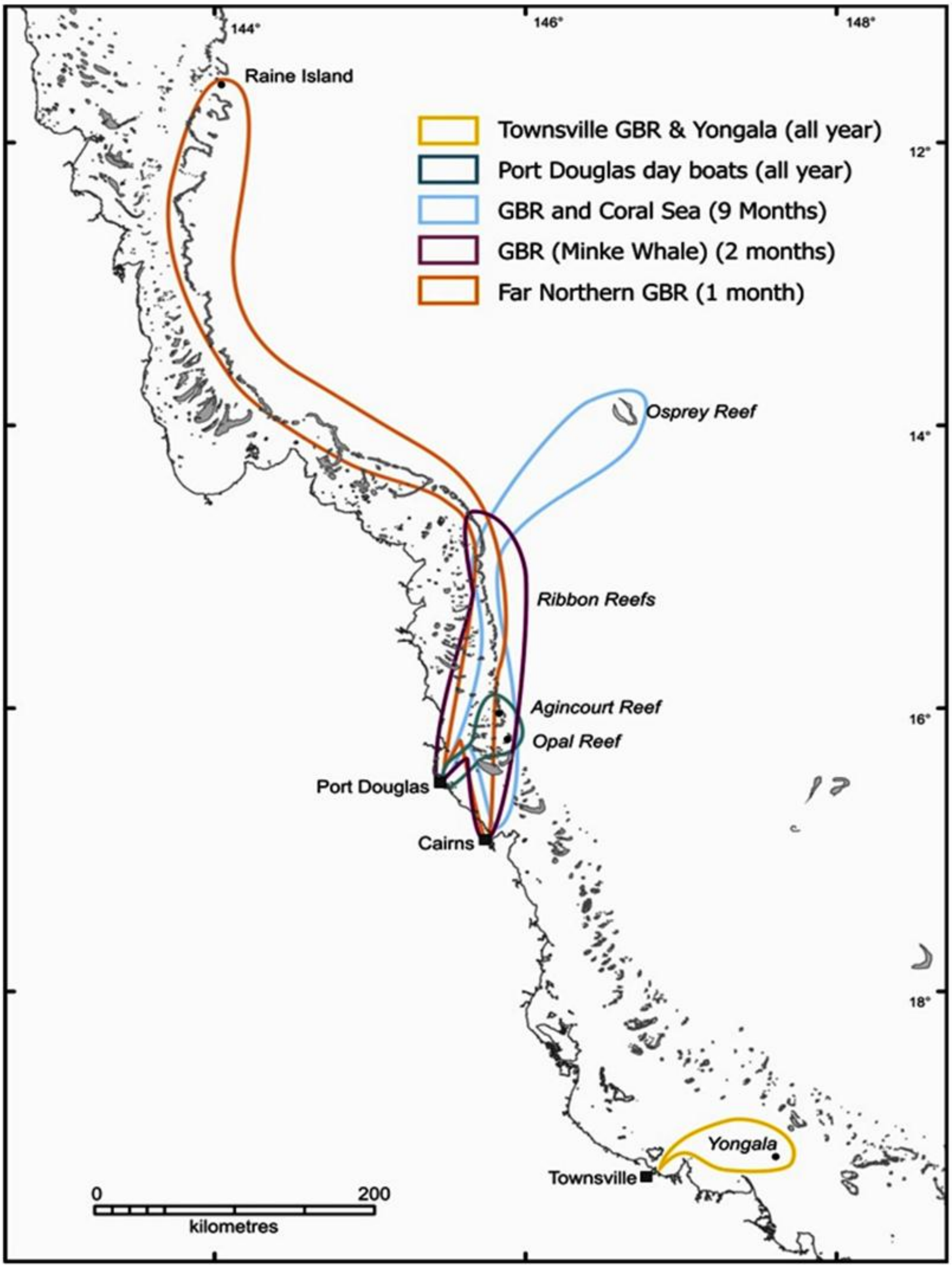

Figure 5.1 Survey areas (Source: Stoeckl et al., 2010a)

A detailed discussion of the survey can be found in Stoeckl et al. (2010b), a summary of which is provided below:

- A survey of passengers going to the Far Northern Section of the GBRMP was conducted on two live-aboard dive tourism vessels (*Undersea Explorer* and

Nimrod Explorer) over 2007-2008 for a period of about a month between October and December. The response rate was calculated at 85 %. Among the range of Reef species encountered on these trips, a key feature of such trips included the opportunity to see and interact with large breeding aggregations of marine turtles in the vicinity of nesting islands/cays.

- A survey was conducted of passengers travelling the Ribbon Reefs with regular scheduled trips (weather dependent) to Osprey Reef in the Coral Sea on five live-aboard dive vessels (*Undersea Explorer, TAKA*, *Spoilsport*, *Nimrod Explorer* and *Spirit of Freedom*). Questionnaires were collected on these trips between November 2007 and December 2008 and the response rate was calculated at 24.3%. Among a range of Reef species encountered regularly, reliable sightings of potato cod occur at the Cod Hole and reliable sightings of white-tip reef and grey reef sharks occur at Osprey Reef in the Coral Sea (in association with feeding/attraction activities).
- A survey of passengers undertaking boat trips to see and 'swim with minke whales' was conducted over two the dwarf minke whale seasons (June-July) 2007 and 2008. Questionnaires were collected from the eight swim with minke whales (SWW) endorsed vessels (including both live-aboard and day-boats). The overall response rate for day and live-aboard trips was 44 %.
- In 2008, passenger surveys were also collected from three non-(minke) permitted Port-Douglas based Reef day-boats: *Haba, Wavelength* and *Calypso*. The survey was conducted during June and July 2008 and the response rate was calculated at 48.9%. A range of Reef species are encountered regularly however reliable sightings of some large resident fish (e.g. Maori wrasse, Malabar cod) and resident turtles are reported for some frequently visited sites. When operating during June / July these boats occasionally encounter dwarf minke whales – and the frequency

of sightings on these vessels has been estimated to occur on between one in five and one in ten days (Mangott, Birtles, Arnold, & Curnock, 2005).

- A survey was conducted of passengers travelling to the S.S. Yongala wreck on two day-trip operations (*Pro Dive/Adrenalin Dive* in Townsville & *Yongala Dive* in Ayr). Data collection commenced in June 2008 and finished in April 2009, and the response rate was 26.6%. The Yongala wreck provides reliable sightings of a range of key species that can be found on the wreck year-round. Such wildlife species include Queensland grouper, marine turtles, large schools of pelagic fish (e.g. trevally) and reef fish (e.g. small mouth nannygai, batfish), other large resident fishes (e.g. Maori wrasse, coral trout, cobia, mangrove jack), rays (e.g. resident marbled rays and occasional sightings of eagle and manta rays) and occasional sightings of bull sharks.

There was a significant difference in response rate because some operators were particularly supportive of the study (Far Northern live-aboard boat trips). These trips were longer, only two boats were involved and there was ample time available for the crew to distribute and collect questionnaires. Other trips such as those to the Ribbon Reefs and Yongala were shorter and more boats were involved. Some of the operators were less supportive of the study for various reasons (carrying higher number of passengers, high crew turnover, and busier itineraries) and the surveys were simply made ‘available’ – rather than actively distributed and collected – on some trips.

Across all groups, visitors were asked to indicate their WTP for a 100% guarantee of sighting 6 different items: Whales and Dolphins, Sharks and Rays, Marine Turtles, Large Fish, ‘Variety’, and seabirds. But not all groups of visitors were asked to evaluate the same ‘menu’ of species. For example, researchers who collected the data considered that it was extremely unlikely that passengers travelling to the Far Northern Section of the

GBR would encounter whales (particularly between November and February). So these visitors were not asked to indicate their WTP for a guaranteed sighting of those marine mammals. And day boat visitors were not asked questions about sea-birds because the 2007 data clearly indicated that the 'values' for seabirds were extremely low, with significant non-response rates. Moreover, many day-boats did not feature seabirds at all in their itineraries. Asking these boats about sea-birds would thus be akin to asking the Far Northern passengers about Whales (largely irrelevant and thus an unwanted distraction for most tourists).In addition to having four different versions of the WTP question (with two different bid-end values, and two different bid presentation orders), this study case also had three different 'menus' of species presented for evaluation as presented in Table 5.3.

Table 5.3 Species presented for evaluation

	Menu 1: presented to passengers on the Far Northern and Ribbon & Osprey live-aboard trips	**Menu 2**: presented to passengers on the Minke Whale live-aboard trips	**Menu 3:** presented to passengers on Day-boat trips (including the Yongala, Minke-whale and Port-Douglas trips)
Whales and Dolphins		X	X
Sharks and Rays	X	X	X
Marine Turtles	X	X	X
Large Fish	X	X	X
'Variety'	X	X	X
Seabirds	X	X	

I thus grouped responses accordingly, which allowed me to use empirical techniques to test for, and where necessary, control for, differences in WTP associated with the experimental design.

5.2.2 Number of responses and respondent characteristics

The number of respondents by type of boat trip and total number of respondents are shown in Table 5.4.

Table 5.4 The number of respondents by type of boat trip

Type of trip	**Size of sample**
Far Northern live-aboard	**130**
Ribbon & Osprey live-aboard	**639**
Minke live-aboard	**440**
Minke day-boats	**467**
Port Douglas day-boats	**386**
Yongala	**118**
Total	**2180**

Amongst other things, respondents were asked to provide some general background information: their age and gender; where they came from and their previous visitation history to this part of the GBR. Researchers who collected the data did not seek information about income, but instead sought information that allowed me to generate an estimate of total expenditure whilst in the region[37] - using this as a proxy for income/wealth[38]. I examined questions that explored many other issues, but they were

[37] That is, they were asked to indicate the approximate amount that they had spent per day on different categories of goods, the total number of days they spent in the local region (Cairns/Port Douglas, or Ayr/Townsville depending upon sample) before and after the boat trip. I then used survey responses to estimate the average daily expenditure of visitors to the region when on land (i.e. in Cairns and Port Douglas) and then multiplied these by the number of days spent in the region before and after the boat-trip, to generate an estimate of total (non-boat) regional expenditures.

[38] The main reason for including measures of income in empirical studies is to account for the fact that WTP is a function of ability to pay. I wish to capture the heterogeneity of tastes that arises because of differences in wealth/income. There is 'the longstanding debate among economists' (Noll, 2007, p.4) on

not found to significantly influence WTP; hence my analysis focuses only on those that do.

Table 5.5 Visitors characteristics

	Far Northern live-aboard	Ribbon & Osprey live-aboard	Minke live-aboard	Minke day-boats	Port Douglas day-boats	Yongala
Proportion Male	0.62	0.61	0.44	0.50	0.40	0.52
Proportion Australian residents	0.34	0.29	0.36	0.50	0.56	0.37
Proportion first-time visitors to the GBR	0.38	0.57	0.53	0.64	0.64	0.83
Mean Age (years)	46.75	38.29	34.01	35.03	35.67	31.14
Mean total (non-boat) regional expenditure plus price of trip (AUS$)	5344	3648	3498	3359	3452	1382

As shown in Table 5.5 the proportion of male respondents was higher for the Far Northern trips then for the other samples. There were fewer international visitors on the Minke and Port-Douglas day boat trips, and many more first-time visitors to the GBR in

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what is the better indicator of well-being or welfare: income or expenditure. The main argument supporting expenditures follows Friedman's (1957) conception of the 'permanent-income hypothesis' that household expenditure has relatively low fluctuation overtime than current incomes which fluctuate significantly both in a short term due to job losses or job changes (Goodman & Oldfield, 2004; Noll, 2007) or in a long term due to 'running up or down savings or debt' (Noll, 2007, p.4). Many empirical studies use current expenditures (Gibson & Kim, 2011; Wadud, Graham, & Noland, 2010) or current incomes as welfare indicators due to the short-term concept of welfare (Mitrakos & Panos, 1998). Current expenditure is often considered as a better proxy to lifetime income than current income because 'households tend to save and dissave in different periods of their life-cycles in an attempt to smooth their consumption and, thus, maximise their utility (assuming that utility is a positive but diminishing function of consumption)' [Mitrakos & Panos, 1998, p.1; Poterba, 1991; Metcalf, 1993; Goodman & Oldfield, 2004; West & Williams, 2004). Moreover, Deaton (1997) noted that in general households tend to underestimate their incomes or they can be more sensitive about revealing their income than their expenditure, so self-reported data that relates to expenditure may be more reliable than that relating to income (Younger, Sahn, Haggblade, & Dorosh, 1999; Deaton, 1997). Ogundari and Abdulai (2012) results supported their arguments. Partly because of these reasons and partly because the majority of tourists on these trips live outside Australia (approximately 59%), making it difficult to know how best to compare incomes across respondents (Using purchasing power parity or the real exchange rate prevailing on the day the questionnaire was completed or the exchange rate prevailing on the day the trip to Australia was booked) current total expenditure whilst in the region was used in this study. I recognise that expenditure cannot be expected to provide an accurate measure of consumer wealth/income; but it is, at least likely to provide reasonable reflection.

Yongala than elsewhere. Mean total regional expenditure was considerably higher in the Far Northern sample, than in Yongala.

5.3 Results

For the reasons outlined previously, I divided the responses into three groups – to reflect the different ‘menus’ presented for evaluation. Figure 5.2 shows the distribution of responses to the WTP questions for each of these different species/menu groups, and Appendix 4 gives details on the open ended responses.

There were a substantial number of respondents with zero WTP, justifying my decision to use a special case of the Kristrom Spike model applied by Hackl and Pruckner (1999) and Hu, Woods, Bastin, Cox, and You (2011) for payment card valuation question (details of the model are provided in Appendix 4).

As noted earlier, I was cognizant of the fact that responses may differ for a variety of reasons introduced through aspects of the study design. These include differences in

a) upper bid ($150 or $300);
b) bid-order ; and
c) the list of species presented for evaluation

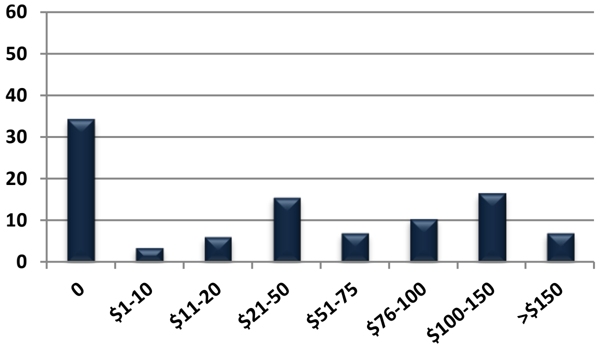
Various statistical tests were thus used to assess the need for, and where evident, control for, the impact of these factors on final estimates concluding that it was necessary to estimate six different models each relating to one of three different ‘menus’ and two different bid ranges (see Appendix 4 for details). Table 5.6 provides some descriptive statistics for the variables used within these models together with the coefficients from the maximum-likelihood estimation of the spike models.

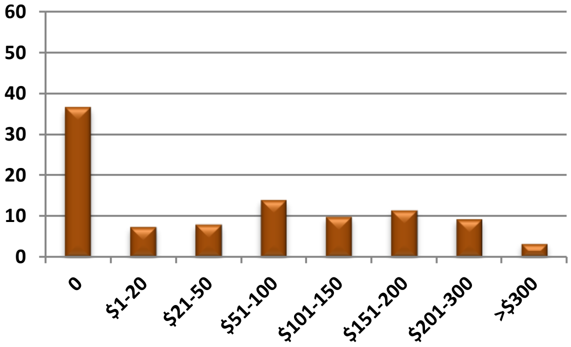
Figure 5.2 Distribution of WTP responses for each species by type of menu

Far Northern and Ribbon & Osprey live-aboard trips

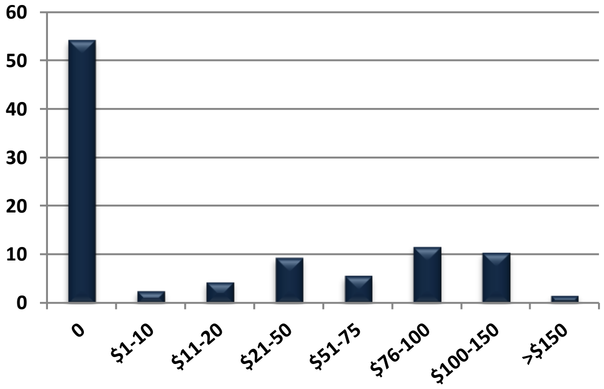
$150 data subset | **$300 data subset**

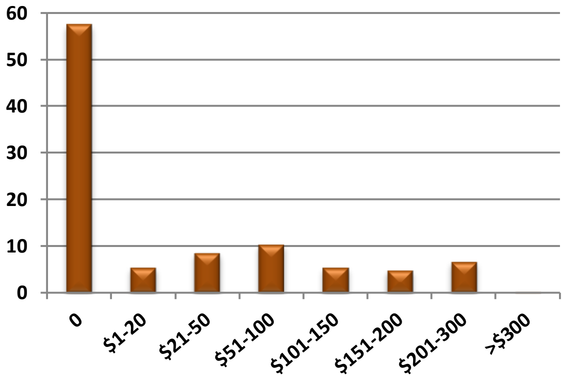
Sharks and Rays



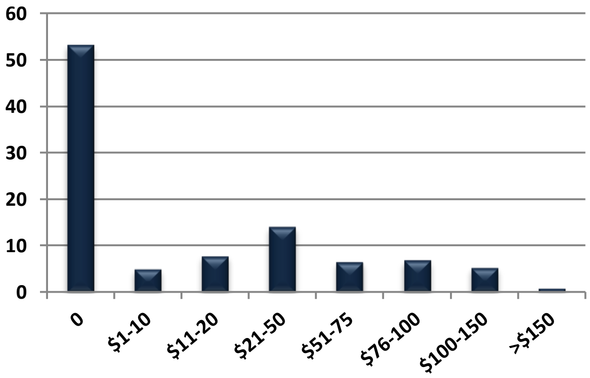


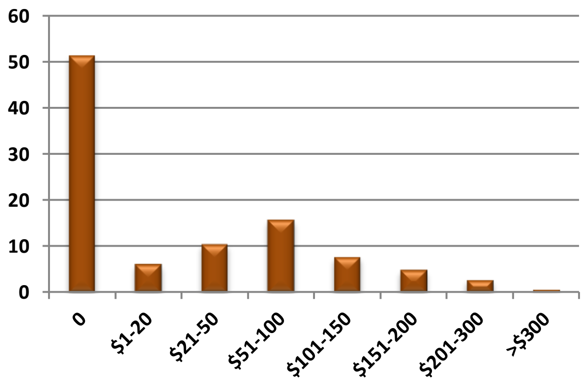
‘Variety’



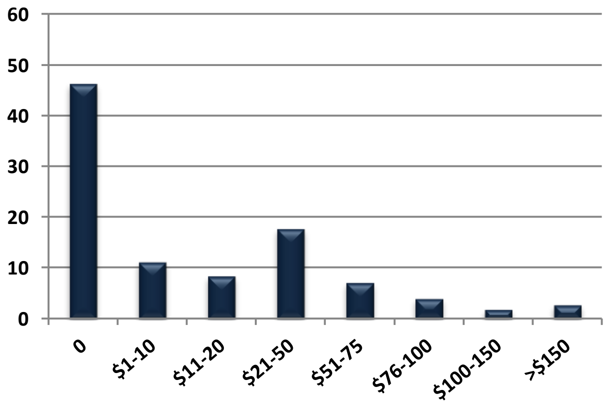


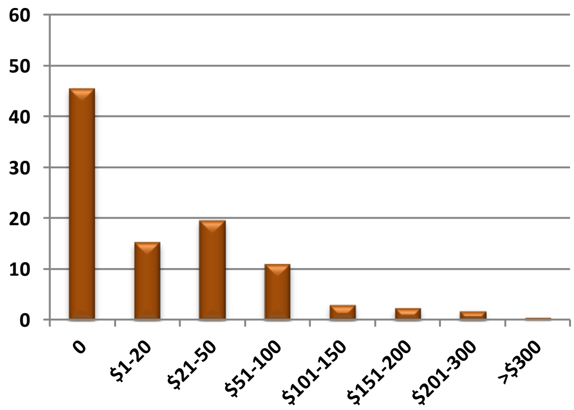
Marine Turtles





Large Fish

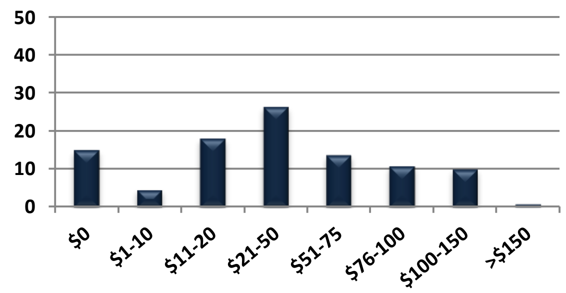


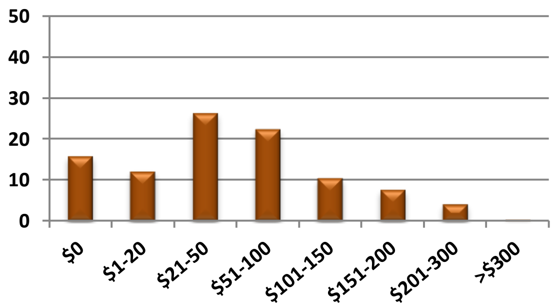


Day-boat trips (Yongala, Minke Whale and Port Douglas trips)

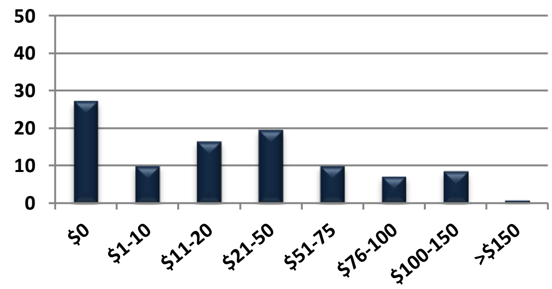
$150 data subset **$300 data subset**

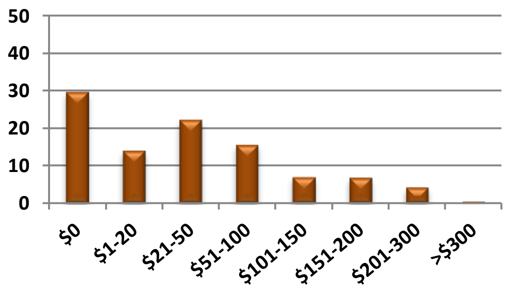
Whales and Dolphins



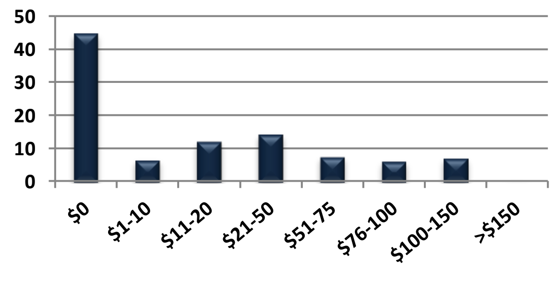


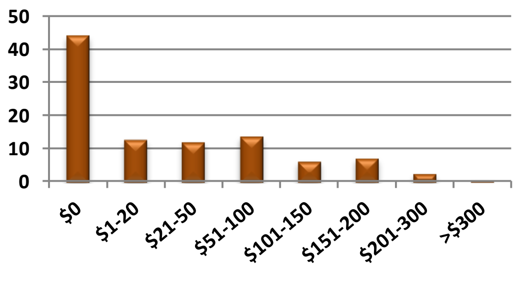
Sharks and Rays



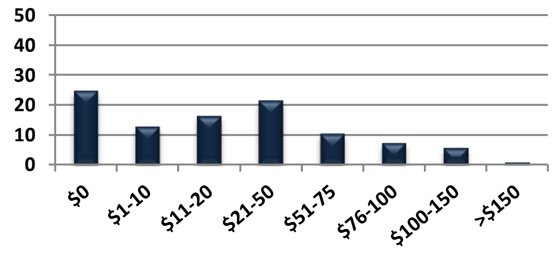


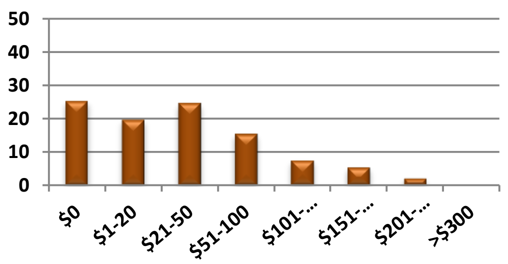
'Variety'



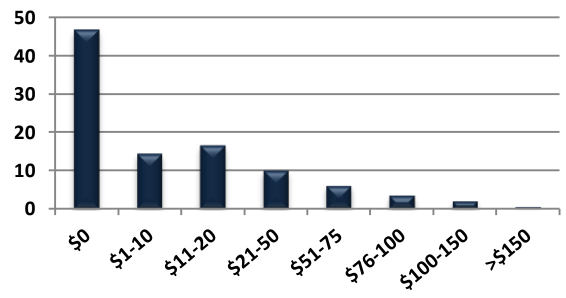


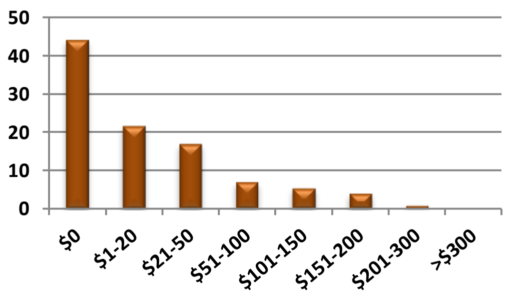
Marine Turtles





Large Fish

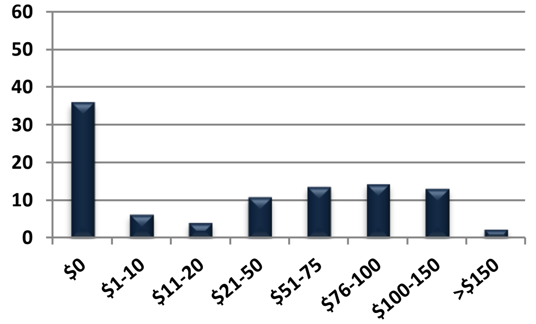


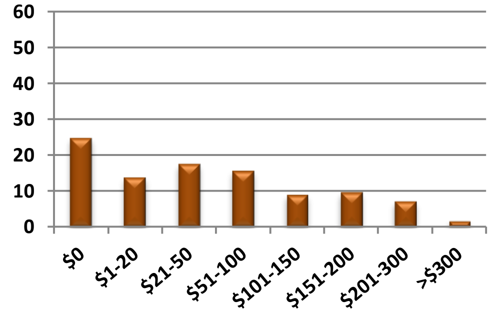


Minke Whale live-aboard boat trips

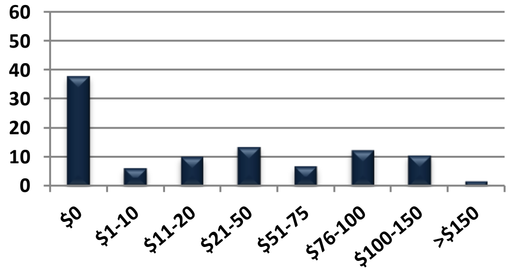
$150 data subset | **$300 data subset**

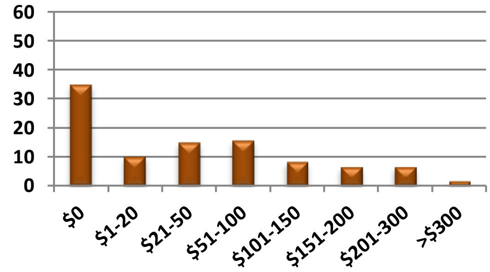
Whales and Dolphins



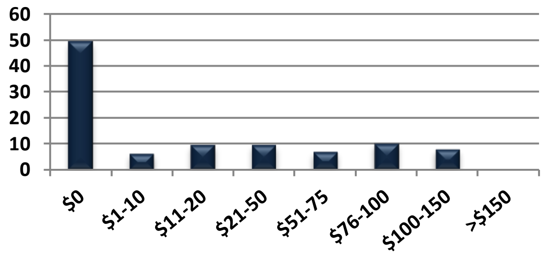


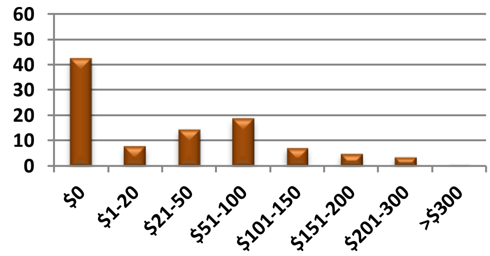
Sharks and Rays



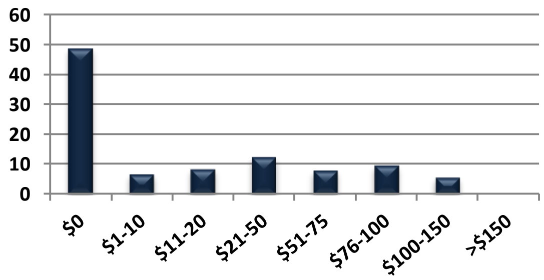


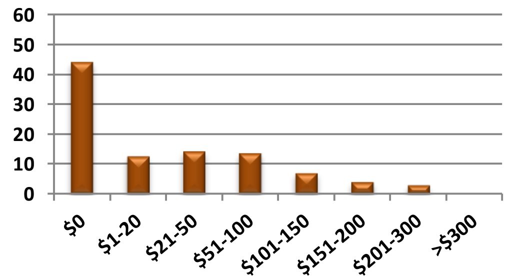
'Variety'



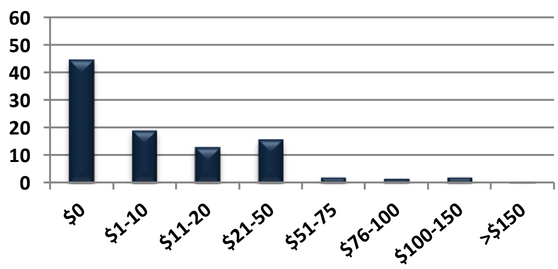


Marine Turtles





Large Fish



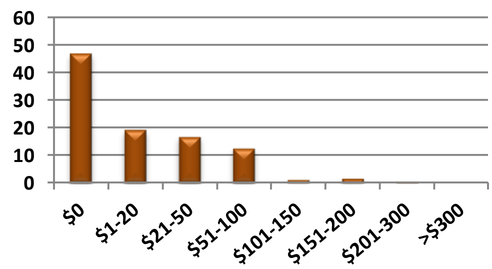


Table 5.6(a) Far Northern and Ribbon and Osprey Reef live-aboard boat trips

Variables	***Sharks and Rays***		***'Variety'***		***Marine Turtles***		***Large Fish***	
	Data subset		**Data subset**		**Data subset**		**Data subset**	
	$150	**$300**	**$150**	**$300**	**$150**	**$300**	**$150**	**$300**
Intercept	1.5028***	0.8632**	0.7356*	-0.1593	1.3778***	0.2713	1.7676***	-0.1708
	(0.4254)	(0.4235)	(0.3891)	(0.4065)	(0.3783)	(0.4552)	(0.3903)	(0.4356)
WTP offer	-0.0253***	-0.01435***	-0.0196***	-0.0130***	-0.0257***	-0.0178***	-0.0329***	-0.0255***
	(0.0019)	(0.0009)	(0.0017)	(0.0011)	(0.0023)	(0.0014)	(0.0029)	(0.002)
Age	-0.0376***	-0.0194*	-0.0270***	-0.0073	-0.0423***	-0.0192*	-0.0521***	-0.0058
	(0.0093)	(0.0095)	(0.0089)	(0.0106)	(0.0083)	(0.0111)	(0.0081)	(0.0101)
Mean	40.27	38.04	40.22	38.04	40.27	38.04	40.27	38.04
ExPrice	0.00012***	0.000055***	0.00004	0.000043*	0.000049	0.000107**	0.00006*	0.000047**
	(0.00003)	(0.00002)	(0.00003)	(0.00002)	(0.00004)	(0.00004)	(0.00003)	(0.00002)
Mean	3920.78	3952.56	3908.72	3952.56	3920.78	3952.56	3920.78	3952.56
Male	0.2477	0.3019	0.0056	0.0310	0.0320	0.1015	0.0444	0.5206**
	(0.259)	(0.2376)	(0.2580)	(0.2458)	(0.2508)	(0.2506)	(0.2544)	(0.2385)
Proportion	0.63	0.59	0.63	0.59	0.63	0.59	0.63	0.59
Australian Resident	0.1081	0.4414	0.1909	0.1296	0.2602	0.4883	0.2781	-0.0751
	(0.2928)	(0.2990)	(0.2933)	(0.2729)	(0.2886)	(0.3113)	(0.2885)	(0.2842)
Proportion	0.29	0.27	0.29	0.27	0.29	0.27	0.29	0.27
WTP Spike model estimate Mean	42.20	74.12	32.03	45.53	26.24	43.48	20.43	28.81
WTP simple mean	44.09	72.42	31.76	44.50	23.73	41.94	18.29	29.12
simple WTP / spike WTP	1.04	0.98	0.99	0.98	0.90	0.96	0.90	1.01
N	224	236	223	236	224	235	224	236
Log likelihood	-349.06	-410.02	-332.25	-350.18	-327.03	-354.84	-294.55	-354.24
Pseudo AIC	590.04	311.54	116.82	157.28	140.69	189.74	363.72	288.98

SE in parentheses ***Significant at 1% level **Significant at 5% level *Significant at 10% level

Table 5.6 (b) Day-boat trips (Yongala, Minke-whale and Port-Douglas trips)

Variables	***Whales& Dolphins***		***Sharks & Rays***		***Marine Turtles***		***'Variety'***		***Large Fish***	
	Data subset		**Data subset**		**Data subset**		**Data subset**		**Data subset**	
	$150	**$300**	**$150**	**$300**	**$150**	**$300**	**$150**	**$300**	**$150**	**$300**
Intercept	2.1169***	1.8366***	2.0351***	1.7944***	1.9711***	1.8413***	1.0079***	1.1950***	0.8090***	0.5545
	(0.2408)	(0.2701)	(0.2532)	(0.2833)	(0.2292)	(0.2705)	(0.2431)	(0.2732)	(0.2352)	(0.4098)
WTP offer	-0.04046***	-0.0264***	-0.0369***	-0.0228***	-0.0398***	-0.0282***	-0.0289***	-0.0197***	-0.0391***	-0.0302***
	(0.0020)	(0.0012)	(0.002)	(0.001)	(0.0021)	(0.0015)	(0.0019)	(0.0011)	(0.0029)	(0.0023)
Age	-0.0205***	-0.0146**	-0.0471***	-0.0374***	-0.0391***	-0.0254***	-0.0300***	-0.0257***	-0.0344***	-0.0248***
	(0.0047)	(0.0066)	(0.005)	(0.007)	(0.0048)	(0.0067)	(0.0053)	(0.0070)	(0.0049)	(0.009)
Mean	34.30	34.28	34.30	34.30	34.27	34.32	34.27	34.31	34.27	34.31
Expenditure+Price	-0.00002	-0.000007	0.000059**	0.000015	0.000066***	0.000025	0.00007***	0.000019	0.00007***	0.00023
	(0.00002)	(0.00002)	(0.00002)	(0.00003)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.0001)
Mean	3283.16	3114.11	3283.16	3109.13	3283.16	3113.98	3283.16	3119.47	3283.16	3114.11
Male	0.1007	0.0707	0.7719***	0.4545**	0.0218	-0.1716	0.0374	-0.2635	0.2660	0.2262
	(0.1848)	(0.1703)	(0.1873)	(0.1951)	(0.1825)	(0.1685)	(0.1961)	(0.1920)	(0.1891)	(0.2542)
Proportion	0.47	0.48	0.48	0.48	0.47	0.47	0.47	0.48	0.47	0.48
Australian Resident	0.2648	0.0096	-0.1519	-0.1915	0.2499	-0.1406	-0.1530	-0.1259	0.0300	-0.2904
	(0.1897)	(0.1935)	(0.1816)	(0.1943)	(0.1903)	(0.1883)	(0.2029)	(0.2027)	(0.1946)	(0.2417)
Proportion	0.49	0.53	0.49	0.52	0.49	0.53	0.49	0.53	0.49	0.52
WTP Spike model estimate Mean	42.56	59.97	33.82	48.31	32.64	43.82	26.72	39.94	17.72	29.79
WTP simple mean	43.85	66.33	33.92	52.67	31.73	46.63	27.09	43.54	16.56	29.75
simple WTP / spike WTP	1.03	1.11	1.00	1.09	0.97	1.06	1.01	1.09	1.03	1.11
N	344	338	344	338	344	338	344	337	344	255
Log likelihood	-646.18	-621.61	-586.89	-594.36	-594.72	-594.13	-547.19	-538.08	-506.35	-378.98
Pseudo AIC	395.36	368.24	301.57	313.36	334.94	330.32	502.23	232.87	240.62	399.71

SE in parentheses ***Significant at 1% level **Significant at 5% level *Significant at 10% level

Table 5.6 (c) Minke-whale live-aboard boat trips

Variables	***Whales& Dolphins***		***Sharks & Rays***		***'Variety'***		***Marine Turtles***		***Large Fish***	
	Data subset		**Data subset**		**Data subset**		**Data subset**		**Data subset**	
	$150	**$300**	**$150**	**$300**	**$150**	**$300**	**$150**	**$300**	**$150**	**$300**
Intercept	2.5187***	1.3535**	2.0245***	1.5632***	1.7592***	1.1058*	2.1133***	1.5677***	1.9572***	0.5126
	(0.4776)	(0.6000)	(0.4717)	(0.5849)	(0.4524)	(0.5970)	(0.4606)	(0.5864)	(0.4493)	(0.5699)
WTP offer	-0.02629***	-0.0209***	-0.0257***	-0.0221***	-0.0263***	-0.0202***	-0.03109***	-0.0209***	-0.04839***	-0.03327***
	(0.0027)	(0.0018)	(0.0027)	(0.0021)	(0.0029)	(0.0021)	(0.0036)	(0.0022)	(0.0064)	(0.0038)
Age	-0.0447***	-0.0368**	-0.0431***	-0.0539***	-0.0424***	-0.0387***	-0.0653***	-0.0482***	-0.0687***	-0.0337**
	(0.0103)	(0.0148)	(0.0105)	(0.0153)	(0.0111)	(0.0147)	(0.0127)	(0.0144)	(0.0108)	(0.0145)
Mean	33.82	32.15	33.82	32.15	33.82	32.15	33.82	32.15	33.82	32.15
ExPrice	0.000018	0.00007	-0.00003	0.00012	-0.00004	0.000029	0.000045	-0.00001	0.00002	0.00007
	(0.00004)	(0.00008)	(0.00005)	(0.00009)	(0.00005)	(0.00007)	(0.00005)	(0.00007)	(0.00005)	(0.00007)
Mean	3695.62	3474.17	3695.62	3383.52	3695.62	3474.17	3695.62	3474.17	3695.62	3474.17
Male	-0.6552*	0.6085*	-0.0282	0.4025	-0.1904	0.2682	-0.2839	0.0950	-0.0643	0.2269
	(0.3480)	(0.3514)	(0.341)	(0.3558)	(0.3391)	(0.3408)	(0.3590)	(0.3553)	(0.3462)	(0.3520)
Proportion	0.44	0.46	0.44	0.46	0.44	0.46	0.44	0.46	0.44	0.46
Australian Resident	0.0597	1.2110***	0.1558	0.9017	-0.1332	0.6198*	0.5606	0.7296*	1.3368***	1.1430***
	(0.3959)	(0.3871)	(0.3969)	(0.4083)	(0.4118)	(0.3738)	(0.4250)	(0.3771)	(0.3895)	(0.3863)
Proportion	0.36	0.37	0.36	0.37	0.36	0.37	0.36	0.37	0.36	0.37
WTP Spike model estimate Mean	44.72	67.88	37.89	51.39	27.23	42.72	24.76	40.79	16.05	23.98
WTP simple mean	43.99	67.66	36.52	58.47	28.85	47.18	27.08	41.19	13.58	22.63
simple WTP / spike WTP	0.98	1.00	0.96	1.14	1.06	1.10	1.09	1.01	0.85	0.94
N	113	111	113	119	113	111	113	111	113	111
Log likelihood	-193.32	-203.27	-187.53	-195.69	-176.89	-171.41	-163.75	-175.74	-128.62	-153.41
Pseudo AIC	74.57	307.87	81.24	145.40	79.78	135.17	90.67	93.14	82.89	104.84

SE in parentheses ***Significant at 1% level **Significant at 5% level *Significant at 10% level

The signs of the WTP offer coefficients are negative (and highly significant – at the 1% level) in all models: results are thus consistent with economic theory and previous WTP studies. Moreover, where significant, the coefficient on respondent expenditure (a proxy for income/wealth) is positive (significance differs across models and species); which is also consistent with economic theory and with previous empirical studies. The coefficient on age is negative, confirming observations from the literature (for example, Lupton, 2008, found that younger people are willing to pay more to encounter manta rays and sharks than the older people). Evidently, the models are 'sound'.

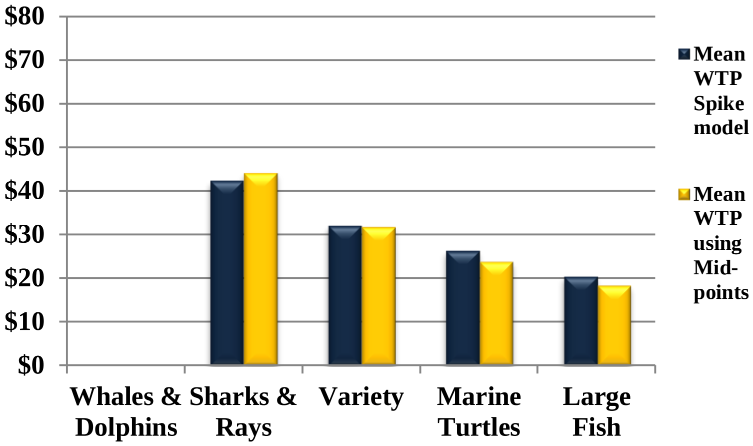
On day boat trips males have a higher WTP to see sharks and rays than females, and Australian residents who were presented with menu option 2 (those on Minke-whale live-aboard boat trips) are willing to pay more for large fish, whales and dolphins, marine turtles and for a wide variety of wildlife than other visitors (those on the Far Northern and Osprey reef live-aboard trips).

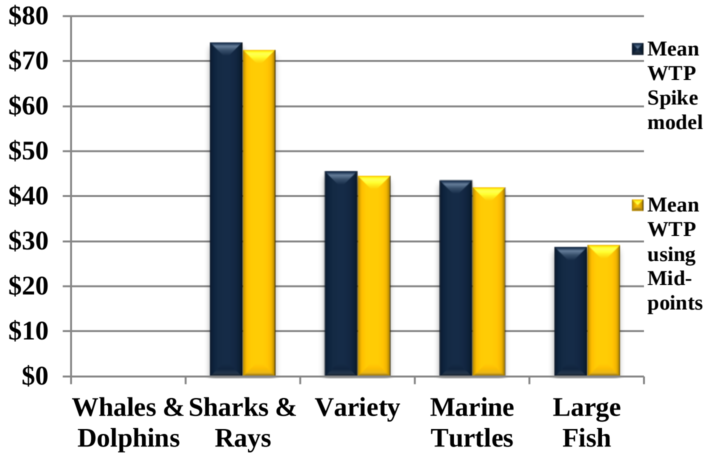
In line with other researchers (Kristrom, 1997; Nahuelhual-Munoz, Loureiro, & Loomis, 2004) means estimates of WTP for each model were generated using the formula $\ln[1 + \exp(\alpha)]/\beta$, (calculated at the mean of the non-bid independent variables). These estimates are consistent with other estimates of non-consumptive use values in the international literature (see Table 5.1).

Figure 5.3 Mean WTP estimates – by bid-range, menu, and estimation type

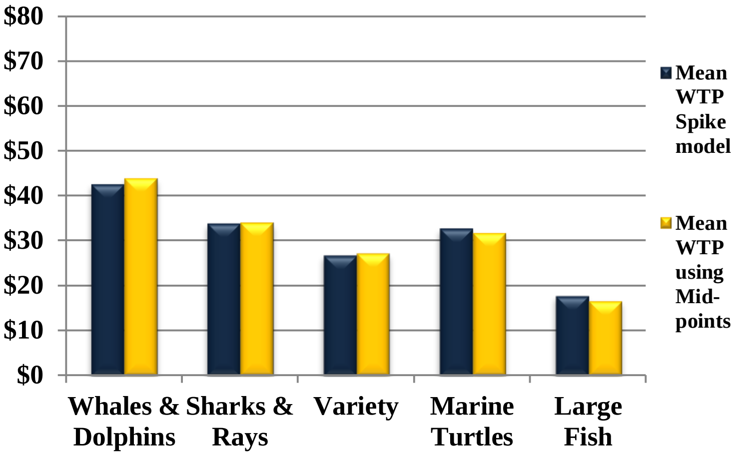
$150 subset **$300 subset**

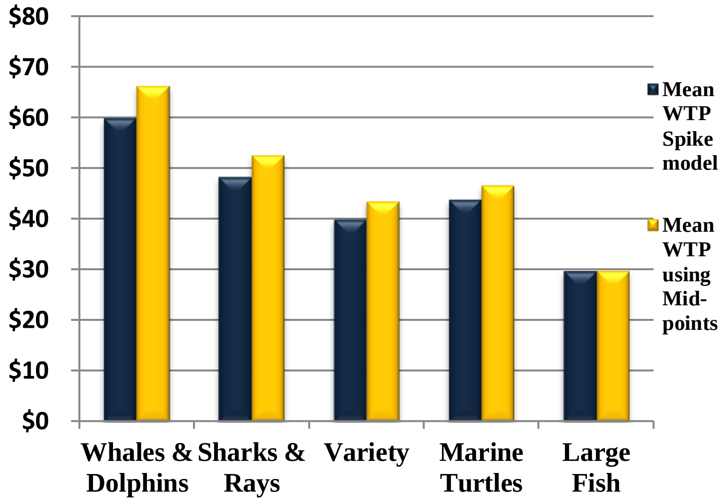
Menu 1: Far Northern and Ribbon & Osprey live-aboard



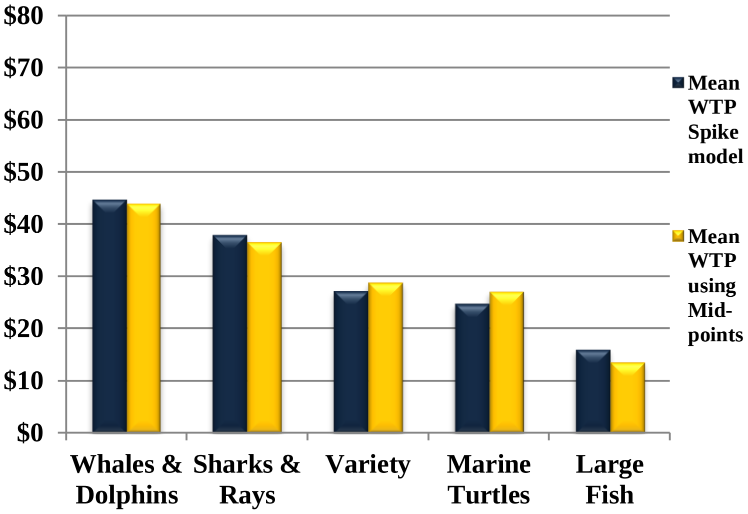


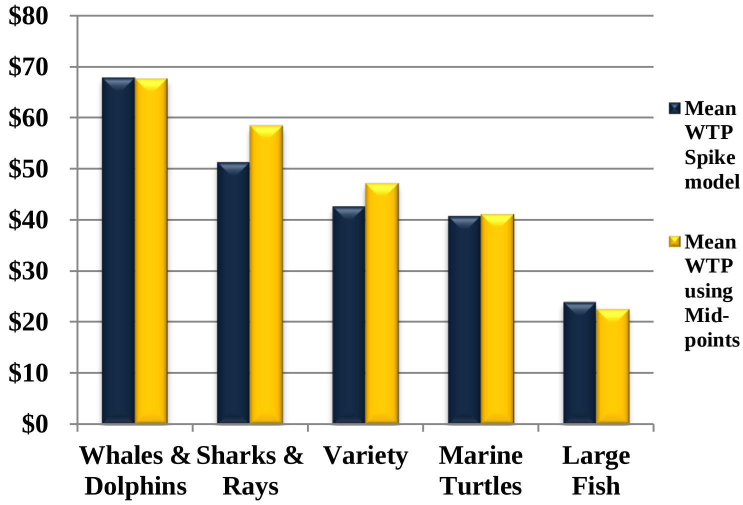
Menu 2: Day- boat trips (Yongala, Minke Whale and Port Douglas trips)





Menu 3: Minke Whale live-aboard boat trips





These estimates were then compared with simple WTP estimates generated by taking the mid-point of each interval from the raw data (e.g. if a respondent indicated they would be willing to pay between $1 and $20, this was recorded as $10.5), allowing a few additional observations (see Figure 3 and Table 6):

1. As expected from the literature (Cameron & Huppert, 1989), estimates of WTP that were generated from mid-points, do not precisely match those generated from the Spike model. But the differences are generally relatively small (e.g. mid-point estimates are generally within 10% of the spike-model estimates – the biggest difference is 14%).

2. As might have been expected given the results from the Likelihood Ratio Tests (LRT), estimates of WTP differ according to the ‘menu’ presented for evaluation. These differences are likely to reflect more than just differences in experimental design – because different menus were presented to visitors taking trips that differed significantly in nature (e.g. day-boat versus live-aboard). Far Northern and Ribbon and Osprey Reef visitors are willing to pay more for sharks and rays than day boat and Minke-whale live-aboard boat visitors. Minke-whale live-aboard boat tourists are prepared to pay more for whales and dolphins than day boat tourists. Nevertheless, it is important to note that estimates of mean WTP associated with any particular species, for any given bid-range, generally vary by less than 20%.

3. Also expected was the evidence of bid-range bias with the mean estimates of WTP varying across questionnaire formats (see Table 5.6). The upper bid ($150) presented in the first set of questionnaires was exactly one-half that of the other set of questionnaires ($300) and as was expected the upper bid induces higher WTP

than the lower bid but this relationship is not linear. Evidently, there is upper bid-effect that warrants future investigation (see Figure 5.3).

That the variation in mean estimates of WTP varies more across bid-range (point 3), and menu/context (point 2) than across estimation technique (point 1) suggests that questionnaire and survey design are more important determinants of the ‘accuracy’ of final WTP estimate than are econometric techniques. Evidently, researchers need to put as much attention into issues associated with questionnaire design as they do into questions associated with data analysis (something not immediately obvious from much of the valuation literature which tends to place a heavy emphasis on econometric methods).

That point aside, it is important to note that the relative importance and, therefore, ranking of species (from ‘most’ to ‘least’ valued) is quite robust across specifications (see Figure 5.3): irrespective of menu, survey site, bid-range or of estimation technique (mid-points or spike model). In all cases, the most valued groups were (in order) whales and dolphins, followed by sharks and rays. ‘Variety’ figured next in the ranking then marine turtles (except for day boat trips where marine turtles were valued more than ‘variety’ but the difference between the WTP estimates were relatively small) and finally large fish (see Tables 5.6 and Figure 5.3).

5.4 Conclusion

The research described in this chapter used data from a study of 2180 domestic and international visitors taking reef trips to the Northern section of the Great Barrier Reef to investigate (a) visitor willingness to pay for a "100% guaranteed sighting" of several different marine species; and (b) the sensitivity of final estimates to various methodological issues. My results show that final estimates were particularly sensitive to the upper bid value presented on the payment card, but that the ranking of species (from most to least 'valued') is robust across a range of methodological specifications.

Unless one can control for the influence that questionnaire design has on final estimates, one must be careful to ensure that end-users of this type of research (e.g. policy makers) do not misinterpret results. WTP estimates – like those presented here – are not precise indicators of value that can be compared to other dollar denominated values which have not, themselves, been subjected to such influences[39] (e.g. derived from similar questionnaires with similar bid ranges). And the use of sophisticated and complex statistical techniques cannot substitute for time and effort spent on questionnaire design ('simple' estimates in this study did not differ substantially from the estimates generated from a complex model).

This does not mean that CV studies cannot generate useful information. My research clearly shows that the method is able to provide robust information about the comparative 'value' of a non-market good (e.g. the non-consumptive value of a shark) relative to the 'value' of another good (e.g. marine turtles) presented in the same questionnaire. Precise cardinal estimates of value may elude, but ordinal estimates are clearly well defined in this instance.

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[39] It should be noted that price of the trip may already include some payment made in anticipation of seeing some of the marine species assesses. WTP also could depend on how many of the targeted species are seen, and tourists may be willing to pay even if there is not a 100% chance of seeing these species'

I found that, across all visitors, the most valued animals were whales and dolphins, followed by sharks and rays. 'Variety' figured next in the ranking, then marine turtles and finally large fish.

That whales have significant non-consumptive/tourism values is relatively well documented in the literature – and this research confirms those findings for the Northern section of the GBR. My research also serves to highlight the fact that sharks and rays have non-consumptive values which are almost as high as those associated with whales and dolphins. This observation is consistent across a variety of different visitor 'types' (e.g. across different age and expenditure groups).

Whether or not such results hold in other parts of the GBR or the world in general, remains to be tested in other studies, but anecdotal evidence suggests that they may. Miller (2006) found that sharks and rays were listed as the 'best' experience by visitors across a range of GBR sites – a finding confirmed by other researchers (Shackley, 1998; Rudd, 2001) – and a survey conducted in England by the BBC called the '50 most important things to do before you die' found that the general public voted diving with sharks as number two (cited in Miller, 2006). Evidently, some species of sharks have significant non-consumptive values and should be protected in some areas of the world.

But this does not automatically mean that the 'best' policy response is to ban all shark fishing. 'Fishing' and 'watching' are not necessarily mutually exclusive. Resource managers might thus derive great benefit from future research that, for example, develops bio-economic fisheries models which do not just allow for the 'externalities' (a cost or benefit that is incurred by a someone else (other party) who is not buying or selling the goods or services causing the cost or benefit (McTaggart, Findlay, & Parkin, 2007) that one fisher's harvest imposes on others, but which also allow for the externalities that a harvest imposes on non-consumptive users (e.g. divers and snorkelers) of the same fish stock. This is a non-trivial task, and it may take many years to develop models that can do so effectively and accurately. In the meantime, it is worth noting that the optimal harvests predicted by such models are unlikely to be zero, but they will almost certainly be lower than those predicted by models which fail to allow for the recreational values of marine species to 'watchers', divers or snorkelers. Natural resource agencies around the world thus need to start recognising the importance of these types of non-consumptive values – a trend which is apparent and heartening.

6 General Discussion and Conclusion

Abstract/Chapter overview

In this chapter I summarise the key findings of my thesis and discuss methodological and empirical contributions relating to the demand for and marginal values of recreational fishing, recreational boating and tourism sectors.

6.1 Introduction

As discussed in Chapter 1, users of marine resources such as commercial and recreational fishers and tourism operators often compete with one another for access to scarce resources. One of the biggest challenges facing natural resource managers is thus to determine how best to allocate scarce resources across these users. The main aim of this thesis was to help refine methodological approaches to assessing demand for and the value of 'fish' to various sectors, focusing predominantly on the recreational fishing sector, partially on the tourism sector, and using the GBR as a study area. As such, my research focused on the challenge of managing and allocating one type of marine resource (fish) in the GBR[40].

6.2 Thesis outcomes

Chapter 2

My literature review identified a gap in the recreational fishing literature. This relates to the fact that most existing studies do not differentiate between the boating and fishing experience. But if one is interested in the problem of allocating scarce fish resources, it is important to focus on the demand for fishing – and this may differ from the demand for boating. Furthermore some monitoring programs and policy implementations need separate information about recreational fishing and boating or boat and land-based fishing. My literature review also identified a relative scarcity of relevant research on recreational fishing and boating activities in the GBR. Thus

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[40] The possibility of conflict could be minimal because the species favoured by tourists overlap little with those targeted by recreational fishers. Similarly for recreational and commercial fishers conflict will vary by species.

Aim 1 was to:

To disaggregate the fishing/boating experience, specifically seeking to

- provide information to managers of the GBR about the characteristics of boaters, boat and land-based fishers;
- determine if the factors which influence the probability of participating in boating activities are the same as those which influence the probability of participating in fishing activities; and
- determine if the factors which influence the intensity of boating, boat-based fishing, and land-based fishing trips are similar or different.

I used Townsville (a city adjacent to the GBR) as a case study area. The region has the second highest number of registered recreational boats in the GBRWHA and has been assessed as having the highest probability of recreational fishing (GBRMPA, 2012b; GBRMPA, 2010b). I collected the data via a mailout survey of randomly selected households in the Townsville region from both participants and non- participants in recreational fishing and boating. The survey was designed to collect data on a wide range of social and demographic factors which previous researchers had found to influence boating and fishing including: fishing and boating participation, preferences, consumptive orientation, occupation and education, migration and household income. Out of 2120 survey initially mailed, 656 valid responses were received while 173 letters were returned due to incorrect addresses or because the recipient had moved away or was deceased. The overall response rate was thus 33.7%.

I applied a hurdle model to identify important determinants of 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. I found that there are differences in determinants. Evidently, there are different demand curves for these activities, suggesting that one needs to look at them separately 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. Although open to further investigation, this general observation (about differences in drivers) is likely to be transferable to other contexts.

Context-specific empirical findings those are relevant to the GBR. Factors influencing boat ownership are gender, marital status and distance to the boat ramps. Married males who live a long way from the boat ramp are likely to own a boat. As regards the boat owners and relatively young people these people are also likely to participate in boating, boat fishing, or land-based fishing at least once in the last 12 months (see Table 6.1 below).

The probability of going boating at least once in the last 12 months differs from the probability of going fishing. Those who are employed as clerical or administrative worker and those on higher household incomes are less likely to go boat fishing but not boating. Relatively low income earners, long term residents and married people are most frequent boaters. Long term residents and people who are not employed as clerical or administrative workers go boat fishing more frequently. The frequency of land-based fishing trips increases when people get older.

As such, those interested in trying to predict likely demand for coast-guard services, or other boat-related infrastructures and/or those charged with developing regional policies that relating to recreational boating in general (e.g. those relating to boat ramps, sewage, pollution and marine crowding) could monitor boat ownership (associated with the probability of going boating at least once in the last 12 months); also income, length of residence and/or marital status (effecting frequency of use).

Table 6.1 Determinants of the probability of participation and frequency of trips

Determinants that increase the probability of <u>participation</u> in boating and fishing trips

a boating trip (fishing and no fishing)	**a boat-based fishing trip**	**a land-based fishing trip**
Boat ownership (+)	Boat ownership (+)	Boat ownership (+)
Age (-)	Age (-)	Age (-)
	Clerical worker (+)	Clerical worker (+)
Migrant to Townsville region in the last 10 years (+)	Migrant to Townsville region in the last 10 years (+)	
Single (+)	Single (+)	
Distance to boat ramp (-)	Distance to boat ramp (-)	
	Income > $100,000 (-)	

Determinants that increase <u>the frequency of participation</u> in boating and fishing

A boating trips (fishing and no fishing)	**A boat-based fishing trip**	**A land-based fishing trip**
Migrant to Townsville region in the last 10 years (-)	Migrant to Townsville region in the last 10 years (-)	
Single (-)		
	Clerical worker (-)	
Income > $100,000 (-)		
	Distance to boat ramp (+)	
		Age (+)

The GBRMPA uses boat registrations as an indicator of fishing pressure (supplemented, of course, with other information, such as that generated from the regular recreational fishing surveys conducted by the Queensland Department of Primary Industries (Taylor et al., 2012). However, boat ownership determines only participation in fishing activities; not the frequency of fishing trips (which is more likely to reflect fishing pressures). My results suggest that the GBRMPA might also wish to monitor migration and employment. The research findings indicate that recent migrants fish less often than long term residents do, so the GBRMPA should not simply use past participation rates and draw inferences or conclusion. Even though with the coastal population growing rapidly, a number of surveys and recreational fishing studies report a decrease in the proportion of local residents who are fishing in the GBR (Higgs & McInnes, 2003; AEC Group, 2005; Sutton, 2006; Young & Temperton, 2007; Taylor et al., 2012). And my research indicates that this decline in participation MIGHT be occurring because the new migrants to the area simply don't fish as often as those who have lived here a long time (i.e. no drop in participation rate of long-term residents, but a drop in participation overall because the new people are less apt to fish).

Females are more likely to be employed as clerical workers and thus this variable is saying that females (clerical workers) are not so keen and frequent fishers. Although as people grow older it seems that they are inclined to reduce their number of boat and boat-fishing trips – instead taking more frequent land-based fishing trips. My research also suggests that an aging population may decrease boating and boat-fishing participation but could increase the number of land-based fishing trips.

However, whether or not more frequent fishing trips (be they land or boat based) directly translates into more pressure on fish stocks, remains to be seen – since not everyone who goes fishing catches a fish, and not everyone who catches a fish, chooses to keep it. It is on that important issue that the next chapter focused.

A research output from this chapter is a journal article

Farr, M., Stoeckl, N., & Sutton, S. Recreational Fishing and Boating: are the determinants the same? to be submitted to Journal of Environmental Management.

Chapter 3

My literature review identified a key gap in the existing literature on C&R behaviour: most previous social science recreational fishing studies on C&R looked at factors affecting the probability that a fisher will keep a particular fish on a particular trip, rather than on the characteristics of those who keep most fish (those who place greatest strain on the resource). A fisher may not keep many fish on any given trip, but if he/she fishes daily, their annual keep – a proxy for fishing pressure - could be substantial. As such, it is the factors associated with annual keep (as opposed to the factors associated with the probability of keeping a particular fish) that are likely to be of most use to fisheries managers. Therefore

Aim 2 was to:

To look at Catch versus Release and to

- provide an an empirical demonstration of a model that allows one to differentiate between factors that influence the keep/release decision and those that influence the total annual keep.
- compare the determinants of the keep/release decision with determinants of the total number of fish kept annually; and
- provide information to fisheries management in the GBR about the characteristics of anglers who are likely to keep most fish annually (and who are thus likely to contribute to fishing pressure in this part of the world).

To meet this aim, I used data from a survey of more than 650 householders in Townsville, Queensland to

- Investigate if the determinants of total annual catch and total annual keep are similar or different
- Provide an empirical demonstration of a model that allows one to differentiate between factors that influence the keep/release decision and those that influence the total keep;
- compare determinants of the keep/release decision with determinants of the total number of fish kept annually; and
- describe the characteristics of anglers who are likely to keep most fish annually (and who are thus likely to contribute to fishing pressure in this part of the world)

To the best of my knowledge this is the first study to differentiate between the probably of keeping/releasing fish and the amount of fish kept annually. The results show that the determinants of total annual catch and total annual keep are different. The determinants of the keep/release decision and of the total number of fish kept annually are also different. Therefore failure to differentiate between them may generate misleading results (e.g. in the GBR failure to do so would mean that managers could be duped into monitoring factors such as age, and commitment (and might misinterpret consumptive orientation), rather than other factors such as boat ownership, income, fishing experience and retirement status).

In this case study region, the big ‘keepers’ were likely to be non-retired, boat owners, to be highly consumptively orientated, to have a relatively low household income, to be relatively less experienced fishers and frequent salt water anglers. I also found evidence to suggest that in this region salt water species are preferable to freshwater species; thus pressures on fish stocks are most likely to be pertinent in the marine environment.

Clearly my results suggest that the frequent boaters differ from frequent fishers, and frequent fishers and the big ‘catchers’ are not necessarily the big ‘keepers’. Thus it is important to know how valuable is to catch or to keep those fish for them. The next chapter focused on this issue.

A research output from this chapter is a journal article

Farr, M., Stoeckl, N., & Sutton, S. Catch and Release in Recreational Fishing: identifying those who place most stress on fish resources which is in review in Fisheries Research.

Chapter 4

My literature review on recreational fishing identified an important methodological gap: most demand and valuation studies of recreational fishing have used *ex post* (actual or historic) measures of catch as a proxy or as a dependent variable to estimate expected catch which is *ex ante* measure. This may be problematic because insights from the social psychology literature suggests that there are good reasons for believing that there may be significant differences in *ex post* and *ex ante* constructs, primarily because individuals tend to revise their expectations or motivations after an event has happen. I also identified an important empirical gap: there is no recreational fishing study in the GBR that would provide information about MV of fish (Prayaga et al., 2010 estimated value of a fishing trip and Rolfe et al., 2011 estimated value of boating, fishing and sailing but not value of a single fish) or look at the drivers of expectations and outcomes. Thus

Aim 3 was to:

- to differentiate between expected and actual recreational catch and to investigate the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch; and
- to estimate and compare the marginal value of fish, using *ex post* and *ex ante* measures of recreational catch

- to provide information about MV of a recreational fish to the GBR management

To meet this aim, I used data collected from a survey of 404 recreational anglers and/or boaters from Townsville region to identify and compare the drivers of expected (*ex-ante*) catch and actual (*ex-post*) catch. Randomly selected individuals were approached while preparing to launch their boats to ensure that expectations were genuine *ex ante* measures. The pre-fishing (boat ramp) survey collected information about the planned trip including: primary reason for going on the trip (motivations), expected duration and destination, species targeted, expected catch and keep, familiarity with fishing sites, cost of the trip, boat ownership, boat quality (assessed by researcher) and number of people on the boat. The participants were also asked about their willingness to participate in a follow-up survey. This was conducted by telephone later (one, two or three days after the trip). The follow-up survey sought additional information about actual duration and destination of the trip, the number and species of fish caught and kept, age, gender, fishing experience and frequency, consumptive orientation and commitment to fishing, level of education, occupation, employment status and household income. They were also asked how many times they had fished on reefs, shoals, offshore islands, bays, estuaries, creeks and freshwater in the last 12 months. In total 428 people were asked to participate in the boat ramp survey. 404 agreed to participate to the pre-trip survey; 366 also participated in the follow-up. The response rate was thus 94% for the 1st part of the survey was and 91% for the follow-up.

I developed and then compared two different models – one looking at determinants of expected, *ex ante* catch; the other looking at *ex post* catch. My analysis indicated that (at least in this part of the GBR and for this particular sample) the determinants of *ex ante* and *ex post* recreational catch are different. Expectations are largely driven by motivations (e.g. importance of fishing for fun and for eating) but the personal variables – such as consumptive orientation, years fishing and gender – have greater influence on outcomes (*ex post* catch). Both the economics and the psychology literature seems to agree that one should use *ex ante* constructs if trying to predict behaviours, so this those interested in predicting behaviours may need to pay greater attention to motivations, and somewhat less attention to socio-demographics.

I also used a Hedonic Trip Price model to estimate and compare the MV of fish, using *ex post* and *ex ante* measures of recreational catch. My marginal, *ex ante* 'value' estimates were much lower than *ex post* 'values' – a result likely to be driven by differences between expected and actual catches. This highlights the fact MV estimates are not 'precise'; amongst other things they depend upon whether one uses *ex ante* or *ex post* constructs to generate them. Policy makers should be aware of this when making allocation decisions.

A research output from this chapter is a journal article

Farr, M., Stoeckl, N., & Sutton, S. The Marginal Value of fish to recreational anglers: ex ante and ex post estimates ARE different which is in The American Journal of Agricultural Economics.

Chapter 5

During the literature review on non-consumptive tourist values associated with 'fish', I identified some methodological and information gaps. Specifically, many valuation studies relevant to tourism estimate the total value of tourism or the total value of a particular trip/experience but few GBR studies have focused on the value of a 'fish' or single species to tourists. Moreover, much research effort has focused on detailed econometric issues, relatively little work seeks to compare the sensitivity of final estimates to other issues (e.g. questionnaire design) relative to econometric ones. Thus

Aim 4 was to:

- to estimate MV of a species for non-consumptive users (tourists)

  to investigate the extent to which variations in methodological approaches (e.g. bid-end values, bid presentation orders, the 'menu' of species presented for evaluation, and the analytical approaches taken – sophisticated econometrics or simple mid-points) affected final WTP estimates; and
- to provide information to managers of the GBR about the importance (or 'value') of key species for non-consumptive uses

To address these methodological and knowledge gaps, I used contingent valuation (CV) data collected from more than 2000 visitors to the Northern section of the GBR and the Kristrom, logit, spike model for PC valuation question to estimate non-consumptive use values for several different marine species including: whales and dolphins; sharks and rays; large fish; marine turtles; and a 'wide variety of wild life'. The experimental design allowed me to not only determine which species were of most/least 'value' to different types of visitors, but to also investigate the extent to which variations in methodological approaches (e.g. bid-end values, bid presentation orders, the 'menu' of species presented for evaluation & the analytical approaches taken – sophisticated econometrics or simple mid-points) affected final WTP estimates.

I found that final estimates were particularly sensitive to questionnaire design, but that the ranking of species (from most to least 'valued') was robust across a range of methodological specifications giving a confidence in the reliability of the observations.

The most valued groups of species were (in order): whales and dolphins; sharks and rays; 'variety'; marine turtles; and finally large fish.

My research also highlighted the fact that sharks and rays have non-consumptive use values which are almost as high as those associated with whales and dolphins. Evidently, whale watching is not the only potentially profitable source of tourism revenue; sharks and rays may be similarly appealing. These potential revenues need to be considered when making decisions about whether or not to conserve marine species. Species-level studies may also be useful if seeking to target monitoring activities – expending resources on species that are considered 'important' to tourists (in addition to those considered important by scientists).

The research outputs from this chapter are a journal article and a conference paper

Farr, M., Stoeckl, N., & Beg, A. R. (in press). The non-consumptive (tourism) 'value' of marine species in the Northern section of the Great Barrier Reef. *Marine Policy*.

Farr, M., Stoeckl, N., & Beg, R. A. (2012). *On Relative Values of Marine Species in the Great Barrier Reef.* Conference paper presented at the 56th AARES Annual Conference, 7-10 February 2012, Fremantle WA.

6.3 Research contributions

Contributions relevant to a broad range of researchers

My research has made a number of contributions that provide insights and help to improve methods for estimating the demand and economic values. These contributions are widely relevant – i.e. they are likely to be useful to researchers investigating a broad range of different issues and 'values' (not just those relating to pressures on fish stocks) in many different parts of the world.

First, I used a two-step (hurdle) model to examine the probability in participation in boating and fishing trips and the frequency of trips. I also used a two-step (ZINB) model when looking at the catch and release. Whilst two-step models have been used in previous investigations of fishing/boating trips, to the best of my knowledge, this is the first study to adapt the approach for catch and release. My results clearly indicate that a two-step approach is likely to generate better quality information about those placing greatest pressure on fishing stocks than simpler one-step analyses that fail to differentiate these groups.

Second, much of my work has sought to find out if the determinants of demand for (or participation in) different types of activities were similar. My results indicate that those who must make decisions about the management and allocation of 'fish', 'fishing' or boating, need to differentiate between

- fishing and boating,
- boat fishing and land-based fishing
- recreational catch and recreational keep
- the probability of keeping/releasing and the total number of fish kept annually

Failure to do so, may generate misleading results. These research findings could be useful when estimating the demand for other fishing sectors (e.g. Indigenous fishing and hunting, Charter fishing) or when estimating demand or economic values in other natural resource environments (e.g. fresh water resources).

Third, I used non-market valuation techniques to estimate the MV of fish to recreational fishers (The Hedonic Trip Price Model) and the MV of broad species groups to tourists

(The Contingent Valuation Method with Payment Card valuation question). Contributions that are broadly relevant are as follows:

- MVs differ depending on whether *ex ante* or *ex post* catch is used – and these differences are closely related to differences between expected and actual catches

- MVs of for tourists are less sensitive to different econometric techniques than to survey design

More specifically, the research findings suggest that natural resource managers or researchers in other parts of the world who need to estimate demand or economic values in the recreational fishing or tourism sectors need to pay attention to *ex ante* and *ex post* constructs. My work demonstrates that estimates of the MV of 'a fish' differ significantly depending upon whether an *ex ante* or *ex post* approach is used; policy makers should be aware of this problem when making allocation of 'fish' decisions. Instead of using just single estimates it might thus be preferable to construct a range of estimates, and my investigation indicates that MVs can be *Post Hoc* estimated but then simply scaled (according to the ratio of expectations versus actuality) to get *ex ante* values. This could considerably simplify the estimation process, while still providing policy makers with a realistic range of estimates (as opposed to a single, possibly imprecise figure).

The results also indicate that expectations are largely driven by motivations but that personal variables have a greater influence on outcomes. Resource managers and researchers should thus use *ex ante* (rather than *ex post*, as is the norm) constructs if trying to predict behaviours and these differences should send warnings to those who instead use *ex post* constructs. They may need to pay greater attention to motivations, and somewhat less attention to socio-demographics. These research findings are not only useful for those who manage the marine resources but they are likely to be transferrable elsewhere. One can apply it when estimating the demand or MVs for hunting, commercial tourism (diving and snorkelling) or spear fishing. It is also likely to be used in event management contexts, when developing (tourism) marketing strategies &/or when using almost any non-market valuation exercise to inform conservation decisions.

Finally, it is clear that those who undertake non-market valuation studies should pay as much attention to issues associated with questionnaire design as they do into issues associated with data analysis. Not only do estimates of 'value' differ according to whether one uses *ex ante* or *ex post* constructs, but they also differ according to a range of CV implementation issues (such as bid range). The values generated by such studies are not precise indicators of value and it may not be valid to compare values from one type of study with values from other studies that have not, themselves, been subjected to similar influences (e.g. derived from similar questionnaires with similar bid ranges). This does not mean that CV or other types of non-market valuation studies cannot generate useful information. My research clearly shows that the method is able to provide robust information about the comparative 'value' of a non-market good (e.g. the non-consumptive value of a shark) relative to the 'value' of another good (e.g. marine turtles) presented in the same questionnaire. Precise cardinal estimates of value may elude, but ordinal estimates are clearly well defined in some instances.

Contributions relevant to the Great Barrier Reef

My research findings have a number of empirical contributions relevant to the GBR.

Frequent boaters differ from frequent fishers. The most frequent boaters are long term residents, people who are not single and with annual household incomes below $100,000 AUS. These are the variables that the GBRMPA should monitor when making decisions associated with recreational boating. The most frequent fishers are long term residents, people who are not employed as clerical or administrative worker and people who live in the outer suburbs. Older people go land-based fishing more frequently than younger people (who are more apt to go boat-fishing).

Big ‘catchers’ and big ‘keepers’ are also different. The big ‘catchers’ are more likely to be a male, to have gone fishing as a child, to fish in fresh water and to be a long term resident (although the quadratic relationship indicates that they do it up to the point and then their catch declines as they grow older). In contrast, the big ‘keepers’ are boat owners, highly consumptively orientated, frequent salt water fishers, less experienced, non-retirees and those with a household income of less than $100,000 per annum. In other words, frequent fishers and big ‘catchers’ are not necessarily big ‘keepers’.

Long term residents are frequent fishers and they catch large quantities of fish each year but they are also likely to release caught fish. On the other hand boat owners and low income earners are not frequent fishers but they are likely to keep larger quantities of fish each year than others. With coastal population growth and an increasing number of recreational boats, the GBRMPA is probably right in monitoring the number of registered boats and using that number as an indicator of boating and fishing pressure along the GBR coast. Monitoring boat ownership is easier and is more cost effective than monitoring annual fishing effort. However, some other variables (particularly household incomes) may also need to be monitored as income is associated with the frequency of boat-trips and also the number of fish kept annually (which is a proxy for fishing pressure).

There are additional variables that the GBRMPA could monitor as approximate indicators of fishing pressure: the fishing experience, retirement status and consumptive orientation of residents. Consumptive orientation is a strong indicator of total annual keep which supports the need for continuation of longer term surveys (such as those run by the Department of Primary Industry in Queensland) – these variables are not ones commonly collected by other agencies but must be considered when analysing the demand for recreational fishing.

In theory the optimal allocation of fish resources between competing sectors is one that maximises the net social value where marginal net benefits to competing users are equal. If seeking maximise the net social benefit of a sector, regulators should reallocate fish resources away from sectors with low MVs to those with high MVs, and they should continue this reallocation process until the net marginal values for both sectors are equal (Blamey, 2002; Holland, 2002; Galeano et al., 2004; Lindner & McLeod, 2011).

Recreational fishers often 'claim that in many cases the social or economic value of recreational fishing for particular species or in particular areas greatly exceeds the social or economic value of commercial fishing for the same species or in the same area' (Henry & Lyle, 2003, p. 23). My research indicates that the MVs of a recreational fish in this particular region was estimated between $7 and $22 AUS. The average price of the trip was $63. So clearly the fishing trip is not only about 'fish' but also about fishing experience. Moreover, my research also establishes that not many people practise C&R in this particular region. If keeping a fish does not have a high MV, but going on a fishing trip does, then my findings suggest that it may be possible for the GBRMPA to, in essence, keep 'utility' fairly constant, but continuing to let people fish, but by simultaneously attempting to reduce fishing pressure by encouraging catch & release practices.

Those points aside, it is important to reiterate the fact that MV estimates are not 'precise'; amongst other things they depend upon whether one uses *ex ante* or *ex post* constructs to generate them. Thus the GBRMPA and fisheries managers should be aware and cautious of using just single estimates reported in this study when considering allocation of 'fish'. Instead of using just single estimates to each competing sector (commercial, recreational and tourism) a constructed range of estimates could be more useful (lower and higher values or a range of marginal values).

Moreover it should be noted that the conflict between recreational fishers and tourists in relation to the take of fish by recreational fishers could be minimal , at least in this instance. This is because the species favoured by tourists overlap little with those targeted by recreational fishers. Similarly, it is possible that conflict between recreational fishers and commercial fishers would vary by fish species for some species it could be more than for the others.

Finally, it is clear that one cannot just simply compare MV of a recreational fish (value of keeping which are more likely to vary by species) with MV of fish for a tourist (value of watching). But my research does provide at least some useful information to the GBRMPA about the relative importance of the consumptive and non-consumptive values of ‘fish’ to recreational fishing and tourism sectors. Although the market price of fish can be used as a guide for assessing the MV of a fish in the commercial sector, there is evidence to suggest that ‘the beneficiaries of commercial fishing are not only the operators, but related businesses, regional economies and the substantial proportion of the national population who are seafood consumers’ (Henry & Lyle, 2003, p. 23) – so readers are cautioned not to simply used the values generated in this study, as if they can be validly compared with each other, or with other marginal values. More information is needed about these benefits before making decisions about the allocation of fish resources.

6.4 Future work

I will discuss several limitations of my thesis and future research work – since findings and associated limitations often highlight opportunities for future research.

The key drivers for boating, boat fishing and land-based fishing are likely to differ across case-study area – so my empirical findings are not generalisable. Clearly more research is needed to investigate these issues further, but it would be valuable to use insights from this thesis to make predictions about the potential longer-term impact of population growth, aging population, migration and change in household composition on the demand for fishing and boating (specifically combining coefficients from my models with time-series demographic data). Better still would be research that could extend such investigations to draw inferences about the potential impact of such demographic changes on the fish stock. Further investigation into the non-fishing recreational boating sector and its key drivers could also be important. There are a small, but nonetheless significant number of boaters in my sample that either do not fish at all or for whom fishing is only a part of other recreational activities while out on a boat.

A study into the social acceptability of C&R in the GBR could also be valuable. The programs were successful in many fisheries around the world and the results from this research suggest that C&R can be considered as a management tool. The MVs of a recreational fish is between $7 and $22 is less than the average price of the trip ($63) thus the value of the fishing trip is not only about the fish caught but also about fishing experience. This can be considered as an indicator that people might be supportive of C&R programs to try and keep healthy fish for themselves and for future generations – while still being able to enjoy the benefits of the holistic fishing trip.

My research does not shed light on whether one should be using *ex post* or *ex ante* constructs but is does clearly highlight that these constructs yield quite different value estimates. Moreover, I find that the difference between these MVs is related to the difference between actual and expected catch: if expectations are greater than actual catch than MV of expected fish will be smaller than MV of actual fish. Future research would benefit from investigation for a range of different species and in a range of different contexts (not only in recreational fishing). Specifically, future research could look at *ex ante* and *ex post* estimates of value in more detail. The aim would be to check if it is possible to simply estimate MVs using *ex post* measures and then scale them to get *ex ante* values (lower and higher values or a range of MVs).

Finally, there is a need for better methods to estimate MV's of single species for tourists. It is difficult to compare the value of 'watching' (a fish) with the value of 'keeping' a fish (one shark can be viewed by 300 people). So it is not possible to compare the MVs generated in my study. This is a non-trivial problem, particularly if working with pelagic species – but might be solvable by firstly attempting to develop ways of doing so with sedentary species, and then adapting methods later.

6.5 Concluding remarks

For those who are in charge with management and allocation of 'fish' my thesis highlights the importance of differentiating between (a) boating and fishing, (b) boat fishing and land-based fishing, (c) recreational catch and recreational keep, and (d) the probability of keeping/releasing and the total number of fish kept annually. It also demonstrates that value estimates are not 'precise' and are more sensitive to a range of methodological issues (e.g. use of *ex ante* or *ex post* constructs; bid range, and 'menu') than to analytical techniques. Thus natural resource managers should be cautious of using just single estimates when considering allocation of 'fish' or any scarce resource across competing using groups. Instead of using just single point-estimates, a constructed range could be more useful – if only because it clearly demonstrates the uncertainties associated with such estimates.

'In the absence of appropriate research', monitoring programs and 'socio-economic valuation information' debates about which sector should have more or less fish are basically unsolvable (Henry & Lyle, 2003, p. 23). My research has not 'solved' this problem, but it does contribute significantly – providing more information about the values

(MVs for recreational fishing and tourism) that the Great Barrier Reef Marine Park Authority must consider when making policy and allocation decisions and also more information about techniques for trying to estimate and better understand competing values.

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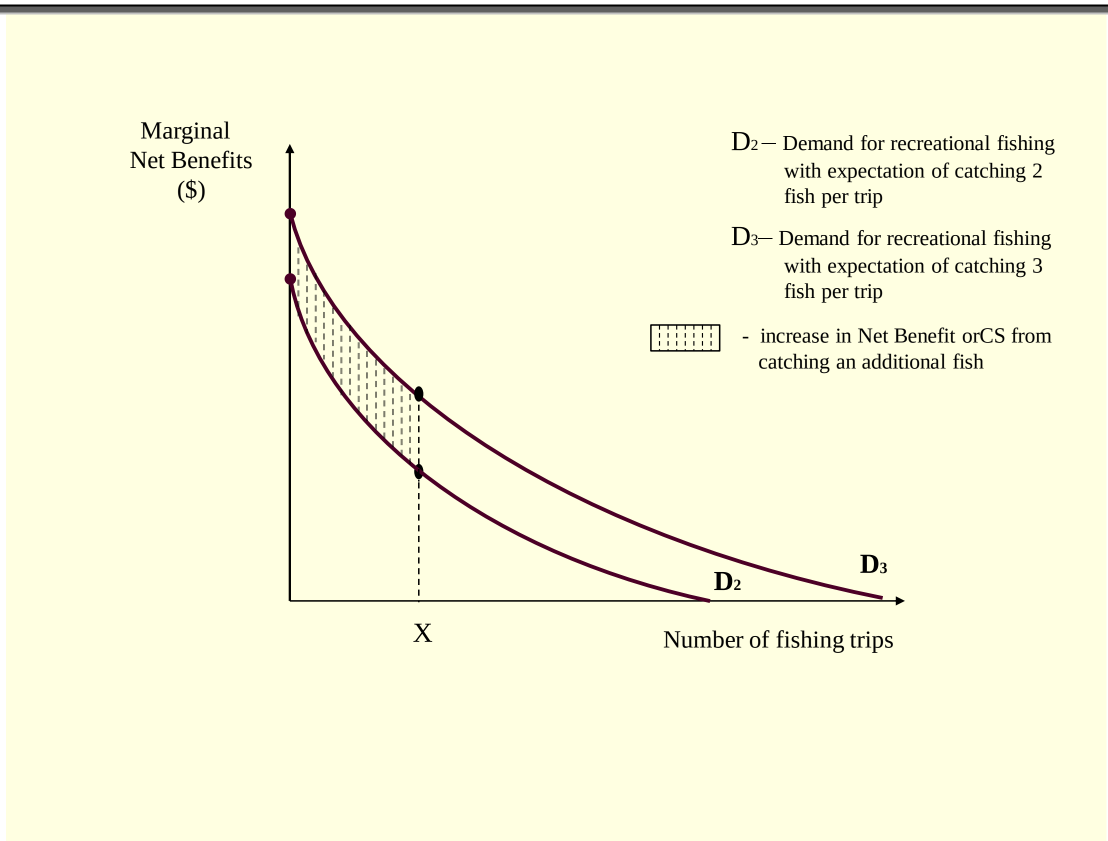
Appendix 1 Chapter 1

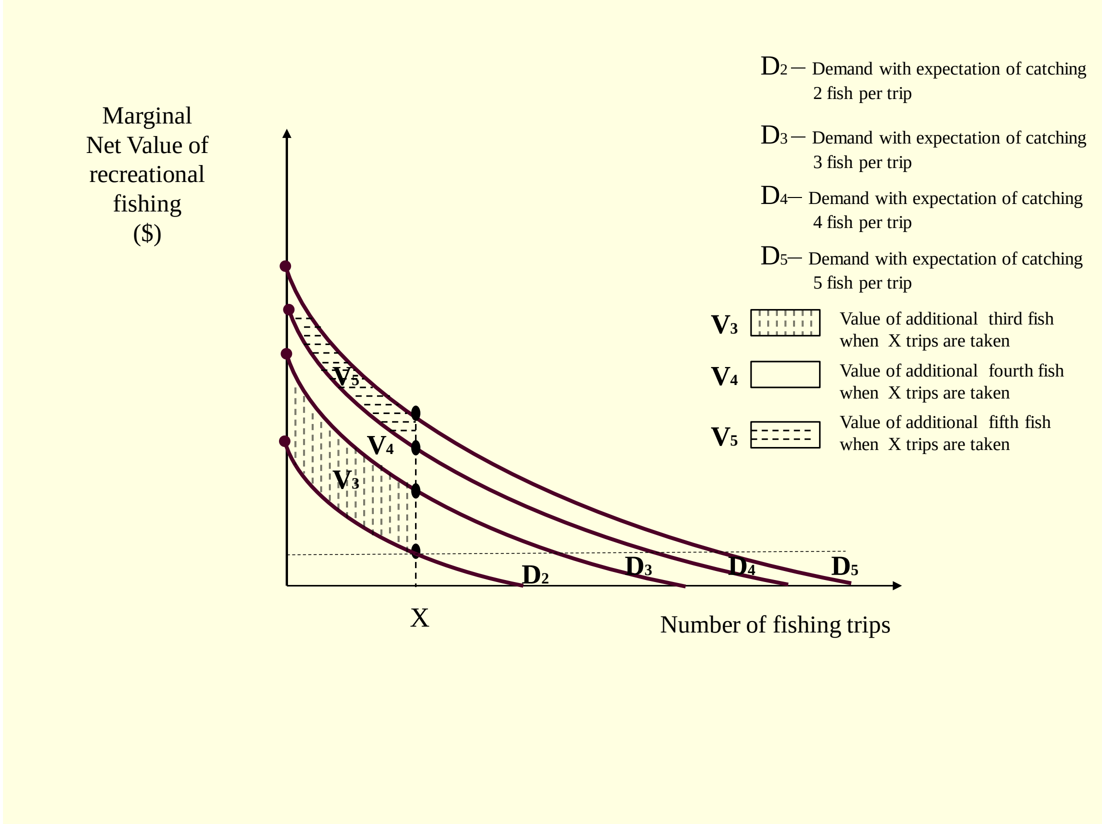
Demand for and Marginal Value of a ‘fish’ – recreational fishers

Recreational anglers ‘derive economic benefits from fishing, just as commercial fishers do’ (Lal et al., 1992, p. 49). These benefits include expectations, the actual capture of fish and benefits from fishing experience. ‘Because recreational fishers do not usually have to pay explicitly for the use of fisheries, the benefits they derive are usually not taken into account in management decisions’ (Lal et al., 1992, p. 49)

The demand for recreational fishing is usually expressed in terms of the number of trips an individual is willing to undertake in a given period of time number of fish that are likely to be caught on each trip. Consequently, one can calculate the marginal value (MV) of an individual fish (to a recreational fisher) as the difference between the willingness to pay (WTP) for a fishing trip given the expectation of catching ‘x’ fish, and the WTP for a fishing trip given the expectation of catching ‘x + 1’ fish (Lal et al., 1992).



(a) Net Benefits in recreational fishing



(b) Demand for recreational fishing trips

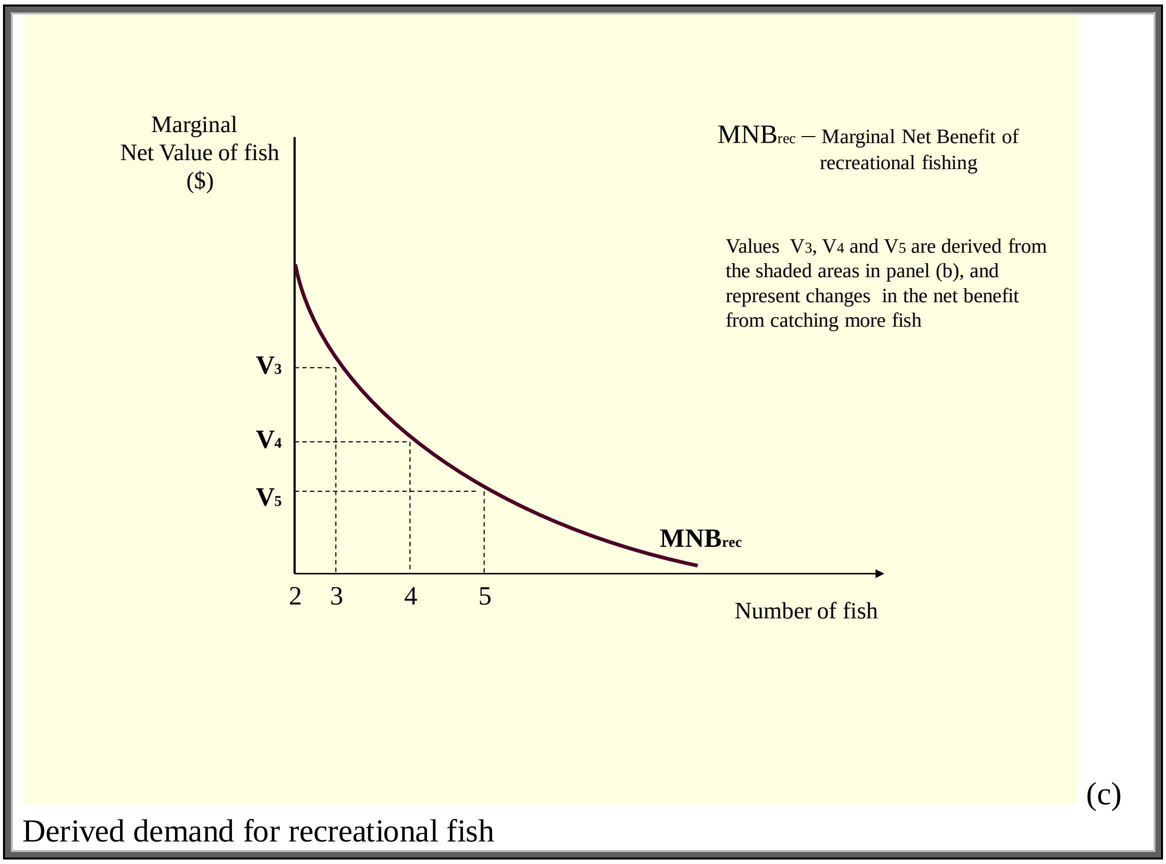


Figure A 1.1 Demand and marginal value of fish in recreational fishing (Source: Lal et al., 1992)

In order to estimate the MV of additional fish caught by recreational angler, it is necessary (explicitly or implicitly) to determine the demand for recreational fishing. This is shown in panel (a), where, for simplicity, it is assumed that only recreational anglers operate in the fishery and that the cost per trip is constant.

D2 is the demand for recreational fishing when expected catch is two fish per trip and D3 is the demand for recreational fishing when expected catch is three fish per trip which is expected to be higher because recreational anglers would be expected to derive greater benefits from catching more fish. For number of fishing trips X, therefore, the difference between two demands is the marginal benefit or the marginal value of an additional fish caught.

Panel (b) illustrates the situation where a recreational angler gains from the probability of catching more additional fish. With an increase in the expected number of fish, fisher would be likely to have greater demand and to be willing to pay more for each recreational fishing trip, and thus, the benefit of catching an additional fish for X number of trips is the difference between two curves and it is the area or value V3 (similarly for value V4 and V5).

As indicated in panel (b) the total benefits to the recreational anglers increases at a decreasing rate as each additional fish caught (the marginal benefit from an additional fish caught is decreasing). That is why the demand curve on panel (c) is downward sloping. The demand curve for the recreational fishing sector is a sum of individual demands. The marginal net benefit of fishing generated from the total benefits of fishing minus related fishing costs and if 'the influences of the demand for recreational fishing do not change, the marginal net benefit of fishing decreases with each additional unit of fish allocated to the recreational sector ' (Lal et al. 1992, p. 52).

Supplementary material on Total Economic Value

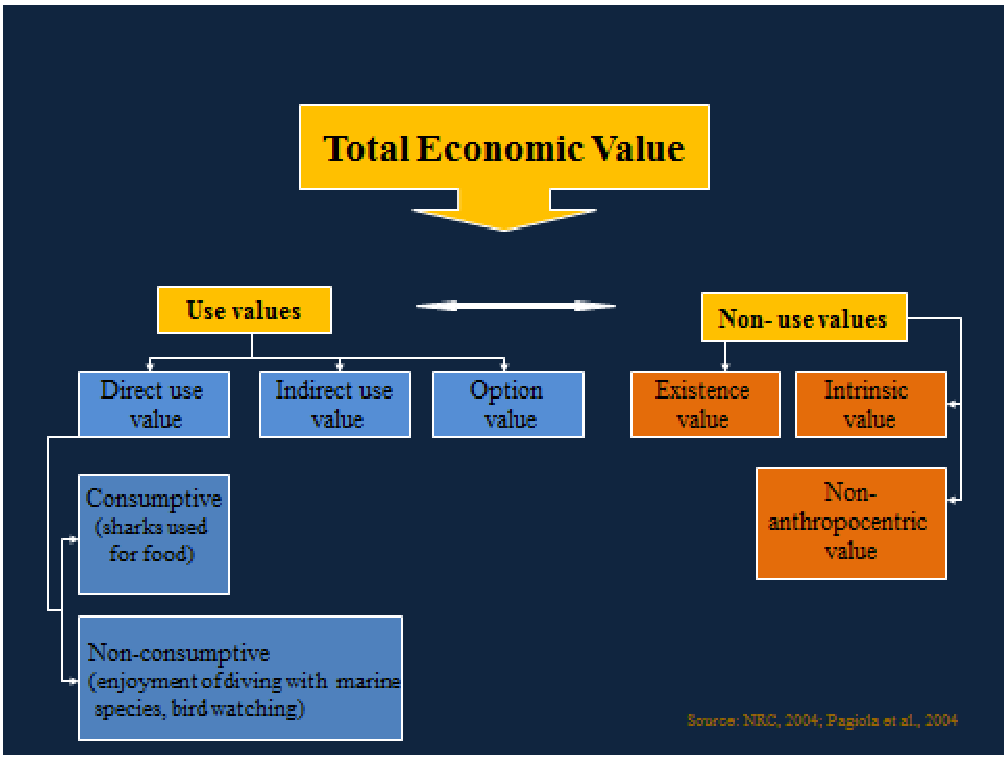


Figure A1.2 Total Economic Value (Source: NRC, 2004; Pagiola et al., 2004)

The Total Economic Value (TEV) generally include the values represented by Table A 1.2.

TEV framework groups these values into use and non-use. Although use-values are often subdivided into 'direct' and 'indirect' use values, and there is some disagreement as to whether option values should be categorised as use of non-use values.

Direct use values refer to goods or services that are 'used directly by human beings' (Pagiola et al., 2004, p.9) and they include consumptive and non-consumptive uses.

Consumptive use values – those which 'relate to the … goods produced by the ecosystem that can be consumed and used by people' (Geoscience Australia, 2011). A relevant example here, is when sharks are used for food.

Non-consumptive use values – those which generate use-benefits for humans but which do not require one to consume the good or service (Campbell & Smith, 2006; Loomis & White, 1996). Corals and marine species such as sea turtles, sharks, and whales 'have non-consumptive use values to divers based on their active enjoyment of diving with these species' (White, 2008, p.7; Wilson & Tisdell, 2011)

Indirect use values are derived from ecosystem 'that provide benefits outside the ecosystem itself' such as 'the storm protection function of mangrove forests which benefits costal properties and infrastructure' (Pagiola et al., 2004,p.10).

Option values refer to preserving the option to use goods and services in the future 'either by oneself (*option value*) or by others (*bequest value*)' (Pigiola et al., 2004, p.10).

Non-use values refer 'to the enjoyment which people may experience by knowing that a resource exists even if they never expect to use that resource directly themselves' (Pagiola et al., 2004, p. 10). They are usually known as existence and bequest values. *Existence values* arise from knowledge of presence while *bequest values* arise from wanting to preserve something for future generations (Jakobsson & Dragun, 2001; Loomis & White, 1996).

Supplementary material on Hedonic Pricing

‘Hedonic’ is derived from Greek words ‘Hedonikos’ and ‘Hedone’ which means sensual delight or desire (The Free Dictionary, 2013; My Etymology, 2013). In general it is associated with ‘*pleasure* or devoted to *pleasure’* and it means ‘to belong or relate to utility’ (Tien, 2012, p. 7).

The foundation of the Hedonic Price Method (HPM) is that ‘the price of a marketed good is related to its characteristics, or the services it provides’ (Ecosystem Valuation, 2013). For example the price of a house reflects its features such as size, number of bedrooms and bathrooms and ‘the like—plus lot size, neighbourhood amenities, and environmental and other attributes of the community’ (McConnell & Walls, 2005, p. 6). Or the price of a car comprises its own the characteristic s (or attributes) such as fuel economy, size, luxury, comfort etc. (Ecosystem Valuation, 2013; McConnell & Walls, 2005). An attribute itself ‘cannot be sold separately but a whole good which is an aggregation of different attributes will be purchased’ (Tien, 2012, p. 8; Rosato, 2008).

The HPM assumes that people value attributes of a product or the services that this product provides rather than a product itself, thus the price will reflect the value of a set of attributes. Therefore this method can be used to value the individual characteristics (marginal changes) of a product (e.g. car) by ‘looking at how the price people are willing to pay for it changes when the characteristics change’ (Ecosystem Valuation, 2013; McConnell & Walls, 2005; Tien, 2012; Thrane, 2005; Galeano et al., 2004).

Appendix 2 Chapter 2

Household Survey (used for chapters 2 and 3)

JAMES COOK UNIVERSITY AUSTRALIA

School of Business
Townsville

Recreation in the Townsville region
Household survey

Source: reef.crc.org.au

I am involved in a research project funded by James Cook University. We are investigating what Townsville residents are doing for recreation and leisure and how important fishing and boating is compared to other recreational activities.

Because we live in such a beautiful environment, sailing and camping, fishing and boating, diving and snorkelling are important recreational activities for Townsville residents and for visitors. These activities are also important to our economy.

But what will happen as Townsville's population grows?

- Will growth affect the demand for recreation and how?
- Will it affect the quality of our recreational experience?
- Will it affect the demand for fishing and boating in Townsville?

To answer these questions **we need your help**.

We need to collect information from a wide variety of people—those people who go fishing and boating and those who do not. We need to know how important fishing and boating is compared to other recreational activities such as playing golf, camping, watching football, going to the restaurants or bars, attending concerts, sailing, snorkelling and diving etc. etc.

We are conducting a broad survey of more than 2000 private householders who live in the Townsville region. Your name has been randomly selected from a large database, for inclusion.

We would be very grateful if you could fill this questionnaire in, and then mail it back to us in the enclosed reply-paid envelope. Other respondents have indicated it has taken them no more than 3-4 minutes and is very easy to complete.

All information which we collect will be kept **strictly confidential**. No information will be attributed to any single person or household, and results will only be released in aggregate form (e.g. approximately 25% of those surveyed are going fishing). Responses to the survey will be stored separately from the names and addresses of households, so that no link can be made between them.

Should you have any queries about the research project or if you are interested in seeing the results of our survey please do not hesitate to contact me. We thank you in advance for your help.

Yours sincerely,

Marina Farr

PhD Candidate
School of Business
James Cook University
Townsville, QLD 4811

Tel: 07 4781 6623
Fax: 07 4781 4019

Email: marina.farr@jcu.edu.au

We need your help!

Should you have any complaints or enquiries relating to the ethical conduct of this research please contact:
Sophie Thompson, Human Ethics and Grants Administrator, James Cook University,
Telephone: 47816575; Fax: 47815521 or email: Sophie.Thompson@jcu.edu.au

Recreation in the Townsville region
Household survey





Some weeks ago, we sent you a letter that described the research project funded by James Cook University and a questionnaire that asked you about your preferences for recreation and leisure and how important fishing and boating to you comparing to other recreational activities.

If you have completed it, thank you very much. If you have not, please think about whether you can make the time to do it. **Your questionnaire is important** for helping to get accurate results. We need to collect information from a wide variety of people—those people who go fishing and boating and those who do not. We have sent questionnaires to many people in Townville, but it is only by hearing from nearly everyone in the sample that we can be sure that our results are truly representative.

A few people have written to say that they should not have received the questionnaire because they no longer live in Townsville. If this applies to you, then please let us know on the cover of the questionnaire and return it in the enclosed reply paid envelope so that we can delete your name from the mailing list.

A comment on our survey procedures. A questionnaire identification number is written on the front of the questionnaire so that we can check your name off the mailing list when it is returned. The list of names is then destroyed so that individual names cannot be connected to our results in any way. As we have noted earlier, no information will be ever be attributed to any single person or household, and results will only be released in aggregate form (e.g. approximately 25% of those surveyed are going fishing). Protecting the confidentiality of people's answers is very important to us and to James Cook University.

We hope that you will fill out and return the questionnaire soon, but if for any reason you prefer not to answer it, please let us know by returning a note or blank questionnaire in the enclosed reply-paid envelope.

Should you have any queries about the research project or if you are interested in seeing the results of our survey please do not hesitate to contact me. We thank you in advance for your help.

Yours sincerely,

Marina Farr
PhD Candidate
School of Business
James Cook University
Townsville, QLD 4811
Tel: 07 4781 6623
Fax: 07 4781 4019 Email: marina.farr@jcu.edu.au






We need your help!

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SECTION A – about you and the importance of boating (compared to other activities)

1. What is your gender? ***(Please tick appropriate box)*** Male ☐ Female ☐

2. In what year were you born? __________

3. How long have you lived in Townsville?

All my life ☐ *or* Years ________ or Months ________

***If you were not born here*, from where did you move?**___________________

4. Compared to other recreational activities (like golf, watching television, going to restaurants or bars, attending concerts) would YOU consider fishing and/or boating to be **(*Circle only one answer please)***:

1 Your most important recreational activity
2 Your second most important recreational activity
3 Your third most important recreational activity
4 Only one of many recreational activities that are important to you
5 Not at all important as a recreational activity

If fishing and/or boating is NOT your most important recreational activity, please tell us what your most important recreational activity is ________________________________

5. Do you own a boat? ***(Please tick appropriate box)*** Yes ☐ No ☐

6. In the last 12 months, how many times have you been out on a privately owned boat (i.e. not a commercial operator who you must pay) in the Townsville region? _____

If 'Never' please go to section B (page 2)

7. Who do you go out on a boat with most often? **(*Circle only one answer please)***

1 By yourself
2 Friends
3 Family
4 Family and friends together
5 Club
6 Other *(please specify)* _____________________

8. Please circle the number that indicates your level of agreement with each of the following statements about issues affecting recreational boating in the Townsville region:

	Strongly disagree				Strongly agree	Don't know
There are enough public boat ramps to meet my needs	1	2	3	4	5	☐
The quality of public boat ramps is good	1	2	3	4	5	☐
There are sufficient parking places near the boat ramp area	1	2	3	4	5	☐
Boating is part of my culture or family tradition	1	2	3	4	5	☐
Most of my friends are in some way connected with boating	1	2	3	4	5	☐

9. Approximately what proportion of the time that you go out on a boat do you fish? ***(Please circle one number)***

Never 1------2------3------4------5 All the time

10. Are there any other recreation activities that provide you with the same level of satisfaction and enjoyment that you receive from going out on a boat? ***(Please circle one answer)***

1 No, for me there is no substitute for going out on a boat

2 Yes, other activities can substitute for boat trips. Please tell us which activities
____

SECTION B – about you and the importance of fishing (compared to other activities)

11. Did you you ever go fishing when you were a child? ***(Please tick appropriate box)*** Yes ☐ No ☐ Not sure ☐

12. Have you been fishing as an adult? ***(Please circle one answer)***

Yes ⟶ ***If Yes, please go to question 13***
No ⟶ ***If No***, Would you like to try fishing someday? **(*Circle only one answer please)***
Yes } ⟶ ***Please go to the section C (page 3)***
No

13. Over the past two years, about how often have you gone fishing? **(*Circle only one answer please)***
1 Once every 2-3 months or less often
2 Monthly
3 A few times a month
4 Weekly or more often
5 Did not go fishing over the past two years ⟶ ***Please go to the section C (page 3)***

14. How many years have you been fishing this often or more frequently? ______

15. How many fish (on average) did you catch ____ and keep ____ on each fishing trip?

16. With whom have you fished with most often? **(*Circle only one answer please*)**
1 By yourself
2 Friends
3 Family
4 Family and friends together
5 Club
6 Other (please specify) ____________________

17. In the last 12 months, how many times approximately have you been fishing on or in ***(Please answer as appropriate)***
1 Reefs ______
2 Shoals, offshore island, etc ______
3 Bays, estuaries, creeks ______
4 Fresh water (rivers, lakes etc) ______

18. What species do you most prefer to catch? ***(Please answer as appropriate)***
1 Don't care – happy to catch anything
2 Most preferred species (please specify)_____________________________
3 Second most preferred species (please specify) _____________________________
4 Third most preferred species(please specify) _____________________________

19. If you could not go fishing, are there any other recreation activities that would provide you with the same level of satisfaction and enjoyment that you receive from fishing? ***(Please circle one answer)***
1 No, for me there is no substitute for fishing
2 Yes, other activities can substitute for fishing. Please tell us which activities____

20. Please indicate the extent to which you agree or disagree with each of the following statements about recreational fishing:

	Strongly disagree				Strongly agree	Don't know
A fishing trip can be successful even if no fish are caught	1	2	3	4	5	☐
The more fish I catch, the happier I am	1	2	3	4	5	☐
The bigger the fish I catch, the better the fishing trip	1	2	3	4	5	☐
I like to fish where I know I have a chance to catch a "big" fish	1	2	3	4	5	☐
	Strongly disagree				**Strongly agree**	**Don't know**
I want to keep all the fish I catch	1	2	3	4	5	☐
I'm happier if I release some of the fish I catch	1	2	3	4	5	☐
The fishing areas are too crowded	1	2	3	4	5	☐
Good fishing sites are easily accessible	1	2	3	4	5	☐
Fishing is part of my culture or family tradition	1	2	3	4	5	☐
Most of my friends are in some way connected with fishing	1	2	3	4	5	☐

21. If you could not fish, would you still go recreational boating? ***(Please circle one answer)***

1 No, for me there would be no reason for going out on a boat if I could not fish
2 Yes, I could do other things while out on a boat. Please tell us about what you would do while on a boat if you could not fish____

SECTION C – about you and your household

This part of the questionnaire asks you for some information about you and your household. Please remember that this information will be kept strictly confidential and is used to ensure that we have collected information from a wide variety of households.

22. What is your marital status? ***(Please tick appropriate box)*** Single ☐ Married ☐ Other ☐

23. How many people in your household? _______ No of children (15 yrs and under) _______

24. What is the highest level of education you have completed? ***(Please tick appropriate box)***

☐ Primary school
☐ Some high school
☐ High school diploma
☐ Trade certificate or apprenticeship
☐ Diploma
☐ University degree (Bachelor or Honours)
☐ Post graduate degree
☐ Other (please specify)________________

25. What is your occupation? ________________________________

26. If employed – On average how many hours per week do you work ______

27. Finally, could you please tell us about your household income (i.e. total taxable income of ALL the people living with you in your house who share expenses with you)?
Please note that all information provided is treated as **strictly confidential**. This information is used to help us determine if people with higher incomes prefer different recreational activities and have different 'values' to people with lower incomes. In what category would you place your total annual (average) taxable income? ***(Please circle one category)***

1 Under $20,000
2 $20,000 to $40,000
3 $40,000 to $60,000
4 $60,000 to $80,000
5 $80,000 to $100,000
6 $100,000 and above

Thank you for your help with this research. Your contribution of time to this study is greatly appreciated. Please return your completed questionnaire in the postage-paid return envelope as soon as possible. Thank you.

Supplementary tables

Table A 2.1 Binary Probit models for participation decision and Zero Truncated Negative Binomial for frequency of trip decision

Variable	**Boating (fishing and no fishing)** M 1 Coeff (RSE)	M2 Coeff (RSE)	**Fishing (boat and land-based)** M 1 Coeff (RSE)	M 2 Coeff (RSE)	**Boat Fishing** M 1 Coeff (RSE)	M2 Coeff (RSE)	**Land-based Fishing** M 1 Coeff (RSE)	M2 Coeff (RSE)
Participation equations Probit model								
Constant	-0.832* (0.453)	-0.164 (0.358)	-0.123 (0.449)	0.761** (0.357)	-0.729 (0.460)	-0.064 (0.364)	0.335 (0.612)	0.184 (0.346)
Boat Owner (predicted values)	4.053*** (1.472)		5.199*** (1.506)		4.118*** (1.503)		-0.812 (2.703)	
Activity Commitment (predicted values)	0.904 (1.143)	4.525*** (0.648)	0.739 (1.181)	5.381*** (0.677)	1.459 (1.149)	5.107*** (0.672)	3.639 (2.602)	2.880*** (0.584)
Occupation CA	0.100 (0.287)	-0.322 (0.234)	0.555** (0.274)	0.016 (0.214)	0.245 (0.290)	-0.184 (0.233)	0.126 (0.340)	0.206 (0.208)
Migrant	0.306* (0.168)	0.098 (0.149)	0.212 (0.168)	-0.038 (0.152)	0.225 (0.179)	0.018 (0.154)	-0.135 (0.187)	-0.101 (0.146)
Age	-0.010** (0.005)	-0.015*** (0.005)	-0.022*** (0.005)	-0.028*** (0.005)	-0.015*** (0.005)	-0.020*** (0.005)	-0.021*** (0.006)	-0.020*** (0.005)
Income	-0.074 (0.166)	0.143 (0.144)	-0.472*** (0.169)	-0.210 (0.145)	-0.287* (0.172)	-0.057 (0.148)	-0.016 (0.199)	-0.060 (0.142)
Single	0.581*** (0.194)	0.405** (0.175)	0.308 (0.199)	0.072 (0.180)	0.349* (0.202)	0.177 (0.183)	0.075 (0.224)	0.115 (0.176)
Distance	-0.037** (0.017)	-0.023 (0.015)	-0.032* (0.016)	-0.012 (0.014)	-0.036** (0.017)	-0.021 (0.015)		
N	470	477	470	477	470	477	477	477
Log likelihood/ pseudolikelihood	-271.33	-274.85	-267.06	-270.29	-248.60	-252.72	-279.79	-279.83
Wald chi2	74.57***	75.24***	96.54***	96.21***	83.74***	82.20***	48.66***	48.64***
AIC	1.193	1.186	1.175	1.167	1.096	1.093	1.207	1.203
BIC	-2293.73	-2342.8	-2302.27	-2351.98	-2339.20	-2387.11	-2332.98	-2339.06
Marginal effects								
Boat Owner PVs	1.509***		2.053***		1.408***		-0.289	
Activity Commitment PVs	0.336	1.681***	0.292	2.125***	0.499	1.745***	1.299	1.028***
Occupation CA	0.038	-0.112	0.218**	0.006	0.088	-0.060	0.046	0.076
Migrant	0.116*	0.036	0.084	-0.015	0.078	0.006	-0.047	-0.035
Age	-0.004**	-0.005***	-0.008***	-0.011***	-0.005***	-0.007***	-0.007***	-0.007***
Income	-0.027	0.053	-0.182***	-0.082	-0.095*	-0.019	-0.006	-0.021
Single	0.225***	0.156**	0.122	0.028	0.126*	0.062	0.027	0.042
Distance	-0.013**	-0.008	-0.012*	-0.005	-0.012**	-0.007		
Consumption equations Zero Truncated Negative Binomial								
Constant	2.259*** (0.804)	2.378*** (0.614)	2.050*** (0.746)		2.427*** (0.858)	1.964*** (0.642)	-0.338 (1.651)	-0.561 (1.018)

Boat Owner (predicted values)	0.813 (2.766)		-4.300** (2.126)	-2.746 (3.194)		-1.233 (7.739)	
Activity Commitment (predicted values)	0.547 (2.015)	1.440 (1.035)	4.239*** (1.543)	2.351 (2.195)	0.273 (1.209)	1.739 (7.735)	0.565 (1.339)
Occupation CA	-0.428 (0.538)	-0.519 (0.329)	-1.109** (0.463)	-1.317** (0.598)	-0.902*** (0.326)	-0.494 (0.826)	-0.390 (0.515)
Migrant	-0.552** (0.282)	-0.581** (0.237)	-0.292 (0.253)	-0.697** (0.337)	-0.512* (0.271)	0.549 (0.657)	0.613 (0.428)
Age	-0.009 (0.009)	-0.010 (0.008)	0.009 (0.009)	0.009 (0.010)	-0.007 (0.009)	0.026* (0.016)	0.027** (0.013)
Income	-0.483** (0.243)	-0.419* (0.235)	0.018 (0.200)	-0.174 (0.294)	-0.283 (0.246)	-0.146 (0.541)	-0.214 (0.321)
Single	-0.775** (0.332)	-0.796*** (0.287)	0.141 (0.408)	-0.650* (0.366)	-0.463 (0.246)	0.592 (0.541)	0.648 (0.497)
Distance	0.033 (0.028)	0.035 (0.022)	0.040 (0.026)	0.075** (0.035)	0.057** (0.026)		
N	170	170	212	148	149	160	160
Log likelihood/ pseudolikelihood	-521.29	-521.16	-715.46	-433.73	-435.93	-459.95	-459.96
Wald chi2	25.68***	25.46***	19.61**	19.07**	17.68**	8.84**	8.81**
AIC	6.250	6.237	6.844	5.99	5.97	5.862	5.850
BIC	220.85	215.46	348.90	177.85	171.31	153.56	148.51
LR chi2	19.30**	19.56***	18.65**	15.48**	14.31**	13.58**	13.56**
Alpha	1.9878	1.978	1.7630	1.8395	1.911	6.132	6.143
LR alpha=0	1041.5***	1044.9***	2419.8***	709.17***	715.35***	1787.0***	1787.4***
Marginal effects							
Boat Owner PVs	5.086			-15.014		-3.694	
Attachment PVs	3.425	9.012		12.856	2.005	5.210	1.691
Occupation CA	-2.681	-3.247		-7.202**	-4.852**	-1.481	-1.168
Migrant	-3.456**	-3.635**		-3.814**	-2.753*	1.644	1.836
Age	-0.057	-0.066		-0.051	-0.042	0.079	0.083*
Income	-3.021*	-2.624*		-0.956	-1.522	-0.437	-0.641
Single	-4.846**	-4.981***		-3.554*	-2.494	1.775	1.939
Distance	0.212	0.220		0.413**	0.308**		

*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: Model 1 includes both Boat Owner and Activity Commitment predicted values (that were instrumented) and their predicted values were used as explanatory variables.
Model 2 includes only 'Activity Commitment' predicted values as an explanatory variable. Other explanatory variables are the same for each type of activity. Distance was irrelevant to land-based fishing model thus excluded from land-based fishing.
Consumption models for Fishing (boat and land-based) with Boat Owner (predicted values) only and Activity Commitment (predicted values) only were performing poor, all variables in the models were insignificant except constant thus the results for Model 2 were not presented here – validating your assertion that we need to deal with these separately
For Model 1 Activity Commitment instrumented variable were estimated with all the instruments plus an extra one- 'level of education' (was highly significant at 1% level in the instrumented variable model) because 'Male' was already used in 'Boat Owner' function and we needed another exogeneous variable to estimate 'Activity Commitment' function when including both in final model (Model 1)

Activity commitment coefficients are positive and highly significant at 1% level for consumption equations for all types of activities (see Model 2). The higher the commitment to fishing as a recreational activity, the higher the probability of having participated in a fishing trip within the last 12 months which is consistent with social science theories and studies (Buchanan, 1985; Sutton and Ditton, 2001) (see Chapter 3 Section 3.2 for more details)

Table A 2.2 Probit model for Activity Commitment (endogenous variable)

Instrumental Variables	**Instrumented variable Activity Commitment** Coefficient (RSE)
Constant	-1.4264***
	(0.442)
Male	0.9409***
	(0.171)
Occupation CA	0.2509
	(0.285)
Migrant	-0.0433
	(0.182)
Age	-0.0061
	(0.006)
Income	0.1337
	(0.178)
Single	-0.3038
	(0.178)
Distance	0.0315**
	(0.015)
N	453
Log pseudolikelihood	-166.51
Wald chi2	35.74***
AIC	0.770
BIC	-2388.53

*** significant at 1% level
** significant at 5% level

Appendix 3 Chapter 4

Boat Ramp Survey (used for chapter 4)

For <u>this particular trip</u> how important is each item to you as a reason for going out today?

Not important **Very important**

To be with family/friends...1........2........3........4........5
For relaxation………………………………………...1……..2……..3……..4……..5
To catch fish for eating……………………………….1……..2……..3……..4……..5
To enjoy nature……………………………………….1……..2……..3……..4……..5
For the fun of catching fish…………………………..1……..2……..3……..4……..5
Other…………………………………………………1……..2……..3……..4……..5

2. What is the most important reason for going out today? ______________________

3. How long do you expect to be out today? ***(Tick all that apply)***
Are you going to the reef today? ☐
Are you going to shoals, offshore islands, etc today? ☐
Are you going to the bays, estuaries, creeks, beaches, breakwaters, etc today?☐

4. Are you planning to fish today?
Definitely Yes☐ Definitely No ☐ Maybe☐

If No – Have you been fishing in the last 12 months? Yes☐ No☐

If Yes or Maybe
On <u>this particular trip</u> are you targeting a specific species of fish or are you just happy to catch a fish (regardless of species)?☐Any A specific spec☐s***

*****How many of ***legal size fish*** do you THINK you are likely to catch and keep today?

Fish type	Catch	Keep	Fish type	Catch	Keep
Barramundi			Other Fish (incl crab):		
Bream					
Cod					
Coral Trout/Trout					
Fingermark					
Flathead					
Grunter					
Jew Fish					
Mackerel (Spotted/Doggie/Spanish)					
Mangrove Jack					
Red Emperor					
Red Throat Emperor (Sweetlip)					
Reef Fish (Coral Reef/Tropical)					
Salmon					
Silver Bream					
Snapper/Squire					
Trevalley/Turrum					
Whiting					
Any fish					

How well do you know the fishing sites that you are going to today?

Not at all **Very well**

1 2 3 4 5

5. When you left home this morning how long did you think you would have to wait at the
boat ramp? ________

6. Before leaving this morning, did you check the weather forecast? Yes☐ No☐

7. How much do you think this trip will cost you? ***(Group___ Individual___)***
How much boat fuel do you think you are going to use _______
How much did you spend on bait________________________$
How many bags of ice did you buy________________________
How much did you spend for food ________________________$
How much did you spend for other things (e.g. alcohol) _______$
Boat hire________ $
Accommodation (if applicable)________$

8. You have told me you just spent _______ on food, alcohol and accommodation. If you were not going out on a boat today, how much of that money would you spent doing other things (e.g. going to a movie) ***(Please circle one answer only)***

All of it About ¾ of it About ½ of it About ¼ of it None of it

---

Date ___________Time of the day __________

	No of people on the boat		
	Under 15	15-60	Over 60
Male			
Female			

Boat quality: Length_____ Engine_____Tiller_____Console_____ Cabin_____

What is your gender? Male☐ Female☐

What is the best time to call you?______________
Name of person to be surveyed: ____
Phone number: _____________________ Ramp ___________________ ID #: ___________
Suburb_________ Postcode_________

SECTION A

Now I will ask you some questions about your last trip

1. Where did you end up going on the trip**?** ***(Please circle as appropriate)***
1 Reefs
2 Shoals, offshore island, etc
3 Bays, estuaries, creeks

2. Did you do any fishing while on this trip? ***(for those that 'maybe' will fish today)***
Yes☐ No☐ ***If No go to the section B***

3. About what time did you get back to the boat ramp? _________

4. How many fish did you catch and keep (total)? _______

5. How many different **legal size** species of fish did YOU catch and and how many did you keep?

Fish type	**Catch**	**Keep**	**Fish type**	**Catch**	**Keep**
Barramundi			Other Fish (incl crab):		
Bream					
Cod					
Coral Trout/Trout					
Fingermark					
Flathead					
Grunter					
Jew Fish					
Mackerel (Spotted/Doggie/Spanish)					
Mangrove Jack					
Red Emperor					
Red Throat Emperor (Sweetlip)					
Reef Fish (Coral Reef/Tropical)					
Salmon					
Silver Bream					
Snapper/Squire					
Trevalley/Turrum					
Whiting					
Any fish					

6. Did you use any bait**?** Yes ☐ No ☐

7. Did you purchase any new fishing tackle prior to taking this particular trip? If so, how much did it cost? ___________$

SECTION B

Now I will ask you some general questions about recreational boating

8. In the last 12 months, how many times have you been out on a privately owned boat (i.e. not a commercial operator who you must pay) in the Townsville region? ______

9. With whom do you go out on a boat with most often? **(*Circle only one answer please)***
1 By yourself
2 Friends
3 Family
4 Family and friends together
5 Club
6 Other (please specify) ____________________

10. Are there any other recreation activities that provide you with the same level of satisfaction and enjoyment that you receive from going out on a boat?

1 No, for me there is no substitute for going out on a boat
2 Yes, other activities can substitute for boat trips. Please tell us which activities

____

Now I will ask you some general questions about recreational fishing

11. Did you ever go fishing when you were a child? Yes☐ No ☐ Not sure ☐

12. Have you ever been fishing as an adult?

Yes ⟶ ***Please go to 13***
No ⟶ ***If No***, Would you like to try fishing someday? Yes ☐ No ☐

Now go to the section C (page 3)

13. Approximately what proportion of the time that you go out on a boat do you fish? ***(Please circle one number)***

Never 1------2------3------4------5 **All the time**

14. Over the past two years, about how often have you gone fishing? **(*Circle only one answer please)***

1 Once every 2-3 months or less often
2 Monthly
3 A few times a month
4 Weekly or more often
5 Did not go fishing over the past two years ⟶ ***Now go to the section C (page 3)***

15. How many years you have been fishing this often or more frequently?_______

16. With whom do you fish with most often? **(*Circle only one answer please*)**

1 By yourself
2 Friends
3 Family
4 Family and friends together
5 Club
6 Other (please specify) ____________________

17. In the last 12 months, how many times have you been fishing on or in

1 Reefs ______
2 Shoals, offshore island, etc ______
3 Bays, estuaries, creeks ______
4 Fresh water (rivers, lakes etc) ______

18. If you could not fish, would you still go recreational boating?

1 No, for me there would be no reason for going out on a boat if I could not fish
2 Yes, I could do other things while out on a boat. Please tell us which other things

____

19. If you could not go fishing, are there any other recreation activities that would provide you with the same level of satisfaction and enjoyment that you receive from fishing?

1 No, for me there is no substitute for fishing
2 Yes, other activities can substitute for fishing. Please tell us which activities

____

20. What species do you most prefer to catch?

1 Don't care – happy to catch anything
2 Most preferred species ____________________
3 Second most preferred species ____________________
4 Third most preferred species ____________________

21. Please indicate the extent to which you agree or disagree with each of the following statements about recreational fishing:

	Strongly disagree				**Strongly agree**	**Don't know**
A fishing trip can be successful even if no fish are caught	1	2	3	4	5	☐
The more fish I catch, the happier I am	1	2	3	4	5	☐
The bigger the fish I catch, the better the fishing trip	1	2	3	4	5	☐
I like to fish where I know I have a chance to catch a "big" fish	1	2	3	4	5	☐
I want to keep all the fish I catch	1	2	3	4	5	☐
I'm happier if I release some of the fish I catch	1	2	3	4	5	☐

SECTION C

22. Please circle the number that indicates your level of agreement with each of the following statements about issues affecting recreational fishing and boating in the Townsville region:

	Strongly disagree				**Strongly agree**	**Don't know**
There are enough public boat ramps to meet my needs	1	2	3	4	5	☐
The quality of public boat ramps is good	1	2	3	4	5	☐
The fishing areas are too crowded	1	2	3	4	5	☐
Good fishing sites are easily accessible	1	2	3	4	5	☐
There are sufficient parking places near the boat ramp area	1	2	3	4	5	☐
Fishing is part of my culture or family tradition	1	2	3	4	5	☐
Most of my friends are in some way connected with fishing	1	2	3	4	5	☐

23. Compared to other recreational activities (like golf, watching television, going to restaurants or bars, attending concerts) would YOU consider fishing and/or boating to be:

1 Your most important recreational activity
2 Your second most important recreational activity
3 Your third most important recreational activity
4 Only one of many recreational activities that are important to you
5 Not at all important to you as a recreational activity

Now I will ask you some questions about your personal details. Please remember that this information will be kept strictly confidential

24. In what year were you born? ________ ***(if not willing to give year, go to age group)***

25. In which of the following age groups do you belong?

15-19	25-34	45-54	65-74	85 and over
20-24	35-44	55-64	75-84	

26. How long have you lived in Townsville?
All my life ☐ or
Years _______ or Months _______

If you were not born here, from where did you move here _______________________

27. What is your marital status? Single ☐ Married ☐ Other ☐

28. How many people in your household? _______ No of children (15 yrs and under) _______

29. What is the highest level of education you have completed? ***(Tick as appropriate)***

☐ Primary school
☐ Some high school
☐ High school diploma
☐ Trade certificate or apprenticeship
☐ Diploma
☐ University degree (Bachelor or Honours)
☐ Post graduate degree
☐ Other (please specify)___

30. What is your occupation? _________________________________

31. If employed - On average how many hours per week do you work _________

32. What is the total, combined, annual (taxable) income of ALL the people who 'normally' live in your house and share expenses? (***Please circle one category***. We do not keep your income details with your personal details - income helps to ensure we have a good cross section of the population surveyed. All of the answers that you give will be strictly confidential)

1 Under $20,000
2 $20,000 to $40,000
3 $40,000 to $60,000
4 $60,000 to $80,000
5 $80,000 to $100,000
6 $100,000 and above

That is all the questions I have for you. Thank you so much for taking the time to answer these questions. Your responses are very valuable to us. Bye.

Explanatory variables frequently used in recreational fishing studies

Explanatory variables frequently used in recreational fishing studies include:

- fishing experience or number of years fishing (Kaoru et al., 1995; McConnell et al., 1995; Schuhmann, 1998; Whitehead & Haab, 1999; Van Bueren, 1999; Schuhmann & Schwabe, 2004; Whitehead, 2006; Alvarez et al., 2012; Gao & Hailu, 2012),
- fishing mode (Schuhmann, 1998; Zhang et al., 2003; Hunt et al., 2007; Hailu, Gao, Durkin, & Burton, 2011; Alvarez et al., 2012; Gao & Hailu, 2012)
- hours fished (Kaoru et al., 1995; McConnell et al., 1995; Schuhmann, 1998; Whitehead & Haab, 1999; Van Bueren, 1999; Zhang et al., 2003; Schuhmann & Schwabe, 2004; Whitehead, 2006; Raguragavan et al., 2010; Alvarez et al., 2012)
- targeted species (Schuhmann, 1998; Whitehead & Haab, 1999; Zhang et al., 2003; Hunt et al., 2007; Whitehead, 2006; Raguragavan et al., 2010; Alvarez et al., 2012; Gao & Hailu, 2012)
- familiarity with fishing sites (Zhang et al., 2003; Schuhmann & Schwabe, 2004)
- boat ownership (Whitehead & Haab, 1999; Whitehead, 2006)
- party size on current trip (Kaoru et al., 1995; Zhang et al., 2003)
- boat engine (Kaoru et al., 1995; Schuhmann & Schwabe, 2004)
- value of fishing gear (Van Bueren, 1999) or gear type (Schuhmann & Schwabe, 2004)
- skill level (Van Bueren, 1999; Hailu et al., 2011)
- bait (Zhang et al., 2003; Schuhmann & Schwabe, 2004; Hailu et al., 2011)
- fishing frequency (Zhang et al., 2003; Schuhmann & Schwabe, 2004)
- season (Schuhmann & Schwabe, 2004) and weather (Gao & Hailu, 2012)

- travel distance (Hunt et al., 2007)
- motivations (Hunt et al., 2007)
- age (Zhang et al., 2003; Schuhmann & Schwabe, 2004; Hunt et al., 2007; Raguragavan et al., 2010; Gao & Hailu, 2012)
- employment and retirement status (Zhang et al., 2003; Raguragavan et al., 2010; Gao & Hailu, 2012)
- annual income (Alvarez et al., 2012)

Tobit model with endogenous regressors

Following StataCorp (2007) and Finlay and Magnusson (2009) an Instrumental variables (IV) Tobit model can be written as

$y_{1i}^{*} = y_{2i}\beta + x_{1i}\gamma + u_i$ (A3.1)

$y_{2i} = x_{1i}\prod_1 + x_{2i}\prod_2 + \upsilon_i$ (A3.2)

for i = 1 ,2 ,3, …N (A3.3)

y_{2i} is $1\times p$ a vector of endogenous variables in the model

x_{1i} is a $1\times k_1$ vector of all exogenous variables

x_{2i} is a $1\times k_2$ vector of additional instrumental variables

β and γ are vectors of structural parameters

$\prod_1$ and $\prod_2$ are reduced form parameters matrices

For compactness we can rewrite the model as

$y_{1i}^{*} = z_i\delta + u_i$ (A3.4)

$y_{2i} = x_i\prod + \upsilon$ (A3.5)

Where $z_i = (y_{2i}, x_{1i})$, $x_i = (x_{1i}, x_{2i})$, $\delta = (\beta', \gamma')$, $\prod = (\prod_1', \prod_2')$

Instead of observing y_{1i}^{*}, we observe

$$y_{1i} = \begin{cases} a & y_{1i}^{*} < a \\ y_{1i}^{*} & a \le y_{1i}^{*} \le b \\ b & y_{1i}^{*} > b \end{cases} \qquad \text{(A3.6)}$$

Where a is the lower bound and b is the upper bound

The residuals (u_i, υ_i) are normally distributed with zero mean and covariance

$$\sum = \begin{bmatrix} \sigma_u^2 & \sum_{21}' \\ \sum_{21} & \sum_{22} \end{bmatrix}$$

'Using properties of the multivariate normal distribution, we can write' (StataCorp, 2007, p. 64)

$u_i = \upsilon_i' \alpha + \varepsilon_i$,

Where

$\alpha = \sum_{22}^{-1} \sum_{21}$; ε_i ~N(0; $\sigma_{u/\upsilon}^2$)

$\sigma_{u/\upsilon}^2 = \sigma_u^2 - \sum_{21}' \sum_{22}^{-1} \sum_{21}$

ε_i is independent of υ_i, z_i, and x_i.

The joint density $f(y_{1i}, y_{2i} \mid x_i)$ can be written as $f(y_{1i} \mid y_{2i}, x_i) f(y_{2i} \mid x_i)$

and the likelihood function with one endogenous regressor is

$$\ln f(y_{2i} \mid x_i) = -\frac{1}{2}\{\ln 2\pi + \ln \sigma_\upsilon^2 + \frac{(y_{2i} - x_i \Pi)^2}{\sigma_\upsilon^2}\} \quad \text{(A3.7)}$$

and

$$\ln f(y_{1i} \mid y_{2i}, x_i) = \begin{cases} \ln\{1 - \Phi(m_i / \sigma_{u|\upsilon})\} & y_{1i} = a \\ -\frac{1}{2}\{\ln 2\pi + \ln \sigma_{u|\upsilon}^2 + \frac{(y_{1i} - m_i)^2}{\sigma_{u|\upsilon}^2}\} & a < y_{1i} < b \\ \ln \Phi(m_i / \sigma_{u|\upsilon}) & y_{1i} = b \end{cases} \quad \text{(A3.8)}$$

where $m_i = z_i \delta + \alpha(y_{2i} - x_i \Pi)$

And where $\Phi(.)$ is 'the normal distribution function so that the log likelihood for observation *i* is (StataCorp 2007, p. 64)

$$\ln L_i = w_i\{\ln f(y_{1i} \mid y_{2i}, x_i) + \ln f(y_{2i} \mid x_i)\} \quad \text{(A3.9)}$$

Where w_i is 'the weight for observation *i* or one if no weights is specified' (StataCorp, 2007, p.64)

Motivations and consumptive orientation

Both motivations and consumptive orientation vary between individual anglers and anglers' populations (Fedler & Ditton, 1994; Aas & Kaltenborn, 1995). 'Motivations are the psychological outcomes one desires from the experience of recreational fishing and include consumptive dimensions (e.g., catching and keeping fish) and non-consumptive dimensions (e.g., relaxation, socializing)' (Sutton, 2006, p.25). These consumptive and non-consumptive features 'of the fishing experience is important because these variables are expected to have a strong influence on fishers' attitudes and behaviours (Sutton, 2006, p.25). Driver (1977) and Sutton (2006) motivations for current fishing trip were measured by asking participants before the trip to rate the importance of five reasons for going out on a boat on a 5-point scale rating from 1 'not important' to 5 'very important'. These 5 individual reasons (items) were measuring 4 different dimensions of fishing trip motivations: catching fish, relaxation/escape, socialisation and experiencing nature. From those only two items 'importance to catch fish for eating' and 'importance of catching fish for fun' have been found significant and therefore were included in the analysis.

"Consumptive orientation is the degree to which a fisher values the specific catch-related outcomes of the fishing experience' (Sutton, 2006, p. 25). To measure consumptive orientation the researchers used 6 items adapted from a scale developed by Graefe (1980) and from a further extended scale by Fedler and Ditton(1986) and Sutton and Ditton (2001). The level of agreement for each item was measured on a 5-point Likert scale. Elicited responses ranged from 'strongly disagree'(1) to 'strongly agree'(5) with 'being neutral'(3) (Sutton & Ditton, 2001; Sutton, 2003; Fedler & Ditton, 1986). The six statements was used to measure different levels of importance on four catching fish aspects placed by an individual : catching something (1 item); number of fish caught (1 item);

catching a trophy fish (2 items); keeping fish (2 items) (Sutton, 2003; Kyle et al., 2007; Anderson et al., 2007) (see also Chapter 3 Section 3.2 for more details).

Supplementary table

Table A 3.1 Results for Tobit models censored at lower level (0) investigating determinants of keep (rather than catch)

Variable	**Expected Keep**	**Actual Keep**
	Coefficient (SE)	Coefficient (SE)
Intercept	-7.6246***	1.2372
	(1.700)	(1.627)
Actual/Expected hours	0.2072***	0.0746
	(0.080)	(0.073)
TSpecies/Species	1.5876***	1.3223***
	(0.440)	(0.405)
Consumptive orientation	-0.0301	-0.1836***
	(0.053)	(0.048)
Years fishing	-0.0228	-0.0900**
	(0.048)	(0.042)
Years fishing squared	0.0006	0.0022***
	(0.0009)	(0.0008)
Male	0.7502	0.3074
	(0.600)	(0.567)
Full moon	-0.0781	0.8777*
	(0.594)	(0.488)
Importance of catching fish for eating for this particular trip	0.6947***	0.2978*
	(0.169)	(0.156)
Importance of fishing for fun for this particular trip	0.5451**	0.3200
	(0.233)	(0.223)
Temperature	0.1121***	-0.0143
	(0.035)	(0.031)
Bait	1.3488**	0.0121
	(0.642)	(0.596)
Log likelihood	-644.33	-315.66
LR chi2	73.68***	39.36***
AIC	4.69	3.93
BIC	-215.82	-156.83
Number of observations	280	167

* significant at 10% level
** significant at 5% level
*** significant at 1% level

Note: participants who completed the 1st part of the survey only where excluded from the analysis for expected and actual catch and keep. We also estimated catch and keep functions using (a) consumptive orientation score without importance of fishing of eating and importance of fishing for fun and (b) using importance of fishing for eating and importance of fishing for fun without consumptive orientation. The signs and significance of the coefficients did not

change but the model fit did not improve either so we decided to keep both consumptive orientation and two variables only that explain motivations for this particular trip in the final model.

Appendix 4 Chapter 5

Methodological background

Over the years, many different valuation techniques have been developed and tested for their ability to quantify the benefits (or costs) of different types of use and non-use values that are associated with non-priced environmental goods such as marine species. Although arguably considered to be more 'reliable' than other approaches (primarily because they use objectively verifiable data), valuation techniques that use market prices are not able to provide information about the marginal value of goods or services if they are not exchanged on the market. Revealed preference techniques such as the travel cost approach or hedonic pricing (using property or land values, wage differentials or other) do not require the existence of a market for the good being studied, but they do require a strong association between the market that is being studied (e.g. housing), and the environmental factor of interest (e.g. views of the ocean) (Mäler, 1974; Palmquist, 2002). If the association cannot be established, stated preference (SP) techniques such as choice experiments and contingent valuation studies offer themselves as attractive alternatives.

Although the number of researchers using choice experiments to estimate WTP is rapidly increasing (Ryan & Gerard, 2003; Ryan, Gerard, & Amaya, 2008; Ryan & Watson, 2009), the contingent valuation method (CVM) has, historically, been one of the most popular of the different SP approaches and has been used in thousands of research studies. This is at least partially because of its simplicity and the economy of the data required (Carson, Flores, & Meade, 2000). For this reason (i.e. its 'economy of data' and ability to generate estimates of WTP without requiring respondents to complete numerous, sometime quite cognitively taxing choice experiments) the CVM was chosen here.

Questionnaire design is critical to the CVM. Researchers must design questions which allow them to elicit an individual's WTP. These valuation questions can be created in several ways, the most common being the: open-ended (OE); dichotomous choice (DC); and payment card (PC) approaches. Many researchers (Kealy & Turner, 1993; Ready, Whitehead, & Blomquist, 1995) have found that the different question formats generate different WTP estimates.

In the OE approach, participants are simply asked how much they are willing to pay for a particular good or service (or 'scenario'). This format has been criticized as being likely to provide unreliable estimates because people are not used to being asked to construct dollar values on environmental goods or services (Reaves, Kramer, & Holmes, 1999). Rather, consumers are more used to facing choice situations (to buy, or not to buy). As such, some researchers have argued that the OE format is likely to misrepresent the consumers' preferences (Arrow et al., 1993; Halvorsen & Soelensminde,1998).

In the DC format, respondents are presented with a specified monetary tradeoffs and asked if they are willing to pay that amount for an environmental improvement or to accept or reject a project (Håkansson, 2008; Reaves et al., 1999). The DC question format can induce anchoring effects (Halvorsen & Soelensminde,1998) and starting point bias (Mitchell & Carson, 1989; Cameron & Quiggin, 1994), and empirical investigations need large samples to generate robust models (Cameron & Huppert, 1991) which can be statistically complicated (Cooper & Loomis, 1992). But the format has been endorsed by the NOAA Panel (Arrow et al., 1993) and found to be superior to the OE approach (McCollum & Boyle, 2005). That said, there is evidence to suggest that the DC approach can, in some instances, overestimate WTP variance (Boyle et al., 1996), and also mean and median WTP estimates (Walsh, Johnson, & McKean, 1989; Boyle et al., 1996) – perhaps at least partially because of "yeah" saying tendencies on the part of respondents.

The payment card (PC) question format addresses the problem of 'yea' saying or 'the tendency of some respondents to agree with an interviewer's request regardless of their true views' (Mitchell & Carson, 1989, pp.240-241) by providing respondents with an ordered range of threshold values starting at $0. Participants are asked to circle the highest amount they are willing to pay, and their true valuation point is assumed to lie 'somewhere in the interval between the circled value and the next option' (Håkansson, 2008, p.176). The PC approach avoids the starting point bias that can occur in traditional bidding applications (Mitchell & Carson, 1984) and allows participants to consider a range of possible WTP bids that represent the participant's maximum WTP (Cameron & Huppert, 1991). As such it 'conserves [respondent] effort because even a fairly detailed set of thresholds can be quickly scanned and there is no need for prompting by an interviewer' (Cameron & Huppert, 1989, p. 231).

For these reasons, the PC approach was adopted in this chapter. However, those working on this project were cognizant of its problems, and thus set out to ensure that their experimental design allowed them to control for those issues.

Specifically, many researchers have shown that the range of values provided in CV questions (starting point/anchoring effects for DC, end point for PC) can influence responses (Mitchell & Carson, 1989; Cameron & Huppert, 1989; Cooper & Loomis, 1992; Rowe, Schulze, & Breffle, 1996; Herriges & Shogren, 1996; Green, Jacowitz, Kahneman, & McFadden, 1998; Roach, Boyle, & Welsh, 2002; McNamee, Ternent, Gbangou, & Newlands, 2010). Although some researchers have found little evidence to suggest that it does (Ryan, Scott, & Donaldson, 2004). Moreover, there is evidence to suggest that the order of bids can affect the pattern of responses and welfare estimates (Alberini, Boyle, & Welsh, 1999). My study thus sought to include mechanisms that allowed me to test the statistical significance of bid-end and bid order bias, by developing four different versions of each PC question. These used two different bid end values ($150 or $300), with associated differences in intervals. Each bid-end value also had two, associated, bid presentation orders ($0 bids presented first or last). A copy of (one version of) the pertinent question appears below.

For this question, please <u>IMAGINE</u> that it is possible for boat operators to provide a 100% GUARANTEE of seeing different types of wildlife. If they could do that, how much EXTRA (above what you have already paid for this trip) would you be prepared to pay for a 100% guarantee to see each of the following? (*Please tick one box for each wildlife category*)

(Categories represent Australian Dollars)

Wildlife	**$0**	**$1-20**	**$21-50**	**$51-100**	**$101-150**	**$151-200**	**$201-300**	**More than $300**
Whales and Dolphins:	□	□	□	□	□	□	□	□ Please specify how much_______
Sharks and Rays:	□	□	□	□	□	□	□	□ Please specify how much_______
Large Fish:	□	□	□	□	□	□	□	□ Please specify how much_______
Marine Turtles:	□	□	□	□	□	□	□	□ Please specify how much_______
Seeing many different types of marine wildlife:	□	□	□	□	□	□	□	□ Please specify how much_______

Note: There were different versions of the questionnaire for different types of trips and tourists – details about the questions and trips are given in section 5.2, analytical approaches for dealing with the differences are discussed in Appendix 4

Recognising that results are also sensitive to the treatment of protest votes (Reaves et al., 1999), but that the existing literature on treatment of protest response in CV is relatively limited and ambiguous in its recommendations (Meyerhoff & Liebe, 2006), I determined to ensure that analytical approaches would generate a predictable, downward bias in final WTP estimates. Firstly, open ended responses (of which there were few) were omitted (see Appendix 4 for details on open-ended responses). Second, if a respondent failed to respond to all parts of the question (all species in the list), then that survey was omitted from the analysis. Third, if a respondent indicated non-zero WTP for at least one species in the list, but gave no indication of WTP for another species, then the non-response was treated as zero. I felt this appropriate since these respondents were clearly WTP something for some species, but not for all, indicating that their WTP for the omitted species was likely zero. Importantly, this decision serves to generate lower

mean estimates of WTP than the alternative (of treating related WTP bids from that respondent as missing), And finally, as recommended by Halstead et al. (1992) and Meyerhoff and Liebe (2006), protest responses were recoded as true zero bids (which, like previous decision, tends to bias welfare estimates downward). Consequently, there were many zero values.

When analysing CV data, researchers almost always assume participants have positive WTP (Bengochea-Morancho, Fuertes-Eugenio, & del Saz-Salazar, 2005). But Strazzera, Scarpa, Calia, Garrod, and Willis (2003) noted that zero values can represent several different things: (i) true preferences; (ii) protest behaviour; and/or (iii) 'the indifference of individuals to the changes …under evaluation' (Bengochea-Morancho et al., 2005, p. 239). This is certainly true of my data, indicating that there is likely to be a discontinuity (or 'spike') in the WTP distribution at the zero value, and that it may be necessary to use techniques to control for that issue: hence the choice of Kristrom's (1997) spike model. Kristrom (1997) developed and estimated a spike model which corrects for the non-zero probability of zero responses in WTP. It allows me 'to sort the respondents in two (or more) groups, without compromising the analysis (Kristrom, 1997, p.1014). This approach is particularly useful when the distribution of WTP is asymmetric and the proportion of zero responses is high (Kristrom, 1997; Bengochea-Morancho et al., 2005).

Finally, when analysing contingent valuation data, WTP is often regressed against several variables. In this chapter, I thus chose to use data on a variety of different socio-economic variables constructing a model that uses not only the 'bid offer' but a variety of explanatory variables to allow for individual heterogeneity.

WTP open ended responses

Far Northern and Osprey live-aboard boat trips:
Sharks and Rays $150 -(> $150*6; $200*4; $250; $300*2; $400; $500*5; $800, $1000*2)
Sharks and Rays $300 -(>$300*2; $350; $500*7; $1000)
'Variety' $150- (>$150*2; $200*3)
'Variety' $300- ($500)
Marine Turtles $150- (>$150*2; $200)
Marine Turtles $300- (>$300; $500)
Large Fish $150- (>$150*2; $200*3; $250; $300; $500*2)
Large Fish $300- ($400; $500)

Minke Live-aboard boat trips:
Whales and Dolphins $150- (>$150*2; $200; $500)
Whales and Dolphins $300 -($500; $1000*2)
Sharks and Rays $150- ($175.5; $200; $250)
Sharks and Rays $300- (>$300*2; $400)
'Variety' $150 – no responses
'Variety' $300- ($500)
Marine Turtles $150 – no responses
Marine Turtles $300– no responses
Large Fish $150 -($200)
Large Fish $300 – no responses

Day boats:
Whales and Dolphins $150- (>$150; $200*2; $300)
Whales and Dolphins $300 -(>$300; $500)
Sharks and Rays $150- (>$150; $200; $260)
Sharks and Rays $300 -(>$300; $1000)
'Variety' $150 –($200)
'Variety' $300 -(>$300;$500)
Marine Turtles $150 –(>$150; $200*2; $260)
Marine Turtles $300– no responses
Large Fish $150 -($200; $260)
Large Fish $300 – no responses

The spike model

Formally, the spike-model approach recognises that each respondent is confronted with a range of 'offers' (or bids) for a particular good or service. Let a bid that is accepted by the i^{th} individual for a given amount of money A^k be denoted by z_1 and a bid that is not taken by i^{th} individual for a given amount of money A^k be denoted by z_0.

The accepted bid thus lies within the interval:

$A^k < WTP < A^{k+1}$, where k (k^{th} interval) = 1, 2, …h

Follow Hackl and Pruckner (1999) and Hu et al. (2011) the probability P_k that the offer is accepted lies within the interval is

$$P_k = F(\Delta v(A^k);\theta) - F(\Delta v(A^{k+1});\theta) = F(A;\theta) \quad \text{(A4.1)}$$

Where the utility difference (Δv):

$$\Delta v_i(A^k) = v(z_1, y - A^k; x) - v(z_0, y; x) \quad \text{(A4.2)}$$

$$\Delta v_i(A^{k+1}) = v(z_1, y - A^{k+1}; x) - v(z_0, y; x) \quad \text{(A4.3)}$$

The distribution of the WTP in this case is the cumulative distribution function $F(A;\theta)$ and it is assumed to be a logistic or cumulated standard normal. It takes the form below:

$$F(A;\theta) = \begin{cases} p & \text{if A = 0} \\ G(A;\theta) & \text{if A > 0} \end{cases} \quad \text{(A4.4)}$$

Where $p \in (0,1)$ correspond to the cumulative density functions when Ais equal to zero (i.e., the non-zero probability that WTP is equal to zero) and $G(A;\theta)$ is a distribution of positive preferences and it is logistic or cumulative standard normal distribution.

The parameters of $F(A;\theta)$ for the payment card can thus be estimated by maximizing the log-likelihood function for the i^{th} individual

$$\ln L_i(\theta) = \sum_{i=1}^{N} \left\{ \begin{array}{l} (1-S_i)I_i^0 \ln[1-F(0;\theta)] \\ + S_i I_i^1 \ln[F(0;\theta) - F(A_i^1;\theta)] \\ + \sum_{k=2}^{H-1} S_i I_i^k \ln[F(A_i^k;\theta) - F(A_i^{k+1};\theta)] \end{array} \right\} \quad \text{(A4.5)}$$

Where

S_i = 1 if the individual *i* is willing to pay positive amount of money and zero otherwise

I_i^0 = 1 if an individual's *i* WTP is zero and zero otherwise

I_i^k =1 if an individual *i* choose A^k and zero otherwise

The PC survey generates interval data for 'the true but unobserved value' (Cameron, Poe, Ethier, & Schulze, 2002, p. 404). Some researchers assign 'the midpoint of the relevant interval as a proxy for the mean of the variable over that interval and employ OLS regression using these midpoints as the dependent variable' (Cameron & Huppert, 1991, p.912). However, if the dependent variable is measured on intervals of a continuous scale, it is more appropriate (and efficient) to use maximum likelihood methods (MLE) for estimation of regression models (Cameron & Huppert, 1989; Cameron & Huppert, 1991; Reaves et al., 1999). Moreover, there a is systematic decrease in the absolute value of the OLS slope estimates with increasing interval width; whereas MLE estimates are more robust to interval width (Cameron & Huppert, 1989). As such, MLE was used.

As noted earlier, many spike models have only used the WTP offer (Kristrom, 1997; Nahuelhual-Munoz, Loureiro, & Loomis, 2004) but I chose to consider models with a variety of other explanatory variables, including:

Age_i – age of the respondent *i*

ExP_i - respondent's *i* total regional non-boat expenditure plus advertised price of the boat trip

Male – dummy variable (1= if the respondent *i* is a male, 0 = if the respondent *i* is a female)

Res – dummy variable (=1 if the respondent I is Australian resident, 0 otherwise)

Given final set of independent variables, the change in utility or utility difference Δv is thus given by:

$$\Delta v_i = a_0 + a_1 A^k + a_2 Age_i + a_3 ExP_i + a_4 Male + a_5 \mathrm{Re}\, s \qquad \text{(A.4.6)}$$

In other words, I expected income (proxied here as expenditure plus price of the boat trip) y and a vector of socioeconomic variables *x* to affect individuals' preferences (thus WTP). I also estimated various other models with different explanatory variables (e.g. diving qualifications, whether or not this was the respondent's first visit to the GBR, the probability of sighting particular species and their satisfaction with the trip). These variables were only significant in some models for some species and were insignificant for most others. Importantly, the coefficients on the WTP offers were robust across all specifications (i.e. there was no change in either the WTP offer coefficients or their significance depending on whether these variables were included or not). They were, therefore, omitted from the analysis, noting that their omission does not significantly alter the final estimates of WTP.

Specification testing

In the first instance, I tested the hypothesis that the two datasets (bid range \$150 subset and bid range \$300 subset) for each species do not differ significantly in terms of how they fit the spike model. This was done with a LR test (LRT), comparing the log-likelihood of each pooled model (\$150 and \$300 subsets combined) for each individual species being evaluated (e.g. Large fish) with the sum of the log-likelihoods from the two separate models. For example for Large Fish, it was calculated as: –2[log-LPooledLargeFish – (log-\$150LargeFish + log-\$300LargeFish)]. Under the null hypothesis, that \$150 and \$300 subsets do not differ, the calculated LRT is 198.62 which is greater than the 0.05 critical value of a $\chi 2(6)$ which is 12.59. Tests indicated that the two data subsets are significantly different under this model, thus it was divided the database into two different subsets (those with WTP values between \$0 and \$150; and those with WTP values between \$0 and \$300).

I then tested for evidence that bid-order (zero bid presented first or last) affected final results, concluding that this was not the case. I used a dummy variable to test if there are any significant differences in bid presentation order: H = 1 if "0" bid was presented first on the payment card for each data subset. For each group of species this dummy variable was insignificant. No further adjustments were made to control for bid order.

Finally, I tested to see if there were 'menu' effects. Again, the LRT was used – comparing the log-likelihood of

- each 'pooled model' (with all three 'menu' groups combined) for each individual species being evaluated (e.g. Sharks and Rays) for each bid range (e.g. those with \$150 versus \$300 upper bids), with

- species models (e.g. Sharks and Rays) for each bid range (e.g. those with $150 versus $300 upper bids) using data from each ‘menu’ group individually.

Results indicated that the groups should be separated.