

GREAT BARRIER REEF
FOUNDATION

VALUING THE EFFECTS OF GREAT BARRIER REEF BLEACHING

AUGUST 2009



OXFORD ECONOMICS

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FOREWORD

The Great Barrier Reef is recognised here in Australia, and around the world, for its outstanding cultural and natural value. However, climate change is directly threatening the Reef. At its most dramatic, climate change on the Reef manifests as coral bleaching.

In August 2008, the Great Barrier Reef Foundation commissioned Oxford Economics to undertake a study of the costs of a total and permanent bleaching on the Reef to the Cairns region and, as part of that study, to reassess the value of the Reef.

Previous studies of the economic value of the Great Barrier Reef have focused on its contribution to GDP, but not looked comprehensively at factors such as national and international preparedness to pay for the Reef's preservation. This study rightly recognises the value which Australians and people all over the world place on the Reef, and having it preserved for future generations to enjoy.

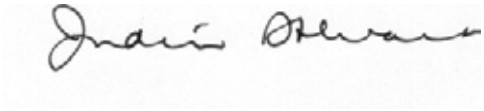
Moreover, the report takes a long-term investment perspective, which is appropriate to the protection of long-lived environmental assets, like the Great Barrier Reef.

Cairns has long been Australia's most important gateway to Great Barrier Reef tourism. The Foundation has focused this report on the Cairns region to bring the true economic cost of climate change into relief. However, simply highlighting the impacts to Cairns is not the Foundation's core objective; instead, it wishes to advance thinking and discussion on the solutions and the adaptation strategies that will be needed if we are to preserve the Reef, and the communities it supports, in the face of this threat.

The findings contained in this report are, of necessity, conservative because on important topics such as non-use values and visitation behaviour, detailed and consistent data has not been collected or commissioned. It is very likely that as we learn more about topics like these, values will increase.

The work of the authors directly benefited from the co-operation of many Australian academics and institutions, with first hand experience of the area and detailed knowledge of similar studies. Likewise, custodians of important data soon became generous contributors. The Foundation is indebted to all those who contributed to this important study.

The Great Barrier Reef is our single greatest national indicator of how our climate is changing. We owe it to Cairns, to all Australians, and indeed the global community, to do all we can to secure its future.



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Report Reference

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Executive Summary

Australia, along with the entire world, faces the tremendous challenge of climate change over the coming decades. Along with its impacts on a wide variety of global ecosystems, climate change has the potential to have long-term impacts on Australia's Great Barrier Reef (GBR). Among the most serious of these are the phenomenon of coral bleaching (or, more properly, bleaching mortality) and its attendant effects on the reef's biodiversity.

Reef-building corals are driven by a partnership between corals, and tiny single-celled plants known as dinoflagellates. The dinoflagellates trap solar energy through photosynthesis, providing both organisms with an abundant source of organic carbon and energy. In return, the coral provides inorganic nutrients which act as fertiliser for the dinoflagellates. As a result of this relationship, corals are able to build the huge structures that are typical of coral reefs.

The symbiosis between reef-building corals and their dinoflagellates is extremely vulnerable to environmental stress. A small increase in sea temperature, for example, will destabilise the symbiosis leading to the rapid loss of the brown dinoflagellates from the tissues of the coral. As a result, the corals lose their overall brown colour, with the brilliant white skeleton gleaming through the otherwise transparent tissues of the coral host (hence the term coral bleaching). Prolonged or intense stress will lead to disease and death. With global warming, the latter is becoming the norm, with huge mortalities being recorded across the planet within coral communities.

The long term effects of coral bleaching (in both the Cairns region and the entire GBR) are the focus of this study. Coral bleaching, and related effects of warming, present a serious threat to the future existence of the reef. The Garnaut Climate Change Review (2008) ("the Garnaut Report") and other recent media commentary has paid particular attention to the issue of the long term survivability of the GBR due to bleaching and there have been growing public concerns about its future.

As noted in a supplementary paper to the Garnaut Report, if atmospheric concentrations of carbon dioxide (CO_2) exceed 500 parts per million (ppm) the GBR is likely to experience a massive loss of biodiversity and ecological function. Any semblance of reefs to the coral reefs of the Great Barrier Reef Marine Park today would vanish, with the GBR having a vastly different appearance to that which attracts tourists at present (Hoegh-Guldberg and Hoegh-Guldberg 2008).

This, in turn, raises the issue of how much the nation (and by extension, the world) values a World Heritage-listed natural resource such as the GBR.

The Great Barrier Reef Foundation invests in science that will maximise the sustainability of the Great Barrier Reef for the benefit of all Australians.

The Foundation's International Scientific Advisory Committee which identifies and recommends research projects for investment to the Foundation's Board has a research vision of *"Understanding and maximising the resilience of reefs (and especially the GBR) to climate change".*

In the context of this vision and the important climate change debate currently occurring in Australia, The Foundation has commissioned Oxford Economics to undertake a study into the cost of the **total and permanent bleaching** of the GBR both in:

- the Cairns region: and
- for the GBR as a whole

This report takes into account:

- direct use values of the commercial, recreational fishing and tourism industries (i.e. profitability);
- direct use values by tourists and recreational fishers (i.e. how much the groups using the GBR truly value the reef, rather than simply how much they spend in the region);
- indirect use values of coastal protection;
- the non-use values of Australians who may not visit the reef but are willing to pay for its continued existence; and
- non-use values for international residents

The analysis has been conducted using a Total Economic Value (TEV) approach, consistent with the concepts set out in the Queensland Government's *Environmental Economic Valuation: An introductory guide for policy-makes and practitioners* (2003). The approach also draws on concepts developed in the recent Garnaut Report and environmental economics literature, including use of a 100 year timeframe and a social discount rate of 2.65%.

As a first step, the total value of the GBR and of the GBR in the Cairns area were derived. From this, estimates of the total cost of bleaching of the GBR and of the GBR in the Cairns area were then calculated. Where there are uncertainties over data, a conservative approach has generally been adopted.

At a preferred discount rate of 2.65%, streamed over 100 years, holding present day values constant, it is estimated that the present value (PV) of the GBR as a whole 9excluding indigenous values) is $51.4 billion, with a value of $17.9 billion estimated for the Cairns area.

From this, an estimate of the cost of bleaching for the Cairns area and the GBR can be derived. If a total and permanent bleaching of the GBR were to occur today, then (holding present day values constant over 100 years, at a discount rate of 2.65%0 the costs (in PV terms) are estimated at $37.7 billion with an estimate of $16.3 billion for the Cairns area.

Put another way, the bleaching cost for the whole of the GBR is roughly equivalent to a constant $1.08 billion per annum over the course of a century.

These values reflect those which can be reasonably attributed to the GBR. For example, tourism motivated by the GBR's coral sites is included but not regional tourism which is focussed on other activities (e.g. swimming, beach visits, visits to friends and relatives).

Charts ES-1 and ES-2 represent these data graphically. The first chart indicates the economic value of the GBR as a whole (and within the Cairns area) in the absence of any bleaching. The second indicates the economic cost which a total, permanent and immediate bleaching of the GBR would have both on the reef as a whole – in effect the economic loss to society from such an event.

All estimates are in 2009 Australian dollars (unless otherwise indicated). Sensitivity tests for various parameters are included in Appendix 1.

What kind of yardsticks are there for the value of the GBR and bleaching costs?

The estimates in this report contain values which are traded both within and outside conventional markets and include some values which accrue to overseas residents.

However, the assessed *present value* of the GBR, as a whole, equates to roughly 4.7% of Australia's *annual* (2007-08) Gross Domestic Product (GDP) while the corresponding bleaching cost is equivalent to 3.5% of annual GDP.

Chart ES - 1 Value of GBR as a whole and in the Cairns area ($ billion PV)

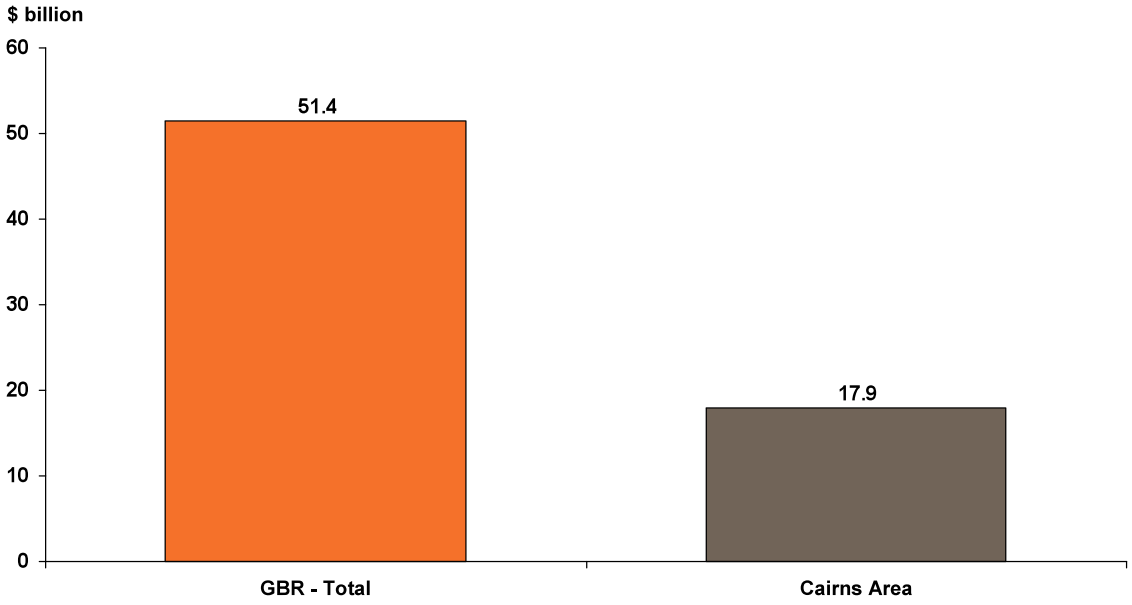
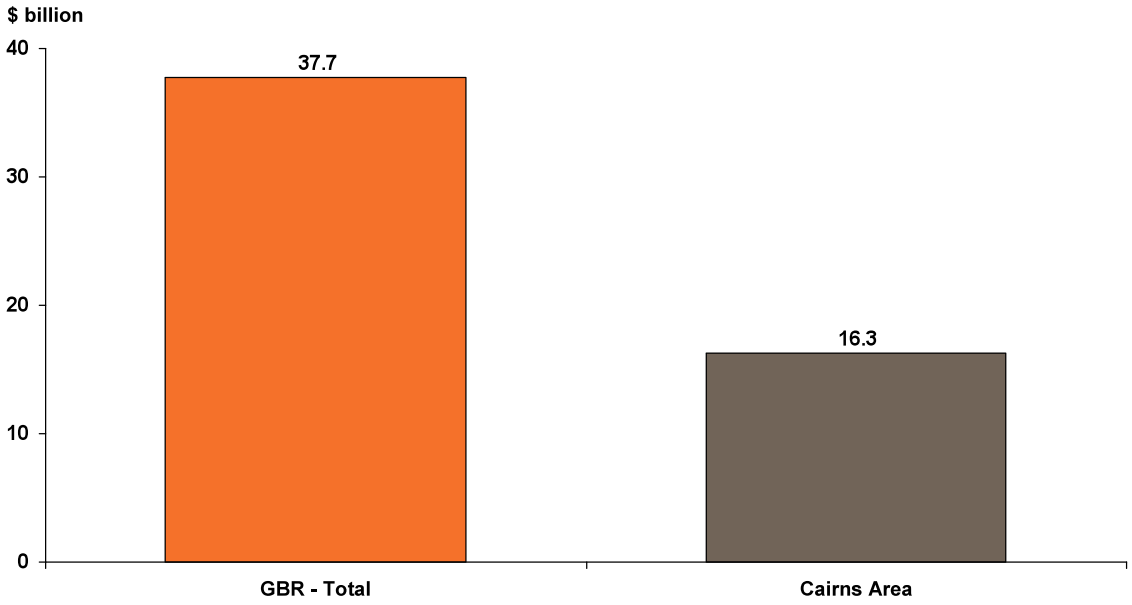


Chart ES - 2 Cost of bleaching in the GBR and Cairns area ($ billion PV)



1. Introduction

1.1. Background

1.1.1. This study

Australia, along with the entire world, faces the tremendous challenge of climate change over the coming decades. Along with its impacts on a wide variety of global ecosystems, climate change has the potential to have long-term impacts on Australia's Great Barrier Reef (GBR)[1]. Among the most serious of these are the phenomenon of coral bleaching[2] and its attendant effects on the reef's biodiversity. The long term effects of coral bleaching (in both the Cairns region and the entire GBR) are the focus of this study[3].

Reef-building corals are driven by a partnership between corals, and tiny single-celled plants known as dinoflagellates. The dinoflagellates trap solar energy through photosynthesis, providing both organisms with an abundant source of organic carbon and energy. In return, the coral provides inorganic nutrients which act as fertiliser for the dinoflagellates. As a result of this relationship, corals are able to build the huge structures that are typical of coral reefs.

The symbiosis between reef-building corals and their dinoflagellates is extremely vulnerable to environmental stress. A small increase in sea temperature, for example, will destabilise the symbiosis leading to the rapid loss of the brown dinoflagellates from the tissues of the coral. As a result, the corals lose their overall brown colour, with the brilliant white skeleton gleaming through the otherwise transparent tissues of the coral host (hence the term coral bleaching). Prolonged or intense stress will lead to disease and death. With global warming, the latter is becoming the norm, with huge mortalities being recorded across the planet within coral communities.

Coral bleaching and related effects of warming present a serious threat to the future existence of the reef. Coral bleaching occurs when stressful conditions associated with high sea temperatures cause corals to expel the algae living within coral tissue. This has the effect of making the tissue transparent, exposing the white skeletal structure of the affected corals. The GBR has been affected by heat-related coral bleaching six times over the past 25 years. The most severe episode to date was in 2002 when 60% of the reefs within the Great Barrier Reef Marine Park were affected, with 5-10% dying (Garnaut 2008). Higher ocean temperatures associated with global warming would lead to an increasing occurrence of bleaching and would ultimately pose a significant threat to the long term survival of the GBR.

The Garnaut Climate Change Review (2008) ("the Garnaut Report") and other recent media commentary has paid particular attention to the issue of the long term survivability of the GBR due to bleaching and there have been growing public concerns about its future.

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1 The term "Great Barrier Reef" may have somewhat different meanings and applications depending on the context. Appendix 6 provides a guide to the usage of this term in this report.

2 The term "coral bleaching" is used throughout this report, though strictly speaking this could be expressed as "bleaching mortality".

3 Note that global warming is likely to have many other major ecosystem effects within the region (e.g. flooding, increased storm intensity). However, this report is focuses on the effects related to coral bleaching

As noted in a supplementary paper to the Garnaut Report, if atmospheric concentrations of carbon dioxide (CO_2) exceed 500 parts per million (ppm) the GBR is likely to experience a massive loss of biodiversity and ecological function. Any semblance of reefs to the coral reefs of the Great Barrier Reef Marine Park today would vanish, with the GBR having a vastly different appearance to that which attracts tourists at present (Hoegh-Guldberg and Hoegh-Guldberg 2008).

In the shorter term, other issues such as water quality and Crown of Thorns Starfish infestations also have the potential to damage the GBR's ecosystem. This, in turn, raises the issue of how much the nation (and by extension, the world) values a World Heritage-listed natural resource such as the GBR.

While some would argue that all natural resources are essentially "priceless", establishing such a value is important as it provides policy-makers with a tool with which to assess the costs of inaction in the face of challenges such as climate change. This is particularly important given that policymakers face a large number of competing short term priorities (e.g. health care, education, support for the elderly) to which they must dedicate limited dollars.

The Great Barrier Reef Foundation invests in science that will maximise the sustainability of the Great Barrier Reef for the benefit of all Australians.

The Foundation's International Scientific Advisory Committee which identifies and recommends research projects for investment to the Foundation's Board has a research vision of *"Understanding and maximising the resilience of reefs (and especially the GBR) to climate change".*

In the context of this vision and the important climate change debate currently occurring in Australia, The Foundation has commissioned Oxford Economics to undertake a study into the cost of the **total and permanent bleaching** of the GBR both in:

- the Cairns region: and
- for the GBR as a whole

1.1.2. Why have a new study of the value of the GBR ?

A number of other studies have attempted to review the "value" of the GBR. The best known of these is the recent series of reports by Access Economics (2005, 2007, 2008).

These studies have been an important source of information to the current work. However, in many cases these are quite dated and none of these has actually estimated a Total Economic Value (TEV) for the GBR (or for its value within the Cairns region) based on clearly specified data.[4] Further, with the exception of Kragt et al. (2009), none of these studies focus on the Cairns area *per se,* while only Kragt et. al. (2009), Hoegh-

4 There have, however, been a variety of recent efforts aimed at estimating elements of a TEV of coral reefs around the world. Further, in a famous paper Costanza et. al. (1997) estimated the value of the world's ecosystems, estimating that coral reefs had an economic value of $US 6,075 per square kilometre per annum (in $US 1997). However, while an intriguing approach, this work faces a host of methodological problems (Pagiola et al 2004; Pearce 2007) which can easily lead to errors of magnitude when applying these generic unit values to Australia or other regions.

Cesar et. al. (2003) estimated the value of coral reefs around the world, and the cost of bleaching. These estimates included an estimate for "Australia" without specifying the GBR. However the sources and methods used by the authors (which also drive their estimates of bleaching costs) are not clearly set out and do not appear to use "local area" data.

Guldberg and Hoegh-Guldberg (2004), and a short section in Access Economics, 2007, address elements of the specific costs of bleaching from an economic perspective. A summary of past studies is offered in Appendix 2.

A TEV approach is consistent with current concerns about the long term degradation of natural ecosystems and with the guidelines issued by the Queensland Government's (2003) *Environmental Economic Valuation: An introductory guide for policy-makers and practitioners.* A TEV is also founded on strong principles of cost-benefit and welfare analysis which form the centrepiece of the study of environmental economics and have long been used to value investment projects.

Given the significance of this issue to Australians and the rest of the world, and heightened concerns about its future in the wake of the Garnaut Report and other publications there is clearly a need for a fresh and comprehensive approach to valuing the reef.

1.2. Report structure

The rest of this report is structured as follows:

- Chapter 2 provides a summary estimate of the total value of the GBR and the cost of bleaching in the GBR and in the Cairns region
- Chapter 3 provides an overview of the methodological approach to this report;
- Chapter 4 provides analysis of the tourism and recreational use value of the GBR;
- Chapter 5 analyses the commercial industry use value for the GBR;
- Chapter 6 analyses the GBR's indirect use values;
- Chapter 7 reviews national non-use values;
- Chapter 8 analyses international non-use values;

A number of Appendices covering more detailed modelling issues are also provided at the end of this report. In particular, sensitivity tests covering a range of parameters are included in Appendix 1.

1.3. Acknowledgements

Oxford Economics would like to acknowledge the co-operation and assistance of Professor Bruce Prideaux, Karen McNamara and Ali Coghlan of James Cook University (JCU) and of the Reef and Rainforest Research Centre (RRRC) and of the Marine and Tropical Sciences Research Facility (MTSRF) in providing data and support, without which the detailed modelling of tourism recreational benefits would not have been possible.

2. Total Economic Value and effects of bleaching

The following chapters detail the methodology and estimation process used to derive a total value of the GBR and of the GBR in the Cairns area. Estimates of the cost of bleaching of the GBR and of the GBR in the Cairns area have been derived from these values.

At a preferred discount rate of 2.65%, streamed over 100 years, holding present day values constant, it is estimated that the present value (PV) of the GBR as a whole (excluding indigenous values) is $51.4 billion, with a value of $17.9 billion estimated for the Cairns area.

From this, an estimate of the cost of bleaching for the Cairns area and the GBR can be derived. If a total and permanent bleaching of the GBR were to occur today, then (holding present day values constant over 100 years, at discount rate of 2.65%) the costs (in PV terms) are estimated at $37.7 billion with an estimate of $16.3 billion for the Cairns area.

Put another way, the bleaching cost for the whole of the GBR is roughly equivalent to a constant $1.08 billion per annum over the course of a century.

Further details on the modelling process are contained in the following chapters and in the Appendices.

The following, in particular, should be noted when considering this study as a whole:

- *Estimation process and conservative bias* – Environmental economics is an evolving field and presents many methodological challenges to analysts. Some of these may manifest themselves as philosophical issues (such as how people value ecosystems they may never directly encounter) or technical ones (e.g. functional form in travel cost modelling). Estimation of the economic value of the environment therefore inevitably involves some element of reasoned judgement. This should be kept in mind when considering this report. Further, a conservative bias has generally been adopted, particularly where there is doubt over data.
- *Value of GBR vs. cost of bleaching* – This report has presented both the value of the GBR and the cost of bleaching. The reason for the difference is that some activities are likely to be unaffected by bleaching. For example, much recreational (and some commercial) fishing is likely to continue irrespective of bleaching.

Values are estimated in 2009 Australian dollars on a PV basis over 100 years at a discount rate of 2.65% (as used in the recent Garnaut Report). As a sensitivity test, a variety of other real discount rates have also been applied, that is:

- 1.35%, the lower discount rate used by the Garnaut Report,
- 4%, a rate previously used by the World Bank (Asafu-Adjaye et.al.) and
- 6% the value used by Queensland Treasury in the past for project evaluation (Asafu-Adjaye et.al.)[5].

5 More recently the Queensland Treasury's *Draft Cost-Benefit Analysis Guidelines* (2006) do not specify a particular rate but suggest consultations between the Queensland Treasury and portfolio agencies as an aid to determining a rate. Reference is also made to HM Treasury's Green Book (2003). This suggests long term discount rates of 3.5% for the first 30 years, 3.0% for 31 to 75 years and 2.5% for 76 to 125 years.

The results of these and other sensitivity tests are reported in Appendix 1.

What kind of yardsticks are there for the value of the GBR and bleaching costs?

The estimates in this report contain values which are traded both within and outside conventional markets and include some values which accrue to overseas residents.

However, the assessed *present value* of the GBR, as a whole, equates to roughly 4.7% of Australia's *annual* (2007-08) Gross Domestic Product (GDP) while the corresponding bleaching cost is equivalent to 3.5% of annual GDP.

Charts 2-1 and 2-2 represent these data graphically. The first chart indicates the economic value of the GBR as a whole and within the Cairns area in the absence of any bleaching. The second indicates the economic *cost* which a total, permanent and immediate bleaching of the GBR would have both on the reef as a whole and within the Cairns area – in effect the economic loss to society from such an event. A 2.65% discount rate has been assumed for these calculations.

Chart 2-1 Value of GBR as a whole and in the Cairns area ($ billion PV)

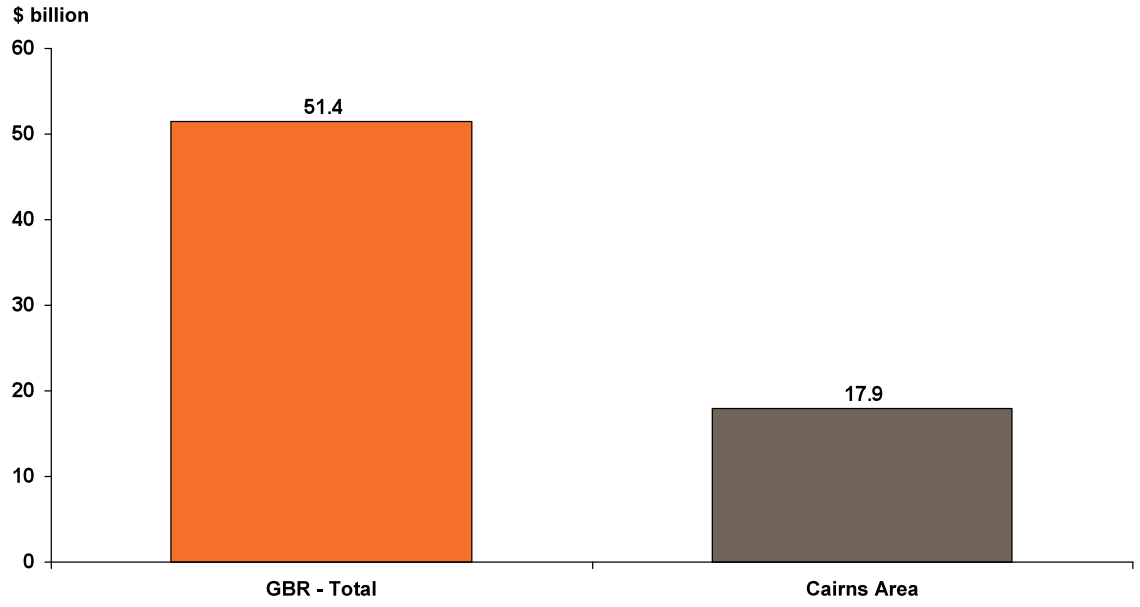
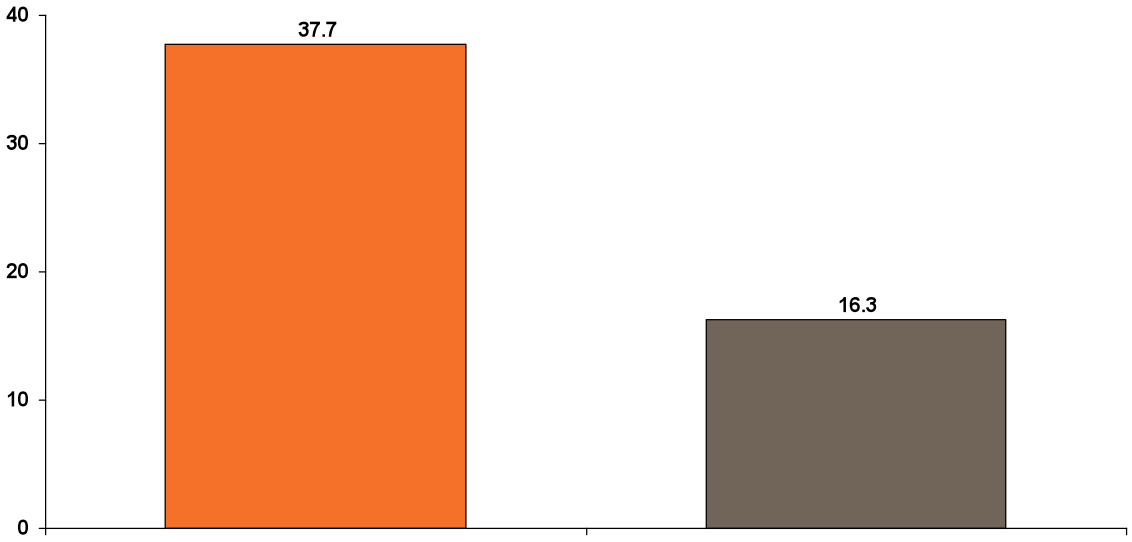


Chart 2-2 Cost of bleaching in the GBR and Cairns area ($ billion, PV)



These values reflect those which can be reasonably attributed to the GBR. For example, tourism motivated by the GBR's coral sites within the Great Barrier Reef Marine Park (GBRMP) is included but not regional tourism which is focussed on other activities (e.g. swimming, beach visits, visits to friends and relatives).

In addition, the scope and basis of valuation for "the GBR" necessarily varies across specific types of economic activity (categories), due to the differing context of the resource in question. For example, tourism values reflect coral site visitation while the GBR's indirect use value reflects its presence as a physical barrier, irrespective of whether it is visited by people.

The following chapters and Appendix 6 provide further details on the scope and valuation basis adopted for the "the GBR" in each category. In addition, Table 2-1 provides an indication of the scope and basis of the valuation.

Table 2-1 Summary of valuation basis and scope

Category	Scope and basis of valuation	
	GBR - Total	Cairns Area
Tourism Consumer Surplus	Reef-motivated tourism visits to coral sites	Proportion of GBR total value based on Tropical North Queensland visitation data
Tourism producer surplus (profit)	Reef-motivated tourism visits to coral sites	Reef-motivated tourism visits to Tropical North Queensland coral sites
Recreational fishing consumer surplus	Assessed value within the GBRMP	Sub-set of GBR total value based on regional proportion of recreational boats
Recreational fishing producer surplus (profit)	Assessed value of regional fishing supplies	Sub-set of GBR total value based on regional proportion of recreational boats
Commercial fishing producer surplus (profit)	Assessed value of commercial fishing within the GBRMP	Sub-set of GBR total value based on regional proportion of commercial fishing value
Indirect use value	Assessed value of GBR as a physical barrier	Proportion of GBR total value based on Cairns/Cooktown Management Area
National non-use value	Assessed value of coral sites and inter-related ecosystems	Proportion of GBR total value based on Cairns/Cooktown Management Area
International non-use value	Assessed value of coral sites and inter-related ecosystems	Proportion of GBR total value based on Cairns/Cooktown Management Area

Source: Oxford Economics

Table 2-2 provides the assessed estimates for the various categories of GBR value and associated loss due to bleaching. As indicated, these figures relate to those which can be reasonably assigned to the GBR itself. For example, tourism profits represent those profits which are attributable to reef-motivated tourism to coral sites. These profits are lost in the event of bleaching, though other regional tourism lies outside the scope of this report and is not assumed to be affected.

In contrast, while the GBR's indirect use value is estimated, it is assumed to be unaffected by bleaching over the timeframe of this study. Accordingly, no bleaching costs have been estimated in respect of this category.

Table 2-2 Present Value of GBR and of bleaching costs

Category	Present Value of GBR ($ billion)		Present Value of Bleaching costs ($ billion)	
	GBR - Total	Cairns Area	GBR - Total	Cairns Area
Tourism Consumer Surplus	16.6	11.7	16.6	11.7
Tourism producer surplus (profit)	3.6	2.8	3.6	2.8
Recreational fishing consumer surplus	2.5	0.3	0.0	0.0
Recreational fishing producer surplus (profit)	0.3	0.04	0.0	0.0
Commercial fishing producer surplus (profit)	1.4	0.2	0.4	0.06
Indirect use value	10.0	1.0	0.0	0.0
National non-use value	15.2	1.6	15.2	1.6
International non-use value	1.9	0.2	1.9	0.2
Total	**51.4**	**17.9**	**37.7**	**16.3**

Source: Oxford Economics

NB: Numbers may not sum to totals due to rounding

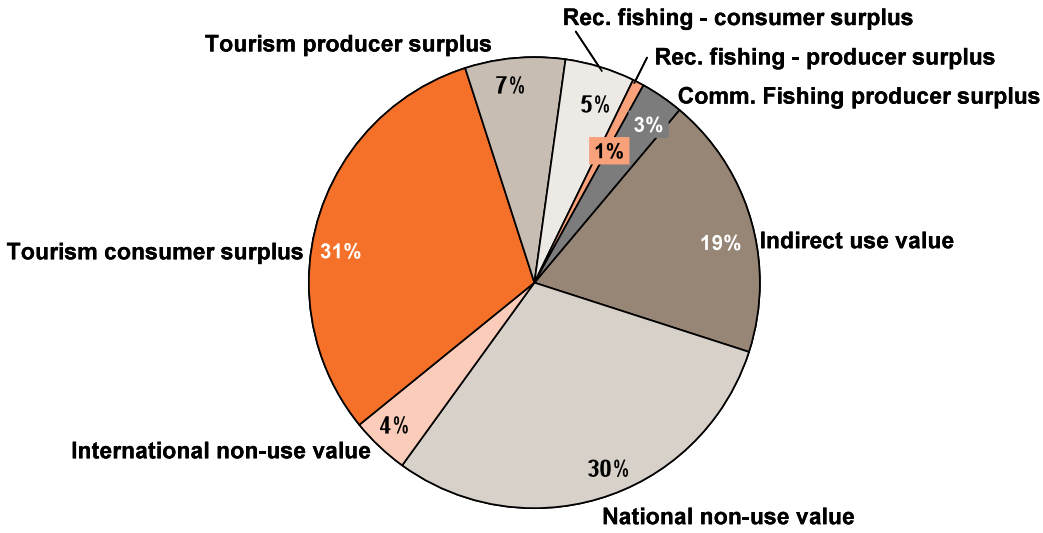
Charts 2-3 to 2-6 present a graphical break-up of these data by type of economic activity.

Chart 2-3 presents a break-up of the economic value of the PV of the GBR in its current form ($51.4 billion). This is essentially an estimate of the economic value of the GBR to (global) society over the next century, assuming no bleaching occurs. The chart indicates the relative importance of various economic activities (such as fishing, coral site tourism, costal protection ("indirect use value") and "non-use values") which comprise this total value of the GBR. Tourist enjoyment from visiting the reef's coral sites ("tourism consumer surplus") accounts for a large proportion of the total economic value, as do national non-use values. There is also a substantial indirect use value (from the reef's coastal protection function).

In contrast, Chart 2-4 presents a similar break-up of the *economic cost of GBR bleaching* over the next century in PV terms. The proportions in this table represent losses relative to the assessed total bleaching cost of $37.7 billion. Tourism consumer surplus suffers the greatest losses in absolute terms, followed by the values people hold for the reef's actual existence (national non-use values). Tourism industry profits (producer surplus) are also heavily impacted, though only coral site tourism is included in these figures.

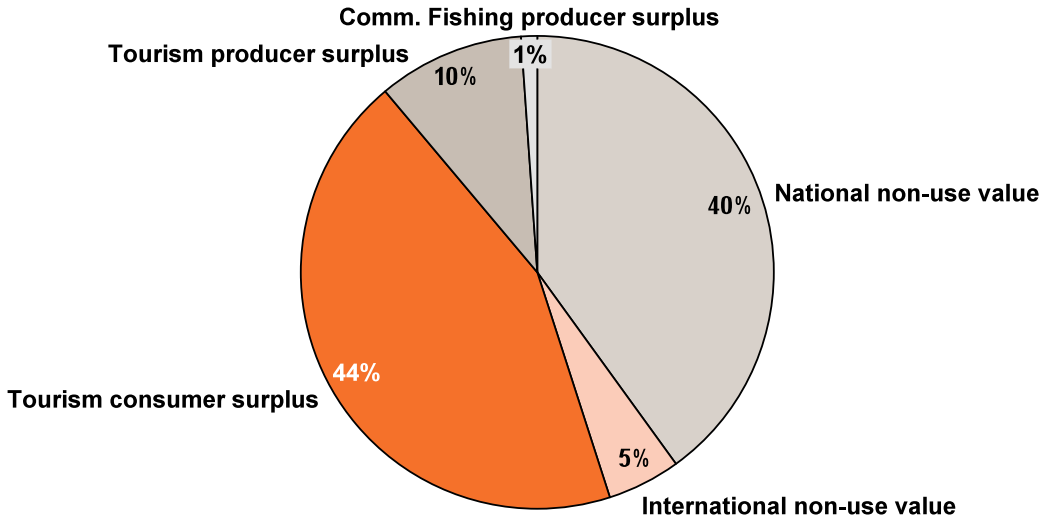
In terms of the Cairns area, Chart 2-5 indicates that tourist use of the GBR constitutes by far the largest single value of an unbleached reef, with tourism industry profits also being important. Likewise, most of the costs of bleaching are likely to be borne by the tourism industry – as indicated in Chart 2-6. Nearly three-quarters of the economic costs of bleaching in the Cairns area relate to the loss of value associated with reduced tourist usage of the reef, with the loss of tourism industry profits also being an important additional factor. As noted, however, tourism activity not related to coral sites is assumed to be unaffected.

Chart 2-3 Present Value of the GBR: $51.4 billion



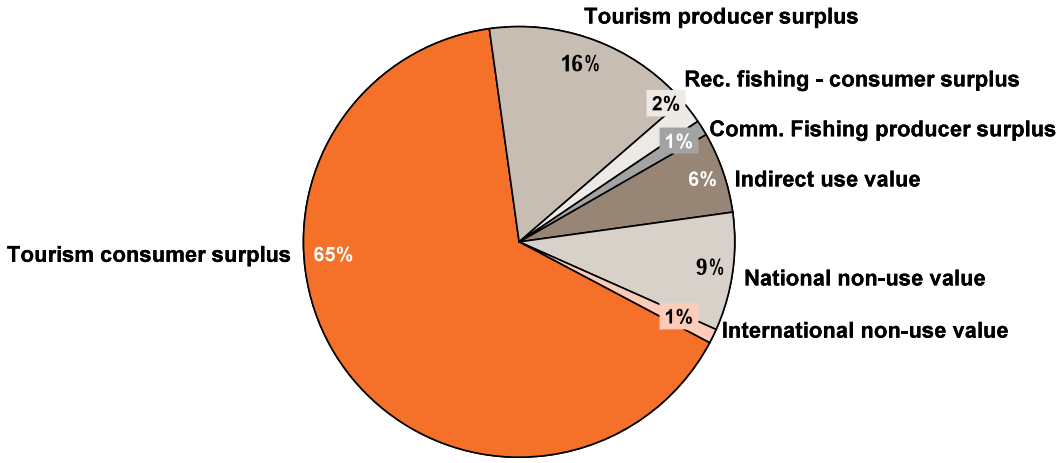
Source: Oxford Economics

Chart 2-4 Present Value of the cost of bleaching of the GBR: $37.7 billion



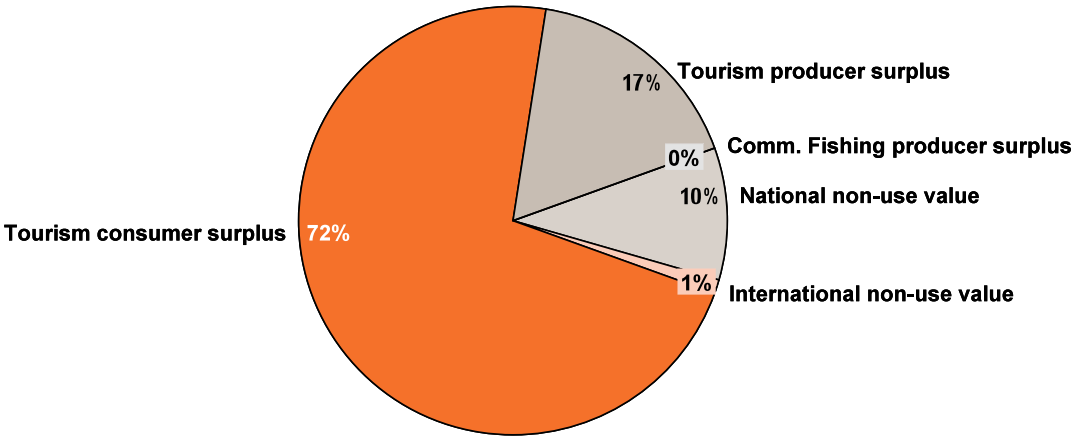
Source: Oxford Economics

Chart 2-5 Present Value of the Cairns section of the GBR: $17.9 billion



Source: Oxford Economics

Chart 2-6 Present Value of the cost of bleaching in the Cairns section of the GBR: $16.3 billion



Source: Oxford Economics

3. Methodology and approach

Key Points

- A Total Economic Value (TEV) approach has been adopted for this report.
- This approach focuses on estimating the Present Value (PV) of the reef over a century, estimated at a 2.65% real social discount rate, consistent with the concepts used in the recent Garnaut Report.
- The cost of bleaching in the Cairns area and the GBR as a whole is then estimated by assessing how much of this value would be lost should it occur.
- Environmental economics is an evolving field and there is a necessity for reasoned judgement in many instances. In general, a conservative bias has generally been adopted.

3.1. Our approach

3.1.1. Possible approaches

There are basically two approaches to estimating the "economic value" of a resource such as the GBR and consequently estimating the cost of bleaching in the Cairns area and the reef as a whole.

- *Market-based "national accounts" (or economic impact) perspective* – This essentially uses the same data employed to estimate national GDP. It estimates the "value added" (i.e. profits + wages) by industries which the GBR supports (tourism, fishing etc) and the flow-on effects of these industries onto others through economic multipliers. This value is typically a snapshot for one year only (e.g. 2009). Access Economics (2005, 2007, 2008) employed this approach to estimate the economic impact of the GBR.
- *Total economic value (TEV)* – This incorporates some of the data used in the market-based approach, but takes on a much broader view, consistent with the methodologies traditionally used by environmental economics. It incorporates industry profits (roughly, producer surplus)[6] but, rather than just calculating how much people pay to visit/enjoy the reef, it estimates *how much more they would be willing to pay to visit it* (as an estimate of its true value to them). It also asks those who might never visit the reef how much they would pay to preserve it for themselves and for future generations. So, the valuation reflects both market-traded commodities and non-traded values. Or, put into technical terms, TEV aims to measure the sum of the producer surplus (i.e. industry profits) and the consumer surplus (i.e. how much users and non-users are willing to pay to visit and preserve the reef) as an estimate of the reef's total economic value.

6 Technically speaking producer surplus is equivalent to profits plus fixed costs.

- Furthermore, given that the reef is a long-lived natural resource, the benefits derived from its existence are estimated stretching into the future using a Present Value (PV) approach (just as a company might estimate its benefits from an investment project, though using a social discount rate rather than, say, a Weighted Average Cost of Capital (WACC)). Such an approach is much closer to growing concerns about the preservation of natural resources, as their loss would deny society benefits not simply in the present but well into the future. The issue of climate change has also focussed policymaker's minds on the long term effects of natural resource degradation on the broader economy as well. For example, the Garnaut Report estimates the PV of Gross National Product (GNP) losses due to climate change for the years up to 2100.

A TEV approach therefore offers a much broader perspective on the value of a key resource such as the GBR than a market-based approach.

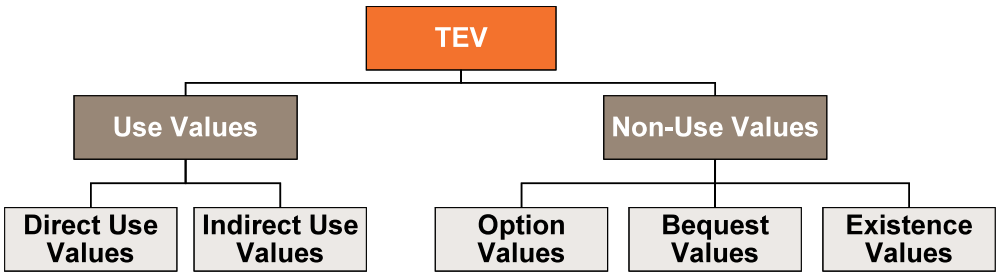
The TEV approach to the valuation of environmental resources, such as the GBR, is set out in – and recommended by - the Queensland Government's *Environmental Economic Valuation: An introductory guide for policy-makers and practitioners* (2003).

Accordingly a TEV approach has been adopted for this study.

3.1.2. The TEV approach

The following diagram and description gives an indication of the factors taken into account in a TEV.

Chart 3-1 Total Economic Value (TEV)



As illustrated in Chart 3-1, a TEV approach takes into account both "use values" and "non-use (or passive) values" in assessing the benefits of the GBR. These values can be summarised as follows:

- *Direct use* –The direct market-based uses of the GBR such as tourism and fishing. In practical terms, the focus is on the profits extracted by industry from the use of the reef (also known as "producer surplus"). However, it also includes an estimate how much more consumers such as tourists would be willing to pay to experience the reef than they currently do pay (direct "consumer surplus")
- *Indirect use* – The indirect "ecosystem services" which the reef provides, such as coastal protection from storms.

- *Option value* – This represents the value attached to potential future benefits from the GBR. It is related to the ideas of risk and uncertainly. For example, people may attach some value to the possibility that they may one day want to visit the reef and/or that natural environments such as the GBR may produce future medical/pharmaceutical benefits. The loss of the reef forecloses these options. (Note that: "option value" may be alternatively defined as either a use or non-use value, depending on the context.)
- *Existence value* – The value attached to the existence of the GBR, irrespective of whether a person ever visits it or not. For example, people may be prepared to donate to environmental causes such as preserving the reef or "saving the whales" even if they have no intention of visiting the GBR or going whale-watching.
- *Bequest value* – The value which the current generation places on preserving the GBR for the benefit of future generations.

Occasionally, values such as "heritage value" or "indigenous value" are also suggested as sources of benefit. In the case of the GBR, indigenous values could cut across several of the types of value described above. There are many arguments both for and against the inclusion of indigenous values within the framework described above. On this occasion, the GBRF has requested that they be excluded from the current evaluation due to the difficulties in quantifying such values.

So, the total economic value of the GBR (and of the Cairns area as a sub-set of this) can be measured as follows:

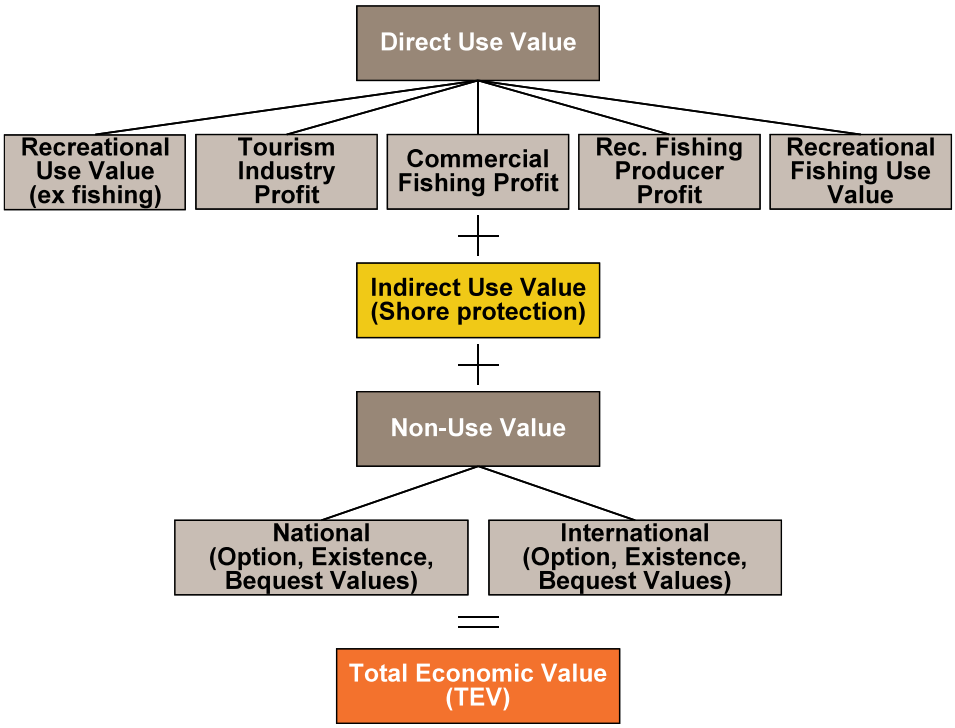
TEV = Direct use values + Indirect use values + Non use values

Or equivalently:

TEV = Producer surplus (GBR tourism and fishing industry profits and some indirect values) + consumer surplus (consumer use and non-use values)

Diagrammatically, this can be represented as in Chart 3-2.

Chart 3-2 Calculation of TEV



As indicated, the TEV is essentially the sum of the consumer and producer surpluses. A simplified example is provided below for the GBR tourism industry. The producer surplus (roughly profit) is difference between the price received by suppliers (the price line) and the minimum price at which they would have been willing to sell commodities (in this case "reef visits") – i.e. supply line. This represents the benefit to industry from the fact the GBR exists, and is captured by the shaded area between the price line and the supply curve.[7]

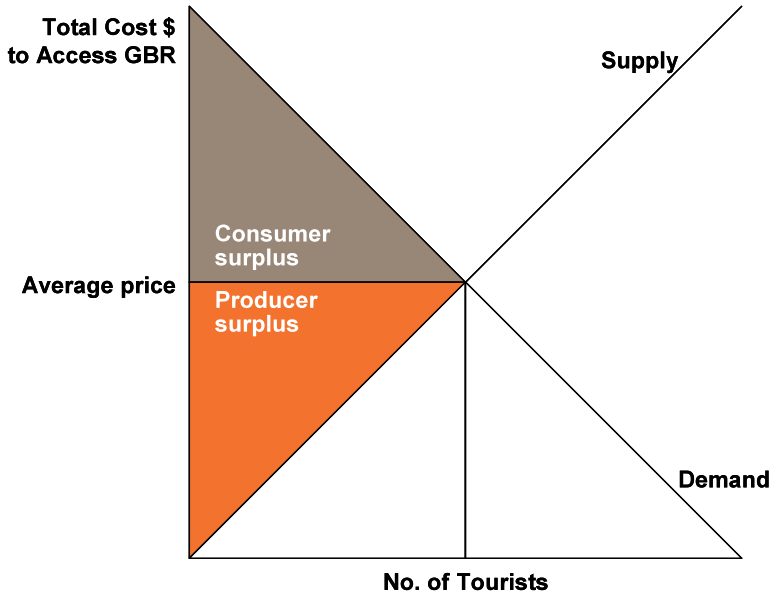
The consumer surplus represents the difference between what consumers pay and the maximum price they would be willing to pay for a commodity (the demand curve). It is represented by the shaded area between the price line and the demand curve. For example, someone may pay $1 for a chocolate bar but enjoy it so much that they would have been willing to pay $3 for it. The consumer surplus is $2.

Adding up the producer and consumer surpluses gives the total benefit to society from the GBR.

Actual modelling of these areas is much more complex in practice, given different starting points and assumptions on the respective demand and supply curves and the shape of these curves. These issues are discussed below.

7 In this study, an estimation of producer surplus is generally derived through an estimate of Gross Operating Surplus (GOS), a National Accounts concept.

Chart 3-3 Consumer and producer surpluses for tourism



GBR Tourism - Consumer and Producer surpluses

3.1.3. Loss from bleaching

Once the TEV is determined, the next step is to calculate the loss from bleaching. The total value of the GBR would not be lost if bleaching occurred. For example, some commercial and recreational fishing is likely to continue. In addition, geomorphologic considerations suggest that even a bleached reef would continue to serve as a coastal protection barrier for a long period of time, though structural integrity is likely to slowly decay over time (Johnson and Marshall 2007).[8]

Chart 3-4 Calculation of bleaching cost



The value of the GBR and the cost of the loss from bleaching can then be streamed over time and calculated as a PV, to reflect the fact that the GBR is a long-lived natural resource. The PV of the GBR in the Cairns area and, finally, the loss from bleaching in the Cairns area can then be determined as a sub-set of the PV for the GBR as a whole.

8 Precisely how long a totally bleached reef could endure is a matter of some uncertainty. This is discussed in more detail in the section on indirect costs.

3.2. Study assumptions and approach

The basic approach to the economic evaluation of bleaching in the Cairns area and the GBR as a whole is set out above. The following should be noted when reviewing the work of this study:

- *Estimation process and conservative bias* – Environmental economics is an evolving field and presents many methodological challenges to analysts. Some of these may manifest themselves as philosophical issues (such as how people value ecosystems they may never directly encounter) or technical ones (e.g. functional form in travel cost modelling). Estimation of the economic value of the environment therefore inevitably involves some element of reasoned judgement. This should be kept in mind when considering this report. Further, a conservative bias has generally been adopted, particularly where there is doubt over data.
- *Starting points bleaching and growth assumptions* – This study calculates the PV of the GBR and associated loses over a 100 year period from 2009 to 2108 (inclusive). This is similar in concept to the Garnaut Report, which measured GNP losses for the years to 2100. However, unlike the Garnaut Report the main body of this study does not attempt to explicitly forecast changes in bleaching, tourism or other outcomes over this period (though some forecasts are offered in the sensitivity tests in Appendix 1). Rather, the current value of tourism, industry profits, non-use values etc are calculated and held constant over the period (rather than growing as, in many cases, might be expected). Likewise, it is assumed that bleaching is total, permanent and immediate (i.e. its losses accrue from 2009 onwards).
- While simple in form, this offers the clearest approach to understanding the value of the GBR and the cost of bleaching. In reality, while serious outbreaks have occurred to date, current "no mitigation" forecasts suggest coral bleaching in the Cairns area (and the GBR as a whole) may not become a "total and permanent" fact until mid century (Garnaut 2008, Hoegh-Guldberg 2007). Thus, allowance could be made that some of the losses should be "ramped up" to that time and beyond. However, it is equally the case that tourism and/or industry profits may grow into the future in a "base case" where no bleaching occurs (which would suggest future losses may be underestimated). Another consideration is that national and international non-use values may grow considerably, especially as the effects of bleaching and other environmental impacts of climate change are apparent, as consumers come to value (increasingly) rare natural resources more highly and as real incomes grow. However, there are also caveats on these assumptions. Some of these issues are taken up in the sensitivity tests in Appendix 1.[9]
- The most transparent approach however is to ask the question: "Given what we know about current industry structures and consumer preferences what kind of long term costs could a permanent and total bleaching incur to the Cairns area and the GBR as a whole?" This study has attempted to answer that question

9 The growth of real income over time is, for example, sometimes taken into account in evaluations of long term transport projects, where the value of time held by consumers typically increases over time (an income elasticity of 0.5 has been suggested – see Hensher and Goodwin (2004)). As indicated in Appendix 1, there are no equivalent measures over time in the environmental economics' literature however a cross-country income elasticity may be used as a proxy.

- *Discounting/ streaming over time* – Unless otherwise stated, a standard social discount rate of 2.65% has been adopted for the modelling. This is the higher of the two discount rates used in the recent Garnaut Report. Sensitivity tests have also been applied to this rate and are indicated in Appendix 1[10].
- *Currency units* – Unless otherwise stated (or clearly a citation of original author's figures) all values are in Australian dollars adjusted for inflation (CPI) to March 2009 values in accordance with ABS (2009).
- *"Cairns area"* – The definition of the "Cairns area (or region) in this report is necessarily broad due to differing data sources. For example, in some cases (such as non use values) it is necessary to refer to the Cairns/Cooktown Management Area of the GBRMP as a measure for impacts. In others, (such as tourism visits) Tourism Australia and/or the Australian Bureau of Statistics (ABS) data relating to the "Tropical North Queensland" Tourism Region or the "Far North" (i.e. Far North Queensland) Statistical Division are the best and most reliable estimates of reef-related activities, rather than data from the Cairns LGA *per se*. These values give a broad indication of regional losses from bleaching.

  Appendix 6 provides an indication of how this term is applied in different sections of this report.
- *WTP vs. WTA* – The values for consumer surplus in this report are provided on a willingness to pay (WTP) basis. An alternative approach is to use Willingness to Accept (WTA) values. These relate to how much consumers would be prepared to accept in compensation for a loss. In practice, WTA values are often larger than WTP values. Economists (and psychologists) have debated the reasons for this. Issues such as risk (or loss) aversion and ownership bias are often advanced as explanations. In other words people tend to value a loss more than a corresponding gain. For example, the person who wins, say $100 at a casino may have positive feelings – but the negative ones of losing $100 often far outweigh these.
- These concepts are important in environmental economics as they imply that in some respects the valuations provided in reports such as this one are highly conservative. People might be willing to pay $100 to preserve the GBR. However, by this measure they might require, say, $300 to compensate them for its loss. Further, even a WTA perspective may not take into account issues of irreversibility and non-substitutability (see below).
- *Irreversibility/ lack of substitutability for natural capital* – Environmental economists have often referred to the concepts of irreversibility (Pearce and Turner 1990) and the non-substitutability of natural capital (Neumayer 2007). Each environmental resource may be considered unique. As such, their loss cannot be simply be replaced through switching to alternatives (like one does with,

10 See the Explanation of Terms for a definition of the social discount rate. The matter of which discount rate is the "correct" one to use is a subject of lengthy discussion among economists - see for example the Productivity Commission staff working paper by Baker et. al. (2008). This report reflects current thinking on the discounting of long term issues such as climate change by employing the rates used in the Garnaut Report. A fuller discussion of the reasoning behind these rates is contained within Chapter 1 of the Garnaut Report itself. The higher of the two discount rates presented in the Garnaut Report is used, consistent with a conservative approach to modelling, however, as indicated, the lower rate (1.35%) is also used as a sensitivity test (along with other rates). The reader is then free to make up his or her mind on which rate is appropriate.

Note that the rates presented in the Garnaut Report are different again from the discount rate used in Treasury-Garnaut modelling for pricing emissions permits (4%). As explained in the Garnaut Report (Chapter 1), this is not a contradiction; the 4% discount rate is intended to reflect the rate at which investors chose to allocate capital between permits and other investments over time.

say, a new brand of toothpaste) even if natural alternatives seem similar (e.g. other reefs in the case of the GBR).[11]

- Likewise, it can be argued that even WTA valuations do not take into account the non-substitutability of natural capital. By this reasoning, simply compensating people in financial terms of the loss of the GBR cannot provide a true "substitute" for its loss, (as, say, an insurance payment for a damaged car might); it is an irreplaceable natural asset.
- McGrath (2008) has argued this point in respect of the GBR. By this reasoning it is difficult to sustain some of the "consumer side" arguments made by Access Economics (2007) in respect of tourism substituting for GBR (or other reef) bleaching by switching visitation patterns; one cannot simply substitute one natural asset for another (or for expenditure on other tourism or goods and services). Even if the full arguments about irreversibility and non-substitutability are not accepted, a partial acknowledgement of them suggests that, to the extent one can measure a consumer surplus associated with the GBR, it is questionable that this can simply be substituted for other activities in the event of bleaching.[12]
- In short, the implications are that arguments about substitute consumption in the face of bleaching face considerable difficulties. Philosophically, to the extent that the losses from bleaching are irreversible, the values in the current report may again be considered conservative given the effective inadequacy of financial compensation.

11 There has also been some preliminary investigation of the effects of developing artificial reefs in the GBRMP. If one rejects a "non substitutability" argument, arguably, these might provide some mitigation of bleaching losses for certain groups such as divers and fishers - though obviously such effects would be minor compared to the losses along the entire GBR due to bleaching. Evidence to date, however, suggests that divers prefer natural reefs over artificial ones. Further, such reefs are unlikely to increase fish stocks and indeed may lead to increased species depletion (Pears and Williams 2005, Sutton and Bushnell 2007).

12 For various other reasons, there are also difficulties with the concept that fishing and tourism industry profits will simply be gained anyway from substituting into other activities in the event of a permanent bleaching. As indicated below, the loss of fish stocks which may follow from bleaching implies that fishers could face rising costs to obtain the same catch or offer fewer fish to market. This would tend to reduce producer and/or consumer surplus. Some tourist operators might decide to open new operations in other areas (e.g. Tasmania). However presumably what has prevented this to date are lower marginal returns, and it is uncertain whether such a shift would maintain profitability. On this last point it should be noted that there may be substantial opportunity costs in setting up and maintaining new capacity. Further, if tourism disperses to disparate locations there may be some loss in economies of scale.

4. Use value – Tourism and recreation (consumer surplus)

Key Points

- It is estimated that some 1,065,000 people visit coral sites on the GBR each year, with 749,000 of these visiting sections near the Cairns area (Tropical North Queensland).
- Many who happen to visit the coral sites on the reef are also motivated to come to the region for other reasons. However, based on past studies, the equivalent of some 50% of reef visitors viewing coral sites are likely to stay away in the event of a total and permanent bleaching.
- Recreational tourism was assessed using the "travel cost method". This reveals how much people actually value the experience of visiting the GBR coral sites (rather simply focussing on expenditure).
- Modelling using the travel cost method (and taking into account the fact that the equivalent of 50% of current coral site visitors are motivated to visit by the reef itself) suggests that the recreational value of the GBR coral sites in PV terms is $16.6 billion, with a value of $11.7 billion for the Cairns area.
- These values would be lost in the event of total and permanent bleaching.
- The value of recreational fishing in the GBR (in PV terms) is put at $2.5 billion and at $0.3 billion in the Cairns area. However as many fishers appear to be largely motivated by "the experience not the catch", it is uncertain if values would be materially impacted by bleaching, and no bleaching costs have been estimated.

4.1. Tourism to the GBR and its coral sites

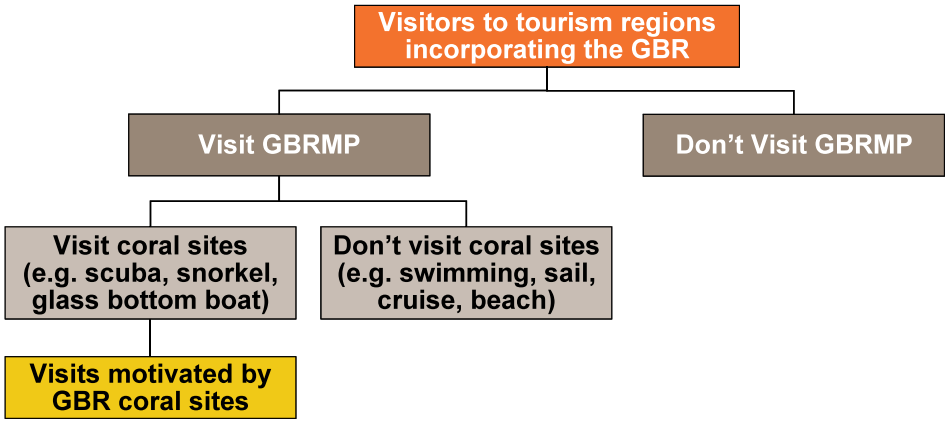
4.1.1. How many people visit the GBR coral sites ?

There is a degree of uncertainty over the precise number of annual visitors (and/or visitor days) to "the GBR". Some of this uncertainly relates to regional definitions, visitor definitions and the counting methods used. In addition, visitors to the GBR area (however defined) may be motivated by a variety of other interests which do not relate to viewing "corals and fishes" *per se* – e.g. visiting a reef island resort simply to go to the beach and/or relax.

For our purposes, GBR coral site visitors[13] should be distinguished from others who simply visit adjoining regions on the mainland and/or who visit island resorts (or who the cruise the waters of the GBRMP) but do not actually view corals and inter-related ecosystems. The focus of this section is on those who actually visited coral sites, and therefore have a demonstrated interest in the GBR coral sites themselves. (A further issue, discussed below, is the importance of coral sites and inter-related ecosystems in motivating those who visit them to come to the region as a whole.)

Chart 4-1 provides an approach to analysing the various subsets of regional visitors.

Chart 4-1 Sub-sets of regional visitors



Establishing how many people visit the coral sites on the GBR every year is important in terms of estimating the direct use value of the reef, both in terms of how many people would be willing to pay to access the reef at present and in the event of a permanent bleaching event.

For this report, a "one-off" study conducted by the Bureau of Tourism Research, commissioned by the Great Barrier Reef Marine Park Authority (GBRMPA) in 2003 (*BTR (2003) Assessment of tourism activity in the Great Barrier Reef Marine Park Region)* is used. BTR (2003) provides a more focussed definition of tourism in sections of "reef facing" Tourism Regions then other past studies. It includes data for "Tropical North

13 The term "coral site visitors" is taken to include those who visit coral sites through some form of activity and/or visit inter-related ecosystems such as the variety of marine line immediately adjacent to coral reefs.

Queensland" (TNQ), in this case used as a proxy for the Cairns area.[14] It also includes a breakdown of regional GBR holidaymakers (as opposed to those just visiting family and friends in the region and/or on business) who had undertaken the "GBR experience". The "GBR experience" was further detailed as including activities such as visiting the reef, snorkelling/scuba diving, fishing, beaching going and other activities.[15]

A further description of various past approaches to visitor numbers is contained in Appendix 3.

The estimate of coral site visitor numbers was performed in two stages:

- First, the snorkelling/scuba diving group identified in BTR (2003) were used by Oxford Economics as a basis for estimates of coral site visitation. This represented the largest sub-group involved in a form of coral site-related visitation and diving trips would likely be considered to be a trip to the reef whether or not the "reef visits box" was ticked.[16]
- Next, allowance was made for the fact that some people may have ticked "visited the reef" without necessarily going snorkelling or scuba diving (e.g. gone on a glass bottom boat tour). This was done by analysing (unpublished) cross-tabs from a Cairns airport exit survey conducted by James Cook University (JCU) in 2007-08 (see below). This data indicated the extent of overlap between snorkelers, scuba divers and those who visited coral sites through other means (e.g. glass bottom boats). Based on this, an uplift factor of 1.16 was applied to snorkelers/scuba divers estimates.

Estimates by Oxford Economics, based on this approach, indicate that coral site visitation in 2002/2003 amounted to the figures presented in the table below:

Table 4-1 Estimated number of visitors to the GBR coral sites: 2002-03[17]

Category	Number of visitors ('000)	
	GBR - Total	TNQ*
Domestic Overnight	279	151
Domestic Day	207	78
International Overnight	579	520
Total	**1,065**	**749**

Source: Oxford Economics, BTR

*Proxy for Cairns area

14 Tourism Australia and the ABS divide Australia into a number of Tourism Regions, of which Tropical North Queensland is one. For precise definitions of the Tourism Regions refer to ABS (2007) *Tourism Region Maps and Concordance Files, Australia, 2007*, Cat. No. 9503.0.55.001

15 Note that respondents could indicate more than one activity or may have effectively used some categories as a substitute for others. So simply focussing on the response to "visiting the reef" could be misleading. For example someone who snorkelled on the reef could tick this category to indicate a reef visit rather than ticking "visited the reef". Alternatively they may have ticked both. Tourism Australia advised that detailed cross-tabs and other unpublished data were not available for this survey.

16 Although day trip visitors were included in BTR (2003), detailed break-ups for such visitors were not provided. Scaled down estimates of scuba/snorkel visits were made for these visitors.

17 Note that, as defined by Tourism Australia, day visitors are those who do not spend a night away from their home as part of their travel. Therefore for all practical purposes, there is no international day visitor category. See the Explanation of Selected Terms for definitions of day and overnight visitors.

These 2002-03 figures were used as a guide to total coral site visitation in 2009 (and the years thereafter) though visitation in 2009 may well be higher when broken into the same categories. This may imply some conservatism in modelling although visitor numbers vary from year to year.[18]

The same breakdown has been used as a guide to recent expenditure by holidaymakers. The issue of expenditure is further discussed in the section dealing with commercial tourism below.

4.1.2. How many people would stop visiting the GBR and its coral sites if long term bleaching occurred ?

No single study has analysed the incremental effects of long term bleaching event on tourism, whether in the Cairns region or in relation to the GBR as a whole, although the Garnaut Report (among others) noted that this was a key issue and various efforts are continuing to assess the effects.

At present, a number of studies allow for a reasoned estimate of visitor numbers in the event of reef bleaching[19]. These include:

- Prideaux and Coghlan (2009 *in press)* conducted a survey of 339 visitors at Cairns domestic airport in summer 2008. These visitors were asked if they would consider visiting the region if coral bleaching occurred. While results are preliminary, overall, 12.5% said they would not revisit the region, while 40.8% said they were not sure if they would revisit the region. However this survey appeared to include both reef visitors and non-visitors. When only those who indicated that the reef was "very important" to their visit were separated out, the corresponding figures rose to 23% and 47% respectively. In an earlier survey by Prideaux, 35% of visitors said they would not revisit and 29% were uncertain (World Tourism Organisation 2008). (However, there is no indication that this survey was confined only to reef visitors.)
- Prideaux et. al. (2006) conducted a survey of backpackers in the Cairns region. 61% indicated that a desire to see the GBR was "very important" in their decision to visit Cairns. When asked to

18. There are plentiful annual tourism data for reef facing local government areas (LGAs) and defined Tourism Regions from sources such as Tourism Australia though 2009 data will, of course, only be released after the completion of this report. However, the survey and approach used in 2003 have not been repeated and, as indicated in Appendix 1, continual growth in visitation is not a certainty. So it is difficult to be certain of the nature of visitation changes and/or if any changes are due to changes in reef visitation rather than in non-reef visitation.

19 It is also possible to cite past international work on the actual effects of coral bleaching on visitation. However the findings of such work are complicated by the differing tourism settings of the sites in question, time frames, lagged effects and the differences between these sites and the GBR. For example, Marshall and Schuttenberg (2006) cite work conducted in the wake of the 1997-98 Indian Ocean bleaching event, with bleaching associated tourism visitation losses ranging from only 1% in the Maldives to a 19% fall in dive related tourism in Zanzibar. However the scope of tourism covered appears to vary in each case and the authors note that the breadth of the tourism sector in the Maldives minimised the impact on tourism. Further, the proximity to Europe and the ready supply of inexperienced divers also appeared to influence the Maldives results. One expectation might be that growing awareness of reef conditions along with more distant locations (such as the GBR) might have much more significant effects.

Andersson's (2007) analysis of the impact of bleaching in Zanzibar tends to confirm that the effects of bleaching are likely to become more significant after a time lag. While her analysis (comparing 1999 and 1997 visitation) finds an *increase* in visitation to Zanzibar as a whole, only 29% of those questioned had heard of bleaching while 73% indicated it would influence their choice of destination and 60% would not dive on a bleached reef. She finds that the key issue is expectations of reef conditions. Once knowledge of widespread bleaching spreads it is likely to have substantial impacts on tourism in the longer term.

Therefore, these short term studies should also be contrasted with long term ones. In considering this, Marshall and Schuttenberg point to a range of factors, including bleaching and over-fishing resulting in a decline in hotel occupancy by divers in the Philippines from 80% to 10% over 15 years. While occupancy rates have recovered to 50% (thanks to a shift to non-dive oriented tourism) this does not take into account the fact that a permanent bleaching would result in the irreversible loss of an environmental value, held by society.

Overall, such international studies are of interest but are limited in their applicability to tourism effects of GBR bleaching due to the major differences in timeframes, scope and local conditions.

nominate the top three places/activities for visiting Cairns, 74% nominated the GBR (far higher than any other activity, with Daintree/Cape Tribulation recording 23%). These results included both reef visitors and non-visitors.

- Kragt et. al. (2009) used a survey of 176 divers and snorkelers at Port Douglas to determine that the number of annual trips undertaken by these visitors would fall by 80% in the event of a "reef quality decline" (i.e. 80% decrease in coral cover, 30% decrease in coral diversity, 70% decrease in fish diversity) due to bleaching .
- Huybers and Bennett (2003) investigated potential UK tourists' responses to environmental conditions in TNQ. The authors found that a decline in regional environmental quality from "unspoilt" to "very spoilt" would be associated with a 58% decline in visitor numbers.
- Hoegh-Guldberg and Hoegh-Guldberg (2008) in a supplementary paper to the Garnaut Report estimated that 62% of visitor nights in regions along the GBR represented "reef interested tourism" with such tourism accounting for 90% of visitor nights in TNQ.
- Coghlan and Prideaux (2008) in surveys of reef visitors taking boat trips at Cairns and various other points along the GBR during November 2006 – October 2007 (n = 2,408) found that they gave visiting the GBR an average rating of 4.5 out of 5 (where 5 = "very important") in terms of assessing their travel motivations to the region. This value was roughly the same for Cairns and the GBR as a whole.
- The Coghlan and Prideaux (2008) published results, above, relate to the period between November 2006 - October 2007. However, frequency data for these and subsequent surveys by JCU covering the period November 2006-September 2008 were also made available for the current report. Analysis of these indicates that 73% of reef visitors considered that the reef was a very "important" motivator for their decision to visit the respective regions along the reef, with 23% indicating it was important (n = 4,755). (In comparison, 24% indicated that the rainforest was a "very important" motivator, with 34% indicating it was important.)
- Moscardo et. al. (2003) asked a sample of 191 reef visitors at Cairns domestic airport and various Cairns hotels about the main factors influencing their choice of destination. 60% indicated that a chance to visit the GBR was a "very important" factor, the highest rating on a four point scale.
- Prideaux and Falco-Mammone (2007) found that 69% of visitors (n = 839) to the Wet Tropics World Heritage Area (WTWHA) (i.e. Daintree and other neighbouring forests) would still visit if there were no rainforests in the study area. This was taken as an implication that the GBR was the main tourist magnet in the region.

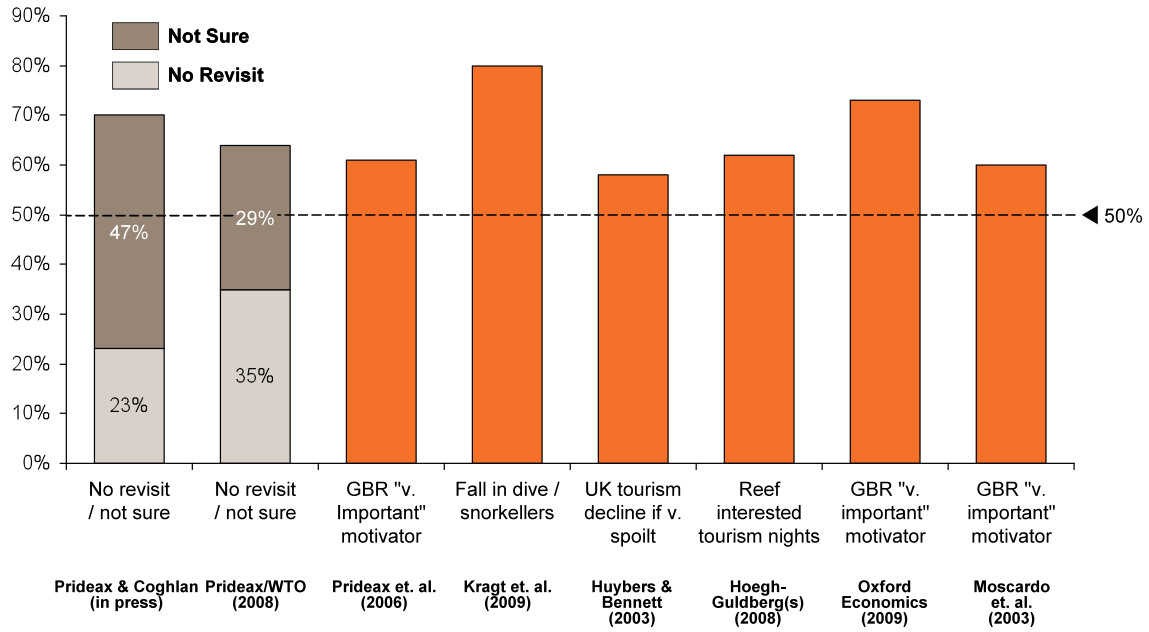
These studies appear to refer to varying bases when deriving their estimates. In some cases the estimates refer to those who have visited the GBR, in others they refer to all tourists in areas such as TNQ while in others the visitor base is unclear.

Nonetheless, when taken together, a reasonable estimate based on these studies, suggests that at least some 50% of international and domestic overnight tourists who visited the GBR coral sites, in the course of their trip would be unlikely to have made their trip if the GBR sites had suffered

permanent bleaching[20]**.** Such a figure would appear to be a reasonable reflection of the attitudes expressed in the studies above and the importance of the GBR in relevant trip decision making.

Chart 4-2 provides a graphical illustration of the importance of the GBR as a trip motivator based on some of the above studies, with a line indicating the "50% mark" for purposes of comparison.

Chart 4-2 Comparison of selected GBR travel motivation studies



Further, many of these studies focus on international and domestic overnight visitors. **In the case of domestic day visitors it is reasonable to assume that the presence of the reef is the sole reason for making the trip**[21]. (However, as indicated in Appendix 4, domestic day trip consumer surplus values are small compared to those for international and domestic overnight travellers, accounting for only 0.3% of total consumer surplus, and have little influence on study results.)

20 More formally, a figure of close to 50% is reached if half of the "not sures" from Prideaux and Coghlan (2009 in press), or equivalently, Prideaux/WTO (2008) are added to the "no revisits" – i.e. it is assumed that half of the "not sure" responses do not return.

Likewise, Hoegh-Guldberg and Hoegh-Guldberg's (2008) work, which is further detailed in Hoegh-Guldberg and Hoegh-Guldberg (2004) deals with the same issue and estimates a slightly higher figure for "reef interested tourism" (62%). This figure relied on extensive background work.

Kragt et al.'s (2009) figure of an 80% reduction in trip numbers relates to snorkellers and divers. Survey estimates for the proportion of GBR visitors who, at least, went snorkelling vary from roughly 65% (derived from Moscardo et al 2003) to 73% (derived from the JCU reef visitor survey data, described above). Taking a mid-point figure of 69% suggests 55% of visits might be deterred by bleaching (e.g. 80%*69% = 0.55) even if "dry feet" visitors aren't allowed for.

Huyber and Bennett's (2003) UK work also points to a decline of 58% with environmental despoliation, noting that UK tourists represent the "median case" for international visitors seeking environmental experiences in Queensland. It would be difficult to argue with the concept that mass bleaching of the GBR would represent a spoilt environment (compared to the present) in the eyes of many people.

A figure of 50% therefore seems reasonably conservative estimate, given the findings of these and other reports.

21. These domestic day trip visits are clearly motivated by the presence of the reef itself, as opposed to the case for international visitors and domestic overnight tourists where the reef may be one attraction among several. In practice some domestic day trips may continue to be made even to a completely bleached reef, though Kragt et al (2009) suggest that 80% of diver and snorkeller trips from all visitor groups would be lost - and their estimate excludes pure sightseeing visits, where effects may arguably be larger. Any residual consumer surplus is unlikely to be large due to the small size of the associated domestic day consumer surplus value. See Appendix 4 for further discussion of domestic day consumer surplus values.

Again it should be noted that this relates to domestic day trips to coral sites for sightseeing, scuba and snorkelling purposes. It excludes domestic day recreational fishing trips which are discussed separately below.

These estimates have been adopted and applied to coral sites when assessing the value of tourist visitation (consumer surplus) and of the tourism industry (producer surplus) and the associated losses from bleaching. In other words, in estimating tourism consumer surplus, it is assumed that 50% of all international and domestic overnight visitors who included a GBR *coral site visit* as a part of their trip would not undertake their trip at all in the event of bleaching, while all domestic day trips are lost. So, of the 1.065 million annual visits to coral sites estimated above, 636,000 annual visits are estimated to effectively be lost in the event of total and permanent bleaching. The reduction in annual visitation to the Cairns area is estimated at 414,000[22].

This estimate reflects the significance of the GBR as a motivator to tourism. At the same time, this estimate allows for the fact that much tourism would continue even in the event of long term bleaching. For example, those not visiting the reef (but nonetheless visiting areas such as Cairns, TNQ, the Whitsunday's etc) are assumed to be unaffected by bleaching. Likewise, 50% of international and overnight domestic tourists who happened to visit the GBR during their trip are assumed to continue with their visits to the region in the event of a permanent mass bleaching[23].

While estimating a 50% loss in international and domestic visitation is felt to represent a reasonable approach given available data, it is also possible to model scenarios based on higher and lower visitation loss. The sensitivity tests in Appendix 1 explore these issues further.

4.2. Recreational tourism values

The GBR, including its coral sites, is a World Heritage Area and draws visitors from around Australia and the world. These visitors must therefore place some value on seeing the GBR and its coral sites – otherwise they would not undertake the trip.

There are several ways in which the value which visitors place on the GBR coral sites can be calculated. The approach taken in this study is to use the Travel Cost Method (TCM). Modelling using the TCM was separately applied to overnight domestic visitors and international visitors based on Cairns airport exit survey data for 2007 and 2008, supplied by JCU for this report.[24] Data on day visitors was modelled using reef visitation survey data also supplied by JCU.[25]

Further details of the travel cost modelling are provided in Appendix 4.

The travel cost modelling allowed for the estimation of consumer surpluses for day, domestic overnight, international visitors from different geographical "zones" around Australia and the world. The charts below

22 That is, from Table 4-1, for the reef as a whole, 0.5*(279,000+579,000) + 207,000 – i.e. half the sum of domestic overnight and international visitors and the whole of domestic day visitors. For the Cairns area the equivalent calculation is 0.5*(151,000+520,000) + 78,000.

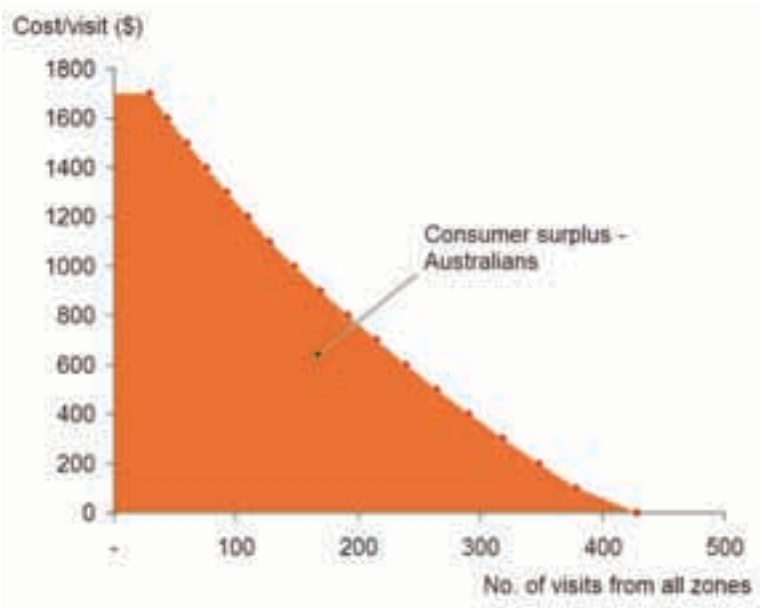
23 It is arguable that other effects may impact on those remaining visitors who still chose to patronise island resorts. For example, a degraded reef may give off unpleasant smells arising from algae. This may shorten (or prevent) the stays of those who visit island resorts. However, there, there has been no long term quantification of such effects in other studies. In addition effect such as these may be highly variable and dependent on geographical and meteorological considerations. So, it is not currently possible to do anything other than speculate on such ancillary effects.

24 Refer to McNamara and Prideaux (2008) for published details of this project. Note that the survey data supplied covered November 2006-June 2008, a longer period than in this published report

25 Refer to Coghlan and Prideaux (2008) for published details of this project. Note that the survey data supplied covered November 2006-September 2008, a longer period than in this published report

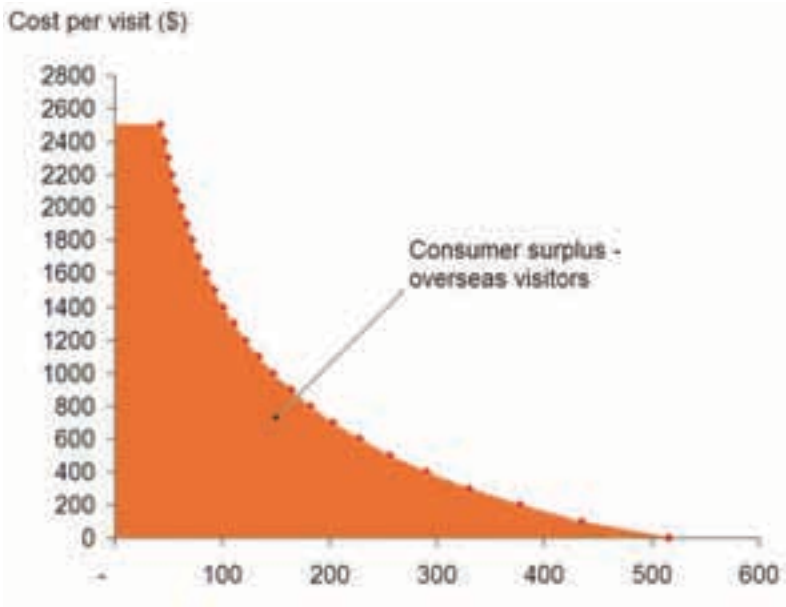
provide an indication of the resultant "raw" consumer surplus estimations for the sample of domestic overnight and international visitors. These were then subject to further modelling, including adjustment to allow for the numbers of visitors who actually visited coral sites (i.e. 1.1 million and 749,000 for the GBR as a whole and Cairns respectively) and the estimated proportion of visits motivated by coral site visitation (i.e. 50%, for international and domestic overnight tourists and 100% for day visitors as discussed above). Correspondingly, this also reflects the loss in consumer surplus resulting from bleaching.

Chart 4-3 Australian visitor consumer surplus



Source: Oxford Economics

Chart 4-4 Overseas visitor consumer surplus



Source: Oxford Economics

The resulting consumer surplus is $474 million per annum for the GBR coral sites as a whole, with consumer surpluses per person in the range of $892-$1,202 for domestic overnight and international visitors, respectively. As a reliability check, this compares to individual consumer surplus estimates made for an earlier GBR travel cost survey by Carr and Mendelsohn (2003) which, when adjusted for inflation and exchange rates at purchasing power parity, suggests a consumer surplus range of $600–1,500 per person.[26] The modelled values are therefore consistent with previous work in the area.

On a PV basis, the consumer surplus for the GBR coral sites is $16.6 billion and for Cairns area (TNQ) coral site visitors, $11.7 billion.

As indicated, while estimating a 50% loss in international and domestic visitation is felt to represent a reasonable approach, given available data, it is also possible to model scenarios based on higher and lower visitation loss. Appendix 1 explores these issues further.

4.3. Value of recreational fishing in the GBR

The GBRMP provides an important resource for recreational fishers, who can be distinguished from the GBR tourists, discussed above. As indicated below, coral bleaching may have the potential to affect fish stocks in the GBRMP, although the precise impacts of this are still unclear (Marshall and Schuttenberg 2006, Johnson and Marshall 2007, Bellwood et al 2006, Graham et. al. 2007, Munday et al. 2008, Hoegh-Guldberg and Hoegh-Guldberg 2004, Hoegh-Guldberg and Hoegh-Guldberg 2008). This raises the issue of the effects of bleaching on recreational fishing activity.

As is the case for tourism, recreational fishers enjoy a consumer surplus from their activities. This is the difference between the price they pay to undertake recreational fishing trips and the total amount they would be willing to pay to undertake such trips. This consumer surplus represents the net economic benefit of recreational fishing.

An assessment of the economic value of the GBR in the Cairns region, and in general, must therefore examine the effects on recreational fishers.

There are a very large number of studies investigating the issue of recreational fishing in the GBR and surrounding areas. While dated, one of the most relevant for the current report is the work of Blamey and Hundloe (1993) as reported with supplementary analysis by Blamey in Driml (1994), though the more recent work of Prayaga et al (2009) is also significant (as discussed below). Blamey and Hundloe's analysis was based on survey work involving over 450 interviews at boat ramps adjacent to the Great Barrier Reef World Heritage Area (GBRWHA). This was supplemented by 750 phone interviews of registered boat owners in regions adjoining the GBRWHA. Blamey and Hundloe's work indicates that the mean consumer surplus (on a willingness to pay basis) for boat owners undertaking fishing trips in the GBRWHA was at least $2,000 in 1990 dollars in that year. This estimate was used to calculate a consumer surplus accruing to boat owners

26 The original Carr and Mendelsohn values were $US 350-800 (2000 dollars). A discussion of the Carr and Mendelsohn work is provided in Appendix 2. While the technical approach to travel cost modelling on a per person basis is rigorous and useful, this per person value is applied to GBRMPA visitation figures of some 2 million people per annum, in contrast to the more restrictive approach taken in the current study.

residing in areas adjacent to the GBRWHA of $50 million (in 1990 dollars) based on estimates of the number of vessels used for recreational fishing in the GBRWHA in 1990[27].

Adjusted to 2009 dollars this is equal to a consumer surplus of some $3,243 per boat owner or roughly $79 million per annum, if no adjustment is made for any growth in the number of recreational boats assumed to be used for fishing in the GBRWHA. Though using different methods and set in a different context, this consumer surplus per boat owner is very similar to that which can be derived from a recent study by Rolfe and Prayaga (2007) for fishers at the Fairbairn Dam in Central Queensland (i.e. $3,340 per fisher per annum).

Several issues arise when considering this figure and the implications of bleaching on recreational fishing:

- In the years since these calculations, the introduction of the 2004 GBRMP Zoning Plan by the GBRMPA increased the amount of "no take" fishing areas from 5% to 33% of the total GBRMP area.
- At the same time, the number of estimated fishing craft in the area of the GBR appears to have greatly increased. Hand (2003) estimates that there were some 40,187 boats used for recreational fishing in the GBR region. Access Economics (2007) suggests that the number of recreational fishing vessels used in the GBRMP was some 50,000 in 2004.[28]
- Regardless of the precise current figure, Hand (2003) argues that access to reef and island areas offshore in the GBRMP requires vessels over 5.1m in length and that 80% of recreational fishing vessels in the region are less than the 5.1 metres in length.[29] He also cites data from the National Recreational Fishing Survey (2003) indicating that only 6% of the recreational fishing effort in Queensland (including from communities adjoining the GBRMP) occurs more than 5 kilometres from the coast. By this reckoning, many boats in the current fleet would be used for close in-shore fishing in areas such as estuaries, although these length restrictions may not apply for fringing reefs such as the Whitsunday's and Keppel.

  A priori, the increase in no-take areas could be argued to reduce the consumer surplus estimated by Blamey and Hundloe (1993). This is because increasing costs, combined with and diminishing catch sizes could be expected to reduce the overall enjoyment of the fishing experience for recreational fishers, thereby reducing the consumer surplus to boat owners. There is some evidence this may have happened (Sutton 2008), although this assumption makes no allowance for rising real incomes (which may counteract these effects to some extent).

27 Note that this study considered the GBRWHA rather than the GBRMP *per se*. However the two have been considered to be synonymous for the purposes of this study, as the GBRWHA is only some 2% larger than the GBRMP. Blamey and Hundloe also estimated a value of $5,000 (1990 dollars) per boat owner based on willingness to accept (WTA) measures. However, this figure implies that fishing in the GBRMP is the property right of recreational fishers. The increase in "no take" zones in 2004 (for which no compensation was paid to recreational fishers) suggests that this is not the case. Interestingly Sutton (2008) finds that 49% of Cairns region fishers do not believe they should have been compensated, with only 17% agreeing (the remainder being neutral).Overall GBR figures were 54% and 15% respectively

28 A check of Queensland Transport data, recorded by GBRMPA website (http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/management/gbr_visitation/rec_vessels/) indicates that 81,795 vessels were registered within the "Great Barrier Reef Catchment area" for recreational purposes of all types as at December 2008. However, obviously some of these were for non-fishing purposes (e.g. these data included 2,189 jet skis).

29 A check of Queensland Transport data recorded on the GBRMPA website at http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/management/gbr_visitation/rec_vessels/ in December 2008 indicates that 77% of recreational vessels of all types (i.e. fishing and non-fishing) are less than 5.01 metres in length.

However, surveys of GBR fishers by Ormsby (2004) suggest that their primary motivations for fishing are for rest and relaxation, to enjoy nature and to be outdoors, with the enjoyment of catching and eating fish less important than all of these in most cases. (All of these tendencies are even more pronounced in the Far North Statistical Division, encompassing Cairns, than is the case for the GBR as a whole.) Therefore fish catch *per se* may not be the primary factor behind fisher WTP.

A sub-section of Ormsby's results is reproduced in the two tables below.

Table 4-2 Sub-set of fishing motivations by GBR Statistical Division

Fishing Motivation	Great Barrier Reef Statistical Division			
	Far North (includes Cairns)*	Fitzroy*	Mackay*	Northern*
For rest and relaxation	4.31	4.27	4.17	4.04
To enjoy nature	4.03	3.88	3.87	3.70
To be outdoors	4.01	3.72	3.89	3.71
Pleasure of catching fish	3.77	3.96	3.90	3.59
To obtain fish for eating	3.51	3.41	3.40	3.13

*Measured on a Likart scale, where 1 = Strongly disagree, 5 = strongly agree

Source: Ormsby (2004)

Table 4-3 Motivations for recreational fishing on the GBR

Question	Agree or strongly agree (%)
A fishing trip can be successful even if no fish are caught	67.9
Doesn't matter to me what type of fish I catch	50.1
It doesn't matter to me if I don't catch fish every trip as long as I have the opportunity to catch fish	73.5
The more fish I catch the better the fishing trip	26.9

Source: Ormsby (2004)

It also follows that if fish catch *per se* is not the prime motivator for fishers than the effect of any fish stock losses associated with bleaching may limited. The uncertainty over actual changes in fish stocks associated with bleaching (discussed in the section of this report dealing with commercial fishing) reinforces this point. Given that half of fishers indicate that type of fish does not matter, any changes in species composition associated with bleaching may also have limited effects on fisher behaviour.

Nonetheless, Sutton (2008) finds that 44% of fishers in the Cairns area felt that the 2004 Zoning Plan reduced their satisfaction from fishing, with 44% indicating that it had increased their costs, 33% indicating it had reduced their time fishing and their frequency of fishing, with 46% indicating it had reduced their catch (Figures from other GBR regions were less negative.) While similar numbers suggested no effects in these categories (and some recorded positive effects) this again might be taken, *ceteris paribus*, as a sign both that catch does have some impact on satisfaction and that the consumer surplus per boat owner has fallen since Blamey and Hundloe's1993 study (though the later point again ignores rising real incomes).

More recent work by Prayaga et al (2009) has helped to clarify these issues. This work involved 318 interviews with fishers and employed the travel cost method to examine the value of recreational fishing along the "Capricorn Coast" (essentially the coastline of Rockhampton Regional Council). Prayaga et al. derived a value of $5.53 million (in 2007 dollars) for recreational fishing - or $5.91 million in 2009 dollars.

The GBRMPA website reports Queensland Transport data on the number of registered vessels in local government areas (LGAs) adjoining the GBRMP[30]. Using the number of boats in the Rockhampton LGA in April 2009 (7,892) as a proxy measure, this figure can be "grossed up" by comparing it to the total GBR registered vessel figure in April 2009 (82,013)[31]. This process generates an annual consumer surplus value of $61 million for the GBR as a whole. This is lower than the figures implied by Blamey and Hundloe's past work but nonetheless within the same "ballpark".

Blamey and Hundloe's work, while dated, is comprehensive in that its geographical scope covers the whole of the GBRMP. Prayaga et. al.'s is geographically limited to the Capricorn Coast but much more recent. Given the broadly similar results generated by both estimates a reasonable approach would therefore be to take the average of the adjusted results of these two studies. This yields a consumer surplus of $70.1 million per annum attributable to recreational fishing in the GBR.

$10.1 million per annum of this can be attributed to Cairns region, based on Queensland Transport data indicating that, in April 2009, some 13% of recreational boats in GBR LGAs were based in the Cairns LGA[32].

Issues such as possible changes in fish stocks, the size of the current consumer surplus and the motivations for fishing also have an obvious bearing on the question of whether bleaching will affect the recreational fishing consumer surplus. As discussed below, bleaching may affect the numbers, diversity and composition of fish stocks, though the extent to which this occurs is still being studied.

However, if it is assumed that fish stocks do decline (and/or that any changes in species composition will not be to the preference of fishers) two basic possibilities may be modelled:

- *"The experience not the catch"* - If fishers do indeed gain enjoyment from "the trip rather than the catch", then a reduction/change in fish stocks from bleaching may not matter much in consumer surplus terms. So there is no bleaching-associated loss. (Of course if bleaching does not lead to a material decline/change in fish stocks there is no loss either.)
- *"Catch matters"* – Based on the findings from the "no take" survey, if it is assumed that "catch really does matter" and that declining/changing fish stocks accompany bleaching then consumer surplus will be reduced

30 See http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/management/gbr_visitation/rec_vessels/

31 An implicit assumption in this estimate is that the ratio of fishing to non-fishing craft is constant for both scales of the analysis.

32 This figure was again derived by reference to Queensland Transport data held on the GBRMPA database at http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/management/gbr_visitation/rec_vessels/

The recent work of Prayaga et. al. also sheds light on this issue. These authors tested the change in fisher's satisfaction (i.e. consumer surplus) associated with a 25% fall in catch sizes. Even such a significant decline in catch sizes is found to have almost no effect on fisher consumer surplus[33]. This supports the argument that reef bleaching is not likely to substantively affect the value of recreational fishing (to fishers). Such values appear to be largely driven by the fishing experience rather than catch numbers *per se*.

Accordingly, this report has adopted the former, more conservative approach. As such, a PV has been assessed for the value of recreational fishing in the GBR ($2.5 billion) and in the Cairns area ($0.3 billion).However, as the effects of bleaching on fisher consumer surplus would not appear to have a major impact on fisher consumer surplus values, no assessment has been made of bleaching costs to recreational fishers.[34]

33 Specifically, the authors find that a 25% decline in catch rates results in fall in consumer surplus of only $111,000 out of a total consumer surplus of $5.53 million.

34 Even a speculative assessment which rejects the results of Prayaga et al and assumes that "catch matters" is likely yield modest results. For example, based on Ormsby's results on what constitutes a "successful fishing trip", assume 1/3 of fisher utility relates to catch and that the loss in fish stocks is directly proportionate to the loss in value described for commercial fishing below (30%). Such calculations suggest a total PV loss from bleaching of $245 million for the GBR as a whole and $31 million for Cairns.

5. Use value – Commercial (Producer Surplus)

Key Points

- The tourism industry derives profits (producer surplus) from the fact that people visit the GBR coral sites and these must be accounted for in any valuation.
- The PV of profits related to the GBR tourism industry (which can be attributed to tourism motivated by visits to GBR coral sites) is $3.6 billion for the GBR as a whole and $2.8 billion for Tropical North Queensland (a proxy for the Cairns area).
- These values would be lost in the event of total and permanent bleaching of the reef.
- While there is considerable uncertainty over effects on the commercial fishing industry, mass bleaching is likely to have an adverse impact on fisheries. Losses due to bleaching are estimated at $428 million for the GBR and $59 million for the Cairns region in PV terms.
- In addition, the recreational fishing industry (i.e. sales of fishing equipment, boats, including hire, and fuel) generates profits. These are valued at $300 million for the GBR as a whole and $38 million in the Cairns region in PV terms.
- However, as it is uncertain if recreational fishing will decline with GBR bleaching, it has been assumed that these industry profits continue even in the event of bleaching.

The commercial use value of the GBR essentially relates to industry profitability (or producer surplus). The commercial value of the GBR can be split into tourism industry value, commercial fishing value and recreational fishing value.

5.1. Tourism industry

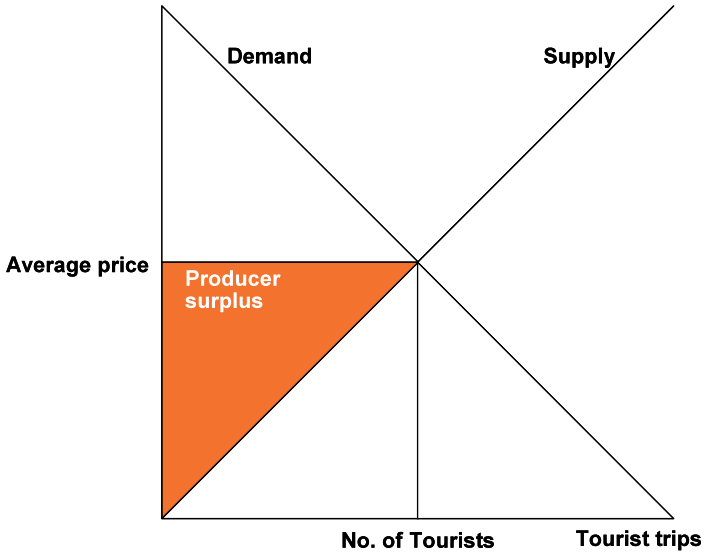
The tourism/recreational use value of the GBR coral sites has been estimated through the use of the travel cost method, described above.

However, this measures only the consumer surplus associated with visits to the GBR coral sites. There is also a need to assess the industry benefit associated with tourism (i.e. the producer surplus).

Chart 5-1 illustrates the concept. The producer surplus is roughly analogous to profit[35] and is the difference between the price received by the seller of the commodity (in this case GBR tourism) and the lowest price at which they would have been prepared to sell it. It is represented by the area between the supply curve and the price line. The Gross Operating Surplus (GOS), a sub-component of GDP can be used as a measure of producer surplus.

35 Technically speaking, economists define producer surplus as equal to profits plus fixed costs.

Chart 5-1 Producer surplus



Many of the visitation statistics described above can be used to derive this measure. As indicated, the estimated number of GBR coral site tourists was some 1.1 million per annum in 2002-03, based on BTR (2003). The same publication produced regional expenditure values for various tourist categories. These were used to derive the expenditure for these tourists in this year. Adjustments to these data were then made to:

- convert to 2009 dollars;
- allow for international airfare expenses, given that the GBR is a global resource and that any benefits (profits) attributable to international airlines should be allowed for[36]

When adjusted to 2009 dollars, and after making an allowance for international airfares, this expenditure is $1.3 billion per annum for the GBR coral sites tourism as a whole or $1.1 billion per annum for coral site visitation in Tropical North Queensland (the best available proxy for Cairns)[37]. Note these figures were not adjusted for any growth in visitation between 2002-03 and 2009, though as discussed elsewhere in this report some figures suggest that coral sites visitation may have been relatively stable since that time.

36 The "raw" expenditure estimates appear to be based on Tourism Australia's Regional Expenditure Model (REM) –see BTR (2003) and Tourism Australia (2008a). While the REM includes many items typically purchased by tourists, it excludes international airfares purchased outside the region. An estimate was therefore made for such expenditure. This was done by estimating the average of international airfares for visitors from the major reef-visiting countries using Tourism Australia (2008b) and unpublished tourism stopover data for Tropical North Queensland provided by Tourism Australia. This allowed for estimation of an average international airfare component ($270 in 2007 dollars) for international visitors to the GBR (i.e. weighted average international airfare ($1,758 in 2007 dollars) divided by weighted average number of stopovers (6.5)). These figures were then indexed to inflation to derive 2009 values.

The REM allocates only a portion of domestic long distance travel costs (including domestic airfares) to the region visited through a complex allocation system. Arguably this might somewhat understate visitation costs (and thereby producer surplus) for the purposes of this study. However, no adjustment has been made for domestic visitors due to the complexities involved in doing so.

37 These expenditure figures were derived on a different basis to the survey figures used for the travel cost modelling above. There are several reasons for this, including the use of "perceived travel cost values", noted in Appendix 4, as well as the inclusion of the full value of estimated travel costs by respondents (n contrast to the REM allocation approach). In general, because of the many forms the travel cost method can take (e.g. the perceived costs approach, a "just travel costs" approach, including/excluding travel time) would not necessarily "line up" with official tourism expenditure figures.

There are numerous possible approaches to estimating a producer surplus figure from this expenditure figure. One approach is to use the ABS *Tourism Satellite Accounts* (TSA) – see ABS (2008b). This publication allows for a comparison between tourism expenditure at purchasers prices (i.e. the actual prices people pay) and Gross Operating Surplus (GOS) for tourism (a measure of tourism profitability). The TSA indicates that the GOS to expenditure ratio is some 15%[38].

This allows for a derivation of the annual producer surplus for the GBR as a whole ($202 million per annum) and Tropical North Queensland, as a proxy for the Cairns region ($160 million per annum).

When these values are streamed forward at a discount rate of 2.65% the PV for the GBR is $7.1 billion and for Tropical North Queensland, $5.6 billion. However, this reflects the tourism industry profits derived from people who *happened* to visit the GBR coral sites as a part of their trip. An adjustment was therefore made based on the estimation, above, that 50% of international and domestic overnight coral site visitors are motivated to make their trips based on the presence of the GBR, while all day trips were assumed to be motivated by its existence.

Allowing for this adjustment, the final producer surplus attributable to the GBR tourism industry attributable to coral site visitation is $3.6 billion and $2.8 billion for Tropical North Queensland

5.2. Fishing industry

The presence of the GBR acts as a magnet to a large variety of marine life and coral reefs in general are acknowledged as one of the most highly complex and diverse of natural ecosystems (Spalding et al 2001, Bryant et al. 1998, Knowlton 2001, European Commission 2008, Ruitenbeek and Cartier1999, Scott Wilson 2008). Nearly 1,500 fish species have been recorded on the GBR with up to 200 species being recorded from single samples on individual dives (Spalding et. al. 2001). Bleaching of the GBR poses an obvious threat to the current structure of the GBR marine ecosystem, although the impacts on the commercial and recreational fishing industries and recreational fishers are not straightforward, as discussed below.

In both cases, the focus is on the value of the producer surplus (i.e. industry profits) as a source of both current benefit and potential loss (should bleaching occur).

38 According to Mules (2004) Hassall and Associates (2002) calculated a gross profit margin (inclusive of depreciation, tax and interest, as well as net profit) of 18.7% for GBR tourism. Use of this margin would produce a higher producer surplus estimate.

5.2.1. Commercial fishing

There are a very large number of possible sources for an estimation of the value of commercial fishing on the GBR. For the purposes of this study, the best estimates are provided in Access Economics (2008).[39] These indicate that in 2006-07 "wild harvest" fishing (i.e. excluding aquaculture) had a Gross Value of Production (GVP) of $114 million in 2006-07 dollars. This figure takes into account the fact that commercial fishing GVP on the reef has been flat or declining in recent years. This is a reflection of both long and short term effects, some of which are debated by various stakeholders, but include a mix of:

- Additional restrictions on fishing catch arising from the 2004 GBRMP Zoning Plan
- Higher oil prices
- Shortages of skilled labour
- Cheaper imported fish prices
- Overfishing

An estimate of the Gross Value Added (GVA) of commercial fishing in the GBRMP ($89 million in 2006-07 terms) is also provided by Access Economics. As this includes aquaculture (which arguably is not truly related to the presence of the reef) an adjustment was made to this figure, based on the proportion of wild harvest to total commercial fishing GVP. After an additional adjustment to 2009 dollars, this yields a GVA figure of $65.7 million per annum.

The Queensland Government's *Queensland Regional Input-Output Tables* (2004) indicates the Forestry and Fishing Gross Operating Surplus (GOS) and allows for calculation of GVA for Forestry and Fishing in various Queensland regions. Taking the Far North Statistical Division GOS/GVA ratio for forestry and fishing (0.62) and applying this to the figure of $65.7 million suggests an annual reef fishing GOS of $40.7 million.

As indicated, GOS may act as a proxy for producer surplus (BTCE 1997; AgEconPlus 2006).

This value was streamed forward at a discount rate of 2.65% to derive a reef-wide PV for commercial fishing of $1.4 billion.

The literature is far less clear on what effects reef bleaching may have on fish catch over time (Marshall and Schuttenberg 2006, Johnson and Marshall 2007, Bellwood et al 2006, Graham et. al. 2007, Munday et al. 2008, Hoegh-Guldberg and Hoegh-Guldberg 2004, Hoegh-Guldberg and Hoegh-Guldberg 2008). While numerous studies have been conducted of fish populations after bleaching events, by definition these have not been long term, making it difficult to ascertain some rough average to project over time. While there are indications that fish diversity may fall by up to 50% (Hoegh-Guldberg and Hoegh-Guldberg 2008), other studies find little change in diversity or abundance in the short term (Bellwood et al 2006). Some of these studies also indicate that there may be replacement of some species types by others (e.g. herbivorous fish) which then raises the question of whether such replacements (if any) would be marketable to consumers (Bellwood et al. 2006, Marshall and Schuttenberg 2006, Johnson and Marshall 2007).[40]

39 Unlike estimates of tourism value the commercial fishing values estimated by Access Economics relate to the GBRMP and so are much more compatible with the definitions used in the current study

40 Of course it might also be argued that fishers will simply shift production away from the GBR to other areas and therefore the economy will not suffer a net loss. However such an approach appears to beg the question of why industry did not locate elsewhere in

Nonetheless, current indications are that the disruption to marine life from bleaching is significant and there is no guarantee that replacement stocks for viable commercial usage will emerge in affected areas. Cesar and Chong (2005) follow Wilkinson et al. (1999) in estimating that coral bleaching in areas such as the Indian Ocean could lead to the loss of some 25% of reef-related fisheries after a period of some 25 years. Hoegh-Guldberg and Hoegh-Guldberg (2004) model a variety of scenarios focussed on the GBR, which suggest the loss of 30-36% of the value of the GBR's wild fisheries (expressed in terms of Gross Regional Product) due to bleaching by 2020. (This represents the effects of a partial bleaching with full bleaching presumably leading to greater losses.)

The most conservative figure from the most relevant local study, Hoegh-Guldberg and Hoegh-Guldberg (2004) - i.e. 30% loss of value - has been assumed for this study. However, as is the case with the other estimates, the modelling has assumed that the effects occur today and are projected forward. (Sensitivity tests exploring variations on the 30% value loss rate are explored in Appendix 1.)

This analysis suggests a PV loss of $427 million from bleaching for the GBR as a whole. The PV loss for Cairns region is $59 million. The Cairns figure was derived from Bureau of Rural Sciences (2003) which indicated that the Cairns area accounted for 13.7% of GBR commercial fishery GVP under the revised 2004 GBR Zoning Plan.

5.2.2. Recreational fishing industry

The "recreational fishing industry" should be distinguished from "recreational fishing" (discussed in Section 4 above). The former relates to the industry involved in the sale of goods and services used by fishers (such as fishing equipment, purchase or rental of boats and petrol).[41] The profits from this industry should be taken into account when assessing the value of the GBR as a whole and in the Cairns area. In contrast "recreational fishing" (that is, the activity of fishing itself) generates a consumer surplus, as discussed in Section 4.

Access Economics (2008) provides estimates based on survey data of expenditure by recreational fishers on boats and other fishing-related items, as well as providing estimates for recreational fishing GVA based on mapping expenditure to ABS input-output categories. This suggests an annual GVA of $39 million in 2006-07 (in 2006-07 dollars) or $42 million in 2009 dollars.

The Queensland Government's *Queensland Regional Input-Output Tables* (2004) was again used to determine GOS. The GOS/GVA ratio for the main industries comprising the recreational fishing industry in

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the first instance if there were (at least) equal profits to be made. In a competitive economy, it would be expected that goods and services should be allocated efficiently. Supply side shocks, such as destruction of fishing stocks, are therefore unlikely to have "no net impact" on producers or consumers, as evidenced from past examples of over-fishing.

Although the scope and context are somewhat different it is also worth noting that $187 million in compensation had been paid to financially disadvantaged fishers and the commercial fishing industry by May 2007 as a result of the implementation of the 2004 GBR Zoning Plan, with many claims still outstanding. This amount greatly exceeded initial estimates of $2.6 million (maximum) made prior to the plan's implantation (Minnegal & Dwyer 2008), and is suggestive of the large effects disruption to commercial fishing could have in the GBR area.

41 This definition and the expenditure estimates below follow the approach adopted by Access Economics (2008). However, the current analysis differs from the Access Economics work and estimates a producer surplus.

the Far North Statistical Division (machinery, miscellaneous manufacturing and wholesale and retail trade) was then determined and applied to the GVA estimate of $42 million.[42]

This indicates an annual GOS of some $8.6 million for the GBR recreational fishing industry as a whole. Assuming that some 13% of this expenditure occurs in the Cairns area (proportionate to the region's share of recreational boat ownership), this implies a producer surplus of $1.1 million for Cairns.

The respective PVs are $300 million for the GBR and $38 million for Cairns.

As no change in the consumer surplus for recreational fishing has been assumed due to bleaching, it is likewise assumed that there is no net loss to the recreational fishing industry. The value identified above, however, was however incorporated into the assessment of the value of the GBR as a whole and in the Cairns area.

42 The input-output tables themselves relate to 1996-97 (the latest available) for Queensland. Though the actual GOS/GVA ratio (0.21) related to the Far North Statistical Division, this was used as a proxy across the GBR as a whole.

6. Indirect use value

Key Points

- Coral reefs such as the GBR may act as natural barriers, protecting coastal communities under normal sea conditions and during cyclones and other storms.
- This coastal protection function has an economic value in terms of avoided loss of productive land and infrastructure (beaches, farmland, homes, buildings and other infrastructure).
- The presence of a reef may therefore be of indirect use to such communities, contributing to both producer and consumer surplus.
- Various studies have been carried out on small reefs around the world; however no study appears to have independently estimated the value of the GBR's coastal protection function.
- A conservative estimate based on the approximate "straight line" length of the GBR itself suggests that this indirect use function is equal to at least $10.0 billion in PV terms, based on low cost coastal defences.
- Bleaching of the GBR may result in the eventual loss of some of this protective function. However this is likely to be a long term process and no immediate impact has been estimated for this report.

6.1. Coastal defence functions and international valuations

Coral reefs such as the GBR may act as natural barriers, protecting coastal communities under normal sea conditions and during cyclones and other storms. It has been estimated that some 70-90% of the energy of wind-borne waves can be absorbed by coral reefs, depending on ecosystem health and other physical and ecological conditions (UNEP 2006).

The presence of reefs as "natural breakwaters" is therefore of considerable benefit to coastal communities, most obviously in the form of reduced erosion. Additional benefits may arise from the reduction in wave-generated damage to fishing fleets and recreational boats.

Therefore both producers and consumers benefit indirectly from the presence of reefs. In the case of the former, the most obvious benefit is reduced coastal erosion, and its impacts on the value of properties such as farms, roads, buildings and other infrastructure. Avoided erosion may allow for consumer benefits such as enjoyment of stable beaches, (with less erosion than would otherwise be the case). As indicated, damage to boating craft from storms may also be reduced, and the reduced sea swells in reef-protected coastal lagoons may allow for better fishing and recreational boating conditions.

Both barrier reefs and fringing reefs offer forms of protection (Cooper et. al. 2008**).** The "Great Barrier Reef" itself is in fact not a continuous formation but a series of 2,900 coral reefs, of which 760 are fringing reefs.

(Department of Environment Heritage Water and the Arts website http://www.environment.gov.au/heritage/places/world/great-barrier-reef/information.html)

As noted below, no independent effort appears to have been made to value the GBR's protective function. However analysis of a combination of sources provides some indication of its significance:

- During tropical cyclone Aivu, which struck North Queensland in 1989, wave heights of 10 metres were reduced to 6 meters after passage over the GBR (Young and Hardy 1993).
- The GBR appears to have its greatest mainland protective function in areas such Cairns and to the north of Cairns, where wave energy is reduced due to the closeness of the reef to the coastline (Johnson and Marshall 2007, BOM 2007). During Tropical Cyclone Larry the highest recorded wave heights were recorded well to the south of the cyclone, where the GBR is much further offshore. Heights of 2.7 metres were recorded at Cairns as opposed to 5.3 metres at Townsville and 6.8 metres at Mackay (BOM 2007).
- Nonetheless, even in the central section of the GBR, where the reef is at it's "most porous", and well offshore, the reef still "considerably attenuates the passage of ocean swell wave energy" (Coastal Engineering Solutions 2007).
- Some evidence of the effects of the destruction of fringing reef protective effects can be found in places such as Heron Island. Blasting of a gap in the reef rim in 1945 to allow small boats access to the island resulted in long term erosion, threatening beaches and buildings. An extensive series of measures including construction of retaining walls and dredging over many years was required to deal with these effects (GBRMPA 1998).

Some attempts have been made to estimate the protective benefits of reefs around the world. These include:

- McKenzie et. al. (2006) who assessed the cost (PV) of coastal protection to deal with erosion arising from atoll mining at $US 235 million for 36.1 kilometres of shoreline over 25 years.
- A study of Belize's Barrier Reef, by Cooper et. al. (2008) indicating that the shoreline protection it offered was equal to an average value of $US 150 million per year.[43]
- Burke et al (2008) who estimated the avoided damages provided by coral reefs in Tobago at $US 18-35 million per annum.
- A value of $US 1.2-4.2 million per square kilometre of reef per year for reefs in Sri Lanka (Berg et. al. 1998). This study also estimates the cost of coastal protection measures in the place of reefs as in the range $US 236,000-836,000 per kilometre.
- Cesar (1996) estimated Indonesian coastal protection values as ranging from $US 820 to $1 million per kilometre of protected coastline depending on land use.

43 As Belize's barrier reef is the second longest in the world, one approach to valuation to the valuation of GBR shoreline protection functions would be to apply values from this study. The authors estimate that the reef protects 342 kilometres of Belize's mainland coast, with an additional 928 kilometres of offshore coast also protected - i.e. a total of 1,270 kilometres of coastline This implies a value of $US 118,000 per kilometre of coast per annum. However, a complex analysis of many factors such as shoreline stability, storm probability and local property values is used to arrive at these figures. These averages may also obscure the fact that the most valuable property appears to lie on the mainland. The methodology therefore does not allow for a direct application of such values to the GBR.

6.2. GBR valuation

No previous independent attempt appears to have been made to estimate the value of the GBR's shoreline protection functions.[44]

In addition, all of the values cited above relate to reefs which are far smaller in size than the GBR. The vastly greater size of the GBR in relation to the reefs investigated to date (combined with the evidence cited) imply that the reef's protective value is likely to be very large. However estimation is complicated by the fact that there is a need to consider local factors such as the rate of erosion, the distance of reefs from shorelines and regional geomorphology.

Cesar et al. (2003) estimated an annual coastal protection value of $US 629 million for all of Australia's 49,000 square kilometres of coral reef. If this value is scaled down to the GBR's 20,055 square kilometres of reef (GBRMPA 1998) and corrected for inflation and exchange rates at purchasing power parity (PPP) than a value of $438 million per annum is obtained. However, the basis for this valuation is unclear, with Cesar et. al. referring only to values from Hawaii, the US and Japan as the basis for the estimate.

A "damage cost" approach to a local valuation could be used. This would estimate the value of land on the coastline facing the GBR and determine the reef's role in preventing its erosion. This approach is similar to some of those described above. The land facing the GBR is used for a variety of purposes, including, agriculture, tourism and accommodation. Cattle grazing, sugar cane and wheat farming constitute the bulk of agricultural activity in the GBR "catchment area", as defined by GBRMPA (GBRMPA 2001). Rolfe et. al. (2005) estimated a gross margin for cane production of $250/ha (2005 dollars) for Douglas Shire while RIRDC (2001) estimated a gross margin of $49.50 (1998/99 figures and dollars) for cattle grazing land in central Queensland. Rolfe et al (2005) also provide estimates for unimproved waterfront land values in Port Douglas and other parts of Douglas Shire.

However such an approach would imply extensive knowledge about erosion rates both with and without the GBR, as well as a comprehensive investigation of land use along the entire affected coastline[45]. This limits its practicality.

Alternatively, a "replacement cost" approach may be attempted. This involves estimating the additional cost involved in preventing erosion (in the absence of the GBR). Recent studies of beach erosion at South Mission Beach, for example indicate that the construction of revetment walls to deal with the problem could cost $2,000 per metre in 2005 dollars, though the cost of such walls was $3,000 per metre (2005 dollars) at Holloways Beach in Cairns (Queensland Environmental Protection Agency 2005). Though this solution was rejected at South Mission Beach it could be applicable in other areas.

The costs of dealing with beach erosion through other means generally appear higher. For example, the *annual* operating cost (including depreciation) of new sand defences to deal with Noosa's long standing problem of beach erosion is estimated at $641,000 (Sunshine Coast Regional Council 2008) or $460,000 per

44 The works of Cesar et. al. (2003) and Blackwell (2005) draw on research from other locations or the work of Costanza et. al. (1997).

45 Berg el al. (1998) estimate that one square kilometre of reef prevents 2,000 square metres of land erosion per year given an erosion rate of 0.4 metres per year in Sri Lanka. However this applies to fringing reefs and its application to local GBR conditions is questionable.

kilometre given 1.4 kilometres of beach. The total cost of the Tweed Sand Bypass project on the NSW/QLD border as at June 2008 was some $76.8 million (NSW Parliament 2008) – which equates to some $4.2 million per kilometre per year, for 2 some kilometres of beachfront.

Given the uncertainties involved, the best approach is to make an effective assumption based on a "straight line" reef length of some 2,300 kilometres (Department of the Environment and Heritage 2006) and employing a "minimum cost" solution, using the South Mission beach figures updated to 2009 values (i.e. construction of an equivalent length of revetment walls at a rounded cost of $2,300 per metre). This equates to a capital cost of $5.3 billion. Assuming a life of some 25 years, and replacement at equal intervals over a century thereafter, this equates to a PV of roughly $10.0 billion. An estimate of $1 billion is derived for Cairns, based on the relative size of the Cairns/Cooktown Management Area within the GBRMP – i.e. 10% of total GBRMP area (Scottish Natural Heritage 2006).

This provides a minimum cost value of shoreline protection. It is likely that a detailed cost estimate would be considerably higher, given that a far greater length of coastline is protected then straight line reef kilometres and that more expensive systems of coastal defence would be required in many areas[46].

6.3. Bleaching and coastal protection functions

Estimation of the effects of coral bleaching on the GBR's coastal protection functions provides an additional set of complexities. Hoegh-Guldberg and Hoegh-Guldburg (2008) indicate that bleached corals would lose their physical structure, given that reef building corals would be unable to keep pace with rates of erosion. Reef systems would become a mix of fleshy seaweed and soft corals and gradually disintegrate.

This process may happen at rapid or slow rates, though Hoegh-Guldberg and Hoegh-Guldburg note that rapid rates of disintegration (i.e. 30-50 years) have been evident at some sites on the GBR. Sheppard et al. (2005) have also studied the relatively rapid disintegration of fringing reefs in the Seychelles following the 1998 bleaching event in the Indian Ocean. The result has been higher wave energy reaching the shore, apparently resulting in increased rates of coastal erosion.

However, Johnson and Marshall (2007) note that many fringing reefs in the GBR have persisted without significant accretion for millennia and still appear structurally robust. They also note that changing rates of carbonate production are difficult to predict and geomorphic responses are likely to be highly variable. In addition, near-shore turbid reefs may be more resilient to climate change impacts.

Information received from GBRMPA also points to the fact that a substantial limestone underlay exists in many sections of the reef. This could allow it to continue to act as a wave barrier in many areas even in the event of bleaching[47].

46 It is also possible to derive equivalent estimates based on the work of Cesar et. al. (2003) as cited above and Berg et. al. (1998). As indicated, Cesar et al.'s estimate appears to equate to $438 million per annum for the GBR. This implies an indirect use value of $15.3 billion in PV terms at a 2.65% discount rate over a century. After adjustment for inflation and US/AUD exchange rates (at purchasing power parity) the average of Berg et al.'s replacement cost estimate ($US 236,000 to $836,000 per kilometre) would equate to a present value of $4.9 billion using the same assumptions as adopted for the estimate used in the main text above (i.e. 25 year replacement cycle). So the estimate used in the current paper falls almost exactly mid-way between these two. However, despite the adjustments made to original figures it is likely that Berg et. al.'s costs would be understated within an Australian context, since the original estimates appear to reflect local labour and materials costs rather than those which would be incurred in the US or Australia.

47 Personal e-mail communication from GBRMPA 18/2/2009

Further, from a practical point of view, even the effects of a relatively rapid (i.e. 30-50 years) of reef destruction following bleaching would be considerably reduced by discounting.

Given these considerations it is likely that even a bleached GBR would retain a considerable part of its shore protection value for some time to come. While bleaching is likely to have a long term impact on the GBR, no assessment of the loss of shore protection functions of the GBR has therefore been made in this study.

7. Non use value – National

Key Points

- Australians who never visit the GBR may nonetheless value it, for its potential uses (be they the option to visit in the future or future benefits such as bio-medicines).
- They may also value the existence of the GBR per se and/or the fact that it should be preserved for future generations.
- These constitute "non-use" values (Queensland Government 2003).
- Past research suggests that Australian non-use values may be some $15.2 billion for the GBR as a whole, with a value of $1.6 billion estimated for the Cairns region.
- Though care should be exercised when estimating non-use values, these figures may prove conservative and future research could offer more precise measures.
- A total and permanent bleaching of the reef would devastate the corals and surrounding ecosystems. Essentially then, these non-use values would effectively be lost in such an event.

As previously indicated, non-use value incorporate existence, bequest and option values. When Australians express concerns about the future of the GBR (as many have in the wake of the Garnaut Report and previous publications) they are generally reflecting some or all of these values.

Path breaking work on non-use values for the GBR was undertaken by Hundloe et. al. (1987) with supplementary analysis by Driml (1994). This indicated a total non-use value of $62.3 million for the GBR in 1986 dollars. This value was based on several components. One was an Australia-wide mail survey asking what respondents would be willing to pay as an entry fee to fund reef management and what they would be willing to pay *in addition* to research and control the Crown of Thorns Starfish (COTS). A separate study asked actual GBR tourists what they would be willing to pay in entry fees. (No entry fees applied at this time).

An extrapolation was then made to the Australian adult population. The resulting amount ($62.3 million in 1986 dollars) effectively captured national option, existence and bequest values. Adjusting for inflation (and for the increase in the number of Australians aged 15 and over from ABS (2008c)) this equates to an annual value for GBR preservation of $194 million in 2009 terms. As the Cairns/Cooktown Management Area accounts for 10.4% of the total area of the GBRMP, a notional value of $20 million can be attributed to Cairns.[48]

48 One caution is that WTP may not be linear, with smaller areas not necessarily being directly proportional to the size of larger ones. For example some survey respondents may provide the same non-use value for a group of lakes as they do for one lake. This may be less of a problem in "scaling down" to smaller areas, however. The main concern arises when small area estimates are scaled up to very large ones.

Hundloe et. al.'s figures are often cited in national and international sources on the valuation of coral reefs (Driml, 1994, Hassall and Associates 2001, Cesar and Chong 2005, Spurgeon et al 2004) though the need for a population growth adjustment is typically overlooked. However, given the passage of time, it would be preferable to compare these with later valuations.

More recently, 1,003 residents of Brisbane, Sydney, Canberra, Melbourne and the regions adjacent to the GBRWHA were surveyed as to their perceptions of the reef area (Green et al. 1999). While 40% of respondents had never been the GBR, 77% felt it should be protected due the fact it was a unique Australian natural resource, as opposed to protection due to "use values" such as recreational or economic benefits (respondents could only choose one category).

Though respondents were not questioned about their willingness to pay for protection, this might be seen as additional evidence for the existence of an intrinsic WTP for non-use values, such as existence, option and bequest value.[49] It is also notable that bleaching was not identified as a threat in the questionnaire, though respondents were asked about concerns over other problems (Crown of Thorns, pollution etc.).

Table 7-1 Previous GBR visits by residence of respondent

Reef Experience	Reef region (%)	Brisbane (%)	Sydney (%)	Canberra (%)	Melbourne (%)	Total (%)
Never Been	16	31	48	46	61	40
Been once or more	84	69	52	54	39	60

Source: Green et al (1999)

NB: "The Great Barrier Reef" was defined as including the Reef area, its islands and surrounding waters

Table 7-2 Why should the Great Barrier Reef be protected, by residence of respondent

Reason for protection	Reef region (%)	Brisbane (%)	Sydney (%)	Canberra (%)	Melbourne (%)	Total (%)
Unique Australian environment	69	82	83	68	82	77
Important economic resource	15	7	5	18	10	11
Good setting for leisure and recreation	13	10	8	13	6	10
None, as I am not concerned	1	1	2	1	1	1
Don't know	2	-	2	1	1	1

Source: Green et al (1999)

NB: "The Great Barrier Reef" was defined as including the Reef area, its islands and surrounding waters

John Rolfe of Central Queensland University is currently undertaking valuation work which seeks to measure Queenslander's non-use valuations for the GBR as a whole, its component sections (including the Cairns region) and various attributes (corals, sea grass etc.).

49 These results also raise the issue of whether geographical distance from the GBR matters to respondents. This issue is further discussed in Appendix 5.

Unfortunately Rolfe's work is not yet available for analysis (though it is anticipated that it will be released in the near future). However earlier work by Windle and Rolfe (2005) also effectively examined Queenslander's non-use values for a section of the GBR lagoon. This asked Brisbane households how much they would be willing to pay for changes to the water quality of the Fitzroy estuary which is connected to (and has a direct impact on) the GBR lagoon. Potential improvements in water quality were linked to the health of the GBR, with respondents being told:

> *"If larger impacts on water quality and quantity occur, they may affect estuarine areas, fish stocks and part of the Great Barrier Reef"*[50]

Windle and Rolfe estimated that Brisbane households valued a 1% improvement in the environmental health of the Fitzroy estuary at an average of $3.21 per household per year (in 2003 dollars). This work has been used in conjunction with Hundloe et. al.'s past results to develop a value for the GBR on a national basis. The details of how this valuation was arrived at are contained in Appendix 5.

Using an approach combining Hundloe et. al.'s and Windle and Rolfe's findings, assessed national non-use values are equivalent in PV terms to $15.2 billion for the GBR as a whole, with a value of $1.6 billion estimated for the Cairns region.[51]

A total and permanent bleaching of the reef would devastate the corals and surrounding ecosystems and it is assumed that these non-use values would effectively be lost in such an event

It should be stressed that this PV represents the streaming of annual values per household *over 100 years* (as opposed to the 20 years worth of payments assumed by Rolfe and Windle) though discounting reduces the impact of the payments in the longer term to some extent.

The GBR-wide value is equivalent to roughly $25.69 per annum for every adult Australian, over 15 (or $57.40 per annum per occupied Australian household)[52].

These annual household WTP values may be seen as relatively conservative when compared with other past Australian non-use valuations for the natural environment. For example:

- Jakobsson and Dragun (2001) found that the conservation value (to Victorians) of Victoria's Leadbeater's possum was a minimum of $29 per household per year (1996 dollars) or $40 in current terms[53].

50 Personal communication with John Rolfe 6/10/08

51 The value for the Cairns region is based on the fact that the Cairns/Cooktown Management area accounts for some 10.4% of the total GBRMP area.

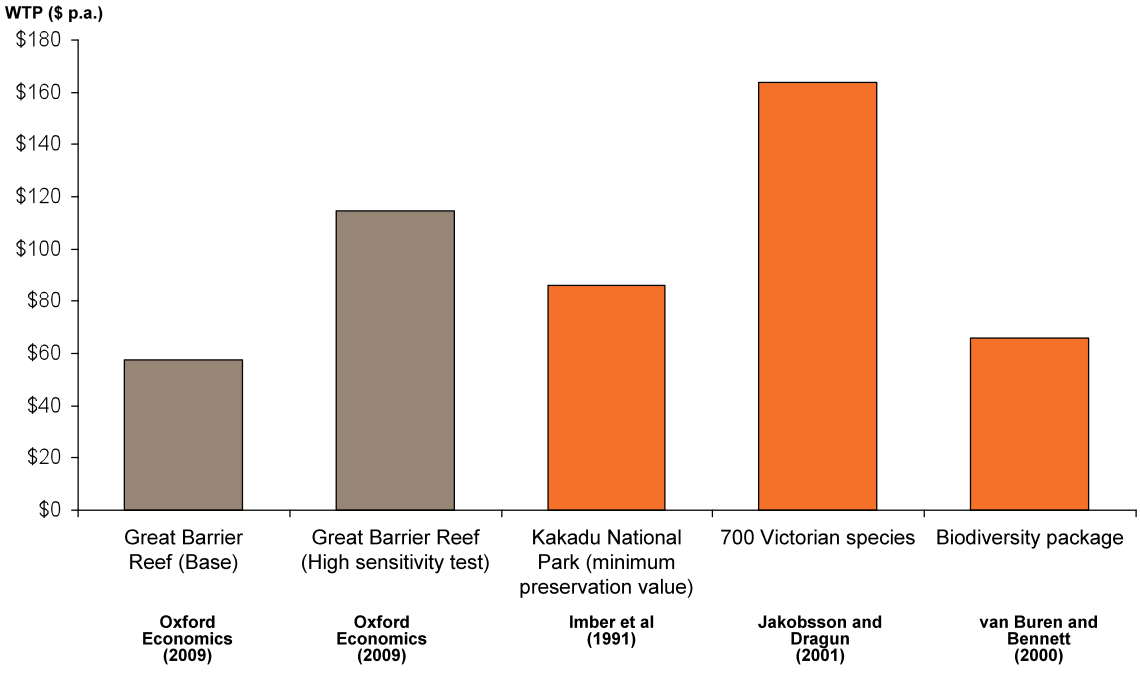
52 Occupied households measured according to 2006 Census results in ABS (2007b). Adult population over 15 in 2008 as estimated in ABS 2008c.

53 Unlike the case for Rolfe and Windle (2005) Jakobsson and Dragun did not adjust their mean sample WTP for response rates when "grossing up" to derive aggregate household population values. The authors argued that this was too conservative an approach. Cases where a distinction is made between sample household (or individual) WTP and overall state/national household (or individual) WTP are noted below. Note that in the case of the derived GBR non-use value a composite approach has effectively been adopted. That is, Hundloe's original work grossed up sample WTP values by population without adjustment for survey response rates while Rolfe's adjusted for sample response rates. These respective approaches were adopted in the updates for the relevant values, as explained above.

- Imber et.al. (1991) found a median Australian willingness to pay of $52.80 – $123.80 in 1990 dollars ($86-$201 in 2009 terms) per household per annum for 10 years to avoid the impacts of mining in Kakadu National Park.[54]
- More recently Bennett et al. (2007) found that a sample of Melbourne households were willing to pay $ 0.65 per annum (over 20 years) for an extra 1,000 hectares of East Gippsland old growth forest. They also derived sample values for East Gippsland rainforest ($11.16 per annum for an extra 1,000 hectares). However these authors suggested that the values should be adjusted by the survey response rate of 50% (i.e. halved) when assessing aggregate population figures.
- On a broader scale, Jakobsson and Dragun (2001) also found a WTP of $118 per household per year in 1996 values (or $164 in 2009 values) among Victorians to preserve all 700 endangered Victorian flora and fauna species.
- Van Buren and Bennett's (2000) Australia-wide survey for the CSIRO's *National Land and Water Resources Audit* (2002) found a *sample* WTP of $112 per household per annum (2000 dollars) over 20 years for a generic "biodiversity protection scenario" – equivalent to $50 once adjusted for a sample aggregation factor ($66 in 2009 terms). This included protection of 100 endangered species, an additional one million hectares of improved landscape ascetics (farmland repaired from erosion or bushland protected) and an additional 200 kilometres of waterways restored for fishing and swimming.

Chart 7-1 compares some household WTP per annum values from the larger scale studies with the derived annual values for the non-use value of the GBR, as well as the "high end" sensitivity test referred to in Appendix 1. (However, note the caveats on non-use value which follow below)

Chart 7-1 Comparison of annual household WTP - non-use values



54 The Imber et. al. survey was the subject of much controversy, however as noted by Driml (1994), the lower of these values can be interpreted as a minimum preservation value for Kakadu as a whole, even if many of the criticisms are accepted.

Given that they examine values for protecting mass ecosystems, broad-based valuations (e.g. Jakobsson and Dragun, van Buren and Bennett) may be seen as more comparable to a valuation involving a large scale highly complex ecosystem, such as the GBR. However, as indicated in Appendix 5, these broader scale valuations also point to the need to consider factors such as "framing" or "embedding" effects and "cause dumping". This suggests caution both in comparing the results of past studies with GBR valuations (particularly small scale studies) and in considering the assessed WTP for GBR preservation itself. Further the present value estimation used in this study assumes that payments will continue over the next century, by current and future generations, rather than 10 or 20 years, as in some of the studies highlighted above.

While taking these important caveats into account, the above methodology may still represent a conservative approach to national non-use valuation. The increased attention given to the GBR in recent years in the context of climate change and other threats and the general growth in environmental consciousness since surveys such as Hundloe et. al.'s (as well as the fact that bleaching constitutes an even greater long term threat than COTS) makes it likely that the GBR non-use values derived above are understated.

Arguably, a desire to prevent a permanent mass bleaching of the GBR could be seen as comparable in some ways to the large scale national ecosystem preservation values estimated by van Buren and Bennett (2000) above. Nonetheless, it is difficult to be certain of this, until additional non-use work (specifically focussed on the GBR and national in scope) is undertaken[55].

Sensitivity tests in Appendix 1 seek to examine the impact of both higher (and lower) non-use values on the results in this study.

55 As indicated, work along these lines is currently being conducted by John Rolfe of Central Queensland University, however this work is focussed on Queensland. Ideally a national non-use study would be undertaken to provide national valuations.

8. Non Use Value – International

Key Points

- The GBR is a World Heritage listed area and a global resource. As such, people around the world would also hold non-use values for it.
- The existence of international efforts to preserve natural ecosystems around the world provides *a priori* evidence that the international non-use value of the GBR must be some amount greater than zero.
- Studies of international existence value are rare, While some researchers have attempted to measure this for reefs, these studies are incomplete, restricted by national contexts and/or may suffer from scale issues relative to the GBR.
- Somewhat better data exists for rainforest valuations. Rainforests present ecosystems of similar complexity to reefs. If the GBR is valued similarly to past valuations of rainforests then a present value of $1.9 billion may be inferred for the GBR and $195 million for the Cairns area. While likely to be a conservative valuation this figure should also be viewed with strong caveats, as it does not reflect a direct opinion on reef preservation.
- A total and permanent bleaching of the reef would devastate the corals and surrounding ecosystems. Essentially then, these non-use values would be effectively lost in such an event.

As indicated, efforts to determine national non-use values face a variety of hurdles. An even more challenging set of issues confronts the analyst wishing to determine international non-use values for ecosystems such as the GBR. Few analyses have attempted to tackle this issue – and some studies of overseas reef values have explicitly indicated that such values are excluded.

Nonetheless, past authors (Hundloe et.al.1987, Driml 1994) have stressed the need to develop an international existence value for the GBR. To neglect to do so implies that the rest of the world places no value on the GBR (or by extension, many other significant natural ecosystems).

The years since these calls have seen a growing awareness of the need to protect the global environment, allied to increasing concerns over the international effects of global warming and its impact, both on local ecosystems and on those across the world. There is increasing recognition that ecosystems are a global concern and that their protection should be globally financed. Analysts such as Costanza et al. (1997) have even attempted to derive a value for the world's entire stock of ecosystem services.

A positive global willingness to pay for ecosystem services can be deduced from the various international initiatives which have evolved to prevent habitat destruction. A few of these include[56]:

- Payments for Environmental Services (PES)
- Conservation Concessions

56 See Pagiola et. al. (2004), OECD (2004) and Landell-Mills and Porras (2002) for a more detailed description of some of these.

- Debt for nature swaps
- Tied aid to developing nations and international transfers which may also be considered a form of PES (e.g. Global Environmental Facility)
- Other payments for specific ecosystems by a variety of NGOs and charitable organisations
- The development of Protected Areas for coral reefs and other global ecosystems, with visitor fees sometimes charged for park maintenance

The European Commission (2008) suggests that $US 8-10 billion is spent annually on such conservation initiatives.[57] On *a priori* grounds there must therefore be a positive global WTP for preserving the GBR as a part of the global ecosystem (i.e. as a "global public good").

Attempts to derive global WTP for specific ecosystems have, to date, largely focussed on rainforests.[58] Notable efforts include:

- Kramer and Mercer (1997) who asked US residents how much they would be willing to pay as a one time contribution to preserve 5% of the rest of the world's rainforests, bearing in mind their budget constraints. They found that they US residents were willing to pay $US 21-31 per household, implying a nation-wide WTP of $US 1.9-2.8 billion.
- Pearce (2007) reviewed a wide variety of studies, including Kramer and Mercer's. He estimated that their findings equated to a US WTP of $US 4/ha/pa and $US 25 per ha/year if estimated as an annualised fund and extended to the developed world's 580 million households.
- A global WTP for tropical rainforests of some $US 20/ha/pa may be derived from Strassburg (2008) after adding his sub-components of option, existence and bequest value.
- Baranzini et. al. (2008) who estimate a Swiss WTP to avoid tropical rainforest deforestation of CHF 95 per person per year.
- A World Bank-led study edited by Debroux et. al. (2007) uses the value of foreign aid for nature conservation to the Democratic Republic of the Congo ($US 18 million per year) as an estimate of the combined option, existence and bequest value of the DRC's forests.

There are also a number of studies which question reef users around the world regarding their WTP a management fee for reef preservation and management (Spash et. al. 1998, Nam and Son, 2005, Seenprachawong, 2005, Cesar and Chong, 2005). These generally find a value of between $US1- 8 per visitor, though some studies generate considerably higher values[59]. However, while these might incorporate some elements of option and bequest value, they are not global non-use values in the strict sense – the visitors generally have experienced, or were about to experience, the marine parks. So their values cannot be inferred to the general population of their home nations. Further, there is no element of abstract existence value.

57 Note that this is an actual rather than a WTP figure. Arguably, global WTP would be much larger.

58 One caution when reviewing such studies is that respondents may be increasingly aware of forest usage as carbon sinks. This has a present as well as a future use to distant populations – therefore, arguably, some elements of use value are captured in these figures. Another issue is that coral reefs do not have the same sink function as tropical rainforests.

59 For example Cesar and Chong (2005) refer to the work of Wright (1994) who finds a visitor WTP of $US 31 per person per year to preserve a Jamaican reef in its current condition.

Some recent work on coral reef existence values includes:

- Fonseca and Noonan (2008) who estimated a WTP of some $US 13.90/household in Atlanta as a one-off payment for the preservation of a small area of Fijian coral reef (with respondents reminded of competing budgetary priorities).[60]
- Alder et al (2006) who estimated existence, bequest, option and indirect values for US coral reefs as a marine habitat (only) to be $US 1,211 per square kilometre per annum using WTP increased prices for seafood.
- Cesar and Chong (2005) cite a biodiversity value of $US 10,000 per square kilometre per annum for two Indonesian marine parks, based on foreign funding.
- Likewise, Subade (2007) used Global Environmental Fund (GEF) payments between 2000-2004 to estimate an implied global willingness to pay of $US 18.75 per hectare per year for the Tubbataha Reefs World Heritage site in the Philippines[61].
- De Groot (1992) estimated an option value of coral reefs of $US 120/ha/pa though this is effectively the equivalent of an estimated total productive value for reefs.
- Ruitenbeek and Cartier (1999) undertook a detailed comparison of rainforest and reef pharmaceutical values with a focus on developing a value for coral reef pharmaceutical bio-prospecting. They estimated a global (PV) value of $US 70 million (1998 dollars) for the coral reefs of Montego Bay, Jamaica. Marine bio-prospecting values were found to be higher than for terrestrial ecosystems, mainly due to higher demonstrated success rates.

In relation to the final point (the bio-prospecting analysis of Ruitenbeek and Cartier) it should be noted that the size of the area of reef cover examined in Montego Bay (18.34 ha) is only a small fraction of the area of reef cover for the GBR. This implies that the global GBR option value (alone) may be very large. Recent research on the GBR has uncovered the existence of 500 new types of marine sponges. Marine sponges have been used in the past for developing drugs such as AZT, which has been employed as a treatment for HIV-AIDS. Sponge extracts may also be useful in the treatment of heart disease and in the treatment of gastro-intestinal diseases and cancers (*Courier Mail*, December 1, 2007).

It is tempting to use the coral-reef specific values developed by analysts such as Fonseca and Noonan and apply them to the GBR through a form of benefit transfer. However, Fonseca and Noonan's survey focussed on a relatively small area of fringing reef. Responses to surveys these may suffer from scale effects when imposed on much larger ecosystems.[62] Likewise, Alder et. al.'s values technically apply only to coral reefs in US territory, though many Americans would be remote from such locations, raising the question of whether WTP for international reefs would be much different. Analysts such as Rolfe et al (2000) have shown that while Queenslanders themselves attached higher values to local rainforests, they nonetheless attach significant ones to international rainforest preservation in various parts of the world.

60 The area involved was 4 miles or 10 miles or reef depending on the questionnaire received by respondents. Note that respondents were allowed to indicate how sure they were of their willingness to pay. If only the "very sure" sub-group were taken into account the mean WTP falls to $US 1.47 per household.

61 As indicated above however, such values represent actual payments rather than WTP. An additional complication, evident in this case, is that funding for specific reefs may only be for a set period of time (though funds may effectively be shifted to other reef systems). This complicates efforts to assess payments in the long run.

62 Fonseca tested for such scale effects for two different sizes of Fijian reefs, however the much larger scale differential between these estimates and the GBR makes it difficult to apply results directly.

Given their frequently cited similarity to tropical rainforests in their ecological diversity (Spalding et al 2001; Bryant et. al., Knowlton 2001, European Commission 2008, Ruitenbeek and Cartier 1999, Scott Wilson (2008)) and various potential option values such as possible medicinal treatments (Ruitenbeek and Cartier 1999, Bryant et. al. 1998, Queensland Government 2003, Moberg and Folke 1999) the most practical approach is to adopt a form of benefit transfer. This approach applies Pearce's estimate for global WTP for rainforest preservation by inferring a similar WTP for coral reefs such as the GBR, noting that Strassburg developed similar values.[63]

This represents the most conservative approach to applying values based on several possible other options (Fonseca and Noonan, Alder et al, De Groot, Ruitenbeek and Cartier). However, benefit transfer techniques generally involve applying values developed for one population's valuation of a natural resource to another, similar, population. In this case, a value is applied over the same population (if Pearce's global estimate is accepted) to another resource (albeit similar in the complexity of its biodiversity) and as such must be the subject of strong caveats (though see the discussion of materiality below).

Pearce's estimated value of $US 25/ha/pa was adjusted to 2009 Australian dollars, allowing for inflation and differing discount rates. This implies a global WTP of $27/ha/pa for GBR preservation. The GBRMP covers some 344,400 square kilometres (Department of the Environment and Heritage 2006). However, although this area coves a complex and interactive ecosystem, it is likely that people would focus on valuing the perceived area of coral reef cover, and it is this area which is directly relevant to issues of bleaching. The area occupied by coral reefs within the entire GBRMP has been estimated at 20,055 square kilometres or some 2.0 million ha (GBRMPA 1998).

These estimates imply a figure of $53.6 million p.a. for global WTP for the entire GBR. Allowing for 572 million households in the developed world, excluding Australia, (Pearce 2007) this equates to some $0.09 per household per annum **(i.e. 9 cents per year).** Given the *a priori* evidence that global WTP for complex ecosystems such as the GBR is not zero, this seems a modest estimate, (which would also accommodate these household's WTP for other local and global ecosystems).

In PV terms this value equates to $1.9 billion for the GBR and $195 million for the Cairns area, if an allocation of value is made consistent with the proportion of the GBRMP taken up by the Cairns/Cooktown Management Area.[64] As the total and permanent bleaching of the GBR would effectively destroy the current ecosystem, it is assumed that these values equally represent the value of a loss from such an event (although this in itself maybe an underestimate given that compensation for losses is likely to exceed WTP for preservation).

63 There are obviously some differences between the two ecosystems, including the fact that, as noted, rainforests may act as carbon sinks, whereas this would not appear to be the case for coral reefs over human lifespans (Moberg and Folke 1999). Nonetheless, though understanding of this fact is increasing, survey respondents may not necessarily be aware of it. It is also the case that reefs grow more slowly than rainforests, though, again, this is unlikely to be known to many survey respondents. Slow growth could also be interpreted as indicative of higher values – as it may emphasise the need for preservation.

64 A second caveat is that, as noted, WTP may not be linear, with smaller areas not necessarily being directly proportional to the size of larger ones. For example, some survey respondents may provide the same value for a group of lakes as they do for one lake. This may be less of a problem in "scaling down" however, if only because it is likely to imply that if anything the smaller estimates may be conservative.

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Appendix 1: Sensitivity Tests

Discount rate sensitivity tests

Discount rates are often a key source of debate among economists. A discount rate of 2.65% was assumed for this report, based on the higher of the two rates used in the Garnaut Report. Values were estimated on a PV basis over 100 years. As a sensitivity test, a variety of other real discount rates have also been applied, that is:

- 1.35%, the lower discount rate used by the Garnaut Report,
- 4%, a rate previously used by the World Bank (Asafu-Adjaye et.al.); and
- 6%, the value used by Queensland Treasury in the past for project evaluation (Asafu-Adjaye et.al.).

The results of these sensitivity tests are reported in the table below. This indicates that losses from bleaching in the Cairns area and for the GBR as a whole remain very substantial even under higher discount rates.

Table A 1–1 Present Value of GBR and of bleaching – discount rate tests

Discount Rate	Present Value of Reef ($ billion)		Present Value of Bleaching costs ($ billion)	
	GBR - Total	Cairns Area	GBR - Total	Cairns Area
1.35%	78.4	27.7	59.0	25.5
2.65%	**51.4**	**17.9**	**37.7**	**16.3**
4.0%	37.0	12.6	26.4	11.4
6.0%	26.2	8.7	17.9	7.8

Source: Oxford Economics

Sensitivity tests were also carried out in order to model a number of other scenarios. These are detailed below. Note that these are confined to estimating the cost of bleaching rather than the present value of the GBR.

Other sensitivity tests – description

Higher and lower tourism and producer surplus loss values

As indicated elsewhere in this report, it is estimated that 50% of domestic overnight and international tourists to coral sites would not have made their trip if permanent mass bleaching were to occur. (The corresponding value for domestic day trips is 100%, though this is not materially significant in the present analysis.)

Arguments may be made for the reef to act as either a stronger or weaker motivational factor in trip decision making. By extension, this implies higher and lower values for the cost of reef bleaching. The scenarios below explore the effect of assuming that only 30% or domestic overnight and international visitors are deterred from making their trips due to mass bleating of the GBR or, alternatively, 70% are.

These scenarios are explored separately and as “offsets” to the other variable which has a major impact on bleaching costs, national non-use values.

Higher and lower national non-use values

As indicated, in the main text and in Appendix 5 below, there is considerable debate about the magnitude of non-use values, although there is little doubt of their existence. Given that Hundloe et. al.'s work is widely cited internationally, this test explores the effect of utilising the updated Hundloe et al. values in isolation as a measure of the non-use values for the reef. This equates to a reduction of some 55% in national non-use values.

Alternatively, a much higher value for the GBR could be asserted. Given its status as an Australian icon, and growing environmental awareness, arguments may be made for higher non-use values. Perhaps the best rough comparator is the work of van Buren and Bennett (2000) as described above and in Appendix 5, which looks at national values for mass ecosystem protection, though great care must be taken in making such comparisons, as discussed in Appendix 5.

Accordingly, a doubling of non-use values (i.e. 100% increase) is modelled. This results in a per household value of $114.79 per annum, with an assumption that these payments will continue to be made over the course of a century[65].

As is the case for tourism and producer surplus loss values, these scenarios are explored separately and as "offsets" to the other variable which has a major impact on bleaching costs, national non-use values

Higher and lower commercial fisheries loss values

The current analysis assumes a loss value in the order of 30% of the estimated current producer surplus. Nonetheless, the effects of bleaching on fisheries are still unclear and arguments could be made for higher or lower values. The sensitivity tests explore the impact of a 10% loss in fisheries and of a 50% loss. Note that the relatively modest size of the commercial fishing producer surplus values limits the material effects of such changes.

Forecast scenarios

An alternative to the approach adopted in the main body of this report is the use of forecasts to estimate outcomes. As indicated in the main text, Australian and global populations and incomes are set to rise substantially in the next century. *A prioiri* this suggests that the approach taken in the main body of the report is conservative, as such rises are not accounted for. Against this is the fact that bleaching is assumed to be immediate, which limits the discounting of future costs.

65 The van Buren and Bennett (2000) work found a "raw" *sample* WTP of $112 per household per annum (2000 dollars) over 20 years for a generic "biodiversity protection scenario". This included protection of 100 endangered species, an additional one million hectares of improved landscape ascetics (farmland repaired from erosion or bushland protected) and an additional 200 kilometres of waterways restored for fishing and swimming.

Once adjusted for a sample aggregation factor (ie allowing for a proportion of households who did not respond to their questionnaire in assessing national household population values) and inflation, van Buren and Bennett's estimates equate to some $66 per household per annum in 2009 dollars. This is higher than the base estimate for the GBR ($57.40 per household) but lower than the "high-end" sensitivity test above, as indicated in the charts in Section 7 and Appendix 5. It should also be noted that van Buren and Bennett assume payments continue for only 20 years, as opposed to the 100 years assumed in this study. The many caveats discussed in Appendix 5 should also be taken into account when considering higher end non-use values (such as whether respondents would be willing to pay for other ecosystems in addition to those they are being questioned about or whether they are "cause dumping" and the related influence of embedding effects even on large scale evaluations.)

In practice, many environmental valuations which adopt elements of a TEV (such as the use of travel cost modelling) estimate a "perpetuity value" based on the discounted projection of current values in real terms. This is the approach taken by Carr and Mendelsohn's (2003) travel cost valuation of the Great Barrier Reef (GBR), Mules et al's (2005) assessment of the value of the Australian Alps and Gillespie's (1997) valuation of Minnamurra Rainforest Centre (though the latter study also identified the issue of changing incomes and populations). Likewise Cesar et al.'s (2003) valuation of the effects of global coral reef bleaching, assessed over a 50 year period appears to make no allowance for population and income changes.

In effect, none of these past studies allows for growth in tourism or real incomes. In this, the current study is consistent with these, though unlike most of these past analyses, it does acknowledge the existence of these issues.

Nonetheless, the use of forecasting can be explored. If such a route is taken the following must be noted:

- Tourism and non-use values are the main drivers of values (or equally bleaching costs) in this study
- The effects of growth in population and real GDP are often cited as *a priori* drivers of tourism
- Likewise, non-use values might also be affected by rising incomes and populations
- If a forecast approach is taken, allowance must be made for the fact that bleaching costs are not immediate but will "ramp up" over time.

A key question is: how will such population and real income rises affect the value of the GBR and thereby the costs of bleaching?

First consider visitation growth. A key issue is, of course, the uncertainties of forecasting which will grow over time, particularly given a forecast period of a century. Unfortunately, forecasts of many socio-economic variables (such as GDP and population) are notoriously problematic, and become even more difficult when considering tourism within a given region, over the course of a century. The magnitude of potential error grows as time passes.

This is particularly so given the ways in which tourism markets tend to develop. Growth in populations and income do not necessarily mean continual growth in visitation to given regions. Butler's (1980) Tourism Area Life Cycle (TALC) recognises this. In essence, the TALC resembles a sideways "S" – slow initial growth followed by rapid acceleration, maturity and possible decline.

In short, while acknowledging population (and income) trends both (within Australia and overseas), this acts as a caveat on expectations of continual growth in visitation to areas such as the GBR over the course of a century. Markets mature. Tastes, costs and the appeal of alternative destinations may all change over time. This applies to the GBR as much as to any other tourist destination[66].

66 Berry (2001) examined such issues in the context of visitation to Cairns. He suggested that by the late 1990's, visitation to Cairns had reached a level consistent with that of a mature tourism market and that further efforts at "rejuvenation" would be required to avoid long term decline in the face of competing tourism destinations. Of course some of this competition might come from resorts elsewhere in the GBR region itself, however the essential issue is that growth cannot be assumed indefinitely.

The changing fortunes of regional tourism in Australia also highlight this. For example, the Blue Mountains, west of Sydney, has had fluctuating fortunes over the course of a century, experiencing high popularity, long periods of decline and subsequent rejuvenation (RTA 2006). Likewise, recent visitation figures for Byron Bay indicate a 20% decline since 2003 (*Daily Telegraph* 10/8/2008).

There may be some signs of this in recent tourism data. Though caution must be exercised, given fluctuations in yearly visitation, Tourism Australia data for the Tropical North Queensland Tourism Region (covering all forms of visitation) gathered for this report suggest compound annual growth rates for international tourism of 1.1% between 1999 and 2007 or 1.4% on a 2-year moving average basis. The equivalent figures for domestic visitation are 1.9% and 1.8%. However these data cover all forms of visitation (holidays, visiting friends and business and other) making it difficult to determine growth in reef-focussed visitation[67].

Perhaps more directly useful are "GBRMPA figures" for visitation, as referred to elsewhere in this report and recorded at http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/management/gbr_visitation/numbers These figures record people on tours within the GBRMP. While the complexities in interpreting these figures have been noted in this report, analysis of visitation between 1994 and 2008 indicates a compound annual growth rate of 1.6%, with the same figure derived on a 2-year moving average basis.

This seems consistent with the domestic and international visitation figures cited above. However, there has been little growth in these figures since 2002, with declines being recorded in some years. A compound annual growth rate of 0.4% can be derived for a 2-year moving average for the years 2002-03 to 2007-08 (inclusive). The recent flattening of growth may simply be a temporary phenomenon. Alternatively, it may point the way to slower growth in GBR tourism in the future.

Secondly, there is the issue of allowing for the fact that people will value environmental goods and services more as time passes through real terms increases in their non-use WTP values. As indicated above, past environmental valuations do not tend to allow for rising incomes or populations and there is sparse discussion of the issue in the literature[68]. Using a meta-analysis, focussed on biodiversity existence values, Jacobson and Hanley (2008) find an income elasticity of WTP for biodiversity conservation of 0.38. However this result is cross-sectional rather than longitudinal. Likewise, Horowitz (2002) reviews past studies suggesting an income elasticity of WTP for environmental goods of 0.2 to 0.3, however he also notes that there is no strong evidence for valuations over time.

With these caveats in mind the following approach was adopted to developing forecast scenarios for the cost of GBR bleaching.

- As indicated, recent compound annual growth in GBR tourism may range from 0.4% p.a. to 1.9% p.a, depending on the period and sub-set of tourists used. While based on the recent flattening of tourism demand, the "lower end" of these estimates may be preferable, especially over longer time frames such as a century.
- Australian Treasury (2008) modelling associated with the Garnaut report suggests compound annual global GDP per capita growth of 2.4% p.a. for the period 2005-2100 and compound annual population growth of 0.4% p.a. over the same period. The equivalent results for Australia are 1.4% and 0.9% respectively.

67 Tourism Australia (2008c) indicates that 29% of domestic tourism nights and 24% of international tourism nights in Tropical North Queensland are for non-holiday purposes.

68 Scheufele and Bennett (2008) at the ANU's Crawford Centre are currently undertaking a research project on potential changes of environmental values over time. However this project has only recently been initiated.

- Applying an income elasticity of 0.3 (the mean of the cross-sectional values suggested by Jacobson and Hanley and Horowitz, above) implies a rough compound annual global growth in WTP for environmental goods and services of 1.2% and 1.3% in the case of Australia.
- Allowing for roughly equal shares of tourism and non-use values in the total valuation, a crude "low end" estimate is therefore to allow for 0.8% compound growth in GBR values (and so in bleaching costs) per annum. However higher rates of 1.2% and 1.6% are also examined below[69]. These would reflect stronger long term tourism growth and/or population and income growth.
- Discounting can be applied on the basis that reef bleaching is effectively total and permanent by mid-century, as suggested by Garnaut (2008) and Hoegh-Guldberg (2007). A 40 year "ramp up" period is therefore assumed with a constant increase in bleaching costs starting in 2009[70]. Of course a variety of other costing scenarios are possible. For example a compound growth rate could be used or reef bleaching could be assumed to occur after major tipping points. However uncertainty over when these are limits the practicality of this approach.

Other sensitivity tests – approach

The results of the sensitivity tests described above are displayed below. Discount rate sensitivity tests are also displayed for purposes of comparison.

69 That is, taking a "low end" perspective, the average of a 0.4% compound growth rate in tourism and a 1.2% growth rate in WTP for environmental goods and services is 0.8%. Likewise, a "high side" rate of 1.6% can be derived with 1.2% being the mid-point. It is acknowledged that this process is crude, however the measures are intended to give a reasoned and indicative approach to growth over time.

70 For example in the 0.8% growth scenario, a 0.8% compound annual growth rate is applied to bleaching costs of $1.08 billion in 2009. This produces notional bleaching costs of $1.47 billion by 2048. However since bleaching does not occur immediately, actual bleaching costs must be ramped up to equate to $1.47 billion in 2048. This is done by assuming a constant increase of $36.8 million in bleaching costs per annum until 2048. After this point, bleaching costs are assumed to increase at 0.8% per annum.

Table A 1–2 Present Value of GBR bleaching loss – additional sensitivity tests

Sensitivity Test	Present value of loss at 2.65% discount rate ($ billion)	
	GBR - Total	Cairns Area
Base value	**37.7**	**16.3**
30% tourism loss	29.7	10.6
70% tourism loss	45.7	22.1
Hundloe non-use values (55% less)	29.3	15.5
Double base non-use values (100% higher)	53.0	17.9
30% tourism loss and double non-use values	44.9	12.2
70% tourism loss and Hundloe non-use values	37.3	21.2
10% commercial fisheries loss	37.4	16.3
50% commercial fisheries loss	38.0	16.4
0.8% compound annual growth in bleaching costs	34.1	14.8
1.2% compound annual growth in bleaching costs	42.1	18.2
1.6% compound annual growth in bleaching costs	52.3	22.6
1.35% discount rate	59.0	25.5
4.0% discount rate	26.4	11.4
6.0% discount rate	17.9	7.8

Source: Oxford Economics

Appendix 2: Past economic evaluations of the Great Barrier Reef

A brief summary of past studies is offered in below. Note that none of these focus on the Cairns area *per se,* while only Hoegh-Guldberg and Hoegh-Guldberg (2004) and a short section in Access Economics (2007) address the specific cost of bleaching:

- *Kragt et al (2009)* – This study provides some valuable insights into the response of divers and snorkelers to coral bleaching on GBR coral sites, including an estimate that the number of annual visits would fall by 80% in the event of a "reef quality decline" (i.e. 80% decrease in coral cover, 70% decrease in fish diversity) due to bleaching .However the survey is limited to a sample of 176 Port Douglas snorkelers and divers, excluding other visitor types (e.g. glass bottom boat visitors) in other locations. In addition, the method used (contingent valuation) may underestimate the consumer surplus accruing to visitors. The estimated consumer surplus per person per trip ($184.84) appears to be modest relative to the actual cost of accessing the GBR, a point acknowledged by the authors. Greiner and Rolfe (2004) noted similar issues when estimating the consumer surplus for the Daintree rainforest.
- *Access Economics (2005, 2007, 2008)* – Versions of this report (and its most recent valuation of $5.4 billion in 2006-07 terms) are often cited when the value of the GBR is quoted. However, while useful in many respects, it does not encompass many of the values contained within a TEV, as discussed below.
  - First, technically speaking, the Great Barrier Reef Catchment Area (GBRCA) definition used by Access Economics appears to cover large areas of hinterland, well away from Cairns and the GBR, as well as apparently including visits to friends and relatives (VFR) and travel taken by reef residents outside the area**.** Therefore, it is of limited use in assessing a true picture of reef visitation and value from a TEV perspective.[71]
  - A second issue is that, traditionally, economic impact studies such as those developed by Access Economics provide a snapshot of the value of a resource (like the GBR) at a given moment. In fact, the existence of a long-lived natural resource such as the reef means that people derive benefits from it stretching into the future.
  - Third, the Access Economics study takes care to ensure that benefits are estimated only for Australians. However, the reef is a natural resource which (as indicated by its World Heritage listing) is of global concern. While Australians are likely to take a particularly keen interest in its future, its loss or damage would be widely recognised as a loss for the world as a whole. Therefore, an approach which merely focuses on Australia will not capture global concerns, which are increasingly apparent in debates over climate change.
  - Fourth, for a verity of technical reasons GDP (or Gross State Product or Gross Regional Product) is a flawed measure of "benefits" (BTE 1999). This is especially so for environmental valuations. It effectively measures what is produced but not necessarily what people want (and

71 It should be noted that many of the shortcomings are acknowledged by Access Economics and the need for further data and research is discussed. However, some of this springs from the requirements of an impact assessment in analysing economic activity over small areas. Perhaps the fundamental issue is the suitability of an impact approach to an environmental evaluation.

does not measure non-market values). Note that the field of welfare economics and cost-benefit analysis, upon which environmental economics is based, does not use generally GDP *per se* as a measure of benefits but rather the concepts of producer and consumer surplus.

- *Asafu-Adjaye et al (2005)* – This study measured the Present Value (PV) of the Great Barrier Reef Maine Park (GBRMP) as $4.6 billion as part of a broader assessment of the value of Queensland's natural resources. This analysis uses some aspects of a TEV. However, no attempt is made to estimate consumer surplus from tourism or national or international existence values (which are likely to be very large sums).
- *Hoegh-Guldberg and Hoegh-Guldberg (2004)* – This report made a valuable contribution to the estimation of some of the damages arising from reef bleaching in areas such as tourism and fishing. However, values are again presented on the basis of regional product rather than on a welfare economics/TEV basis and do not include non-use or indirect use values
- *Carr and Mendelsohn (2003)* – This study estimated a consumer surplus for visitors to the Great Barrier Reef using the Travel Cost Method. The per person consumer surplus values derived (i.e. US $ 300-800 or $600-1500 when adjusted to current Australian dollar values) provide a valuable consistency check for the travel cost analysis carried out in the current study. However, the application of these values to GBRMPA visitation figures is questionable, due to the issues surrounding these visitation data, outlined in Appendix 3. In addition, this analysis relates only to tourism use value and not other values (e.g. non-use, fishing etc.).
- *Cesar et. al*. (2003) – This report provided estimates of the global value of coral reefs as well as for those in "Australia", without separately identifying the GBR. The total value of Australia's coral reefs was estimated as $US 168 billion in present value terms (using a 3% discount rate over 50 years) though the identified reef area (49,000 square kilometres) would appear to be over twice that of the GBR (approximately 20,000 square kilometres). The methods and sources used by the authors are somewhat unclear however, with Australian values apparently derived from a survey of Hawaiian coral reefs. Likewise, the methodology for bleaching costs is driven by sensitivity tests based on the initial reef value figures, rather than by "local area" data. The present value of severe bleaching costs for Australia is estimated by the authors as some $US 28 billion.
- *Hand (2003)* – This report discusses both market and non-market values and presents a version of TEV. However, the actual quantification is presented in terms of GDP and gross financial values. As indicated, these are sub-optimal measures of benefits, particularly from an environmental economics perspective. Further, although some non-market values are discussed (such as Hundloe et. al.'s past work) these are not integrated with direct use values to form a comprehensive picture of the GBR's TEV.
- *KPMG (2000)* – This publication contains a variety of useful data, based on the work of Driml. However the scope is limited to values of financial expenditure (e.g. tourism spending) and GDP, neither of which are appropriate measures for valuing an environmental resource such as the GBR.
- *Driml (1994, 1999)* – Driml's past work acknowledges the importance of a TEV and provides a very valuable data source. Unfortunately, much of the information is dated and no attempt is ultimately made to bring together the disparate strands of value to form a final total value. In addition, Driml acknowledged the need to include estimates of "missing items" such as international existence

values and many issues have emerged since her work was conducted. These include the issue of bleaching itself and a reappraisal of what constitutes appropriate long term social discount rates.

- *Hundloe et. al. (1987)* – Hundloe et. al.'s work is frequently cited and would appear to be the only one which sought to survey community willingness to pay to preserve the reef among both visitors and non-users. This work is particularly valuable and elements of it, appropriately adjusted have been incorporated into the current study. However, even this study only considered the more limited issues of respondents' willingness to pay for reef management and for research/control of the Crown of Thorns Starfish infestations. Hundloe et. al. also conducted a travel cost survey to assess consumer willingness to pay to visit the GBR, which, while dated, is also of use.

There have also been a variety of recent efforts aimed at estimating elements of a TEV of coral reefs around the world. Further, in a famous paper Costanza et. al. (1997) estimated the value of the world's ecosystems, estimating that coral reefs had an economic value of $US 6,075 per square kilometre per annum (in $US 1997). However, while an intriguing approach there a host of methodological problems (Pagiola et. al. 2004; Pearce 2007) which can easily lead to errors of magnitude when applying these generic unit values to Australia or other regions.

Appendix 3: How many people visit the "Great Barrier Reef"?

Conceptual framework

There is a degree of uncertainty over the precise number of annual visitors (and/or visitor days) to "the GBR". Some of this uncertainly relates to regional definitions, visitor definitions and the counting methods used. In addition, visitors to the GBR area (however defined) may be motivated by a variety of other interests which do not relate to viewing "corals and fishes" *per se* – e.g. visiting a reef island resort simply to go to the beach and/or relax.

For our purposes, GBR coral site visitors[72] should be distinguished from others who simply visit adjoining regions on the mainland and/or who visit island resorts (or the cruise the waters of the GBRMP) but do not actually view corals and inter-related ecosystems. The focus in this Appendix is on those who actually visited coral sites, and therefore have a demonstrated interest in the GBR coral sites themselves. (A further issue, discussed in the main report is the importance of coral sites and inter-related ecosystems in motivating those who visit them to come to the region as a whole.)

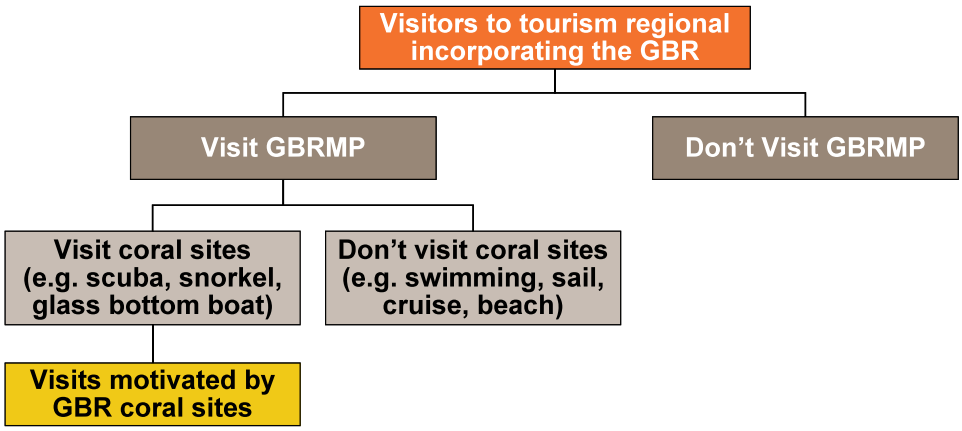
Establishing how many people visit the coral sites on the GBR every year is important in terms of estimating the direct use value of the reef, both in terms of how many people would be willing to pay to access the reef at present and in the event of permanent bleaching.

Chart A3-1 provides an approach to analysing the various subsets of regional visitors. The question of visitation can be broken down in the following way:

1) The starting point is to ask how many people visit the Tourism Regions, as defined by the ABS (2007a), incorporating the GBR and sections of the "reef facing" mainland (i.e. Tropical North Queensland, Northern, Mackay, Whitsundays, Fitzroy, Bundaberg).
2) The next step is to ask how many people who visit the selected Tourism Regions do or don't visit the GBRMP
3) Following this, the number of people entering the GBRMP and who actually visit coral sites must be distinguished from those who enter the GBRMP but don't visit such sites (e.g. just stay in the resorts, swim)
4) Finally, there is a need to estimate the number of tourists visiting coral sites who were actually motivated to come to the region as a whole by the presence of the reef's coral sites and associated ecosystems

72 The term "coral site visitors" is taken to include those who visit coral sites through some form of activity and/or visit inter-related ecosystems such as the variety of marine life immediately adjacent to coral reefs.

Chart A 3–1 Sub-sets of regional visitors



Past approaches

Access Economics (2005, 2007, 2008) examined regional tourism as a part of its review of the economic impact of the GBR. This included definition of a Great Barrier Reef Catchment Area (GBRCA). However, the GBRCA definition used by Access Economics appears to cover large areas of hinterland, well away from Cairns and the GBR, as well as including visiting friends and relatives (VFR) travel and travel taken by reef residents outside the area**.** Therefore, while detailed and useful for a variety of purposes, the tourism numbers and expenditure data cited by Access Economics are of limited use in assessing a true picture of reef visitation and value from a TEV perspective.[73]

A large number of other studies by various local organisations (such as the Cooperative Research Centre for the Great Barrier Reef World Heritage Area (CRC Reef Research Centre), James Cook University (JCU), the Reef & Rainforest Research Centre (RRRC) and the Great Barrier Reef Marine Park Authority (GBRMPA)) have also examined reef visitation in terms of market segments. These are all useful reference sources, although none precisely defines the number of individual visitors to the GBR coral sites *per se*.

Past studies and press releases often cite "GBRMPA figures" (GBRMPA 2008 http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/management/gbr_visitation/numbers) as indications of the number of visitors to "the GBR". These figures record people on tours within the GBRMP. By these figures, total numbers have risen from some 1.5 million in 1994 to some 1.9 million in 2008 though total numbers do not appear to have exhibited sustained growth since 2002.

The GBRMPA figures are often taken at face value when estimates of reef tourism are cited. However, as Access Economics (2005, 2007, 2008) points out (and GBRMPA's website indicates) these data are closer to a count of visitor days than numbers.[74]

73 Nonetheless Access Economics (2005, 2007, 2008) provides a partial estimate of reef visitation, as discussed below.

74 Private recreational vessels are not recorded by GBRMPA, although the number involved is likely to be very small (telephone conversation with Prof B Prideaux, JCU, October 2008).

A number of attempts have been made to derive a more precise estimate of reef visitation, *per se*. Hundloe et. al. (1987) estimated visitation to "coral sections", while KPMG (2000) estimated the number of boat passengers entering the GBRMP as some 1.2 million individuals in 1997/98. Tourism Australia provided estimates of visitor numbers to "the Great Barrier Reef" (essentially overnight visits to islands in the GBRMP) of some 407,000 in 2007 in unpublished data drawn from their annual International Visitor Survey and National Visitor Survey, requested for the current study. While the problems with the GBRCA used by Access Economics above have been noted, Access Economics (2005) did estimate a more refined figure of 625,000 visitors for the year ending September 2004.

However all of these estimates have their drawbacks. Hundloe et al's analysis is dated. KPMG's analysis does not actually indicate if tourists visited the reef *per se* (as some may simply have been cruising and/or travelling to islands for "R&R" with no intention of visiting coral sites). The Tourism Australia figure is based only on overnight visitation to the islands and, so excludes day visitors from the mainland to the reef (but also may include those who simply visit the islands with no intention of viewing the GBR coral sites *per se*). Likewise, the Access Economics estimates include only those tourists staying overnight on the GBR islands and day visitors from within their defined GBRCA. Those staying on the mainland and making day trips to the GBRMP (likely to be a very large source of tourism) are excluded.

Our approach

A way forward is offered by a "one-off" study conducted by the Bureau of Tourism Research, commissioned by GBRMPA in 2003 (*BTR (2003) Assessment of tourism activity in the Great Barrier Reef Marine Park Region)*. BTR (2003) provides a more focussed definition of tourism in sections of "reef facing" Tourism Regions then other past studies. It includes data for "Tropical North Queensland" (TNQ), in this case used as a proxy for the Cairns area. It also includes a breakdown of regional GBR holidaymakers (as opposed to those just visiting family and friends in the region and/or on business) who had undertaken the "GBR experience". The "GBR experience" was further detailed as including activities such as visiting the reef, snorkelling/scuba diving, fishing, beaching going and other activities.[75] Those who made day trips from the mainland and those who stayed overnight on the islands and/or the mainland are also identified.

The estimate of coral site visitor numbers was performed in two stages:

- First, the snorkelling/scuba diving group identified in BTR (2003) were used by Oxford Economics as a basis for estimates of coral site visitation. This represented the largest sub-group involved in a form of coral site-related visitation and diving trips would likely be considered to be a trip to the reef whether or not the "reef visits box" was ticked.[76]

75 Note that respondents could indicate more than one activity or may have effectively used categories as a substitute for others. So simply focussing on the response to "visiting the reef" could be misleading. For example, someone who snorkelled in the reef could have ticked this category to indicate a reef visit rather than "visited the reef". Alternatively they may have ticked both. Tourism Australia advised that detailed cross-tabs and other unpublished data were not available for this survey.

76 Although day trip visitors were included in BTR (2003), detailed break-ups for such visitors were not provided. Scaled down estimates of scuba/snorkel visits were made for these visitors. This was done first assuming that the respective proportions of visitors within the GBRMP experience sub-groups were *the same* as for domestic overnight visitors. The proportion of all Tourism Region day visitors who had taken part in the GBRMP experience (27%) was then compared with the corresponding proportion of domestic overnight visitors who had done so (40%). The proportions of day visitors in the various GBRMP experience sub-groups were then scaled down accordingly.

- Next, allowance was made for the fact that some people may have ticked "visited the reef" without necessarily going snorkelling or scuba diving (e.g. gone on a glass bottom boat tour). This was done by analysing (unpublished) cross-tabs from a Cairns airport exit survey conducted by JCU in 2007 and 2008 as detailed in the main report. This data indicated the extent of overlap between snorkelers, scuba divers and those who visited coral sites through other means (e.g. glass bottom boats). Based on this, an uplift factor of 1.16 was applied to snorkelers/scuba divers estimates.

Estimates by Oxford Economics based on this approach indicate that coral site visitation in 2002/2003 amounted to the figures presented in the table below:

Table A 3–1 Estimated number of visitors to the GBR coral sites: 2002-03[77]

Category	Number of visitors ('000)	
	GBR - Total	TNQ*
Domestic Overnight	279	151
Domestic Day	207	78
International Overnight	579	520
Total	**1,065**	**749**

Source: Oxford Economics, BTR

*Proxy for Cairns area

These 2002-03 figures were used as a guide to total coral site visitation in 2009 (and the years thereafter) though as discussed in Appendix 1 it is also possible to allow for visitation growth scenarios in conjunction with other assumptions.[78]

The same breakdown has been used as a guide to recent expenditure by holidaymakers. The issue of expenditure is further discussed in the section of the main report dealing with commercial tourism.

77 As defined by Tourism Australia, day visitors are those who do not spend a night away from their home as part of their travel. Therefore, for all practical purposes, there is no international day visitor category. See the Explanation of Selected Terms for definitions of day and overnight visitors.

78. There are plentiful annual tourism data for reef facing local government areas (LGAs) and defined Tourism Regions from sources such as Tourism Australia though 2009 data will, of course, only be released after the completion of this report. However, the survey and approach used in 2003 have not been repeated and as indicated in Appendix 1, continual growth in visitation is not a certainty. So it is difficult to be certain of the nature of visitation changes and/or if any changes have been due to variations in reef visitation, rather than in non-reef visitation.

Appendix 4: Travel cost modelling

The GBR, including its coral sites, is a World Heritage Area and draws visitors from around Australia and the world. These visitors must therefore place some value on seeing the GBR and its coral sites – otherwise they would not undertake the trip.

In the case of the current study, we wish to determine the value of the GBR coral sites to visitors. There are several ways in which the value which visitors place on the GBR coral sites can be calculated. The approach taken in this study is to use the Travel Cost Method (TCM).

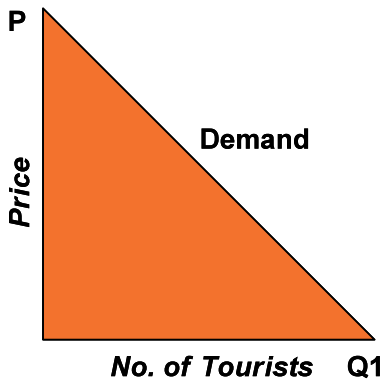
The TCM has a long history in environmental valuation. In its traditional form it involves deriving a "travel cost" to a natural resource such as the GBR coral sites. The cost of travel acts as a proxy for the price consumers are willing to pay for "consuming the experience" of the GBR coral sites or any other natural resource. Using survey (or other) data, travellers are allocated to various zones of origin (such as countries, regions or postcodes depending on data) and a demand curve is estimated based on the cost of access from each zone and the corresponding number of visitors from each zone. This allows for the calculation of the consumer surplus for visits to the site (Mules et al 2005) - i.e. *the difference between what tourists did pay to visit and what they would have been willing to pay to visit an area such as the GBR coral sites*.

The resulting consumer surplus can then be added to other measures of benefits derived from the continuing existence of the GBR coral sites.

Chart A4-1 below provides a theoretical example, where the price of entry to a national park is zero. In such a situation we might be interested in determining how much a visitor would be prepared to pay as an entry fee if one is imposed (taking into account the fact they have already paid to get to the area) and use the TCM (with various price levels) to draw out a demand curve. The shaded area beneath the demand curve represents the consumer surplus – the difference between willingness to pay and actual payment.

In the current instance we model how much more visitors from various areas (zones) are willing to pay to visit the GBR coral sites given that we know something about how much they currently pay to visit and the numbers involved in doing so.

Chart A 4–1 Park visitor consumer surplus



Source: Driml (1994)

In order to develop modelling based on the TCM, then, it is necessary to have either "actual" travel cost data (from sources such as airlines) or data provided through surveys of individuals. The latter approach was taken in this case in relation to the modelling of overseas and domestic overnight visitors. (The modelling of domestic day visitors is described in the domestic day visitors section below.)

JCU conducted extensive "exit surveys" of departing travellers at Cairns airport over the period November 2006 – October 2007 and January 2008 - June 2008. Data from these exit surveys were provided to Oxford Economics with the assistance of Professor Bruce Prideaux and Karen McNamara at JCU. Published results from a sub-set of these data are reported in McNamara and Prideaux (2008).

Visitors were questioned about whether or not they had visited the GBR at some point and asked:

> *Thinking about this trip to TNQ, what was the overall budget for your travel party? (including airfares, accommodation, tours, and all other expenses)?*

Although the traditional travel cost method seeks to measure "travel costs*" per se* in theory, in practice the definition of these is not clear cut. For example, some analysts measure the cost of travelling from "point A to point B". Others include accommodation at destinations or *en route* (or alternatively adjust for stopover costs), while others include the value of time as an opportunity cost of making the trip (Driml 2002, Mules et. al. 2005). There are also a wide variety of "functional forms" (i.e. equations) which can be used for modelling purposes.

All of these methods have their advantages and drawbacks. For example, while measuring the "point A to point B" travel costs may seem the simplest and best approach, the question of whether and how to allow for stopovers (and their attractions) occurs in many cases. This is an obvious problems with the GBR (and it's many overseas visitors making trips to various other locations) with the added fact that many people may have been drawn to the area for more than one reason (e.g. "reef and rainforest").

All of these caveats should be borne in mind when interpreting the results of these and other approaches using the TCM. The TCM has been found to be particularly sensitive to researcher judgement and measurement error (Mules et al 2005). However, a "reasonableness test" based on a comparison of the results from this work and a previous travel cost study for the area is offered below.

In this case, the survey data did not allow for a break-up of travel vs. non-travel costs. A simpler approach has therefore been adopted for the estimates involving international and domestic overnight visitors, with respondent estimates of total travel costs to TNQ being used.[79] However, this may not be a disadvantage. By one line of reasoning, it is subjective (i.e. user defined) travel costs that determine recreational behaviour (Mules et. al. 2005). In visiting the GBR, tourists may implicitly price the total cost of their experience as a perceived (opportunity) cost (including accommodation and other costs). Their responses to surveys such as that of JCU may also reflect such perceived costs.[80]

79 No allowance for travel time costs has been made in the estimations. This is another contentious area. Travel time costs could have been estimated based on point of origin, though there are many complexities associated with this, particularly for international tourists. Given that there was no primary evidence for travel time costs a decision was made to exclude them from the analysis.

80 Mules et. al. (2005) note that one should also apply a plausibility test to reported expenditure, but also that there seems to be a well behaved relationship between "subjective" and objective travel costs. Similar debates also occur in the field of transport economics when comparisons are made between people's perceived motoring costs (often including only petrol and fuel costs) and resource costs (excluding taxes but including vehicle operating costs). The former are often more consistent with observed demand curves.

The travel cost modelling separately estimated consumer surpluses for international, domestic overnight, and domestic day visitors from different geographical "zones" around Australia and the world. A description of the modelling is offered below.

International visitors

Data for the period November 2006- October 2007 were obtained from the JCU airport exit study referred to above.[81] A total of 516 usable responses were obtained. All of these responses indicated that they had visited the "Great Barrier Reef".

International visitors were divided into seven zones by their major origin countries (UK, US, Canada, New Zealand, Germany, Ireland and other European countries "Other Europe"). Information on the number of party members (adults and children) was provided in the survey, allowing for the estimation of the average cost per person. Children were weighted as 0.5 of one adult.

Responses from Asian and other (i.e. non-European and non-North American) countries were excluded due to a relatively low response relate and unreliable data (the survey was only issued in English).

The average reported total cost per person was $2,302 in 2007 dollars, ($2,390 in 2009 terms) with an average length of stay of 6.6 nights.[82]

A double log model was used to specify the relationship between the visitation rate per thousand tonal population and visitation cost per zone. The resulting function was:

$$\ln V = 19.05 - 3.4 \ln C$$

where

V = visits per thousand zonal population

C = costs per person

81 Only data from "Year One" of the JCU survey have been used for the international model. International data for the first six months of 2008 appear to be affected by outliers and have not been used. This did not appear to be a problem with the Australian domestic overnight model and 2008 data were used in that case.

82 As indicated, if a purely subjective (user defined) travel costs approach is adopted, this figure can be seen as reflecting the perceived opportunity cost of the travel experience (excluding travel time). By this line of reasoning, this is the cost that matters in determining recreational behaviour.

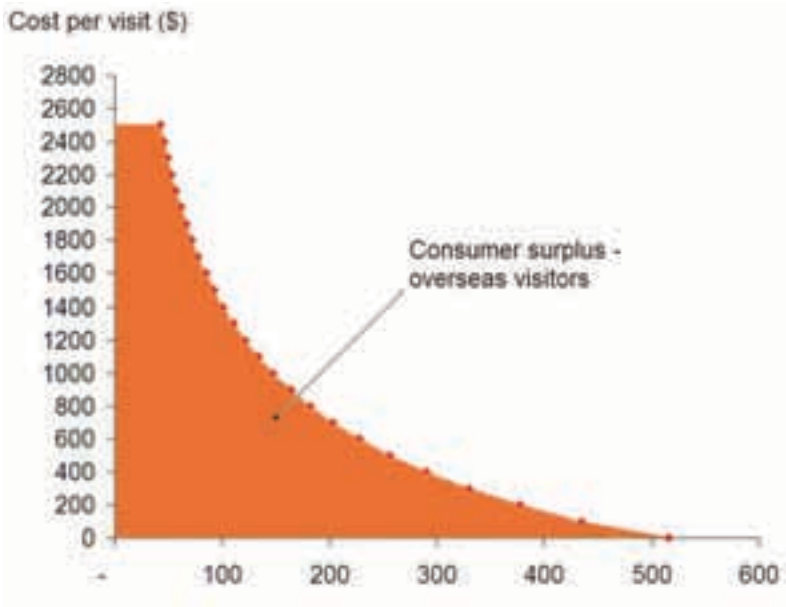
Nonetheless, a comparison can be made with "objective" data, Tourism Australia data indicate that the average expenditure per visit for all non-package tourists to Tropical North Queensland in 2004 was $994, excluding international airfares (Collins et. al. 2006) or $1,141 if inflated to 2009 values using Australian Consumer Price Index data (ABS 2009). (As many Asian visitors, in particular, take package tours this may be roughly comparable to the sample obtained for the current modelling.) A weighted average of European and North American and New Zealand non-package airfares was developed using data from Tourism Australia (2008b) and unpublished Tourism Australia International Visitation Survey data for Tropical North Queensland, provided for this study. After adjusting to 2009 values, this indicates that on average, visitors from these countries paid some $2,179 in airfares to reach Australia. So, in aggregate, the total "objective" cost of an air ticket to Australia and a visit to Tropical North Queensland could be calculated as some $3,320 in 2009 dollars. However, the total cost of a trip to Australia is likely to be considerably more than this, as visitors typically make several stopovers within the country.

Although there are some differences in scope with all of these numbers, this implies that, in aggregate, respondents did not simply "roll in" the total cost of their air ticket to Australia along with all other travel costs incurred within the country when answering how much they spent on their trip to Tropical North Queensland.

The model R^2 was 0.63, with p values of 0.08 and 0.03 obtained for the intercept and coefficient of lnC respectively.

This function was then sensitivity tested to derive a set of price points and a demand curve. This indicates how much more international visitors would be willing to pay to visit the GBR above and beyond what they currently do pay. This curve, with its implied "raw" consumer surplus, is indicated in Chart A4-2 below.

Chart A 4–2 Overseas visitor consumer surplus



Source: Oxford Economics

The final consumer surplus was then derived using a second regression. A linear model provided the best fit for this purpose. The following function was specified as:

$$V = 358.59 - 0.15\ P$$

where

V = visits

P = price per visit

The model R^2 was 0.83, with both the intercept and coefficient terms significant at the 1% level. A consumer surplus per visitor of $1,158 (2007 values) was calculated based on this regression or $1,202 in 2009 terms. This value was applied to the estimated total number of international visitors who viewed coral sites (i.e. 579,000 as indicated in the main report)[83]. An adjustment was then made to allow for the fact that 50% of

83 The per person consumer surplus was applied to *all* international visitors, though, as indicated, these values were based on European, North American and New Zealand visitors. Implicitly visitors from Asia and other parts of the world were therefore assumed to have the same average per person consumer surplus as those accounted for in the survey. Given that visitors from Asia in particular make up a significant portion of visitors to coral sites, it would obviously have been preferable to include their values directly in the survey and subsequent modelling. Ideally future surveys could allow for translation into several languages.

visitors were motivated to come to the region by the presence of the GBR, producing a final consumer surplus estimate of $348 million per annum.[84]

Domestic overnight visitors

Domestic overnight visitors were modelled in a similar way to the approach adopted for international visitors above. Data for the period November 2006-October 2007 and January 2008-June 2008 were obtained from the JCU airport exit study referred to above. A total of 428 usable responses were obtained. All of these responses indicated that they had visited the "Great Barrier Reef". An average visitor cost of $1,801 (2007 dollars) was obtained or $1,870 in 2009 terms.

One difficulty in using airport survey data is that many overnight visitors may arrive in or leave the area using modes of transport other than planes. This is likely to be a particular issue for Queensland residents, many of whom would drive or catch buses into the region, given their closer proximity to the area.

The raw data appeared to confirm that this was the case. The airport survey results were compared to reef visitation data from a recent JCU survey[85]. Data from a survey sub-set of 1,803 domestic overnight visitors indicated that 27% originated from Queensland, compared with 15% in the airport survey, though the match between the airport and reef visitation surveys was much closer for other States and Territories. The airport survey visitation data were therefore re-weighted based on the reef survey data, to derive a more accurate measure of visitation per head of State/Territory population.

Australia was then divided into seven zones, according to State/Territory (NSW and ACT were treated as one zone).

A semi log model was used to specify the relationship between the visitation rate per thousand zonal population and visitation cost per zone. The resulting function was:

$$V = 0.22 - 0.03 \ln C$$

where

V = visits per thousand zonal population

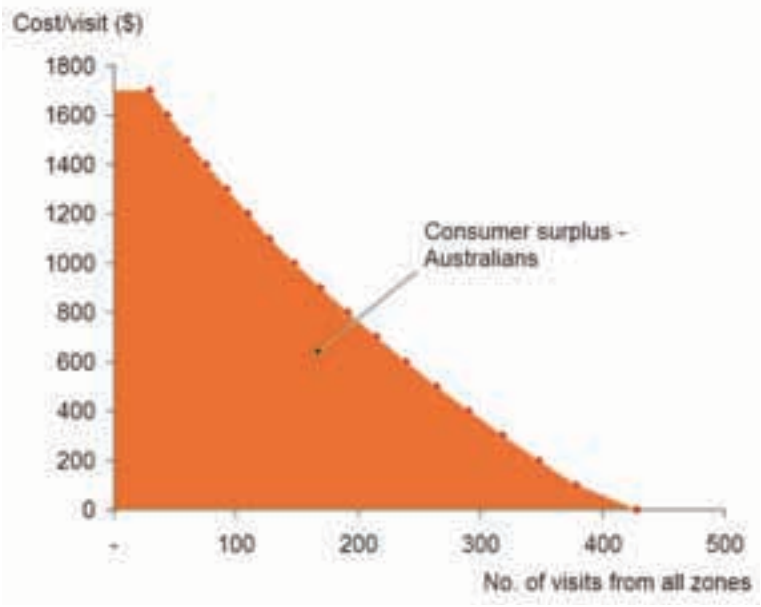
C = costs per person

The model R^2 was 0.73, with the intercept and coefficient of lnC both significant at the (rounded) 1% level. As was the case for the overseas visitors, this function was then sensitivity tested to derive a set of price points and a demand curve. This curve, with its implied "raw" consumer surplus, is indicated below:

84 The consumer surplus for the Cairns area was calculated after the reef-wide consumer surplus for international, domestic overnight and domestic day visitors was estimated. This was done by adjusting for the proportion of "Tropical North Queensland" visitors relative to total visitors, as described below.

85 Refer to Coghlan and Prideaux (2008) for published details of this project. Note that the survey data supplied covered November 2006-September 2008, a longer period than in this published report.

Chart A 4–3 Australian visitor consumer surplus



Source: Oxford Economics

The final consumer surplus was then derived using a second regression. A linear model again provided the best fit for this purpose. The following function was specified as:

$$V = 387.55 - 0.23\ P$$

where

V = visits

P = price per visit

The model R^2 was 0.98, with both the intercept and coefficient terms significant at the 1% level. A consumer surplus per visitor of $859 (2007 dollars), or $892 in 2009 terms, was calculated based on this regression. This value was applied to the estimated total number of domestic overnight visitors who viewed coral sites (i.e. 279,000 as indicated in the main report). An adjustment was then made to allow for the fact that 50% of visitors were motivated to come to the region by the presence of the GBR, producing a final consumer surplus estimate of $124 million per annum.

Domestic day visitors

Rather than being based on airport exit data, Australian day visitors were modelled based on JCU reef visitation survey data described above. This data was collected during 2007 and 2008 and provided to Oxford Economics by Professor Bruce Prideaux and Alexandra Coghlan of JCU. Published details of this survey work are described in Prideaux and Coghlan and Prideaux (2008).

The following approach was utilised for these data:

- The JCU reef visitation data were collected from visitor surveys during the period November 2006-October 2007 and January 2008-September 2008. These data were collected from a number of participating marine tourism operators at four locations across the Great Barrier Reef (Port Douglas, Cairns, Townsville and Airlie Beach).
- Activities sampled including pontoon trips, helicopter tours, scuba diving activities (intro/resort, certified and training), helmet dives, snorkel tours, viewing chambers, semi-submersible tours, glass-bottom boat tours, sailing and visiting the islands. Trips involving fishing and stays at islands resorts were *not included*.
- Frequency data were provided on the characteristics of these visitors for each region. These included postcode of origin and number of nights stay in the town from which the tour was taken.
- Frequency data for 4,850 survey responses was provided. Some 322 responses indicated that they had a "0 nights" length of stay, suggesting that they could be potential day visitors.
- Unfortunately no cross-tabs were available for this survey. In the case of trips originating from Airlie Beach and Townsville a comparison was made of the number of visitors who indicated that had a length of stay of "0 nights" and the number of visitors who originated from postcodes where the largest town was within 200 (road) kilometres of the reef tour departure towns. Since the latter was larger then the former in these cases, the number of visitors from these postcodes was scaled down to match the number of "0 night" visitors.
- 36 "0 night" visitors were observed for the Airlie Beach sample, compared to 51 people who originated from towns within the 200 kilometre area. In the case of Townsville, 12 "0 nights" visitors were recorded against 101 visitors originating from within 200 kilometres.
- A different approach was taken for Cairns/Port Douglas visitors since no break-up was available for survey collection points between these two locations and since the number of "0 night" visitors (284) was observed to exceed the number of responses from postcodes within 200 kilometres of either town (126). In this case, some "0 nights" visitors may well have been international or domestic overnight visitors who stayed in either Cairns or Port Douglas but took a reef tour from the other town. Therefore estimates of visitation were based on the 200 kilometre road distance criterion.
- As no data on reported travel costs were recorded in this survey it was necessary to use "objective" travel costs – i.e. the costs of car travel per person to and from the reef departure towns. (Day visitors were assumed to drive to the reef departure locations). Only petrol costs were allowed for. There was no allowance for vehicle operating costs or the costs of boat trips to the reef itself.[86]
- The road distances from major towns within each postcode to the reef departure towns were determined using the TravelMate website (http://www.travelmate.com.au/MapMaker/MapMaker.asp). Fuel consumption per kilometre (9

86 This is consistent with a view held by many transport economists that vehicle operating costs should, in the first instance, be modelled based on perceived rather than resource costs. Doing so makes them consistent with actual demand curves. Since people generally perceive the costs of a car trip in terms of actual petrol prices (including tax) this is the relevant cost to apply to car trips, even though, in reality, resource costs would include non-fuel operating costs such as vehicle maintenance costs.

litres/100 km at 60kph) and non-business hours vehicle occupancy rates (1.97) were determined by reference to the NSW Road and Traffic Authority's Economic Analysis Manual (2004).

- The average cost of fuel was determined by reference to FuelTrac data (http://www.aaa.asn.au/issues/petrol.htm). An average of the price of Cairns Townsville and Mackay for Jan 07-Dec 08 ($1.30 per litre) was used.
- Using this information, and assuming a round trip distance between the reef departure town and the point of origin allowed for the calculation of a per person travel cost.
- Populations for major postcodes were determined by reference to 2006 ABS Census data, reported at CData Online (http://www.abs.gov.au/CDATAOnline).
- Combining these data allowed for the creation of a 32 zone, postcode based travel cost model. A semi-log model provided the best fit to these data.

The resulting function was:

$$V = 0.71 - 0.27 \ln C$$

where

V = visits per thousand zonal population

C = costs per person

The model R^2 was 0.25, with the intercept and coefficient of lnC both significant at the 1% level. As was the case for the other models, this function was then sensitivity tested to derive a set of price points and a demand curve. A second regression, using a linear model, was then run. The function was specified as:

$$V = 153.46 - 13.29 P$$

where

V = visits

P = price per visit

The model R^2 was 0.94, with both the intercept and coefficient terms significant at the 1% level. A "raw" consumer surplus per visitor of $5.77 in 2007 dollars was calculated based on this regression, or $5.99 when adjusted to 2009 values.

This value was applied to the estimated total number of domestic overnight visitors who viewed coral sites (i.e. 207,000 as indicated in the main report) to produce a final consumer surplus figure of $1.2 million per annum. As all day visitors were assumed to be motivated to make their trips by the presence of the GBR no "motivation adjustment" was made to this figure, in contrast to the adjustments made for international and domestic overnight visitors.

The relatively small consumer surplus for day visitors, compared to others, is partly a product of the segmentation of various visitor groups and the differing modelling approaches adopted. The day visitor model used actual fuel costs, while the overnight visitor models used subjective costs for travel, accommodation food and other related costs.

By way of comparison, the estimated (fuel only) day trip consumer surplus per person value of $5.99 is similar in magnitude to the figures developed by Blackwell (2007) for Mooloolaba Beach. Blackwell's work also allows for a "trip to the water's edge" approach. He estimates a (fuel only) consumer surplus of $2.39 per person for "local area" residents accessing Mooloolaba Beach, ($3.25 in 2009 terms) although the precise geographical definition of "local" residents is not provided.

Nonetheless, it is still the case that while accommodation costs are not relevant to day visitors, no allowance has been made for food or the cost of actual reef activities in modelling day visitor activities, as the JCU reef visitation survey data did not provide these. So, if food and accommodation and boat trips to coral sites themselves are accepted as a part of a travel costs model, the currently modelled consumer surplus for day visitors is likely to be conservative. More detailed survey data on day visitor costs may allow for the incorporation of such items in future work[87].

Total consumer surplus estimate

The estimated consumer surplus estimates for international, domestic overnight and domestic day visitors were combined to derive a total consumer surplus estimate for the reef's coral sites as a whole ($474 million per annum). Note that the consumer surplus for day visitors ($1.2 million per annum) is only 0.3% of this total.

The consumer surplus per person for international and domestic overnight visitors was in the range $892-$1,202 (in 2009 dollars). As a reliability check, this compares to individual consumer surplus estimates made for an earlier GBR travel cost survey by Carr and Mendelsohn (2003) which, when adjusted for inflation and exchange rates at purchasing power parity suggests a per person consumer surplus range of $600–$1,500.[88] The modelled values are therefore consistent with previous work in the area.

87 Tourism Australia (2008c) indicates that day trippers in the Tropical North Queensland Tourism Region spent an average of $122 per day in 2007 (in 2007 dollars). However this expenditure is for all types of day visitors (i.e. including those visiting friends and family) and includes "shopping" costs which may not relate to visitors to GBRMP visitation. Excluding shopping, suggests a per day cost of $76 (in 2007 dollars). A break-up of this adjusted expenditure indicates that some 37% (or $28 in 2007 terms) was spent on fuel, with 45% spent on food and drink, 8% spent on "transport fares and packages" and the remainder spent on other purposes.

The assessed per person fuel costs in the current modelling ranged from an effective cost of zero (for those taking trips originating within their postcode) to $22 in 2007 terms (or $23 in 2009 dollars). Despite differences in survey scope, this suggests that the current estimates probably understate day visitor consumer surplus – particularly if it is accepted that items such as food and drink and boat trips themselves be included. The current estimates could therefore be seen as conservative "minimum case" ones. However, even if it were possible to include other cost items, when treated in isolation, day trip consumer surplus is likely to be much smaller then international and domestic overnight visitor consumer surplus given the considerable differences in travel costs and, if accepted, the inclusion of accommodation costs for overnight visitors.

88 The original Carr and Mendelsohn values were $US 350-800 (US 2000 dollars). An adjustment was made by inflating US dollar costs by the US Consumer Price Index, as recorded by the US Bureau of Labour Statistics (2009) (see http://www.bls.gov/CPI/) and by converting to Australian dollars at purchasing power parity (PPP) exchange rates, as reported by OECD (2009) . The authors do not indicate if day visitors were included, however their focus appears to be on international and interstate visitors.

While the technical approach to travel cost modelling on a per person basis in Carr and Mendelsohn is rigorous and useful, this per person value is applied to some 2 million people –i.e. the GBRMPA figure for visitation. This is in contrast to the more restrictive approach taken in the current study.

Consumer surplus values for the Cairns area were developed based on the number of coral site visitors to Tropical North Queensland (TNQ). As indicated in the main report, there were 749,000 visitors to the coral sites in TNQ and 1.065 million to the reef coral sites as a whole. So the consumer surplus for Cairns was estimated as $333 million per annum (i.e. 749,000/1,065,000 *474,000,000).

On a PV basis, the consumer surplus for the GBR coral sites is $16.6 billion and for Cairns area (TNQ) coral site visitors, $11.7 billion.

Appendix 5: National Non use values

National non-use values for the GBR were determined by analysis and comparison of the results of two previous studies – Hundloe et al (1987) and Windle and Rolfe (2005). The approach adopted is outlined below.

Hundloe et al (1987) results

Work on non-use values for the GBR was undertaken by Hundloe et.al.(1987) with supplementary analysis by Driml (1994). This indicated a total annual non-use value of $62.3 million for the GBR in 1986 dollars. This value was based on several components. One was an Australia-wide mail survey asking what respondents would be willing to pay as an entry fee to fund reef management and what they would be willing to pay *in addition* to research and control the Crown of Thorns Starfish (COTS). A separate study asked actual GBR tourists what they would be willing to pay in entry fees. (No entry fees applied at this time).

An extrapolation was then made to the Australian adult population (i.e. those over 15 years of age). The resulting amount ($62.3 million in 1986 dollars) effectively captured national option, existence and bequest values. Adjusting for inflation (and for the increase in the number of Australians over 15 from ABS (2008c)) this equates to an annual value for GBR preservation of $194 million in 2009 dollars.

Rolfe and Windle et. al. (2005) results

Later work by Windle and Rolfe (2005) effectively examined Queenslander's non-use values for a section of the GBR lagoon. This asked Brisbane households how much they would be willing to pay for changes to the water quality of the Fitzroy estuary which is connected to (and has a direct impact on) the GBR lagoon. Potential improvements in water quality were linked to the health of the GBR, with respondents being told:

> *"If larger impacts on water quality and quantity occur, they may affect estuarine areas, fish stocks and part of the Great Barrier Reef"*[89]

Windle and Rolfe estimated that Brisbane households valued a 1% improvement in the environmental health of the Fitzroy estuary at an average of $3.21 (in 2003 dollars) per household per year over 20 years.

In addition to estimating how much Brisbane residents were willing to pay for estuary improvements, Windle and Rolfe also estimated the impact of *reductions* in estuary quality, though explicit valuations were not provided. An examination of the relevant equation coefficients used in their modelling, however, suggests that the reduction of estuary quality by 15% (i.e. from 65% health to 50% health) was valued by respondents as equivalent to a loss of $38 (in 2003 dollars)[90]. Extrapolating linearly, this implies that the reduction in estuary quality by 60% (i.e. with only 5% of the estuary being in good health) would be valued by respondents as equivalent to a loss of $152 in 2003 dollars (or $178 in 2009 terms).[91]

89 Personal communication with John Rolfe 6/10/08

90 That is, the "15% loss" coefficient for the estuary (0.3602) was divided by the cost coefficient (0.0095) to derive a loss of utility equivalent to $37.92.

91 Windle and Rolfe caution against linear interpolation in terms of estuary *improvements*, as there appears to be an environmental health point beyond which respondents would not be willing to pay more for improvements. Their range of modelled values makes it less

Windle and Rolfe assumed that only 50% of Brisbane households (the survey response rate) would share the non-use values of respondent households. This (quite conservative) approach can be adopted to derive an implied value for all Australian households for losses in estuary (and by extension GBR) health, based on the assumption that health is reduced such that only 5% of the area is considered to be in good condition. That is, it was assumed that 50% of all Australian households held the same values as the survey respondents[92]. The number of Australian households was assessed using ABS 2006 Census data as reported at ABS (2007b).

This approach suggests an annual non-use value of $678 million for the GBR as a whole in 2009 dollars.

Final analysis

Taking the midpoint between the Hundloe et. al. and Windle and Rolfe estimates produces a GBR non-use value of $436 million per annum for the GBR as a whole. This is equivalent to roughly $25.69 per annum for every adult Australian, over 15 (or $57.40 per annum per occupied Australian household).[93]

As the Cairns/Cooktown Management Area accounts for slightly over 10% of the total area of the GBRMP, a notional value of $45.5 million per annum can be attributed to Cairns[94].

The assessed values are equivalent in PV terms to a non-use value of $15.2 billion for the GBR as a whole, with a value of $1.6 billion estimated for the Cairns region.

It should be stressed that this PV represents the streaming of annual values per household *over 100 years* (as opposed to the 20 years worth of payments assumed by Rolfe and Windle) though discounting reduces the impact of the payments in the longer term to some extent.

The GBR-wide value is equivalent to roughly $25.69 per annum for every adult Australian, over 15 (or $57.40 per annum per occupied Australian household)[95].

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clear what happens when severe degradation occurs, though their data suggest that, if anything, a linear approach may understate losses.

Also note that since the survey instrument was based on a WTP approach, these values would differ if respondents were explicitly asked what compensation they would accept for the loss in environmental quality (i.e. WTA approach). As WTA values are typically higher than WTP ones, a WTA approach would be likely to produce higher values for the loss in environmental quality.

92 The authors originally assumed that 15% of Queensland households outside Brisbane would share these values. However no justification was given for this assumption and it has not been adopted here. In general even the use of household response rates is seen as a conservative approach to non-use valuations – see van Bueren and Bennett (2000).

One caveat on this approach is the issue of distance and "responsibility" effects in such studies. That is, people in more geographically distant regions may feel less affinity and/or responsibility for environmental resources than those closer to them. However the GBR is a national icon and it is debatable how strong such effects are in this case. As indicated in the main report, the Green et al. (1999) survey work indicates people appear to share similar views about GBR environmental preservation. Further, Hundloe et al. (1987) found no statistically significant differences in State WTP for reef preservation by non-users. Indeed, Western Australian non-users were found to have a higher weighted WTP for COTS control than those in all other States except NSW. Nonetheless, it is difficult to be certain of the impact of distance effects until a new national study is conducted. This issue is further discussed below.

93 Occupied households measured according to 2006 Census results in ABS (2007b). Adult population over 15 in 2008 as estimated in ABS (2008c).

94 As noted below, one caution is that WTP may not be linear, with smaller areas not necessarily being directly proportional to the size of larger ones ("scale and scope effects" or "embedding effects"). For example some survey respondents may provide the same non-use value for a group of lakes as they do for one lake. This may be less of a problem in "scaling down" to smaller areas, however. The main concern arises when small area estimates are scaled up to very large ones.

95 Occupied households measured according to 2006 Census results in ABS (2007b). Adult population over 15 in 2008 as estimated in ABS 2008c.

These annual household WTP values may be seen as relatively conservative when compared with other past Australian non-use valuations for the natural environment. For example:

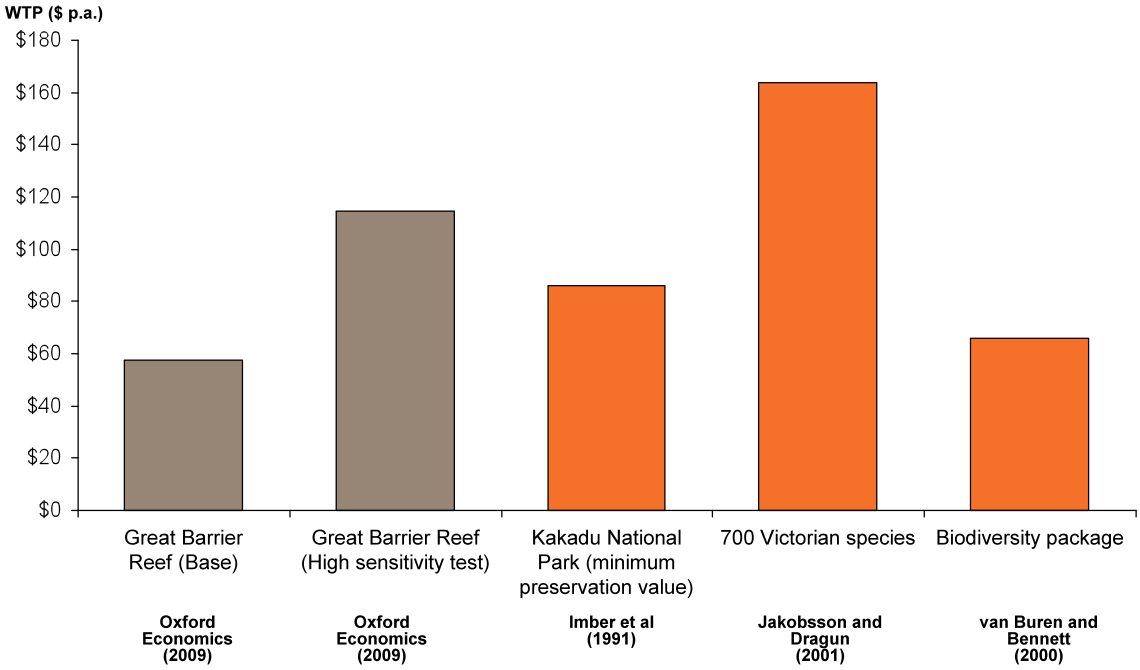
- Jakobsson and Dragun (2001) found that the conservation value (to Victorians) of Victoria's Leadbeater's possum was a minimum of $29 per household per year (1996 dollars) or $40 in current terms[96].
- Imber et.al. (1991) found a median Australian willingness to pay of $52.80 – $123.80 in 1990 dollars ($86-$201 in 2009 terms) per household per annum for 10 years to avoid the impacts of mining in Kakadu National Park.[97]
- Respondents also appear to hold substantial non-use values even for lesser-known areas. Blamey et al.'s (2000) analysis of the marginal countryside of Queensland's desert uplands found a *one-off* WTP for Brisbane households of $117 in 1997 dollars (or $162 in 2009 terms) for a regional "package", relative to the status quo. This preserved 10 endangered species, along with preventing the loss of an additional 45% of non-threatened species and an extra 20% of unique ecosystem area.
- More recently Bennett et al. (2007) found that a sample of Melbourne households were willing to pay $ 0.65 per annum (over 20 years) for an extra 1,000 hectares of East Gippsland old growth forest. They also derived sample values for East Gippsland rainforest ($11.16 per annum for an extra 1,000 hectares). However these authors suggested that the values should be adjusted by the survey response rate of 50% (i.e. halved) when assessing aggregate population figures.
- On a broader scale, Jakobsson and Dragun (2001) also found a WTP of $118 per household per year in 1996 values (or $164 in 2009 values) among Victorians to preserve all 700 endangered Victorian flora and fauna species.
- Van Buren and Bennett's (2000) Australia-wide survey for the CSIRO's *National Land and Water Resources Audit* (2002) found a *sample* WTP of $112 per household per annum (2000 dollars) over 20 years for a generic "biodiversity protection scenario" – equivalent to $50 once adjusted for a sample aggregation factor ($66 in 2009 terms). This included protection of 100 endangered species, an additional one million hectares of improved landscape ascetics (farmland repaired from erosion or bushland protected) and an additional 200 kilometres of waterways restored for fishing and swimming.

Chart A5-1 compares some household WTP per annum values from the larger scale studies with the derived annual values for the non-use value of the GBR, as well as the "high end" sensitivity test referred to in Appendix 1. (However, note the caveats on non-use value which follow below).

96 Unlike the case for Rolfe and Windle (2005) Jakobsson and Dragun did not adjust their mean sample WTP for response rates when "grossing up" to derive aggregate household population values. The authors argued that this was too conservative an approach. Cases where a distinction is made between sample household (or individual) WTP and overall state/national household (or individual) WTP are noted below. Note that in the case of the derived GBR non-use value a composite approach has effectively been adopted. That is, Hundloe's original work grossed up sample WTP values by population without adjustment for survey response rates while Rolfe's adjusted for sample response rates. These respective approaches were adopted in the updates for the relevant values, as explained above.

97 The Imber et. al. survey was the subject of much controversy, however as noted by Driml (1994), the lower of these values can be interpreted as a minimum preservation value for Kakadu as a whole, even if many of the criticisms are accepted.

Chart A 5–1 Comparison of annual household WTP - non-use values



While the GBR (base) *annual* household WTP value appears lower than those for other studies, the current study streams this value over 100 years (i.e. it is effectively assumed to a value held by respondents and future generations). Many past studies have questioned respondents about their willingness to pay over shorter periods of 10-20 years and some have streamed values only over these periods. Respondents may have been willing to pay less per annum if they were told that payments would be indefinite, though further research is needed in this area[98].

Aside from this, given that they examine values for protecting mass ecosystems, broad-based valuations (e.g. Jakobsson and Dragun, van Buren and Bennett) may be seen as more comparable to a valuation involving a large scale highly complex ecosystem, such as the GBR. However these broader studies also highlight the care which must be taken when interpreting the results of past work, particularly studies focussing on regional valuations alone. In particular, "framing" or "embedding" effects mean that respondents can be willing to pay more for a good when it is assessed individually compared to when it is included within a broader package of substitute or complementary environmental goods. The scope of the resource being valued may also affect valuations.

So, as van Buren and Bennett (2000) note, respondents may be willing to pay $150 to protect an area of remnant vegetation if offered in isolation, but only $15 if offered as a part of a larger package of environmental outcomes. Jakobsson and Dragun's assessed valuations for a single possum as opposed to their valuations for 700 species suggest that such embedding effects could have influenced study results.

98 No "time limit" appears to have been set in the case of Jakobsson and Dragun's work, however, which asked respondents whether they would agree to an increase in State taxes to finance conservation. The issue of whether respondents would differ in their responses to time period also raises the issue of personal discount rates (and their compatibility with "ethical" rates of time preference).

Geographical distance and responsibility effects may also affect values though these are may be of less importance for "national icons" such as the GBR.

A related set of considerations involves the need to consider other ecosystem services apart from the one under consideration in a given survey. Many studies remind respondents that the ecosystem services under consideration are not the only ones for which they could or should allocate their money. Nonetheless, care must be taken in assuming that values expressed for differing ecosystems services in separate studies can simply be freely "added up" and the risk that environmental WTP for a single species or ecosystem can form a type of "cause dumping" should not be ignored (Scott Wilson 2008)[99]. This suggests caution both in comparing the results of past studies with GBR valuations and in considering the assessed WTP for GBR preservation itself.

While taking these important caveats into account, the above methodology may still represent a conservative approach to national non-use valuation. The increased attention given to the GBR in recent years in the context of climate change and other threats and the general growth in environmental consciousness since surveys such as Hundloe et. al.'s (as well as the fact that bleaching constitutes an even greater long term threat than COTS) makes it likely that the GBR non-use values derived above are understated.

Arguably, a desire to prevent a permanent mass bleaching of the GBR could be seen as comparable in some ways to the large scale national ecosystem preservation values estimated by van Buren and Bennett (2000) above. Nonetheless, it is difficult to be certain of this, until additional non-use work (specifically focussed on the GBR and national in scope) is undertaken[100].

As indicated, sensitivity tests in Appendix 1 seek to examine the impact of both higher (and lower) non-use values on the results in this study.

99 Also related to this is debate about "warm glow" effects initiated by Kahneman and Knetsch (1992).

100 Work along these lines is currently being conducted by John Rolfe of Central Queensland University, however this work is focussed on Queensland. Ideally a national non-use study would be undertaken to provide national valuations.

Appendix 6: Explanation of Selected Terms

"Cairns area" – The definition of the "Cairns area (or region) in this report is necessarily broad due to differing data sources. For example, in some cases (such as non use values) it is necessary to refer to the Cairns/Cooktown Management Area of the Great Barrier Reef Marine Park (GBRMP) as a measure for impacts. In others, (such as tourism visits) Tourism Australia and/or the Australian Bureau of Statistics (ABS) data relating to the "Tropical North Queensland" Tourism Region or the "Far North" (i.e. Far North Queensland) Statistical Division are the best and most reliable estimates of reef-related activities, rather than data from the Cairns LGA *per se*. These values give a broad indication of regional losses from bleaching.

The term "Cairns area" has therefore been applied as follows:

- In Sections 4.1 ,4.2 and 5.1 the term relates to the Tropical North Queensland (TNQ) Tourism Region, as defined by the ABS and used by Tourism Australia
- In Sections 4.3 and 5.2.2 the application of the term is based on the proportion of recreational boats based in the Cairns Local Government Area (LGA)
- In Section 5.2.1 the term refers to the regional proportion of commercial fishing value as assessed by the Bureau of Rural Sciences (2003)
- In Sections 6,7 and 8 the term is based on the Cairns/Cooktown Management Area section of the Great Barrier Reef Marine Park (GBRMP)

Consumer surplus - The difference between what consumers pay and the maximum price they would be willing to pay for a commodity. It is commonly used as a measure of benefit derived from consuming a commodity.

Coral site visitors - Those who visit coral sites on the Great Barrier Reef (GBR) through some form of activity and/or visit inter-related ecosystems such as the variety of marine life immediately adjacent to coral reefs.

Day visitors – Day visitors are defined as per Tourism Australia (2008a). That is: "day visitors (or same day visitors) are those who travel for a round trip distance of at least 50 kilometres, are away from home for at least 4 hours, and who do not spend a night away from home as part of their travel. Same day travel as part of overnight travel is excluded, as is routine travel such as commuting between work/school and home". Note that this definition effectively precludes international visitors and the vast majority of domestic visitors visiting the GBR from other States.

Discount rate – Economists assume that people value benefits or costs more if they occur in the present than if they occur in the future. The discount rate reflects the lowering in importance attributed to gains or losses in the future (Pearce and Turner 1990).

Domestic overnight visitors – The definition of these is consistent with that provided in Tourism Australia (2008a). That is: "overnight trips are defined as trips involving a stay away from home for at least one night, at a place at least 40 kilometres from home". Only those trips where the respondent is away from home for less than 12 months are included.

Far North – The geographically classified Statistical Division covering Cairns and surrounding areas, defined in the Australian Bureau of Statistics (ABS') (2008a) *Australian Standard Geographical Classification (ASGC)* ABS Catalogue No. 1216.0

Great Barrier Reef (GBR) /"the reef" – As is the case for the "Cairns area", the application of this term varies with context and is necessarily broad in some cases due to differing data sources. It is also important to make a distinction in some cases between the large area covered by the GBRMP and the coral sites and inter-related ecosystems, commonly visited by tourists.

The term has therefore been applied as follows:

- In Sections 4.1, 4.2 and 5.1 the term (in isolation) relates to visitation to the GBRMP. More specific reference is made to visits to the coral sites (and inter-related ecosystems) frequented by tourists, as discussed in these Sections. The actual assessment of economic value in these Sections relates to coral site visitation within the GBRMP and its related effects.
- In Sections 4.3 and 5.2 the term relates to the GBRMP (used interchangeably with the GBRWHA).
- In Section 6 the term relates to the physical presence of the reef itself as a storm protection barrier
- In Sections 7 and 8 the term is taken to refer to the coral sites and inter-related ecosystems immediately adjacent to them, whether or not these are ever visited by people

International visitors – The definition of these is consistent with that provided in Tourism Australia (2008b). That is: "overseas visitors coming to Australia for a period of less than twelve months".

Producer surplus - The difference between the price received by suppliers and the minimum price at which they would have been willing to sell commodities. This term is roughly analogous to "profit" though more correctly equivalent to profit plus fixed costs.

Tropical North Queensland – The Tourism Region, covering Cairns and surrounding areas, as referred to by the ABS and Tourism Australia. For precise definitions of the Tourism Regions refer to ABS (2007a) *Tourism Region Maps and Concordance Files, Australia, 2007*, Cat. No. 9503.0.55.001



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