Environmental-economic values of marine and coastal natural assets of the Fitzroy NRM Region, Great Barrier Reef

October 2015

Prepared by TropWATER James Cook University for the Fitzroy Basin Association

FITZROY BASIN ASSOCIATION

Our country, Our future

www.fba.org.au

Environmental-economic values of marine and coastal natural assets of the Fitzroy NRM Region, Great Barrier Reef

FINAL REPORT

A report for the Fitzroy Basin Association

No. 15/58
October 2015

Colette Thomas and Jon Brodie

Centre for Tropical Water & Aquatic Ecosystem Research

(TropWATER)

James Cook University
Townsville
Phone : (07) 4781 4262
Email: TropWATER@jcu.edu.au
Web: www.jcu.edu.au/tropwater/

This report should be cited as:

Thomas, CR and Brodie, JE 2015. *Environmental-economic values of marine and coastal natural assets of the Fitzroy NRM Region, Great Barrier Reef*. TropWATER Report 15/58, Townsville, Australia.

For further information contact:

Colette Thomas
Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER)
James Cook University
Email: Colette.Thomas@jcu.edu.au
This publication has been compiled by the Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University.

Acknowledgements

The authors of this report would like to thank the Fitzroy Basin Association for the project funding, and to all of the authors for their valuable contributions to the project.

Disclaimers

Contents

Executive Summary ... 1
1. Introduction ... 3
1.1. Economic value of the environment ... 3
2. Economic valuation of regional coastal and marine ecosystems ... 10
2.1 Non-market valuation via asset quantification ... 10
2.2. Market values ... 12
2.2.1 Direct and indirect economic contributions ... 13
2.2.2 Issues with existing market valuations ... 13
2.2.3 Valuation of reef-based tourism ... 15
2.3 Extension of Burnett-Mary region south of the GBRMP boundary ... 17
2.3.1 Reef-based tourism ... 17
2.3.2 Recreation ... 18
2.3.3 Commercial fishing ... 19
2.4 Exclusion of economic activity within Western Cape York Peninsula and the Gulf of Carpentaria ... 20
2.4.1 Reef-based tourism ... 20
2.4.2 Recreation ... 21
2.4.3 Commercial fishing ... 21
2.5 Monetisation of non-market value estimates ... 22
2.6 Total monetary value estimates ... 22
3. Gaps ... 24
4. Recommendations ... 25
4.1. Ecosystem services in marine policy and planning ... 26
4.2 Ecosystem services for WQIPs: a preliminary analysis ... 30
4.2.1 Defining ecosystem services for application in WQIPs ... 33
5. Conclusion and Recommendations ... 34
6. References ... 35
Appendix 1 - A preliminary ecosystem services framework: reef-specific tourism ... 40

List of Figures

Figure 1. Classification of environmental values (from Barbier et al. 2011; NRC 2005)........................ 4

Figure 2. A. Restricting access moves an environmental good or service towards a higher degree of excludability, making it more like a private good. B. Congestion and over-use can move a good or service towards a more rivalrous condition. (Adapted from Fisher et al. 2009) 7

Figure 3. A. Close-up of the underside of a gecko's foot as it walks on a glass wall. Van der Waals forces, activated between finely divided hairs on the toes and the glass, provide the gecko with enormous adhesive strength. (Photo from Tørrissen 2009). B. Scanning electron microscopy of (i) setae attached to a section of toe pad, and (ii) an array of spatulae at the tip of a set. (From Rizzo et al. 2006) 8

Figure 4. A. Patenting is one example of how an additive (non-rival) ecosystem service can be moved towards excludability. B. An ecosystem good or service can move towards both rivalry and excludability. Fencing off a beach may allow access to be controlled to different degrees. (Adapted from Fisher et al. 2009) 9

Figure 5. A. Estimated non-monetary contribution (km2) of key environmental assets to the total asset area of the FBA NRM region of the Great Barrier Reef. B. Regional distribution of estimated non-market value as a function of total asset area (km2). Source: DEHP 2014. . 11

Figure 6. Eastern Cape York Peninsula and Great Barrier Reef Marine Park. (From Reef Plan 2014).. 20

Figure 7. A. The relative contribution of key reef industries to total market value estimate for the FBA NRM region. B. The estimated monetary contribution (AUD million per year) of the FBA NRM Region to the total monetary value of the GBR. From DAE (2013) and others as described in the text. Refer to the original documents for detail....................................... 23

Figure 8. A. Relative contribution of market and non-market monetary value estimates (AUD million per year) to the total monetary value estimate for the FBA NRM region. B. Estimated contribution of monetised non-market value (AUD million per year) of NRM regions to the total monetary value of the GBR. (From DAE (2013) and others as described in the text. Refer to the original documents for detail.).. 24

Figure 9. The ecosystem services concept provides an organising framework for considering the relationships between ecosystems and their beneficiaries. (From Brauman et al. 2014).... 26

Figure 10. Considerations for applying the ecosystem service concept. Effects of ecosystem service provision to human well-being, and the effects of human use on ecosystems, are represented by black arrows. Societal choices about what counts as a service or benefit, and which ecosystem processes and components are desirable for promoting them, are represented by white arrows. The integration of societal preferences about values and choices with ecological information is achieved by posing questions about the different components of the ecosystem services concept, and how it should be applied. (From Jax et al. 2013) 29

List of Tables

Table 1. The interaction between rivalry, excludability and congestibility. (Adapted from Daly & Farley 2010; Kubiszewski 2010; Kubiszewski et al. 2010) 5

Table 2. Estimated non-monetary contribution (km2) of key environmental assets to the total asset area of the FBA NRM region of the Great Barrier Reef. Source: DEHP 2014. 11

Table 3. Total economic contribution of reef-dependent commercial activity to the Australian economy (AUD millions in 2012). (Adapted from DAE 2013) 14

Table 4. Tourism total economic contribution to the Australian economy (direct value-add plus indirect) by GBR NRM. (Adapted from DAE 2013) 15

Table 5. Reef tourism expenditure (AUD million) estimates from 2012 EMC data. (From DAE 2013) 16

Table 6. Redistribution of estimated total economic contribution of reef-dependent tourism (AUD613.2 million) to align with the regional distribution of EMC expenditure data (see Table 5) 16

Table 7. Total contribution of GBR-dependent recreation to the Australian economy (direct value-add plus indirect), by NRM unadjusted for the entire Burnett-Mary area. (Adapted from DAE 2013) 18

Table 8. Total economic contribution of GBR-dependent commercial fisheries to the Australian economy (direct value-add plus indirect), by NRM unadjusted for the entire Burnett-Mary area. (Adapted from DAE 2013) 19

Table 9. Visitation rates to eastern and western Cape York Peninsula (from Queensland Tourism 2002).......... 21

Table 10. Monetary value estimates (AUD million per year) and ranks for Great Barrier Reef NRM regions. Adapted from DAE (2013) and others as described in the text. Refer to the original documents for detail. 23

Table 11. Market and non-market monetary value estimates for GBR NRM regions. Adapted from DAE (2013) and others as described in the text. Refer to the original documents for detail. 24

Table 12. Identification of intermediate and final services is dependent on the benefit being valued. An individual final service may be instrumental for multiple benefits, and some benefits require complementary (non-ecosystem) goods and services to be available before they can be realised. (Adapted from Boyd & Banzhaf 2007; Fisher et al. 2009).......... 32

Table 13. An example of how types of ecological benefits that can be realised from a local system might be defined to simplify the process of generating an inventory. (Adapted from Boyd and Banzhaf 2007).......... 33

Executive Summary

Ecological goods and services provide the conditions and processes for ecosystems to sustain human life and well-being, including the delivery, provision, production, protection and maintenance of these goods and services. The regulation of natural processes that ecological goods and services provide affects human welfare and production both directly and indirectly. The importance of the environment can be expressed in terms of its ecological, socio-cultural, and economic values. Economic use values refer to the benefits that humans realise when interacting with the environment in some way, and economic non-use values represent the value that an individual or community attaches to the environment in addition to or irrespective of their use values. The total of all ecological, socio-cultural and economic values of a resource or aspect of the environment is its total value. The total value of the Great Barrier Reef (GBR) could not be estimated here because many of these values have not been quantified (and may never be). This report summarises the most recent economic valuations that are available and can be consistently decomposed into regional scale estimates. The total values reported here at the GBR scale have therefore been generated purely to provide a consistent reference and context point against which regional estimates can be assessed and do not assume to provide a true estimate of total absolute value of the Great Barrier Reef.

Assigning monetary values to ecosystem goods and services can be a powerful way to ensure that ecosystem services are valued and represented in management and policy decision processes. This report collates existing information on monetary values of the GBR regions to support water quality improvement planning (WQIP) management prioritization tasks conducted using the Investment Framework for Environmental Resources (INFFER) process. Although estimates of the value of the whole GBR are useful for large-scale planning, they are a relatively blunt instrument for developing regional scale policy. To this end, regionally-specific estimates of the economic value of GBR ecosystems were derived to facilitate future analysis of the spatial distribution of social, economic and ecological costs and benefits of land management change to the Great Barrier Reef. Information on three main types of value of the GBR is readily accessible and suitable for application to the WQIP process;

1. the market (monetary) value of commercial activities dependent on GBR assets and resources,
2. non-market values measured as the amount (e.g. total area) of ecological asset present across regions of the GBR, and
3. monetisation of non-market values to obtain approximate total market estimates.

The Fitzroy Basin Association (FBA) Natural Resource Management (NRM) coastal and marine region comprises the second-largest asset area mapped for the GBR NRM regions in this project. Reefs in the region comprise approximately 39 % (4,855 km^2) of the total asset area. Seagrass (5,775 km^2) and wetlands (1,848 km^2) comprise 46 % and 15 % respectively of total seagrass and wetland habitat mapped for the GBR. Collectively these assets represent 18 % of the total area of GBR assets.

The FBA NRM region contributes approximately 10 % (AUD127 million per year) of the estimated total monetary (market and non-market) value of the GBR; 8 % of the total market value and 18 % of the total non-market value of the GBR.

The market value of the region, estimated from commercial economic activity, is derived predominantly from the recreation sector. Recreation contributes 47 % (AUD40 million per year), commercial fishing contributes approximately 35 % (AUD30 million per year) and reef tourism contributes approximately 18 % (AUD33 million per year) to the Australian economy.

There is substantial uncertainty associated with the habitat area estimates, particularly for seagrass, which changes dynamically and is monitored infrequently. Commercial value estimates also contain reasonable levels of uncertainty which arises from two primary sources: the scarcity of reliable non-market and non-use values for the GBR and its regions. To remedy this, the application of a systematic ecosystem services framework for the GBR is recommended to facilitate the development of a comprehensive assessment of ecological values for consideration in future prioritisation and policy decisions tasks.

> *"At its heart the decline in Australia's ecosystems can be attributed to a habit of seeing every ecological debate as a contest between biodiversity and socio-economic benefit, where the resulting compromise decisions diminish ecosystem health. The ecosystem services concept provides an increasingly rigorous framework to engage a broad range of stakeholders in considering these debates in a more sophisticated light. Using this framework to identify a greater diversity of ecosystem services and options for their management can help Australian institutions choose actions to provide a broader range of benefits for people."*

- (Pittock et al. 2012)

1. Introduction

Ecological goods and services provide the conditions and processes for ecosystems to sustain human life and well-being, including the delivery, provision, production, protection and maintenance of these goods and services (Crabbé & Manno 2008). Their regulation of natural processes affects human welfare and production both directly and indirectly. Conventional agricultural practices, which rely heavily on non-renewable substitutes for natural processes, are the leading cause of habitat and biodiversity loss and degradation (Farley et al. 2011). Economic market mechanisms that favour immediate economic benefits over sustainable production are much of the cause. It is perhaps surprising that there are three reasons why adopting an economic perspective to environmental management issues can be useful for environmental protection (Farley 2010).

1. Environmental degradation is primarily of economic origin because all economic production relies on raw materials and energy.
2. Economics provides a stopping rule, i.e. conversion of ecosystems to economic outputs should stop when costs of ecosystem services lost equal the benefits of economic services gained.
3. Economics provides a framework to efficiently allocate resources towards scarce conservation resources across alternative desirable ends.

The three fundamentally desirable ends of economic activity are sustainability (e.g. ecological resilience), justice (e.g. avoidance of inequalities) and efficiency (e.g. efficient use of resources); all of which are normative value judgments, and therefore socially determined (Farley 2012). This report collates information suitable to support the application of a cost-benefit valuation to aid prioritisation during resource management decision processes, and considers what form may best support the strategic application of economic tools in future work.

1.1. Economic value of the environment

The importance of the environment can be expressed in terms of its ecological values, for example its functional integrity or diversity, its socio-cultural values such as cultural identity and heritage (Chiesura & de Groot 2003) and economic values (de Groot et al. 2010). There are two main types of economic values: use values and non-use values (Figure 1). Probably the most familiar types of values are 'use values', which typically refer to the benefits that humans realise when interacting with the environment in some way (Barbier et al. 2011). Non-use values, on the other hand, represent the value that an individual or community attaches to the environment in addition to, or irrespective of, their use values, for example, its pure existence is valued (existence value), it is valued for its potential use by future generations (bequest value), or for its potential to be used in as yet unforeseen ways (option value) (Barbier et al. 2011).

The total of all use and non-use values, that is, the total of all ecological, socio-cultural and economic values, of a resource or aspect of the environment is its "true" or total value (de Groot et al. 2010). Perhaps the simplest way to quantify environmental value is to use an existing measurement unit. Most commonly this is a monetary unit, such as Australian dollars (National Research Council (NRC) 2005). Monetary values can provide intuitive metrics for goods and services that are traded in markets (i.e. bought and sold) because trading prices directly reflect consumer estimates of worth.

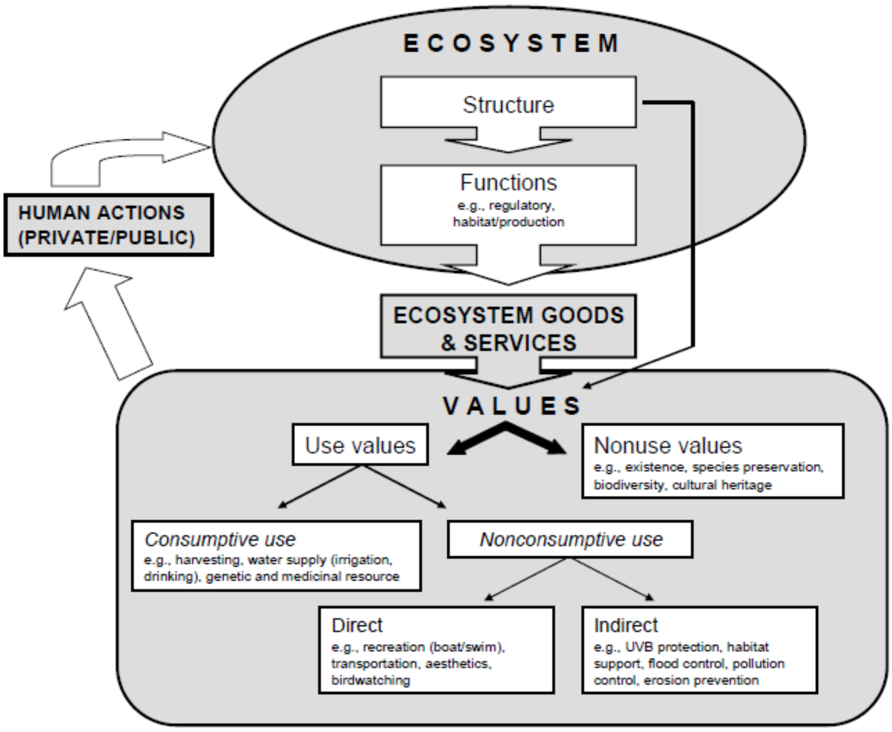


Figure 1. Classification of environmental values (from Barbier et al. 2011; NRC 2005).

Assignation of monetary values (i.e. prices) to environmental goods and services that are not traded in markets (i.e. which have non-market value) allows the relative value of market and non-market services to be directly compared, and thus trade-offs can be explicitly assessed. Usually trade-offs across alternate economic ends are made using cost-benefit analysis (Baker & Ruting 2014). A number of techniques are available to elicit or translate economic and some socio-cultural values in monetary value terms, but these are not widely used in Australian environmental policy analysis (Baker & Ruting 2014). The most common types of non-market valuation are revealed preference and stated preference methods. Revealed preference methods are generally considered valid processes; however, they cannot be used in all circumstances (Baker & Ruting 2014). Stated preference methods can estimate almost all types of environmental value but their application can be controversial (Baker & Ruting 2014).

The assignation of monetary values to ecosystem goods and services can be a powerful way to ensure that they are valued and represented in policy decisions. Valuation (i.e. the quantification of value attributes) of ecosystem goods and services is useful when informing policy trade-off decisions, providing compensation and liability estimate for damage assessment, and incorporating changes in natural assets into national accounts (NRC 2005).

The first point is directly relevant to current WQIP processes, which require management decisions to be prioritised in terms of their implementation costs and likely consequences to the environment, the economy and society. To determine the relative values of goods and services, and how these values may change under alternative management decisions, the goods and services must be ranked, which requires that their values first be quantified (NRC 2005). In turn, the design of the valuation exercise must be dictated by the requirements of the decision context, which defines the purpose of valuation and how the valuation will be used in policy and management decision making (Boyd & Banzhaf 2007; Fisher et al. 2009; NRC 2005).

To be efficiently produced and distributed, market goods and services must be *rivalrous* and *excludable* (Daly & Farley 2010), as described in Table 1, where purely private goods are rival and excludable, and purely public goods are non-rival (generally free but costly or impossible to replace) and non-excludable (Brauman et al. 2014; Fisher et al. 2009). A third characteristic applies to information, which can be neither rivalrous nor excludable, but *additive* i.e. improves with use (Figure 2).

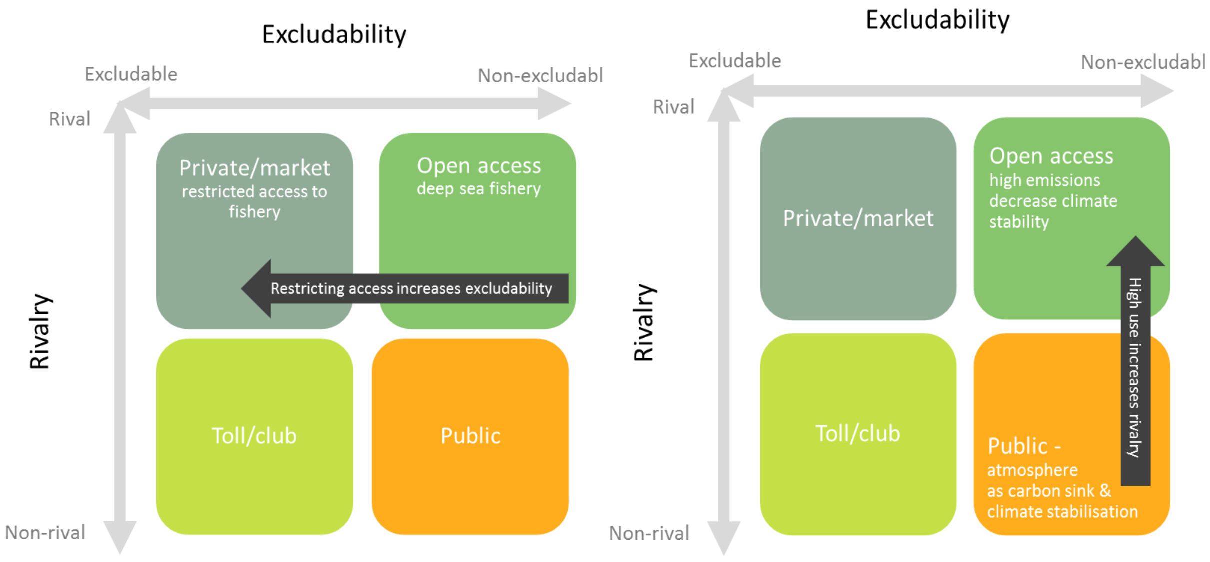
Table 1. The interaction between rivalry, excludability and congestibility. (Adapted from Daly & Farley 2010; Kubiszewski 2010; Kubiszewski et al. 2010)

	Easy to exclude	Almost impossible to exclude
Rival	**Market goods** food, clothes, cars, houses, waste absorption capacity of regulated pollution	**Open access** ocean fisheries, logging in unprotected forests, waste absorption capacity of unregulated pollution
Congestible *lightly used or abundant* *heavily used or scarce*	**Zero marginal value** best efficiency if prices change with usage or clubs prevent resources becoming scarce **Operate as market goods**	**Open access** efficient if excludable during periods of high use e.g. non-toll roads, public beaches, national parks
Non-rival	**Potential market good** e.g. flood protection	**Pure public good** lighthouses, streetlights, national defence, most ecosystem services
Additive (non-rival)	e.g. telephones	e.g. internet

A rivalrous good or service is one for which use of a unit by one person prohibits use of the same unit at the same time by another, leaving less for others to use, for example, deep-sea fish (Daly & Farley 2010). A non-rival good or service is one for which use by one person has an insignificant impact on the quality or quantity available to another (Daly & Farley 2010). Rivalrous goods and services exist along a spectrum of exhaustibility; the more exhaustible (or congestible — a different type of exhaustion) they are, the more likely they are to operate as rivalrous (Fisher et al. 2009). Excludable goods and services, on the other hand, exist along a spectrum of accessibility and exclusivity.

Completely excludable goods and services can be made unavailable to select users. That is, other users can be prevented from accessing them. Some goods and services are more easily made excludable than others. For example, in Figure 2a, a deep sea fishery can be considered rival because stocks are small and easily exhausted with modern fishing technology. It is also extremely difficult to prevent others from accessing those stocks. However, if a new technology or environmental condition made it easy for a small number of people to restrict access, the fishery would move into the ‘excludable’ zone, and operate more like a private fishery. Most goods and services are quantitatively rivalrous, but some are more abundant than others, which affects their congestibility (Daly & Farley 2010).

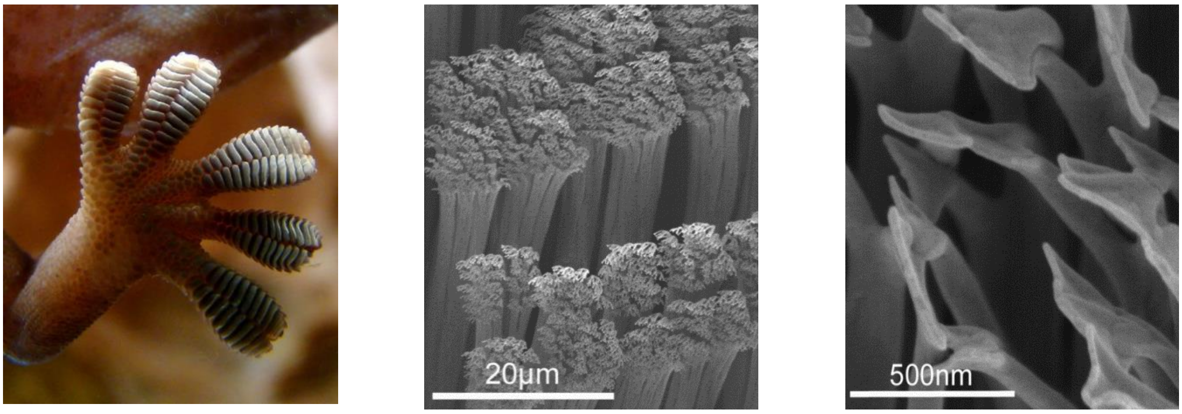
Goods and services that are congestible are subject to over-use or overcrowding. Figure 2b illustrates how a good or service’s congestibility can affect the efficiency of social, economic or ecological costs and benefits. Carbon storage by the atmosphere provides an example. Before the Industrial Revolution, the capacity of the atmosphere to absorb carbon was large compared to the emissions being produced; it operated as a non-rival service (Fisher et al. 2009). As emissions grow the resource becomes congested; the opportunity for any one country to use it as a carbon sink is reduced and the atmosphere now operates akin to a rival service (Fisher et al. 2009). Another example of how congestion can increase rivalry might be if a small reef becomes crowded, decreasing the dive benefits (Szuster et al. 2011).



A. **B.**

Figure 2. A. Restricting access moves an environmental good or service towards a higher degree of excludability, making it more like a private good. B. Congestion and over-use can move a good or service towards a more rivalrous condition. (Adapted from Fisher et al. 2009)

Exclusion can also occur with non-rival goods and services. Additive non-rival environmental goods and services include information about properties of the natural world. A famous example is the discovery that a multitude of specialised hairs on geckoes' toes allows them to bond with surfaces at a molecular level, enabling them to seemingly defy gravity (Figure 3; Rizzo et al. 2006). Information about how geckoes generate high adhesive strength is non-rival because it does not degrade with use, nor does your reading of it now leave less information for others. The information is also additive because increased use (more people accessing the information) can create increased value as the information can be used to develop new and better ideas (Kubiszewski et al. 2010). For example, scientific information on gecko morphology and function has been used to synthetically engineer commercial adhesives such as NanoGrip and Geckskin.



A **B(i)** **B(ii)**

Figure 3. A. Close-up of the underside of a gecko's foot as it walks on a glass wall. Van der Waals forces, activated between finely divided hairs on the toes and the glass, provide the gecko with enormous adhesive strength. (Photo from Tørrissen 2009). B. Scanning electron microscopy of (i) setae attached to a section of toe pad, and (ii) an array of spatulae at the tip of a set. (From Rizzo et al. 2006)

However, Figure 4 shows that non-rival goods can also transition between excludable and non-excludable states. Continuing the gecko example introduced above, if some person or institution were to patent their discovery of the adhesive properties of geckoes, access becomes restricted, and less public. It has been suggested that when basic research findings are patented and licensed exclusively to secure higher commercial profits, patent holders may also inhibit innovation and development that would have otherwise been available to some follow-on developers (Buchanan & Yoon 2000). Mirroring the problem of over-usage of the public's goods terms the tragedy of the commons, such examples of under-usage of public goods (especially additive goods), have been termed the 'anti-commons' (Buchanan & Yoon 2000; Kubiszewski et al. 2010).

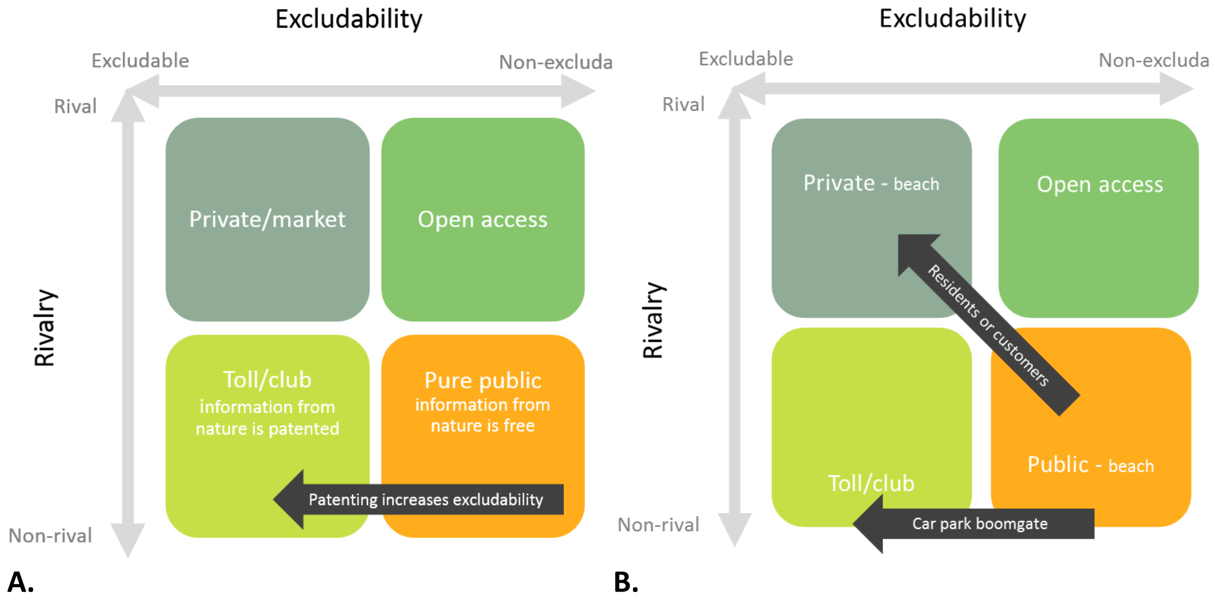


Figure 4. A. Patenting is one example of how an additive (non-rival) ecosystem service can be moved towards excludability. B. An ecosystem good or service can move towards both rivalry and excludability. Fencing off a beach may allow access to be controlled to different degrees. (Adapted from Fisher et al. 2009)

Similarly, a non-rival public good or service, such as a beach can be made more excludable, as shown by the arrow moving to the left in Figure 4. For example, beach access can be controlled non-selectively by installing a car park boom gate that opens when a toll is paid. Anyone can use the beach, as long as the toll is paid. Usually, goods and services that are costly and difficult to manage exclusively sit closer to the non-excludable end of the spectrum, and goods that are cheap and easy for others to control are positioned more towards the excludable end of the spectrum.

It is conceivable that a public good or service can be made both more excludable and more rival, as shown by the arrow moving diagonally up and the left in Figure 4. A long, open beach adjoining some public lands may be too difficult and costly to fence and surveil, and not susceptible to congestion. Such a beach, which is virtually non-excludable and non-rival, is a public beach. Other beaches may be small, surrounded by private lands, or owned privately. If an exclusive group of people have this beach gated and fenced, access is no longer public. The beach functions with a higher level of excludability. The exclusive group decides who they grant access to, so it has become a private beach. However, fencing the beach also leaves less beach space for everyone else to use, thus increasing congestion.

2. Economic valuation of regional coastal and marine ecosystems

The GBR's economic value can be derived using different types of value estimates under varying levels of spatial and temporal resolution. Although monetary or other economic estimates of the GBR's value are useful for large-scale planning, they are a reasonably blunt instrument for developing policy at the regional level. Regionally-specific estimates of the economic value of GBR ecosystems allow analysis of the spatial distribution of the relative social, economic and ecological costs and benefits of land management change (Thomas et al. 2012; van Grieken et al. 2013). Information on three main types of value of the GBR is readily accessible and suitable for application to the WQIP process.

1. the amount (e.g. total area) of ecological asset present across regions of the GBR
2. the market (monetary) value of commercial activities dependent on GBR assets and resources and,
3. non-market value estimates.

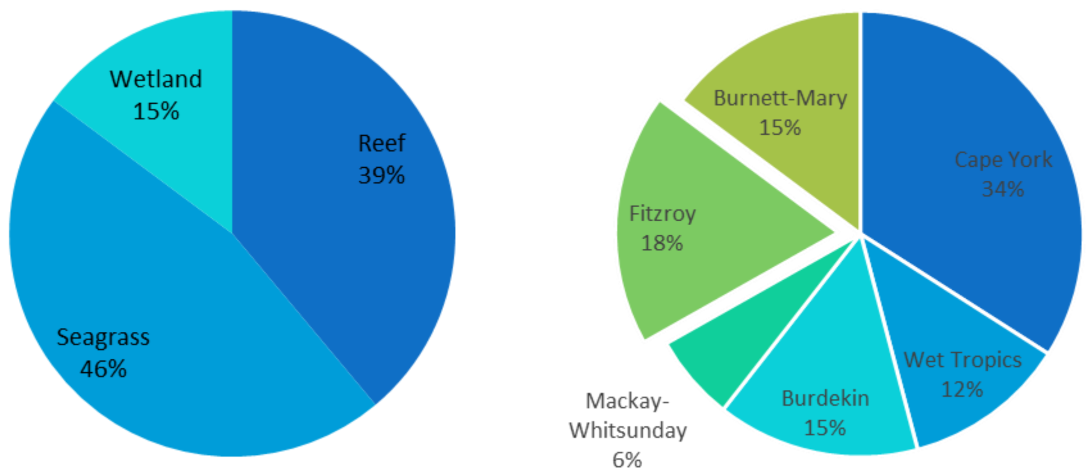
2.1 Non-market valuation via asset quantification

The regions of the GBR are socially, economically and ecologically diverse. These regions support different types and intensities of industrial development, including agriculture, tourism and mining, among others. Regional industries, and the communities that surround and support them, depend upon and value the GBR in different ways. Similarly, the coastal and marine ecosystems adjacent to each region are also diverse, supporting different amounts and types of seagrass, coral reef and wetland habitats. Consequently, the coastal and marine benefits that are provided to each region vary, as are the management needs and priorities to maintain them.

An ecosystem-based perspective can be used to tease out regional differences that may be important to management and policy prioritisation decisions. It could be assumed that if all environmental assets are of equivalent value, regional values are proportional to their contribution to the total area of environmental assets in the GBR. Data available for coral reef, seagrass and coastal wetland (≤5 km from the coast) asset areas (Department of Environment and Heritage Protection (DEHP) 2014) were used to estimate the relative value in terms of asset area for the FBA NRM region (Table 2 and Figure 5). These data are described in detail in the Marine Status Supporting Summary — note that the Marine Status Report refers to all wetland areas, not just coastal wetland areas.

Table 2. Estimated non-monetary contribution (km^2) of key environmental assets to the total asset area of the FBA NRM region of the Great Barrier Reef. Source: DEHP 2014.

NRM Region	Reef	Seagrass	Coastal Wetland	Total	Rank
Cape York	10,353.6	11,377.8	1,407.2	23138.6	1
Wet Tropics	2,426.6	4,867.6	748.9	8043.1	4
Burdekin	2,965.4	6,083.2	945.7	9994.3	3
Mackay-Whitsunday	3,212.2	430.2	612.5	4254.8	6
Fitzroy	4,854.8	5,774.7	1,848.2	12477.7	2
Burnett-Mary	322.7	9,209.3	539.3	10071.4	5
Total	**24,135.3**	**37,742.8**	**6,101.8**	**67,979.9**	



A **B**

Figure 5. A. Estimated non-monetary contribution (km^2) of key environmental assets to the total asset area of the FBA NRM region of the Great Barrier Reef. B. Regional distribution of estimated non-market value as a function of total asset area (km^2). Source: DEHP 2014.

The most extensive ecological asset in the region is seagrass habitat, which represents 46 % of the total asset area for the region. Interestingly, wetlands comprise 15 % of the total measured asset value, but represent the largest contribution to total GBR wetland area (30%). Of the 44,477 km^2 of key habitat mapped in the GBR NRM regions 8,096 km^2 (18 %) is associated with the FBA NRM region. The FBA NRM region has the second-largest total asset area in the GBR mapped for this project.

2.2. Market values

The monetary (market) value of ecosystem benefits provided by coral reefs and coastal systems globally has been estimated to be worth over 2 billion (international) dollars per hectare per year (de Groot et al. 2012). Estimates of economic value for the GBR reveal the significance of this asset at the national level. For example, an early study assessed the present value of the GBR at approximately 4.7 % of Australia's annual (2007–08) gross domestic product (Oxford Economics 2009).

More recently, the direct economic contribution of the key reef-dependent industries was estimated at just over AUD7 billion, of which tourism contributed approximately AUD6.4 billion, recreation AUD330 million, and commercial fishing AUD190 million (Deloitte Access Economics 2013). Tourism is a substantial industry in GBR regions. Snapshots of tourism economics studies reveal the breadth and diversity of the ecological structures and processes that support it. For example, Stoeckl et al. (2010) report that each year, live-aboard dive boats are directly responsible for generating at least AUD16 million worth of income in the Cairns-Port Douglas region. Similarly, the annual value of tourism expenditure exclusively attributable to whale-watching in Hervey Bay is over AUD7 million per year, and over one season approximately AUD30 million is injected into the region each year, including indirect and employment values (Knowles & Campbell 2011; Wilson & Tisdell 2003).

The total recreational value of Australian coral reefs, including recreational fishing, is approximately USD120 per visitor (Brander et al. 2007). The fishing component of recreational reef trips can be significant. For example, Prayaga et al. (2010) calculated the consumer surplus per trip on the Capricorn Coast at AUD385.34 per (group) trip, or approximately AUD5.53 million for this region of the GBR alone. Similarly, earlier work by Fenton & Marshall (2001a) reveals the total annual gross value of production (GVP) for GBR charter fishing tourism businesses was approximately AUD23 million. The same project showed that annual GVP for commercial fishing businesses at that time was ten-fold more, at AUD224 million (Fenton & Marshall 2001b).

Like tourism, commercial fishing in the GBR is diverse, and many species are dependent on seagrass meadows for substantial parts of their life cycle. Although few studies have examined the economic contribution of GBR seagrass meadows to fishery values, the loss in 1995–96 of 12,700 ha of seagrass meadows in Australia has been associated with losses to fishery production of approximately AUD235,000 (McArthur & Boland 2006). In contrast, international estimates have valued the provision of mangrove wood and fish nursery areas by mangroves and seagrass meadows at USD215,000 per hectare (Thorhaug 1990).

A purely financial-economic approach can be taken, whereby each region is allocated value reflecting the contribution that each makes to the total monetary value of the GBR (Deloitte Access Economics 2013). Monetary values derived from commercial activity may be the simplest type of economic value both to directly quantify and also to apply in cost-benefit analyses for management prioritisation planning.

2.2.1 Direct and indirect economic contributions

The tourist, commercial fishing and recreation sectors are the largest industry sectors undertaking commercial activities that are directly dependent upon the status and composition of the GBR. Reliable economic data are available for these sectors and these data have been summarised for the GBR on previous occasions, the most recent update was produced by Deloitte Access Economics (DAE) in 2013. These values include direct expenditure as well as indirect monetary benefits that flow on to the rest of the economy via the multiplier effect. A brief explanation of the figures that were used from DAE (2013) follows, then the regional value breakdowns are presented.

Direct economic contributions occur when money is initially spent within a sector, e.g. for salaries, supplies, raw materials and operating expenses. This initial spending creates additional business-to-business supply-chain transactions; business that benefits from the initial spend will spend more on other businesses. These values are calculated using multipliers derived from national input-output tables, and this is the approach used in DAE (2013) to calculate the economic contribution of the GBR.

Induced economic contributions are a third type of impact, and can occur when businesses experiencing direct and indirect benefits increase payroll expenditures (e.g. by increased hiring, payroll hours, salaries etc.), increasing both personal income levels and household-to-business expenditure activity. Induced economic contributions are not considered in this report. The direct tourism demand is, for example, the price of the traveller's meal; whereas the indirect tourism demand generated from the purchase of the meal is the value of intermediate inputs such as the electricity for cooking and the production of meat and vegetables (Tourism Research Australia (TRA) 2013).

To avoid double-counting, direct value-added contributions are calculated as the value of direct outputs expenditures (meal prices) minus the value of inputs required to create them (the electricity and meal ingredients). That is, the direct contribution is the value-added generated in the restaurant sector. This report uses the value-added and indirect estimates of economic contributions reported by DAE and updates them with regionally relevant information to increase their accuracy. In this report, regional breakdowns are presented for each of the industry sectors reported in DAE (2013), and updates and refinements to sectoral or regional estimates are described in corresponding 'adjustment' sections.

2.2.2 Issues with existing market valuations

The 2013 DAE report finds that the total value-added economic contribution (in 2012) by industries reliant on some aspect of the GBR to be AUD5.7 billion, the Wet Tropics contributing roughly 40% of total GBR direct value-add contributions (Table3).

Table 3. Total economic contribution of reef-dependent commercial activity to the Australian economy (AUD millions in 2012). (Adapted from DAE 2013)

Region	Value-add
Direct	
Tourism, commercial fishing and recreation activity	
Torres Strait	1.2
Cape York	106.9
Wet Tropics	1,213.3
Burdekin	524.2
Mackay-Whitsunday	489.0
Fitzroy	515.7
Burnett-Mary	267.0
Scientific research and management	
All regions	50.2
Total direct value-add	***50.26***
Indirect	
GBR catchments	1,226.3
Rest of Queensland	192.7
Rest of Australia	1,091.1
Total indirect	***2,510.16***
Total economic contribution	***5,677.8***

Although economic contribution figures are provided at the industry level for each region elsewhere in that report, several issues prevent the DAE (2013) figures being immediately and directly applied within current the WQIP process. These issues will be briefly introduced, and the means by which the existing data can be used to develop and accommodate economic values assessments for purposes of WQIP prioritisation planning will be described.

It is important to bear in mind that although dollar estimates of regional value across industries are useful for regional-level planning, inter-regional comparison of relative value are also important for GBR-wide planning. For these decisions to be made, a consistent estimate of total GBR value must be developed from which relative values can be calculated and consistently compared. This supporting study addresses several shortcomings and misalignments between the DAE report and the WQIP requirements, to develop revised monetary value estimates for the GBR and its regions. These adjustments are as follows.

1. The WQIPs do not consider economic contributions from science and management as relevant to management planning prioritisation. Thus, for WQIP purposes, these values must be excluded from regional and total value estimates.
2. Torres Strait is not part of the GBR for WQIP purposes and must be excluded from regional and total value estimates.
3. Economic contributions from tourism, commercial fishing and recreational activities undertaken in coastal and marine areas of the GBR adjacent to the Burnett-Mary region, but outside the Great Barrier Reef Marine Park (GBRMP) boundary, are excluded from the DAE

(2013) estimates. The commercial economic values of these areas are relevant to WQIP processes and must be included in regional and total value estimates.

4. A more comprehensive account of the reef-based component of tourism commercial value in the Great Barrier Reef catchments.
5. East versus west Cape York adjustment. The commercial economic values of activities undertaken in western Cape York Peninsula catchments and/or dependent on Gulf of Carpentaria coastal and marine ecosystems are not relevant to WQIP processes and must be excluded in regional and total value estimates.

2.2.3 Valuation of reef-based tourism

The regional contribution to total GBR value as reported by DAE (2013) can be directly applied to the commercial fishing and recreation sectors, but similar breakdowns for reef-based tourism are not readily available. The tourism values in the DAE (2013) report were collected from tourists who visited anywhere in the GBR catchment area, and were not restricted to reef-based tourism activity.

Table 4. Tourism total economic contribution to the Australian economy (direct value-add plus indirect) by GBR NRM. (Adapted from DAE 2013)

Region	AUD millions 2011-12
Cape York	83.7
Wet Tropics	1173.4
Burdekin	472.7
Mackay-Whitsunday	460.5
Fitzroy	478
Burnett-Mary	230.3
Total direct value-add	*2,898.6*
Indirect to GBR catchments	1,127.6
Indirect to rest of Queensland	172
Indirect to rest of Australia	976.7
Total indirect	*2,276.3*
Total economic contribution to Australia	**5,174.9**

This report is concerned with the value of the Great Barrier Reef Marine Park as an entity separate from adjacent or connected (e.g. catchment) systems. For first-time visitors, rainforest destinations are almost as important as the reef (Prideaux 2013), and many visitors to the GBR regions generally undertake non-reef activities (Koo et al. 2010). Although DAE (2013) also estimates the economic contribution that can be attributed purely to reef-related tourism, estimates used are based entirely on reef tourism activity that is subject to the Environmental Management Charge and recommends further analysis to account for the additional 2.3 million passenger transfers to islands for which sufficient expenditure data are not available (DAE 2013). Although the full scope of recommendations for improving reef-related tourism estimates cannot be implemented in this supporting study (refer to DAE for detail), an interim improvement can be implemented by considering previous reports that of the tourists who visit the GBR catchments. Of those, 15.8% visit the GBR (GBRMPA 2009), and invoking two assumption that, given that 84% of tourists in the regions *don't* visit the reef, of the tourists who *do* visit the reef, 25% would come to the region anyway, even in the absence of the reef (D. Pannell 2015 pers. comm.).

These assumptions can be expressed mathematically and applied to the economic contribution of total tourism from DAE (2013), such that:

- if the total economic contribution of GBR catchment and reef tourism = x , and
- if it is assumed that, on average, reef tourists spend the same amount in total as regional non-reef tourists, then the value of reef-dependent tourism (y) can be calculated as per Equation 1:

Equation 1: $$\boldsymbol{y = (x \times 0.158) \times 0.75}$$

Application of Equation 1 produces an estimated total (direct value-add and indirect) economic contribution of reef-dependent tourism to the entire GBR of AUD613.2 million per year.

The regional contributions to this value were distributed to regions in proportion to regional reef-related tourism expenditure calculated from 2012 Environmental Management Charge data (Tables 5 and 6).

Table 5. Reef tourism expenditure (AUD million) estimates from 2012 EMC data. (From DAE 2013)

EMC regions	AUDm/year
Far North	1.2
Cairns	235.9
Cooktown	8.8
Townsville	19.4
Whitsundays	179.5
Mackay-Capricorn	36.5

Table 6. Redistribution of estimated total economic contribution of reef-dependent tourism (AUD613.2 million) to align with the regional distribution of EMC expenditure data (see Table 5)

EMC region	NRM Region	Expenditure (AUDm/year)	% total GBR	Relative contribution (AUDm/year)
Far North Cooktown	Cape York	10.0	0.021	12.7
Cairns	Wet Tropics	235.9	0.490	300.6
Townsville	Burdekin	19.4	0.040	24.7
Whitsunday Mackay-Capricorn	Mackay-Whitsunday	191.7	0.398	244.2
Mackay-Capricorn	Fitzroy	12.2	0.025	15.5
	Burnett-Mary	12.2	0.025	15.5
			Total	**613.2**

2.3 Extension of Burnett-Mary region south of the GBRMP boundary

Reef-specific tourism, commercial fishing and recreational values arising from activities undertaken in coastal and marine waterways adjacent to the Burnett-Mary region that lie outside the GBRMP boundary are excluded from the DAE (2013) estimates. Regional comparisons that fail to account for the marine and coastal values of these waterways of the Burnett-Mary will be therefore invalid. To address this problem, additional commercial economic values of the Burnett-Mary, as published in the peer-reviewed literature, were used to adjust the values from the DAE (2013) report.

2.3.1 Reef-based tourism

Two data sets were identified for which relatively recent comparative direct expenditure (but not value-added) tourism data are available. The first comprises wildlife-based tourism at Hervey Bay and Mon Repos, to watch whales and nesting sea turtles, respectively, and the second refers to charter fishing activity.

Knowles and Campbell (2011) used data collected by Wilson and Tisdell (2003), O'Connor et al. (2009) and Stoeckl et al. (2005) to estimate the tourism value of whale-watching. They report the annual value of tourism expenditure that can be exclusively attributable to whale-watching in Hervey Bay to be at least AUD7.2 million per year (Knowles & Campbell 2011). Similar analysis for the Mon Repos rookery indicates total expenditure that can be exclusively attributable to sea turtle viewing is approximately AUD833,000 per season, and the total expenditure in the region during the season is approximately AUD2.7 million (Wilson & Tisdell 2003). Collectively, the sea turtle and whale-watching activities in the region contribute an estimated AUD9.9 million expenditure to the region each year.

An additional source of commercial tourism is the charter fishing industry. Data collected by Fenton and Marshall (2001b) in 1999–2000 indicate that the annual total gross value of production for charter fishing tour operations in Hervey Bay was approximately AUD1.9 million (Fenton & Marshall 2001b). Currency rates were not adjusted to current values.

The literature reports suggest that the failure to include the southern range of the Burnett-Mary NRM region of the GBR under-estimates the economic contribution of reef-dependent tourism expenditures by at least AUD11.5 million per year. Converted to value-add, this means an additional AUD5.2 million per year can be added to the total economic expenditure estimates for the Burnett-Mary region presented in Table 6.

Reef-specific tourism values for the Burnett-Mary region were increased by AUD5.2 million to AUD20.7 million per year. This estimate accounts for additional direct value from whale-watching in Hervey Bay (AUD7.2 million), visitation to the Mon Repos turtle rookery (AUD2.7 million), and charter fishing (AUD1.9 million) expenditures converted to value-add. This adjustment does not include indirect economic contributions, thus is considered a conservation estimate of the total economic contribution of reef-dependent tourism activity in this region.

2.3.2 Recreation

DAE (2013) defines recreational contributions as expenditures generated by locals through the activities of fishing, boating, sailing and visiting an island. Locals were defined as "households within the Reef catchment, other than those in the following LGAs [local government areas], which were deemed as far enough away from the Reef to be classified as tourists: Central highlands; Banana; North Burnett; Cherbourg; and South Burnett." (DAE 2013)

Trip-related expenditure for households within the World Heritage Area was derived from Rolfe et al. (2011), and expenditure on recreational equipment was sourced from the Australian Bureau of Statistics Household Expenditure Survey 2009–10 (ABS cat. no. 6530.0). Data collated by Rolfe et al. (2011) exclude recreation activities undertaken from catchment areas south of Bargara in the Burnett-Mary region, that is, areas that are not directly adjacent to waterways within the GBRMP boundary were excluded. The waterways of the Great Sandy Strait and Hervey Bay — adjacent to the Burnett-Mary region but outside the boundary of the GBRMP — are among the most intensively recreationally fished areas on the Queensland coast (Fisheries Research and Development Corporation (FRDC) 2013). Consequently, the economic recreational value of the Burnett-Mary region is likely to be significantly underestimated by the DAE (2013) figures, shown in Table 7.

Table 7. Total contribution of GBR-dependent recreation to the Australian economy (direct value-add plus indirect), by NRM unadjusted for the entire Burnett-Mary area. (Adapted from DAE 2013)

Region	AUD millions 2011–12
Cape York	3.1
Wet Tropics	57.7
Burdekin	53.3
Mackay-Whitsunday	28.6
Fitzroy	40.2
Burnett-Mary	60.3
Total economic contribution to Australia	**243.2**

Although Prayaga et al. (2010) report that recreational fishing trips contribute approximately AUD5.5 million per year to the Capricorn Coast, most of the data used in the study were collected from the Rosslyn Bay boat ramp, near Yeppoon. Although the boat ramp is located in an excised portion of the GBRMP, the waterway that this location provides access to is largely within the GBRMP boundary, and therefore may have been used in the recreational value estimates reported in DAE (2013). Monetary valuation studies of recreational activities directly and unambiguously attributable to the Great Sandy Strait and/or Hervey Bay waterways of the Burnett-Mary region could not be located.

Recreation values for the Burnett-Mary region were not adjusted and remain at AUD60.3 million per year.

2.3.3 Commercial fishing

DAE (2013) estimates commercial fishing as the gross value product (2010–11) of line, pot, net and trawl fisheries, harvest, and aquaculture. The value-add contribution to the GBR estimated in DAE (2013) is presented in Table 8.

The total annual gross value of production for commercial fishing businesses in 1999–2000 was AUD19.9 million (Fenton & Marshall 2001a). Expressed in 2011–12 dollars (AUD28.9 million; ABS 2015), and converted to value-add using the multiplies reported in DAE (2013; 0.483), an additional AUD14.0 million in economic market value can be attributed to the Burnett-Mary region, and the GBR as a whole.

Commercial fishing values for the Burnett-Mary region were increased by AUD14.0 million to AUD23.9 million per year. This adjustment does not include indirect economic contributions, thus is considered a conservation estimate of the total economic contribution of reef-dependent commercial fishery activity in this region.

Table 8. Total economic contribution of GBR-dependent commercial fisheries to the Australian economy (direct value-add plus indirect), by NRM unadjusted for the entire Burnett-Mary area. (Adapted from DAE 2013)

Region	AUD millions 2011–12
Cape York	37.4
Wet Tropics	17.9
Burdekin	41.9
Mackay-Whitsunday	23.9
Fitzroy	29.5
Burnett-Mary	9.9
Total economic contribution to Australia	**160.5**

2.4 Exclusion of economic activity within Western Cape York Peninsula and the Gulf of Carpentaria

Figure 6. Eastern Cape York Peninsula and Great Barrier Reef Marine Park. (From Reef Plan 2014)

Cape York Peninsula is the only region in the Great Barrier Reef Catchments that drains to a marine region other than the GBR. Data and statistics for environmental assets and economic values in the Cape York NRM region are typically not reported separately for eastward- and westward-draining catchments. Neither the DAE report (2013) nor its predecessor (GBRMP 2009) disaggregate eastern Cape York Peninsula from western Cape York Peninsula economic values.

It should be noted that very little economic data is available for the Cape York Peninsula region (EcoSustainAbility 2012).

2.4.1 Reef-based tourism

The Cape York Peninsula Visitors Survey provides a breakdown of visitation rates reported as across the percentage of visitors responding to the survey at each important tourist location (Queensland Tourism 2002). These data were disaggregated into eastern and western catchments (D. Audas 2015 pers. comm.), and the total number of visits was calculated (Table 9).

Based on these data, locations in eastern Cape York Peninsula receive 53% of the region’s tourism. In the absence of data to the contrary it is reasonable to assume that the same east-west ratio applies for all types of tourism, including reef tourism.

Table 9. Visitation rates to eastern and western Cape York Peninsula (from Queensland Tourism 2002)

Location *	Respondents	Drainage	% visitors	Number of visits
Mt Carbine	19	Western	5	1
Palmer River	29	Western	8	2
Lakeland	130	Eastern	34	44
Laura	110	Eastern	29	32
Hann River	84	Eastern	22	18
Musgrave Roadhouse	204	Western	54	110
Coen	225	Western	59	133
Archer River	252	Western	66	166
Weipa	247	Western	65	161
Moreton Telegraph Station	132	Western	35	46
Heathlands	47	Western	12	6
Bamaga	217	Western	57	124
Injinoo	15	Western	4	1
Seisia	243	Western	64	156
Umagico	15	Western	4	1
Punsand Bayn	162	Western	43	70
Pajinka	29	Western	8	2
Cooktown	239	Eastern	63	151
Lockart River	44	Eastern	12	5
Aurukun	2	Western	1	0
Pormuraaw	3	Western	1	0

Cape York Peninsula tourism data were adjusted by a factor of 0.53 to derive the adjusted market value AUD6.8 million per year of reef-dependent tourism activity to the GBR.

2.4.2 Recreation

Recreational fishing is a substantial contributor to Cape York's economic value (Donald 2012); however, no reports or data could be located that allow the relative contribution of GBR-based activities versus those undertaken in the Gulf of Carpentaria. No adjustment factors are currently available to disaggregate eastern from western Cape York Peninsula recreation value.

2.4.3 Commercial fishing

Commercial fisheries that operate in this region include the East Coast Trawl Fishery, the Northern Prawn Fishery, and set net fisheries for barramundi and threadfin salmon. Cape York Peninsula fish stocks are managed through the Queensland Fisheries Management Authority, advised by the Far North Queensland and the Gulf of Carpentaria Zonal Advisory Committee and similar committees

(Kleinhardt Business Consultants (KBC) 2007). Data on relative contribution of eastern and western fishery activities were not readily available at the time of writing; however, these management agencies should be approached in future value estimations to account for these discrepancies. No adjustment factors are currently available to disaggregate eastern from western Cape York Peninsula commercial fishery value.

2.5 Monetisation of non-market value estimates

The DAE (2013) report does not provide monetised non-market value estimates for the GBR. Non-use values of the land and water resources of the GBR are more important than use values and, as such, any estimation of NRM improvement must include these values (Windle & Rolfe 2006).

The Windle & Rolfe (2006) study provides a range of non-market value estimates by households for improvements in NRM outcomes similar to those that would be achieved via implementation of WQIP management actions. Value estimates for each 1% improvement in resource condition ranged between AUD4.64 and AUD6.62 for the three improvement categories examined. Using these figures as an approximate guide, non-market values were subjectively estimated as AUD10 per person per year, equating to a present value of AUD193 over 50 years for every person in Australia (i.e. 22.7 million people). This gives a total non-market value of AUD227 million per year.

Non-market monetary value was distributed across regions in proportion to each region's total asset area to derive a monetary non-market value estimate per region, as shown in **Error! Reference ource not found.**. This approach essentially generates a blanket non-market value of AUD3,154 per year, for each km^2 of coral reef, seagrass or coastal wetland assets mapped in the GBR. It is unlikely that each habitat is valued equally by all of those who experience it. Further research is required to determine whether these assumptions are supported by the available data.

2.6 Total monetary value estimates

The total market value estimated for the Fitzroy NRM region is AUD85 million per year. Of this, a little over 47% derives from recreational activities (Table 10 and Figure 7). Overall, the Fitzroy NRM region contributes approximately 8% of the estimated total monetary (market) value of the GBR (AUD1030 million per year). If regionally-specific estimates were not achievable, and the value estimate for the entire GBR was distributed equally to all regions (AUD1030 million per year), the monetary value estimate for the Fitzroy NRM region would be AUD171 million per year.

Table 10. Monetary value estimates (AUD million per year) and ranks for Great Barrier Reef NRM regions. Adapted from DAE (2013) and others as described in the text. Refer to the original documents for detail.

Region	Reef tourism	Commercial fishing	Recreation	Total	Rank
Cape York	6.8	37.4	3.1	124.6	6
Wet Tropics	300.6	17.9	57.7	403.0	1
Burdekin	24.7	41.9	53.3	153.3	3
Mackay-Whitsunday	244.2	23.9	28.6	310.9	2
Fitzroy	15.5	29.5	40.2	126.9	5
Burnett-Mary	20.7	23.8	60.3	138.4	4
Total	**612.4**	**174.5**	**243.2**	**1257.1**	

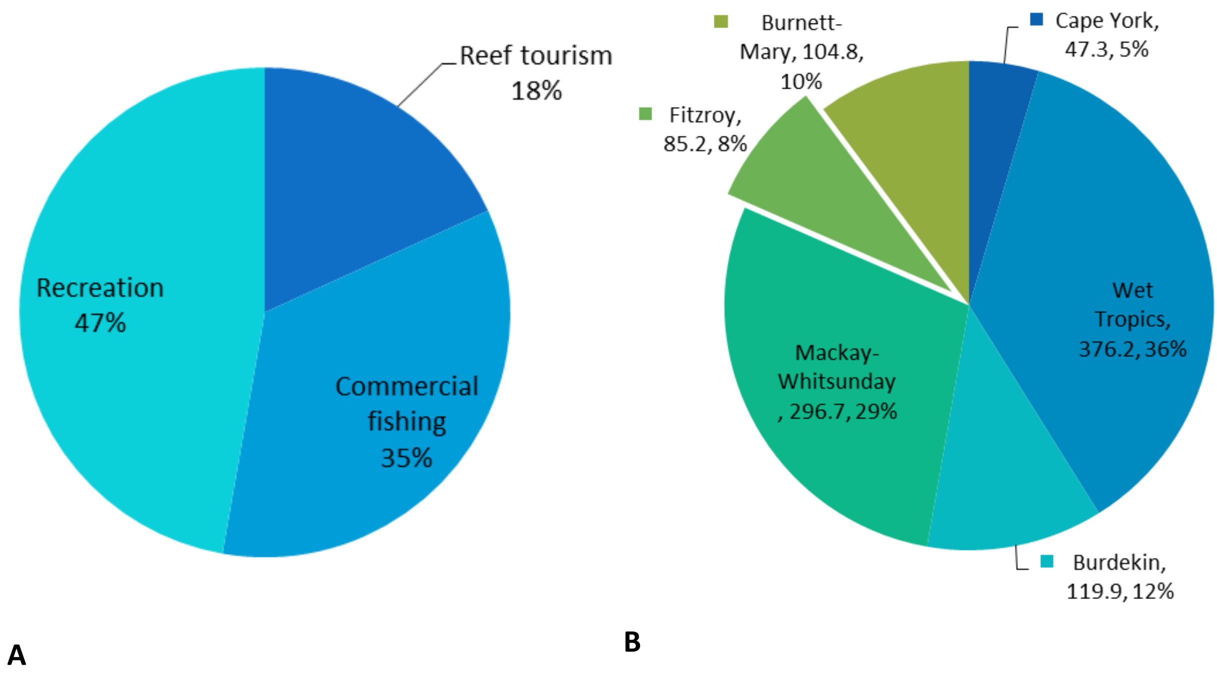


Figure 7. A. The relative contribution of key reef industries to total market value estimate for the FBA NRM region. B. The estimated monetary contribution (AUD million per year) of the FBA NRM Region to the total monetary value of the GBR. From DAE (2013) and others as described in the text. Refer to the original documents for detail.

Including monetised non-market value estimates into the total monetary value estimate increases the total estimated monetary value of the FBA NRM region from AUD85 million per year to AUD127 million per year (Table 11 and Figure 8). The Fitzroy region non-market values comprise 18% of the total non-market value estimates for the GBR (**Error! Reference source not found.**), and 33 % AUD41 million per year) of the total estimated monetary value for the FBA NRM region, and 10 % of the total monetary value of the GBR. Given that the FBA NRM region has the second-largest non-market contribution to the GBR, it is likely that this region will benefit from further and improved non-market valuation studies for its reef assets.

Table 11. Market and non-market monetary value estimates for GBR NRM regions. Adapted from DAE (2013) and others as described in the text. Refer to the original documents for detail.

Region	Market value	Non-market value	Total monetary value	Rank
Cape York	47	90	137	5
Wet Tropics	376	25	401	1
Burdekin	120	19	139	3
Mackay-Whitsunday	297	18	315	2
Fitzroy	85	41	127	6
Burnett-Mary	105	34	139	4
Total	**1,030**	**227**	**1,257**	

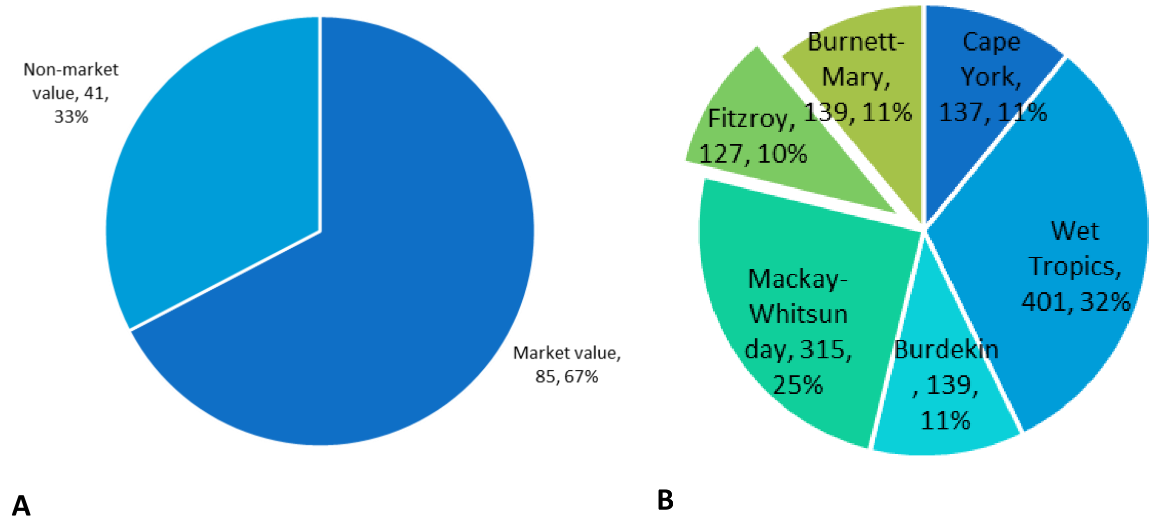


Figure 8. A. Relative contribution of market and non-market monetary value estimates (AUD million per year) to the total monetary value estimate for the FBA NRM region. B. Estimated contribution of monetised non-market value (AUD million per year) of NRM regions to the total monetary value of the GBR. (From DAE (2013) and others as described in the text. Refer to the original documents for detail.)

3. Gaps

- The approach used to monetise non-market value essentially generates a blanket non-market value of AUD3154 per year, for each km^2 of coral reef, seagrass or coastal wetland assets mapped in the GBR. It is unlikely that each habitat is valued equally by all of those who experience it, e.g. highly modified wetlands are valued the same as lacustrine wetlands. Further research is required to improve these estimates.

- In the absence of an agreed estimate, or process for estimating, monetised non-market values, subjective estimates were adapted from the most relevant recent literature as an approximate guide. These values will change depending on the assumptions used in specific valuations studies. Given the relative importance of non-market values to the Fitzroy region, the region will likely benefit from improved non-market valuation estimates in the future.
- Cultural and spiritual values have not been explicitly addressed in this report and are unlikely to have been comprehensively captured in the reported non-market value estimate. These are important values and should be taken into account in future iterations.
- Values have not been developed for system repair activities. This report focusses on protection of reef assets rather than repair; however, in some cases where mitigation and repair cannot be avoided economic value will be useful information in determining catchment priorities.
- Many economic values associated with coral reef systems, for example natural shoreline protection, could not be analysed in this report. These values are important and should be considered in future iterations.
- Economic valuation approaches that are conducted outside a beneficiary-based ecosystems services framework are unlikely to provide a full range of estimates that are useful for decision making, or adequately prevent double-counting. The following recommendations address this issue in detail.

4. Recommendations

Strategic and integrated assessment of human impact on the marine environment is becoming increasingly important (Börger et al. 2013). The ecosystem-based approach, which takes account of environmental, social and economic factors, is a critical aspect of marine planning in the United Kingdom and United States of America (Börger et al. 2013). In the marine environment, the focus on the management of *places* is one of the key features of ecosystem-based frameworks, and represents “a marked departure from existing approaches that usually focus on a single species, sector, activity or concern” (Potschin & Haines-Young 2013).

Different ecosystems and their components exhibit interdependencies across scales, requiring decision makers to make trade-offs across ecosystem services, benefits and beneficiaries (Granek et al. 2010; Maguire et al. 2012; Pittock et al. 2012). By providing a common set of details and a common process for measurement, the ecosystem services concept can provide a common language for ecosystem-based management decision processes across diverse beneficiaries (Granek et al. 2010).

Estimating the provision of ecosystem services under alternative management scenarios offers a systematic way to incorporate biogeophysical and socioeconomic information and the views of individuals and groups in the policy and management process (Figure 9; Granek et al. 2010). Ecosystem service values could be used to provide objective and transparent data and a framework to help decision makers track how management alternatives can, and do, affect marine ecosystems (and ultimately, people), and what changes are most important from economic, ecological and social perspectives (Börger et al. 2013). By assessing how current ecosystem service delivery could respond to alternative or status quo land use and management practice regimes, ecosystem services analysis can help avoid unintended social and ecological consequences (Brauman et al. 2014; Thomas et al. 2012).

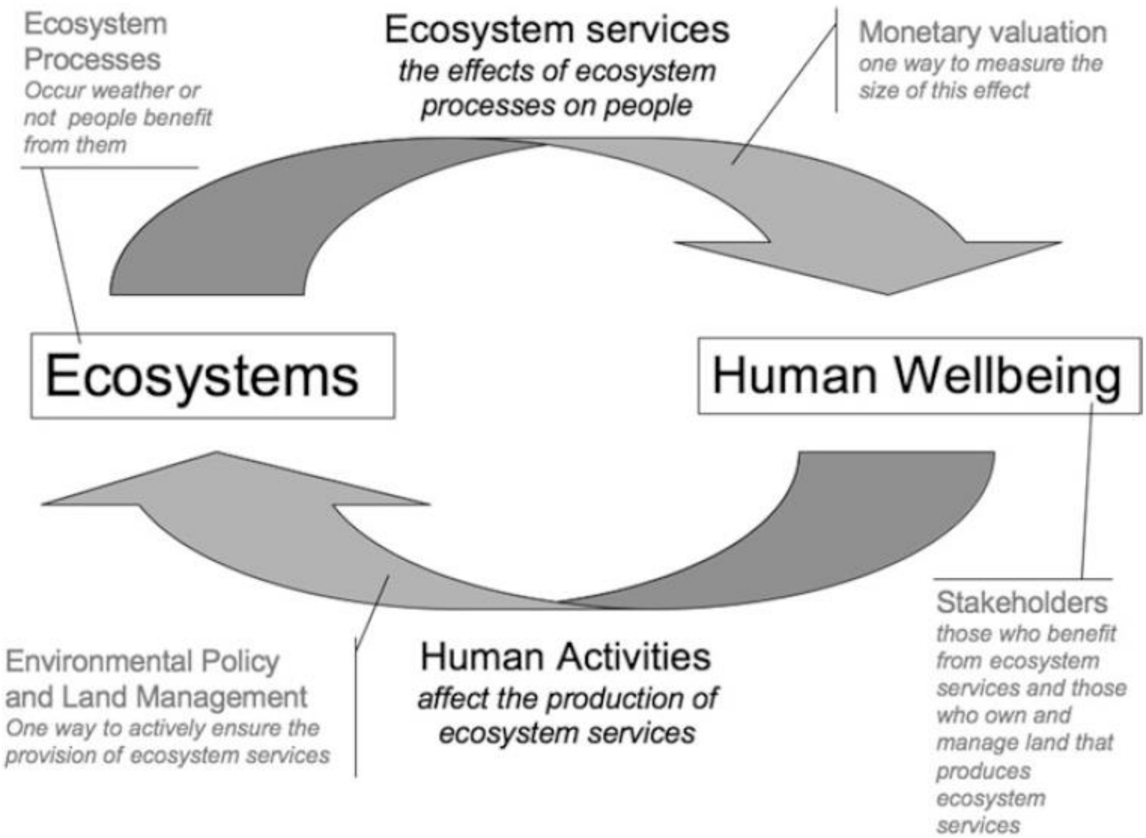


Figure 9. The ecosystem services concept provides an organising framework for considering the relationships between ecosystems and their beneficiaries. (From Brauman et al. 2014)

4.1. Ecosystem services in marine policy and planning

The current driving role of ecosystem service frameworks in United States and European Union agricultural policy suggests the concept will have increasing influence in shaping environmental policy internationally (Matzdorf & Meyer 2014). The strengths of the ecosystem services framework for policy makers are mainly conceptual, such as cross-sectoral cooperation, a landscape-scale focus, and explicit consideration of win-win and trade-off objectives (Matzdorf & Meyer 2014). The main weaknesses of the framework are operational, particularly with respect to ecosystem service valuation processes (Matzdorf & Meyer 2014).

Although restricted to an assessment of market-based policies, Matzdorf & Meyer (2014) provide guidance to defining an 'ideal' ecosystem services policy. They suggest four conditions must be met.

1. **Ecosystem capacity**: focus on the capacity of the ecosystem to maintain or enhance the supply of goods and services
2. **Socio-economic assessment**: goals will be determined by the economic and social benefits derived from natural processes and structures
3. **Environmental trade-offs and sectoral collaboration**: consider the inter-relationships and trade-offs between environmental objectives, and foster the cross-sectoral collaborations required to make these trade-offs
4. **Financial incentive programs**: focus on beneficiary demand and implementation of financial incentives including, but independent from, monetary valuation

Application of the ecosystem service concept globally appears to be most highly developed in the arena of water policy, for example in the European Water Framework Directive (Matzdorf & Meyer 2014). In Australia the concepts, frameworks and language of the ecosystem services paradigm have been used extensively by governments and non-governments to describe the dependence of humans on ecosystems; however, a lack of effective strategic frameworks, goals and leadership has hampered the realisation of expected achievements (Pittock et al. 2012).

Despite this, strategic application of the ecosystem services concept is credited as instrumental in shifting the focus of governance from individual reefs to regional seascapes in the GBR (Olsson et al. 2008) despite limited understanding of the processes supporting the social-ecological system (Bohensky et al. 2011; Stoeckl et al. 2011; Thomas et al. 2012). Generally, the approach by GBRMPA appears to somewhat satisfy conditions 1 and 3, and progress towards condition 2 is being addressed in efforts such as the Social and Economic Long-Term Monitoring Programme for the Great Barrier Reef catchments. On the whole, policies to support and maintain the development and implementation of a strategic ecosystem services framework for the GBRMP are likely to see continued future investment.

The mainstreaming of ecosystem services concepts into strategic policy and planning processes requires that a suitable framework be available (Potschin & Haines-Young 2013). Effective ecosystem service frameworks are essential to provide consistent, structured, multidisciplinary and collaborative processes for identifying and applying useful knowledge about the relationships between ecosystem processes, services and beneficiaries (Cowling et al. 2008).

Programs that attempt to manage multiple values across multiple jurisdictions will do well to consider the full range of ecosystem services, benefits and beneficiaries and the processes that support them, as a process for informing planning, and ensure participants in the process have clear expectations of what can be achieved (Pittock et al. 2012). Nahlik et al. (2012) propose that, although ecosystem service frameworks will necessarily differ in the detail of how they meet specific objectives, successful frameworks will share the following attributes.

1. **A conceptual framework**: at minimum, a definition the ecosystem service concept being applied and a classification system for identifying and categorising services
2. **A trans-disciplinary approach**: the language, concepts and methods used within the framework should be accessible to all relevant disciplines and audiences
3. **Community engagement**: individuals, groups and firms with an interest in the ecosystem should be involved in service identification and/or valuation to facilitate legitimacy
4. **Flexibility**: the framework needs to have strategies that accommodate changing social attitudes, economies, environmental conditions and policy and management decisions
5. **Cohesion and coherence**: the framework needs to be conceptually sound, logically structured and feasible
6. **Policy relevance**: the framework should collect information that helps identify and inform potential ecological outcomes of policy and management decisions

The importance of these attributes is reiterated by Jax et al. (2013) and Figure 10, who state:

> *"Although there are … problems associated with the conceptualisation and use of the ecosystem services concept, many of them can be dealt with when it is clearly defined and by making explicit the specific aim, value dimensions under consideration, and possible trade-offs involved in specific decision- or policy-contexts. This can be achieved by adopting integrative perspectives that involve and balance different scientific disciplines and divergent stakeholder groups and perspectives. Different contexts and purposes entail different needs for the definition of ecosystem services, and these in turn have different ethical implications accompanying its use and influencing its usefulness."*

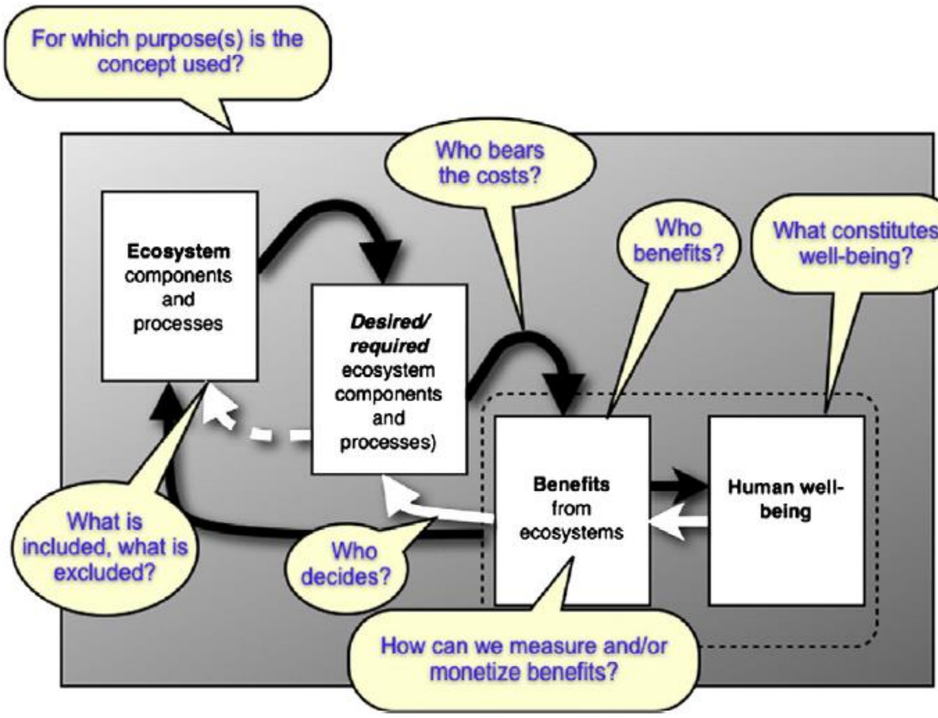


Figure 10. Considerations for applying the ecosystem service concept. Effects of ecosystem service provision to human well-being, and the effects of human use on ecosystems, are represented by black arrows. Societal choices about what counts as a service or benefit, and which ecosystem processes and components are desirable for promoting them, are represented by white arrows. The integration of societal preferences about values and choices with ecological information is achieved by posing questions about the different components of the ecosystem services concept, and how it should be applied. (From Jax et al. 2013)

Perhaps the best example of a policy-relevant, operational ecosystem service framework is the South East Queensland (SEQ) Ecosystem Services Framework (Maynard et al. 2010; Nahlik et al. 2012). This framework assesses 28 ecosystem services, and is established as the program for regional planning policy including State of the Region and other regional and local natural resource management reporting tools (Maynard et al. 2010). The SEQ framework comprises four hierarchical components for assessment, shown in **Error! Reference source not found.**, primarily derived from illennium Ecosystem Assessment (MEA) reporting structures (MEA 2005). Inter-relationships between adjacent components were captured in matrices with simple scores and supported by geographic information systems (GIS) mapping.

1. ecosystem reporting categories — adapted from MEA reporting categories
2. ecosystem functions — adapted from MEA categories of regulating, provisioning, supporting and cultural ecosystem services
3. ecosystem services — categorised as regulating, provisioning and cultural services
4. constituents of human well-being — developed from the MEA and categorised as existence, health, security, good social relations, and freedom of choice and action.

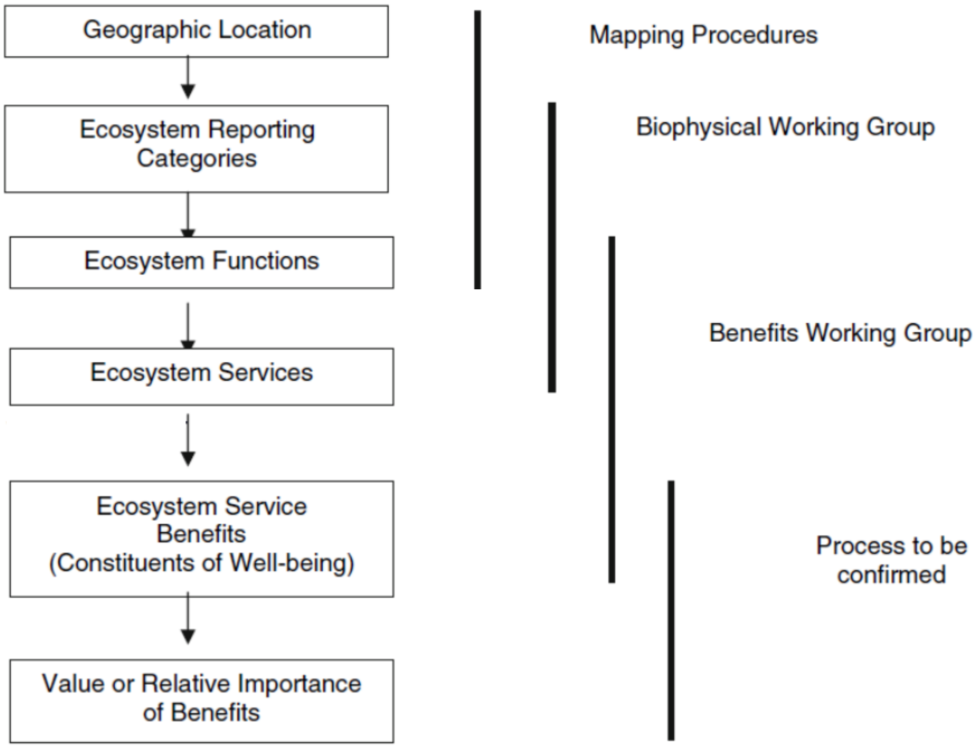


Figure 11. Processes and components of the SEQ Ecosystem Services Framework. Information about factors affecting service provision, such as socio-economic considerations, legislation and community values and preferences need to be added by users separately. (From Maynard et al. (2010)

4.2 Ecosystem services for WQIPs: a preliminary analysis

Clear and precise definitions of ecosystem services are important for comparing or combining ecosystem research across teams, contexts and studies (Ringold et al. 2013). That said, ecosystem services must also be defined in way that is consistent with the decision- or policy-context (Boyd & Krupnick 2013). For the purposes of the Fitzroy Region WQIP, ecosystems services need to be defined in a way that facilitates their application to management prioritisation processes.

Consequently, for the purposes of this investigation, ecosystems services are defined as those aspects of an ecosystem (biophysical features, quantities and qualities) that actively or passively contribute to human well-being (Boyd 2007; Boyd & Banzhaf 2007; Boyd & Krupnick 2013; Fisher & Turner 2008; Ringold et al. 2013). More specifically, we define ecosystem services as final services. Final services are the things humans experience as a result of accessing a component of nature. Because ecosystem services are explicitly defined from a perspective of human values, they can be considered end-points of nature (Boyd & Banzhaf 2007). Many researchers describe advantages of defining ecosystem services as final, rather than intermediate, services (e.g. Boyd & Banzhaf 2007;

Boyd & Krupnick 2013; Cosier & McDonald 2010; Cosier & Sbrocchi 2013; Ringold et al. 2013). Most notably, these advantages are:

- encapsulation of the most appropriate features to be communicating about with beneficiaries
- application to social well-being analysis
- avoidance of double-counting
- application to environmental accounting applications
- application to cost-benefit analysis
- differentiation of service price from service quantity, allowing changes in each to be tracked.

In both common and scientific usage, concepts of ecosystem services and ecologically-derived economic benefit are often conflated (Principe et al. 2012). In contrast to services, *benefits* have a specific impact on human well-being, for example beautiful views, clean air, recreation, hazard avoidance and drinking water (Boyd 2007; Fisher & Turner 2008). Benefits often rely on and are created by the combination of final ecosystem services with additional inputs including time, human resources (skill), and capital (i.e. complementary) goods or services, as shown in Table 12 for recreational fishing and drinking water (Boyd 2007; Boyd & Banzhaf 2007; Fisher & Turner 2008).

Table 12. Identification of intermediate and final services is dependent on the benefit being valued. An individual final service may be instrumental for multiple benefits, and some benefits require complementary (non-ecosystem) goods and services to be available before they can be realised. (Adapted from Boyd & Banzhaf 2007; Fisher et al. 2009)

Intermediate services	Final services	Benefits	Complements
water quality safe for secondary contact **water quality** suitable for sustaining fish soil quality	the water body fish population riparian cover	recreational angling	access points, equipment
Wetlands riparian cover	**water quality** safe for human consumption	drinking water	infrastructure
Mangroves	storm protection	property protection	nil
coral reefs	storm protection	protection of livelihood assets	nil
upstream land cover Wetlands	natural stream flow **water quality** safe for secondary contact	Kayaking	access points, equipment
upstream land cover	natural stream flow	Irrigation	infrastructure
upstream land cover	natural stream flow	hydroelectric power	built capital

A downside of defining ecosystem services as final services is that information on quantity and price are often not wholly available, particularly for non-market services realised (i.e. benefits delivered) at the local scale. A second problem is that although double-counting is avoided, the intermediate services that support the realisation of final services are not explicitly acknowledged, but are instead embedded within the estimate of final service value (Brouwer et al. 2013). This problem could easily be remedied by providing additional documentation or conceptual models describing key dependencies between and/or ecological processes supporting intermediate and final services.

A beneficiary-based approach emphasises identification of spatially explicit, concrete beneficiary groups for modelling and valuation (Boyd & Banzhaf 2007; Fisher et al. 2008; Haines-Young & Potschin 2010; Nahlik et al. 2012). This approach is consistent with recommendations to identify consistent sets of "final ecosystem goods and services" (Johnston & Russell 2011; Nahlik et al. 2012). It also avoids the double-counting problem by considering ecosystem services to be only those processes that directly contribute to a benefit, and not those processes that indirectly support other benefits (Bagstad et al. 2013a).

4.1.1. Defining ecosystem services for application in WQIPs

Final ecosystem services can be explicitly identified for the WQIP in terms of the wants, needs and perceptions of human beneficiaries to create a range of potential benefits. Some basic types of benefits have been provided in Table 13.

Table 13. An example of how types of ecological benefits that can be realised from a local system might be defined to simplify the process of generating an inventory. (Adapted from Boyd and Banzhaf 2007)

Benefit types	Description
Harvests (commercial, traditional hunting)	Managed commercial, subsistence, traditional hunting, pharmaceutical
Amenities and fulfilment	Aesthetic, bequest / spiritual / emotional, and existence benefits
Coastal protection	Protecting property e.g., shoreline erosion, storm surge, flooding
Waste assimilation	Avoided disposal cost, e.g. waste dumping, dredge spoil disposal, sewage discharge, bilge discharge, runoff
Recreation - fishing, boating	Fishing, boating, swimming
Commercial Tourism	Fishing, diving, snorkelling, island resorts

Different beneficiaries may interact with different ecosystem components, and are thus accessing different ecosystem services, or different users may interact differently with the same ecosystem components, and are thus creating different service-benefit relationships (Ringold et al. 2013). Such benefit-dependency is a recognised characteristic of most of ecosystem service classification systems (Boyd & Banzhaf 2007; Fisher et al. 2009). To systematically develop a comprehensive inventory of benefit-dependent ecosystem services, a comprehensive benefits inventory is required. Following Ringold et al. (2013) beneficiary categories spanning monetary (market and non-market) and non-monetary (non-use) values can also be developed to help clarify ecosystem service components and identify how benefits can be distributed within and across systems.

These techniques were applied in a trial application of an ecosystem services approach for commercial reef-based tourism in the Fitzroy region. Appendix 1 provides a preliminary list of the likely coastal and marine ecosystem components that are providing ecosystem services in the region. This table was used to help generate the inventory of specific ecosystem services to commercial reef-based tourism that could be affected by a change in water quality and are important to track through time (Appendix 1). For example, water clarity (visibility), coral cover, coral diversity and coral reef structural complexity are all important determinants of tourist diver satisfaction and willingness to return. Trends in these characteristics could therefore be prognostic of future demand for tourism activity in affected regions.

To determine the relative values of goods and services, and how these values may change under alternative management decisions, the goods and services must be ranked, or quantified and aggregated (NRC 2005). In turn, the design of the valuation exercise must be dictated by the requirements of the decision context, which defines the purpose of valuation and how the valuation will be used in policy and management decision making (Boyd & Banzhaf 2007; Fisher et al. 2009; National Research Council 2005). WQIP processes require management decisions to be prioritised in terms of their implementation costs and likely consequences to the environment, the economy and society.

A comparative analysis of the decision support tools available for ecosystem-based management and ecosystem services assessment and/or valuation suggests that environmental valuation studies have a history of being ad hoc and unsystematic (Bagstad et al. 2013b). Continuation along this path will not equip scientists and managers to address the basic challenges required to incorporate ecosystem services values in marine planning.

5. Conclusion and Recommendations

This report applies a comprehensive approach to the economic estimation of regional contribution to the value of the GBR, drawing extensively upon and integrating existing literature. On the basis of this approach, the coastal and marine environmental assets of the Fitzroy Basin Association NRM region were estimated to contribute AUD127 million per year (or 10 % of total monetary value) to the GBR, mainly through reef tourism.

The approach used here has some limitations, which can be improved in future studies. Monetary valuations allow aggregation of ecosystem service values into total estimates that are easily comprehended by a wide range of stakeholders and that allow the like-for-like comparisons between multiple ecosystem services that are required in trade-off analysis. Monetary valuation is only one of several economic techniques for comparing ecosystem services. Processes that support trade-off analysis across monetary and non-monetary benefits can overcome the limitations of a single method of valuation (e.g. health or well-being indices) and the different economic perspectives of value that arise across stakeholders, contexts and scales of application.

Some aspects of ecosystem function — particularly at the whole-of-region ecosystem scale — are best assessed in terms of their proximity to tipping points and managed in terms of safe minimum standards. Systematic valuation processes customised for the decision context are considered current best practice. Outcomes of this study show that a comprehensive application of such a process is warranted.

There is substantial uncertainty associated with the habitat area estimates, particularly for seagrass, which changes dynamically and is monitored infrequently. Commercial value estimates also contain reasonable levels of uncertainty that primarily arise from two sources: the scarcity of reliable non-market value estimates for the GBR and regions; and a similar lack of information about environmental non-use values. The effect of these uncertainties on estimates of the relative contribution of regions to the value of the GBR is unknown. It is recommended that uncertainty analysis be integrated into future iterations.

6. References

Bagstad KJ, Johnson GW, Voigt B & Villa F (2013a) Spatial dynamics of ecosystem service flows: A comprehensive approach to quantifying actual services. Ecosystem Services 4:117-125.

Bagstad KJ, Semmens D, Waage S & Winthrop R (2013b) A comparative assessment of decision-support tools for ecosystem services quantification and valuation. Ecosystem Services 5:27-39.

Baker, R. & Ruting, B. (2014) Environmental policy analysis: A guide to non-market valuation. Productivity Commission Canberra.

Barbier, E.B., Hacker S.D., Kennedy C., Koch E.W., Stier A.C., et al., (2011) The value of estuarine and coastal ecosystem services. Ecological Monographs 81:169-193.

Bohensky E, Butler JRA, Costanza R, Bohnet I, et al., (2011) Future makers or future takers? A scenario analysis of climate change and the Great Barrier Reef. Global Environmental Change 21:876-893.

Börger T, Beaumont NJ, Pendleton L, Boyle KJ et al., (2013) Incorporating ecosystem services in marine planning: The role of valuation. Marine Policy 46:161-170.

Boyd J (2007) Nonmarket benefits of nature: What should be counted in green GDP? Ecological Economics 61:716-723.

Boyd J & Banzhaf S (2007) What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63:616-626.

Boyd J, & Krupnick A (2013) Using ecological production theory to define and select environmental commodities for nonmarket valuation. Agricultural and Resource Economics Review 42:1-32.

Brander LM, van Beukering P, & Cesar HSJ (2007) The recreational value of coral reefs: A meta-analysis. Ecological Economics 63:209-218.

Brauman KA, van der Meulen S & Brils J (2014) Ecosystem services and river basin management. Risk-Informed Management of European River Basins (eds J Brils, W Brack, D Müller-Grabherr et al.,) Springer Berlin, Heidelberg. pp. 265-294.

Brouwer R, Brander L, Kuik O, Papyrakis E, et al., (2013) A synthesis of approaches to assess and value ecosystem services in the EU in the context of TEEB: Final report. VU University Amsterdam: Institute for Environmental Studies, Amsterdam, pp144.

Buchanan JM, Yoon YJ (2000) Symmetric tragedies: Commons and anticommons. Journal of Law and Economics 43:1-14.

Chester G & Driml S (2012) The Potential Economic Benefits of Protecting and Presenting Cape York. A report to report for Cape York Sustainable Futures to present to the Department of Environment and Heritage Protection, ver 3.0, pp 141.

Chiesura A & de Groot R (2003) Critical natural capital: a socio-cultural perspective. Ecological Economics. 44:219-231.

Cosier P & McDonald J (2010) A common currency for building environmental (ecosystem) accounts: A proposed standard for environmental (ecosystem) accounting for the international 'System of integrated Environmental and Economic Accounts' 16th Meeting of The London Group on Environmental Accounting. 25 - 28 October, 2010 Vol. 25, Santiago, Chile, 2010, pp. 28.

Cosier P & Sbrocchi C (2013) Initial observations from the Australian regional environmental asset condition accounts trials. Wentworth Group of Concerned Scientists, Sydney, Australia, 2013, pp. 24.

Cowling RM, Egoh B, Knight AT, O'Farrell PJ, et al., (2008) An operational model for mainstreaming ecosystem services for implementation. Proceedings of the National Academy of Sciences 105:9483-9488.

Crabbé P & Manno J (2008) Ecological integrity as an emerging global public good. Reconciling Human Existence with Ecological Integrity: Science, Ethics, Economics and Law (eds L. Westra, K. Bosselman and R. Westra), pp. 73-86v. Earthscan, London.

Daly HE & Farley J (2010) Ecological economics: principles and applications. Island Press.

de Groot RS, Alkemade R, Braat L, Hein L & Willemen L (2010) Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7:260-272.

De Groot R, Brander L, van der Ploeg S. et al.. (2012) Global estimates of the value of ecosystems and their services in monetary units. Ecosystem Services 1:50-61.

DEHP (2014) http://wetlandinfo.ehp.qld.gov.au/wetlands/

Deloitte Access Economics (2013) Economic Contribution of the Great Barrier Reef, Great Barrier Reef Marine Park Authority, Townsville, pp52.

Donald D (2012) Identifying indigenous business opportunities in the recreational fishing tourism industry on Cape York Peninsula. FRDC Project Number 2010/230. Fisheries Research and Development Corporation, Canberra, Australia.

Farley J (2010) Conservation through the economics lens. Environmental Management 45:26-38.

Farley J (2012) Ecosystem services: The economics debate. Ecosystem Services 1:40-49.

Farley J, Schmitt F, Alvez J, & de Freitas Ribeiro Jr N (2011) How valuing nature can transform agriculture. Solutions 2:64-73.

Fenton D & Marshall N (2001a) A guide to the fishers of Queensland. Part A: TRC-analysis and social profiles of Queensland's commercial fishing industry. CRC Reef Research Centre Technical Report.

Fenton D & Marshall N (2001b) A guide to the fishers of Queensland. Part C: TRC-analysis and social profiles of Queensland's charter fishing industry. CRC Reef Research Centre Technical Report.

Fisher B & Turner RK (2008) Ecosystem services: Classification for valuation. Biological Conservation 141:1167-1169.

Fisher B, Turner KR & Morling P (2009) Defining and classifying ecosystem services for decision making. Ecological Economics 68:643-653.

FRDC (2013) Revitalising Australia's Estuaries. Fisheries Research and Development Corporation, Canberra, pp. 165.

Granek EF, Polasky S, Kappel CV, Reed DJ et al., (2010) Ecosystem services as a common language for coastal ecosystem-based management. Conservation Biology 24:207-216.

GBRMPA 2009. Economic Contribution of the Great Barrier Reef Marine Park, 2006-07. Research Publication No. 98, a report prepared for the Great Barrier Reef Marine Park Authority by Access Economics Pty Ltd. Great Barrier Reef Marine Park Authority, Townsvile, Australia, pp77.

Haines-Young R & Potschin M (2010) The links between biodiversity, ecosystem services and human well-being. Ecosystem Ecology: a new synthesis. (Eds, D. Raffaelli & C. Frid) BES Ecological Reviews Series, Cambridge University Press, pp31.

Jax K, Barton DN, Chan KMA, de Groot R, et al., (2013) Ecosystem services and ethics. Ecological Economics 93:260-268.

Johnson RJ & Russell M (2011) An operational structure for clarity in ecosystem service values. Ecological Economics 70:2243-2249.

KBC (2007) Cape York Peninsula Regional Economic & Infrastructure Framework. A report to the Cape York Peninsula Development Association and the Queensland Department of Tourism, Regional Development and Industry. Kleinhardt Business Consultants, Cairns, Australia, pp142.

Knowles T & Campbell R (2011) What's a whale worth. Valuing whales for National Whale Day. A Report for the International Fund for Animal Welfare (IFAW), Australia. Economists at Large, Melbourne, Australia.

Koo TTR, Wu C-L & Dwyer L (2010) Ground travel mode choices of air arrivals at regional destinations: The significance of tourism attributes and destination contexts. Research in Transportation Economics 26:44-53.

Kotchen MJ (2013) Voluntary- and information-based approaches to environmental management: A public economics perspective. Review of Environmental Economics and Policy 7:276-295.

Kubiszewski I (2010) Searching for the sweet spot: Managing information as a good that improves with use. PhD thesis, University of Vermont.

Kubiszewski I, Farley J & Costanza R (2010) The production and allocation of information as a good that is enhanced with increased use. Ecological Economics 69:1344-1354.

Lopes R & Videira N (2013) Valuing marine and coastal ecosystem services: An integrated participatory framework. Ocean & Coastal Management 84:153-162.

McArthur LC & Boland JW (2006) The economic contribution of seagrass to secondary production in South Australia. Ecological Modelling 196:163-172.

Maguire B, Potts J & Fletcher S (2012) The role of stakeholders in the marine planning process—Stakeholder analysis within the Solent, United Kingdom. Marine Policy 36:246-257.

Matzdorf B, & Meyer C (2014) The relevance of the ecosystem services framework for developed countries' environmental policies: A comparative case study of the US and EU. Land Use Policy 38:509-521.

Maynard S, James D & Davidson A (2010) The development of an ecosystem services framework for South East Queensland. Environmental Management 45:881-895.

MEA, (2005) Ecosystems and human well-being: Synthesis. Millennium Ecosystem Assessment, Washington, pp. 155.

Nahlik AM, Kentula ME, Fennessy MS, & Landers DH (2012) Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice. Ecological Economics 77:27-35.

NRC (2005) Valuing ecosystem services: toward better environmental decision-making. National Academies Press, Washington.

O'Connor S, Campbell R, Cortez H, & Knowles T (2009) Whale watching worldwide: tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare. Yarmouth MA, USA, prepared by Economists at Large.

Olsson P, Folke C & Hughes T (2008) Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. Proceedings of the National Academy of Sciences 105:9489-9494.

Oxford Economics (2009) Valuing the effects of Great Barrier Reef Bleaching. Great Barrier Reef Foundation, Newstead, Australia pp101.

Pittock J, Cork S & Maynard S (2012) The state of the application of ecosystems services in Australia. Ecosystem Services 1: 111-120.

Potschin M, & Haines-Young R (2013) Landscapes, sustainability and the place-based analysis of ecosystem services. Landscape Ecology 28:1053-1065.

Prayaga P, Rolfe J, & Stoeckl N (2010) The value of recreational fishing in the Great Barrier Reef, Australia: A pooled revealed preference and contingent behaviour model. Marine Policy 34:244-251.

Prideaux B (2013) The role of tourists icons in first and repeat visitation-vital information for destination marketers. Tourism Tribune 28:9-12.

Principe P, Bradley P, Yee SH, Allen PE, et al., (2012) Quantifying Coral Reef Ecosystem Services. National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC, EPA/600/R-11/206, pp158.

NCS Pearson (2002) Cape York Peninsula Visitors Survey July – October 2002. Market Research Report Prepared for Tourism Queensland. NCS Pearson Pty Ltd, Brisbane, Australia.

ReefPlan (2014) First Report Card (2009 Baseline)/Cape York regional summary. Last updated: 27 August, 2014. http://www.reefplan.qld.gov.au/about/regions/cape-york/cape-york-first-report-card/

Ringold PL, Boyd J, Landers D & Weber M (2013) What data should we collect? A framework for identifying indicators of ecosystem contributions to human well-being. Frontiers in Ecology and the Environment 11:98-105.

Rizzo NW, Gardner KH, Walls DJ, Keiper-Hrynko NM, et al., 2006. Characterization of the structure and composition of gecko adhesive setae. Journal of The Royal Society Interface 3:441-451.

Rolfe J, Gregg D, & Tucker G (2011) Valuing local recreation in the Great Barrier Reef, Australia. Environmental Economics Research Hub, Crawford School of Economics and Government, Australian National University, Canberra, pp. 88.

Schröter M, Zanden EH, Oudenhoven APE, Remme RP et al., (2014) Ecosystem services as a contested concept: a synthesis of critique and counter-arguments. Conservation Letters 7:514-523.

Stoeckl N, Birtles A, Farr M, Mangott A. et al., (2010) Live-aboard dive boats in the Great Barrier Reef: regional economic impact and the relative values of their target marine species. Tourism Eocnomics 16:995-1018.

Stoeckl N, Hicks C, Mills M, Fabricius , et al., (2011) The economic value of ecosystem services in the Great Barrier Reef: Our state of knowledge. Ecological Economics Reviews 1219:113-133.

Stoeckl N, Smith A, Newsome D, & Lee D (2005) Regional economic dependence on iconic wildlife tourism: Case studies of Monkey Mia and Hervey Bay. Journal of Tourism Studies 16:69-81.

Szuster BW, Needham M, McClure B (2011) Scuba diver perceptions and evaluations of crowding underwater. Tourism in Marine Environments 7:153-165.

Thomas CR, Gordon IJ, Wooldridge SW & Marshall P (2012) Balancing the tradeoffs between ecological and economic risks for the great barrier reef: A pragmatic conceptual framework. Human and Ecological Risk Assessment: An International Journal 18:69-91.

Thorhaug A (1990) Restoration of mangrives and seagrasses – economic benefits for fisheries and mariculture. Environmental Restoration: Science and Strategies for Restoring the Earth (ed. J. Berger), Island Press, Washington, pp265-281.

Tørrissen BC (2009) Gecko_foot_on_glass.JPG. http://en.wikipedia.org/wiki/File:Gecko_foot_on_glass.JPG.

TRA (2013) Tourism's Contribution to the Australian Economy, 1997–98 to 2011–12. Tourism Research Australia, Canberra pp40.

UNEP-WCMC (2006) In the front line: shoreline protection and other ecosystem services from mangroves and coral reefs. UNEP-WCMC, Cambridge, UK.

van Grieken ME, Thomas CR, Roebeling PC & Thorburn PJ (2013). Integrating economic drivers of social change into agricultural water quality improvement strategies. Agriculture, Ecosystems & Environment 180:166-175.

Wilson C & Tisdell C (2003) Conservation and economic benefits of wildlife-based marine tourism: Sea turtles and whales as case studies. Human Dimensions of Wildlife 8:49-58.

Windle J & Rolfe J (2006) Non market values for improved NRM outcomes in Queensland. Research Report 2 in the non-market valuation component of AGSIP Project #13, Central Queensland University.

Appendix 1 A preliminary ecosystem services framework: reef-specific tourism

Table 14. Categories of ecosystem benefits and example associated services. Adapted from Boyd and Banzhaf (2007)

Benefit type	Benefit sub-type	Example services
Harvests	Managed commercial[1,2]	sediment quality
		shade and shelter
		water availability
	Subsistence	target fish
		crop populations
	Unmanaged marine	target populations
	Pharmaceutical	biodiversity[3]
Amenities and fulfillment	Aesthetic	natural land cover in viewsheds[4]
	Bequest/spiritual/emotional	wilderness
		biodiversity
		varied natural cover
	Existence benefits	relevant species populations
Damage avoidance	Health	air quality
		drinking water
		land uses or predator populations hostile to disease transmission
	Property	wetlands
		forests (e.g. mangroves)
		natural cover
Waste assimilation	Avoided disposal cost	surface and ground water
		open land
Drinking water provision	Avoided treatment cost	aquifer
		surface water quality
	Avoided pumping and transport cost	aquifer availability
Recreation	Birding	relevant species population
	Hiking	natural land cover
		vistas
		surface water
	Angling	surface water
		target population
		natural land cover
	Swimming	surface water
		beaches

NOTES: 1) managed commercial crops include row crops, and marine and terrestrial species managed for food, fibre or energy; 2) commercial services may not be valued in environmental accounting frameworks; 3) biodiversity is thought by some to promote pest resistance; 4) the area from which a particular sight can be seen.

Table 15. Assets and environmental values likely to be present in the Burnett-Mary region (example only).

Ecosystem Component		Environmental value					
		Harvests	Amenity & fulfilment	Coastal protection	Waste assimilation	Recreation	Commercial tourism
Coral reef	inshore	✓	✓	✓	x	✓	✓
	offshore	✓	✓	✓	x	✓	✓
Seagrass	inshore	✓	✓	✓	✓	✓	x
	offshore	✓	✓	✓	x	✓	x
Mangroves		✓	✓	✓	✓	✓	✓
Coastal wetlands		✓	✓	✓	✓	✓	x
Islands		x	✓	✓	x	✓	✓
Iconic spp.	cetaceans	x	✓	x	x	✓	✓
	seabirds	x	✓	x	x	✓	✓
	dugong	✓	✓	x	x	✓	✓
	turtle	✓	✓	x	x	✓	✓
	fish/sharks	✓	✓	x	x	✓	✓
	crustaceans	✓	✓	x	x	✓	x

NOTE: for details on categories of environmental values, see Table 13

Table 16. Example of a hypothetical trend assessment of selected ecosystem services and benefits to commercial reef-based tourism beneficiaries as a result of water quality change in the Fitzroy region under the scenario that assumes a WQIP is not implemented by 2020.

Environmental benefit	Final ecosystem service[1]	Trend	Score
Diving and snorkelling	Water clarity (visibility)	Stable (offshore - good) Stable (inshore- moderate)	3
	Coral cover	Decline (inshore) Stable (offshore)	1
	Coral diversity	Decline (inshore) Stable (offshore)	1
	Coral reef structural complexity	Stable (offshore) Moderate decline (inshore-WQ)	2
Viewing fauna and wildlife	Iconic species e.g., grouper, whales, sharks, turtles	Moderate decline	2
		Status score	**9**
		Overall status score	**2**

NOTES: only natural features that are expected to be affected by water quality change are considered.

Our country, Our future.

Fitzroy Basin Association Incorporated
PO Box 139, Rockhampton QLD 4700
Phone: (07) 4999 2800
Fax: (07) 4921 2860

www.fba.org.au

FITZROY BASIN ASSOCIATION