The Economic Value of Natural and Built Coastal Assets

Part 1: Natural Coastal Assets

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27/06/2011

This paper was motivated by the Australian Federal Government climate change adaptation initiatives. The authors are members of the Australian Climate Change Adaptation Research Network for Settlements and Infrastructure (ACCARNSI), one of eight networks within the National Climate Change Adaptation Research Facility (NCCARF)

THE ECONOMIC VALUE OF NATURAL AND BUILT COASTAL ASSETS.

In light of climate change uncertainties and the likelihood of increased impacts to our natural and built coastal environment, the aim of this review is to highlight past and recent studies related to the valuation of coastal assets within two papers: Part 1 – natural assets and Part 2 – built assets, with the underlying consideration that these assets are under pressure not only from human population needs but also from a changing climate. This paper (Part 1) will provide a brief overview of environment economic valuation techniques and a discussion of several economic assessments covering a range of coastal ecosystems and uses: coastal and marine ecosystems, marine parks, beaches (including visitation – residential and tourism, and surfing), coral reefs, coastal lakes and the intertidal zone (wetlands , salt marshes, mangroves, estuaries and seagrass).

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1.0 INTRODUCTION

Australian culture is closely linked with our coastline. Many of us live, work, and play within the coastal zone. Increasing migration to coastal areas in Australia and around the world illustrates our affection towards the coast. In 2001, approximately 85% of the population were living within 50km of the Australian coastline (ABS, 2002) and this number is expected to grow in the future.

The coastal zone supports a range of natural and built environments, all of which contain some economic or societal value. Within the context of this paper, we define:

- a value as how much something is worth. From an economic viewpoint, the value of an item represents how much a buyer is willing to pay for the item and how much a seller is willing to give the item (King and Mazzotta, 2000).

- an asset as an item of worth and natural assets can be defined as natural resources from which goods are produced and services provided (landforms, flora, fauna, waterways, wetlands, etc).

- ecosystem services as the benefits that people receive from the natural environment (i.e. transformation of the natural asset into products valued economically (World Bank, 2004).

- the built environment as man-made objects and settings; these typically take the form of infrastructure.

Examples of the services provided by natural assets associated with the coastal zone include:

- visual amenity;
- dwelling in proximity to the coastline;
- recreational opportunities that link closely with our lifestyle choices;
- indigenous, spiritual and cultural values and heritage;
- habitat and nursery ground for many coastal and estuarine plants and animals;
- mangroves and sand dunes that have biodiversity values and protect our developments during storms;
- waterways that filter pollutants and provide sources of water; and
- climate regulation

(GCCM, 2010; URS, 2007).

The natural environment can be thought of as a spider's web: it is intricately connected at many levels, and often plays multiple roles through the goods and services provided by natural assets. For example, a waterway may provide any or all of the following: habitat, sediment sinks/sources, a source of water for both consumption and irrigation, and a place of recreation, etc. The values that we place on these natural assets are intrinsically linked to the natural environment and can vary across society's needs and wants. Varying uses of the natural environment are often conflicting and provides a challenging context in determining which values are worth the most

The built environment is highly valued to provide shelter, sustenance (food and water), transport and access, safety, health care, protection of property, education, trade opportunities, electricity and social needs. Civilisation's survival has direct dependence on the built environment and its assets and many societies place expectations on what infrastructure and services should be provided. The built environment associated with the coastal zone includes:

- residential and commercial buildings;
- holiday homes;
- ship terminals, ports and harbours;
- bridges;
- beach protection works such as groynes and jetties;
- sand by-passing and beach nourishment;
- artificial reefs;
- fishing piers;
- parks and pathways;
- surf clubs;
- boat access points;
- navigational channels; and
- public infrastructure such as showers, fencing and viewing platforms.

Increased population growth and the shift of population to the coastline (seachange phenomenon) have created an increasing usage/pressure on Australia's coastal assets. Where resources are limited, competition between users can lead to conflict. Conflicts occur between urban development, lifestyle values, conservation, commercial industry and land uses such as agriculture (URS, 2007) and population growth within a small coastal town can lead to a shift in the socio-economic profile. A common example is the use of river mouth by recreational boating and surfers resulting in direct conflict between the two user groups. The potential for conflict has implications in how the coastline is managed. The competing pressures also have implications for coastal managers and policy makers and thus there is a need to value all components of the goods and services provided by the coastal environment.

There are considerable flow-on effects related to the loss of coastal assets and their services from both the built (i.e. loss of revenue, employment, tourism, personal well-being, lifestyle choice, health, sense of place and community and recreation opportunities) and the natural (i.e. loss of habitat, ecological processes and species) environment. In addition to the potential loss of a natural asset, there are also costs involved with replacing the service the asset provided or restoring the environment. What nature once did for free, society must now pay for that same service within the built environment. Examples include the cost of building a revetment wall for storm surge protection in a place where mangrove forest was removed or replanting riparian vegetation to assist with improving water quality.

To add a further implication, the world is experiencing a changing climate that is occurring at an alarming rate (IPCC, 2007). Management plans and tools will need to consider current uncertainties and prediction for the future if sustainable management is to be achieved (Martinez et al., 2007). Climate change will place further pressure on our coastline in particular in terms of increased storminess (leading to coastal erosion and flooding), drought, changes in wave climate, warmer sea temperatures, saltwater intrusion and sea level rise (IPCC, 2007; Cowell et al., 2006; Walsh, 2004). While natural coastlines can evolve with such changes, the built environment is limited in the extent it can adapt. Examples of such instances include wetland and mangrove loss adjacent to development as a result of sea level rise and changes in water salinity or beach amenity loss due to the shoreward retreat limit imposed by hard coastal engineering structures such as seawalls and revetments. The impacts of climate change are also likely to cause greater conflicts between the built and natural coastal environment (Walsh, 2004) and have further impacts on important coastal industries such as tourism and fisheries in the future.

2.0 ENVIRONMENTAL ECONOMIC VALUATION

The Australian Government defines economics, in this context, as being "… primarily concerned with efficient allocation of resources in order to maximise society's welfare" (page 1, Chapter 2, Australian Government, 1995). Economics is based on human well-being or utility and the choices that people make to obtain such welfare.

Environmental economic valuation is used to place a value on the goods and services provided by the natural environment. The concept of value is linked to the changes in welfare of a society (Australian Government, 1995) and is based on the principle that people are willing to pay for goods or services (Lipton, et al., 1995). Green and Tunstall (1991 p.126) state "nothing has a value in its own right only the value that people place on it" and therefore economics is based on people's spending preferences - what they are willing to pay (alternatively: what people are willing to forego in other goods/services in order to obtain the good/service in question (King and Mazzotta, 2000)). Typically, preferences are expressed every day in the market place in terms of what we choose to purchase. Spending preferences are then used to determine the value of the good or service (Moberg and Folke, 1999).

The manner in which people value the natural environment can vary. Value can be associated with direct uses, such as fisheries or tourism which are captured within the market place, along with indirect uses, such as mangroves providing a nursery for juvenile fish species. Indirect uses are usually found outside of the market place and are effectively unpriced. Natural systems have values that are intrinsic and are difficult to place a price against. Therefore, determining the full value of a natural asset is challenging and often overlooked. Sustainable management of natural resources requires that the full value of all goods and services are captured, only then can appropriate tradeoffs and allocations be made.

In economic terms, when the true costs are not reflected in the economic value, market failure occurs (Turner et al., 2004; King and Mazzota, 2000). Externalities are one example and occur when costs or benefits are incurred by recipients that did not pay for or agree to the action. For example, impacts may occur far from the actual source (changes in water quality downstream) or many years after the implementation of the decision (Robinson and Ryan, 2002). Robinson and Ryan (2002) argue that the general market does not take into account the externalities in the use of natural resources and this leads to economic gain at the expense of the environment. Another common form of market failure occurs when property rights are not established leading to the open access of a resource and subsequent over-use of over-exploitation (Davis and Gartside, 2001). Davis and Gartside (2001) discuss a number of economic instruments in place to reduce market failures (e.g. taxes, user-pays, licensing, quotas, entrance fees and restricted access) and assist in ensuring full costs can be accounted for in the market place. These instruments reduce the potential for the exploitation of natural resources.

The natural environment is a scarce resource, and competition between uses can lead to an increase in scarcity (where the needs of people (demand) cannot necessarily be met by the supply). The degree of scarcity is therefore controlled by supply and demand (Blackwell, 2005) and is then reflected in price (i.e. an increase in scarcity is reflected by an increase in price and a higher value placed on the asset (Heuting et al., 1998)). When aspects of the environment are recognised as being scarce, choices between competing uses need to be made (Goodman et al., 1998).

2.1 Comparing Apples to Oranges

Environmental economic valuation provides a mechanism to place a dollar value on environmental goods and services to assist in appropriate decision making. Placing a dollar value on the environment will often stimulate debate, especially when nature is considered 'priceless'. Although the use of money has been criticised, a dollar value provides a language that many can relate to (WorldBank, 2004). It provides a relative figure for comparison (Green and Tunstall, 1991), a common denominator, and supports the notion to compare apples to oranges. Furthermore, Green and Tunstall (1991) portray the use of money as a 'yardstick' with which economists can measure relative values. The 'measure' is a numeral value that is relevant to both the market place and people's understanding, and can greatly assist in the management of a resource and in policy development (Pendleton et al., 2007). Use of a relevant measure also assists the public in understanding the value of our natural assets (Blackwell, 2005).

Furthermore, if no value is placed on environmental goods and services there is a risk that they will be perceived as having no value (zero worth) and can therefore be exploited (Robinson, 2001). In addition to this value of zero, there is also risk in placing an infinite value on ecological services (World Bank, 2004). Although on one hand the value of services should be considered infinite, due to the very nature of these services, it is recognised that this does not lead to effective management strategies or priorities being set (World Bank, 2004; Costanza et al., 1997;). Blackwell (2007a p.2) states that "…without monetary value to society, net gains and losses can only be speculated."

The concept of valuation can also be viewed as being anthropocentric in nature and utilitarian (URS, 2007; Sinden, 1994), based solely around the benefit humans obtain from the environment. However, there is a view that humans should be the guardians of the Earth (Australian Government, 1995) and since we exploit the Earth, we also have a responsibility to guarantee that it can provide resources in the future. The natural environment also has intrinsic values that are independent of human needs and are of significant importance. Arguably, the development of policy and planning has direct implications to the management, use and protection of the environment. Without representing the environment in a manner that can be compared to other costs and benefits, there is a great risk of exploitation of natural assets. Through the provision of a dollar value onto a resource, a foundation is formed for decision-making to take into account the full losses and gains (Australian Government, 1995).

2.2 Our Coastal Assets

Population growth has resulted in increased demand and pressure on the goods and services that our natural assets provide within the coastal zone. The coastal environment has always played a major role in our economy (Walsh, 2004) and it is now recognised that much of this value is found outside the market place (Pendleton et al., 2007). Given that a value is placed upon coastal resources that can be traded in conventional markets (e.g. fish), the environment from which they are extracted (i.e. rivers, estuaries, and mangroves) also needs a measure of value due to their interconnectivity. If left unvalued (or under-valued), these services run the risk of not being fully recognised when decisions are made and tradeoffs chosen within the coastal zone (URS, 2007), which may have catastrophic consequences.

An additional pressure upon today's manager is the uncertainty of climate change and the associated impacts to our coastal environment and resource needs. With a changing climate comes the potential increase in the vulnerability of our coastline that may result in changes to the way it has traditionally been managed. This in turn creates difficulties for management and decision making as the values of one user-group often compete against the values of another. Long term

planning is an essential tool in dealing with this complexity, which is why including and estimating the full value of assets will assist in determining that appropriate tradeoffs can be made. The questions we must ask are: *How important are these values*? A*nd to whom*? (World Bank, 2004).

3.0 VALUATION TOOLS

There are many economic tools to estimate value. In financial evaluation, the costs and benefits are directly associated with the returns on the investment (QEPA, 2003). In contrast, environmental valuation considers the full costs and benefits, including those that may both positively and negatively affect the wider community (QEPA, 2003). These benefits can have both market value and non-market value. Non-market values are values that are not traded directly in the market place yet provide utility (welfare or satisfaction) to an individual. Non-market values can have direct and indirect use as well as non-use.

3.1 Total Economic Value

The concept of Total Economic Value (TEV) has been developed to incorporate all aspects of the use of natural assets. This framework assists in estimating the overall value (market and non-market) of the asset and the environmental goods and services that are provided (Robinson, 2001; Costanza et al., 1997). The TEV framework therefore includes both use values (explicit) and non-use values (implicit). A commonly used diagram is provided in Figure 1.

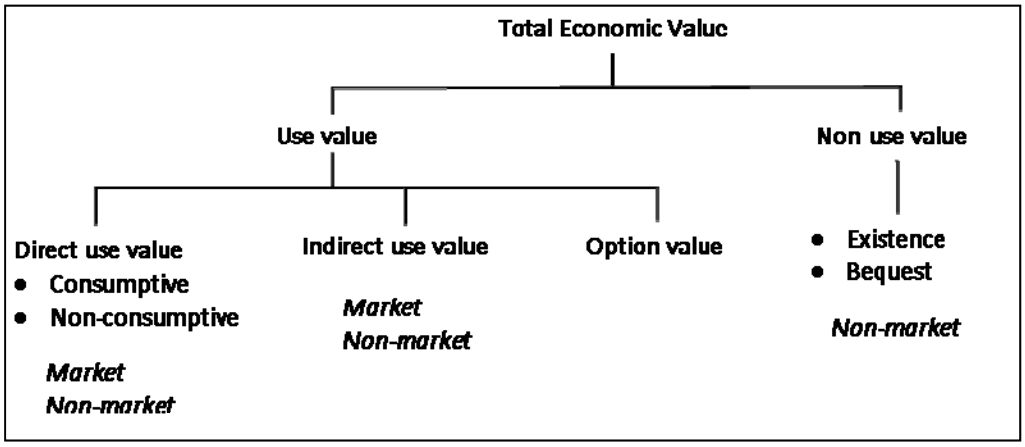

Figure 1. The Total Economic Framework (adapted from: Word Bank, 2004).

Use values:

- Direct use values: goods and services that are directly used by people. They can be consumptive (market) such as catching fish, collecting timber or non-consumptive (non-market) such as recreational visits (snorkelling).
- Indirect use values: benefits that are found outside of the ecosystem itself, such as storm protection from mangroves.
- Option values: benefit is found in an individual knowing that a resource is available for their use in the future.

Non-use values:

- Bequest values: knowing that a natural asset will be available for future generations.
- Existence values: the satisfaction of knowing that a natural asset exists, whether or not there is any future intent to directly use the asset.

(World Bank, 2004).

Direct and indirect uses reflect the value that the society place on an asset (Pendleton et al., 2007). Direct uses are generally easier to calculate as the benefits are observable through, for example, the price paid for the product or experience (World Bank, 2004). Estimating the value of indirect uses is difficult because they are hard to 'price'. For example, the quantities the service provides can be difficult to determine (i.e. how much protection do the mangroves specifically provide) and these services do not usually enter the market place at all (World Bank, 2004). There is further difficulty in determining the option, bequest and existence values of a natural asset. These values generally aren't reflected directly by people's behaviour in a monetary sense, again not entering the market place (World Bank, 2004).

The concepts of willingness to pay and consumer surplus are used to assess how much an individual gains from the use or non-use of the environment[1]. The consumer surplus is the amount that a person (or consumer) values the good/service above the price paid (QEPA, 2003), representing the difference between what is paid for a good and what people would be willing to pay for the good (Lazarow, 2007). This occurs as people are willing to pay in excess of what they have to pay to ensure benefit from the good or service. There are several valuation techniques used to determine this value and these are discussed below.

3.2 Valuation Techniques

Several valuation techniques have been developed to assist in capturing non-market values. Economic valuation methodology was formally introduced in 1970 (Heuting et al., 1998) and prior to this several early methods were already in use to determine the value of the natural environment. For example, Harold Hotelling proposed in 1947 a method to determine the economic attributes of National Parks in the US by estimating the costs of travel (the travel cost method) (see Section 3.2.5) (Arrow and Lehmann, 2005). Furthermore, in Australia in 1955, Molnar (1955, cited in Sinden, 1994) used land value to estimate the damage from soil erosion. Over the subsequent decades both the literature and general interest has grown with many environmental economic assessments undertaken in Australia (see Sinden, 1994).

There are many comprehensive documents that provide detailed explanation of valuation techniques, both market based and non-market. Non-market valuation techniques can be described as having revealed or stated preferences. Revealed preferences estimate the value based on people's behaviour that has already taken place (for example the money they have spent travelling to a destination) and stated preferences are based on people's opinions and their expressed statements (Lazarow et al. 2007; Pendleton et al., 2007). Stated preference techniques can estimate non-use values.

The US National Ocean Economics Program (a web-based program that provides current economic and socio-economic information for the US coastal zone) provides a full list of 14 methods to assess non-market values (NOEP, 2009). King and Mazzotta (2000) provide the following list of commonly used techniques. Below is a brief description of each technique directly sourced from King and Mazzotta (2000) and further detailed information for each technique is available at their website, "Ecosystem Valuation" at www.ecosystemvaluation.org.

- Market price method
- Productivity method
- Hedonic pricing method

[1] See www.ecosystemvaluation.org for a more detailed explanation of willingness to pay and consumer surplus

- Damage cost avoided/replacement/substation cost
- Travel cost method
- Contingent valuation method
- Contingent choice method
- Benefit transfer method

3.2.1 Market price method

The market price method is a revealed preference and uses the market price of the ecosystem goods and services to estimate their value (King and Mazzotta, 2000). Changes in the market place are related to the quality of the environment from where the resource is supplied (QEPA, 2003).
www.ecosystemvaluation.org/market_price

3.2.2 Productivity method

The productivity method is used to estimate the value of the goods and services that contribute to the production of a marketable good (NOEP, 2009; King and Mazzotta, 2000).
www.ecosystemvaluation.org/productivity

3.2.3 Hedonic pricing method

The hedonic pricing method is a revealed preference technique that uses variations in the market value to determine the value of an environmental characteristic. This method is commonly applied to housing prices to value, for example, a view or open space/parklands. For example the willingness to pay is revealed in the market price of housing (King and Mazzotta, 2000). This technique uses actual property values and can reflect how people value amenities, however limitations include assumptions on how individual perceive values and ensuring other factors do not play a role in the variation in property process (e.g. neighbourhood features).
www.ecosystemvaluation.org/hedonic_pricing

3.2.4 Damage cost avoided/replacement/substation cost

This method estimates the cost of avoiding damages due to lost services, the cost of replacing ecosystem service and the cost of providing a substitute for services (King and Mazzotta, 2000). These methods use assumptions to determine the costs.
www.ecosystemvaluation.org/cost_avoided

3.2.5 Travel cost method

The travel cost method is another revealed preference technique that estimates the use value of an asset for recreational purposes. The willingness to pay is estimated through the behaviours of the visit such as the cost of travel and time to access the site. It is based on the notion that the number of trips to visit the site will decrease as the distance travelled increases. The method is based on actual behaviour and costs, however can be limited by effectively estimating the opportunity costs of time, when multiple sites are visited in one trip and may not capture the value of people that highly value the site and therefore chose to live close by (Pendleton et al., 2007, King and Mazzotta, 2000).
www.ecosystemvaluation.org/travel_cost

3.2.6 Contingent valuation method

The contingent valuation method is a simulated market approach and is undertaken in the absence of market data. The concept is to undertake a survey and ask respondents to state their preferences, i.e. their willingness to pay or willingness to accept compensation for an environmental good or service. This method can estimate non-use values such as option, existence and bequest values and the valuation is based on the respondent's opinion (King and Mazzotta, 2000). The technique can be limited by questions being misinterpreted or taken into a context that causes the individual to

change their answer. Additionally, a further limitation is bias in responses and responses that are dishonest or align with a strategy or agenda of the individual (QEPA, 2003; Australian Government, 1995).
www.ecosystemvaluation.org/contingent_valuation

3.2.7 Contingent choice method

The contingent choice method (or choice modelling) asks respondents to make tradeoffs among sets of environmental characteristics, without directly asking them to state their values in monetary terms (NOEP, 2009; King and Mazzotta, 2000). The respondent states their preference between one set of environmental characteristics at a given price/cost and another set at a different price (King and Mazzotta, 2000). Limitations within this technique are similar to those described above for the contingent valuation technique.
www.ecosystemvaluation.org/contingent_choice

3.2.8 Benefit transfer method

The benefit transfer method uses data available from studies completed in one place or context and transfers the estimates into a different place/context. This method is useful if funds are limited and a full study can not be carried out, however the results will only be accurate as the original study and conditions at both places/within both contexts need to be similar (NOEP, 2009; World Bank, 2004; King and Mazzotta, 2000).
www.ecosystemvaluation.org/benefit_transfer

It is recognised that there can be limitations in the use of environmental valuation techniques:

- results can be dependent on the specific methods used, for example when using survey techniques bias can be created with the questions used and the sample group targeted
- each technique requires different types of information as input and the output reflects the quality of the initial data
- results may be context specific (Moberg and Folke, 1999)
- difficult to transfer results across different sites as many values are unique to a specific area
- values will change over time and may be influenced by changes in wealth
- availability of data can be limited
- costs for large scale valuation studies are generally high
- some techniques require intensive data analysis
- analysis can involve assumptions related to people's preferences
- people may not perceive their dependence on the natural asset (Moberg and Folke, 1999).

Despite these limitations, valuation studies do provide an insight into the prospective value of natural assets and assist in accounting for services that may have been overlooked or undervalued (Sinden, 1994). Valuation studies should be considered as estimates (NOEP, 2009) and caveats are often highlighted by authors. Additionally, economists use a confidence interval to provide the range in which the true value should fall (NOEP, 2009). Use of confidence intervals provides an indication of the accuracy of the results and improves the integrity of the study.

4.0 EVALUATING ECOLOGICAL GOODS AND SERVICES

An initial step in valuation, is determining the ecological services that people gain (direct or indirect) from goods and services provided by the natural environment (Maynar et al., 2010; Blackwell, 2007a). Examples include food and water (goods) and purification of air, nutrient cycling, and seed dispersal (services) (World Bank, 2004). A milestone project, the Millennium Ecosystem Assessment, was published in 2005 and provided a global study that considers human influence on ecosystem change over time and how these changes, in turn, influence human well-being (Millennium

Ecosystem Assessment, 2003). The study found that a majority of the world's ecosystem services are in a state of degradation. An outcome of the assessment was a conceptual framework to assist managers in measuring the impact of ecosystem services against economic and cultural needs to find a balance between protecting the ecosystem service and ensuring that human productivity can be maintained (Millennium Ecosystem Assessment, 2003). An ecosystem services framework is currently being applied in South East Queensland through a project initiated by South East Queensland Catchments (Maynard et al., 2010). This currently on-going project has involved the development of an operation framework, a model and a series of maps to prioritise areas based on ecological significance and is currently ongoing.

Within the Millennium Ecosystem Assessment, the coastal environment can be separated into a number of natural asset types such as open ocean, beaches, estuaries, mangroves, and seagrass. Each asset type may provide a number of market and non-market services: commercial (market), environmental (non-market) and social (non-market). The Millennium Ecosystem Assessment separated these services into four broad categories including:

- provisioning services (e.g. food and water (direct benefit))
- regulating services (e.g. flood and disease control (direct benefit))
- cultural services (e.g. visiting sites of historical value (indirect benefit))
- supporting services (e.g. nutrient cycling (indirect benefit))

(Blackwell, 2007a; Millennium Ecosystem Assessment, 2003; World Bank, 2004)

For example ecosystem services provided by:

- An open beach would include:
  - Provisioning services such as food and minerals
  - Regulating services such as storm protection and erosion buffers
  - Cultural services such as spiritual values, recreation and amenity
  - Supporting services such as nutrient cycling and habitat

- A coral reef provides a number of services such as:
  - Provisioning services
    - food
    - pharmaceutical products
    - market products e.g. fisheries, shells and aquarium fish
    - sand and lime
    - gas/oil
  - Regulating services
    - storm protection
  - Supporting services
    - habitat
    - biodiversity
    - biogeochemical services e.g. nitrogen fixing
    - ecosystem regulation
  - Cultural services
    - recreation
    - aesthetics
    - climate record
    - spiritual values

  (Moberg and Folk, 1999)

Studies incorporating a number of ecosystem services and their functions have been completed on both a worldwide (Costanza et al., 1997; Martinez et al., 2007) and national scale (Blackwell, 2005

and 2007a) that aim to highlight the contribution of the natural environment to society and human well-being.

In a 'landmark study', Costanza et al. (1997) attempted to value the world's ecosystem goods and services, placing a value on 17 ecosystems worldwide using published data (via the benefit transfer method) and further calculations. The assessment included specific coastal environments and concluded that ecosystem services are an important component of human well-being.

The coastal ecosystems included in the study were:

- open ocean
- coastal
- estuaries
- seagrass
- algae beds
- coral reef
- continental shelf

The study placed a total value of USD$577 per hectare per year for coastal ecosystems and a total of USD$20,949 billion per year, illustrating a potentially considerable value for the world's coasts.

This study was highly criticised and reactions ranged from direct criticism of the methods to the terminology used (e.g. Herendeen, 1998; Heuting et al. 1998; Serafy, 1998) and further highlighted the debate and difficulty in placing a dollar value on natural ecosystems (Norgaard et al., 1998; Opschoor, 1998; Rees, 1998). However, authors also recognised that this research was a starting point for the conversation and that for future planning and protection of the ecosystem, the environment would need to be recognised with a monetary value and ecologists need to speak the economic language (Herendeen, 1998).

A range of studies on the assessment of ecological value have been undertaken worldwide. Pendleton et al. (2007) provides a detailed review of a number of online lists of relevant literature, namely the Environmental Valuation Reference Inventory (EVRI), Coastal and Ocean Resource Economics Program (CORE), ENVALUE (an Australian valuation database) and National Ocean Economics Program (NOEP) (USA).

- Environmental Valuation Reference Inventory EVRI www.evri.ca
- Coastal and Ocean Resource Economics Program CORE www.marineeconomics.noaa.gov/
- ENVALUE www.environment.nsw.gov.au/envaleapp/
- National Ocean Economics Program NOEP www.oceaneconomics.org/

5.0 What is the 'value' worth? – Australian Studies

The total value of Australia's natural assets is not well known (Blackwell, 2005). Several studies have focussed on specific environments and Sinden (1994) provides an extensive review of previous Australian literature. In Australia, the value of the coastline is becoming more recognised and is highlighted in reports providing assessments of the value of the coastline to Victoria (URS, 2007) and New South Wales (NSW Government, 2006a). More recent studies of the value of Australia's coastline and beaches, (e.g. Victoria (URS, 2007), Sydney (Anning et al. 2009), Gold Coast (GCCM, 2010; Lazarow, 2009; Raybould and Lazarow, 2009) and Adelaide, illustrate the increased interest and investment into understanding the economic value of coastal assets. In addition to studies focussed on beaches, marine ecosystems such as the Great Barrier Reef have also been well studied in terms of the economic value of the associated tourism and fisheries (Access Economics, 2007;

KPMG, 2000; Driml, 1997). Several studies also identify the lack of data for valuing environmental goods and services (Anning et al., 2009; Lazarow et al., 2007; URS, 2007; Blackwell, 2005), thus limiting the overall goal of sustainable coastal management (Anning et al., 2009).

These studies have enormous relevance to our settlements due to the significant reliance on open coastal spaces for lifestyle choices and tourism. Recreation opportunity has an important place in our culture and society and Wiegel (1994) refers to an early *Shore & Beach* article with the phrase "The Age of Leisure" presented by L.H Weir, who predicted an increase in recreation with the improvement of technology of manufacturing goods and constructing infrastructure. In fact, as the developed economies have grown so too has the time and money available for recreation.

This section will provide a brief summary of previous studies on several natural coastal assets relevant to Australia including:

- Coastal and marine ecosystems
- Marine parks
- Beaches
    - Visitation (residents and tourists)
    - Surfing
- Coral reefs
    - Great Barrier Reef
- Coastal lakes and wetlands
- Intertidal areas
    - Estuaries
    - Mangroves
    - Seagrass

5.1 Coastal and Marine Ecosystem

Australia's coastal and marine ecosystems consist of a variety of habitats and support many stakeholders. The most obvious being the commercial fisheries industry with the value clearly seen within the market place. These ecosystems also provide significant value and utility to the coastal population in terms of non-market values and non-use values.

The immense value of the coastline to the commercial industries that rely on them was recently highlighted in a study of the economic value of the Victorian coastline (URS, 2007). The annual output value for these industries (namely port, shipping, commercial fisheries, coastal tourism, and wind energy) was calculated at $2,796 million. When excluding the Port of Melbourne, tourism was the largest industry at $908 million per year (URS, 2007). The study went on further to assess the recreational value of the coastline and estimated a consumer surplus of $45 per visitor per day, and when placed against visitation rates to the coastline came to a value of $1.9 billion per year. These figures highlight the major role recreation and tourism play in the economies of our coastlines, along with the need to ensure management practices consider the needs and uses of all industries.

The economic value of non-market uses in marine environments was explored by Hassell and Associates (2001) on behalf of the National Oceans Office for the south east marine region of Australia (waters off Victoria, Tasmania, southern New South Wales, eastern South Australia and Macquarie Island). This study provided a detailed discussion of the non-market values and non-use values specific to this coastal region, however did not provide monetary estimates.
Non-market values specific to this marine region included:

- nutrient storage and cycling

- atmospheric gas and climate regulation
- waste reception, treatment and assimilation
- biological control (predator-prey relationships)
- biological support (habitat)
- biodiversity maintenance
- protection of terrestrial and other marine habitats

Hassell and Associates (2001) further provided a description on non-use values relevant to this marine region:

- Option values – particularly regarding the opportunity to discover new biological resources in the future
- Existence values – the fact that people donate to conservation organisations illustrates that people value the environment when they may never visit specific places
    - Social values – particularly cultural and spiritual values
    - Artistic values – sale and enjoyment of art and photographs
    - Protection values – region provides a home for endangered species
    - Historic values – for example Macquarie Island provides an example of the earth evolution
    - Intrinsic values – value of ecosystems independent of utility to people, for example providing marine protected areas
- Vicarious use values
- Bequest values

A two-part study was undertaken by Blackwell (2007a; 2005) as a component of the Cooperative Research Centre for Coastal Zone, Estuary and Waterways Management (Coastal CRC) project titled 'The economic value of Australia's natural coastal assets'. The project included a macro level assessment based on estimates provided by the global ecosystem goods and services study by Costanza et al. (1997) and a micro level assessment using estimates from a variety of previous studies both within Australia and overseas literature. The outcome of the paper was a 'mosaic' of ecosystem services highlighting key knowledge gaps and a broad estimate of dollar values for several natural assets including estuaries, open beaches, subtidal and intertidal zones (seagrass and mangroves).

The macro-level assessment was a rapid study that took preliminary estimates of the area of each ecosystem type and placed an estimated dollar value using figures provided by Costanza et al. (1997). The study provided an indicative overall annual value of $1,359.3 billion (2005 $) for marine ecosystems (Blackwell, 2005). A further value of $464 billion was estimated for open ocean and the continental shelf was valued at $597.9 billion due to the vast area covered (Blackwell, 2005). With the study heavily relying on estimates of ecosystem areas from previous studies and monetary figures by Costanza et al. (1997) the author acknowledges some limitations in the estimates and offers them as a starting point for future investigations (Blackwell, 2005).

The second part of this study was a micro-level assessment with the aim of reducing the limitations noted above. This included a listing of numerous studies by ecosystem service category and natural coastal asset or ecosystem type. Of the ecosystem types reviewed, estuaries and open beaches were the most studied and intertidal and subtidal zones were the least studied. The author highlights the overall lack of research available, particularly relating to the latter ecosystems, and also limitations in estimating the full potential of the assets in terms of all ecosystem goods and services categories (Blackwell, 2007).

A further study has provided a broad assessment of the coastal environments of the Gold Coast using the benefit transfer method (AECgroup, 2007). Although this document is not yet available to the public, the study applies data from relevant studies that use the contingent valuation and choice modelling techniques, in addition to hedonic pricing method and the travel cost method. The study also recommends the use of 'innovative combinations' by combining choice modelling and a citizen's jury (use of representatives in the form of a jury) or the contingent valuation and contingent behaviour (estimates future visitation behaviour based on a scenario) methods (AECgroup, 2007).

5.2 Marine Parks

There are many protected marine parks within Australia and their values are paramount to the protection of marine biodiversity and in supporting the sustainability of Australia's commercial fisheries industry. Economic based studies of marine parks in Australia have included estimations on non-use values (Ningaloo Marine Park), use values (Cape Byron Marine Park) and the impacts of rezoning of marine parks (Great Barrier Reef (see Section 5.4) and the south west marine region of Western Australia).

Strong economic debate usually accompanies proposals for rezoning (or zoning) marine parks. The focus of the debate is the tradeoffs between the potential negative impacts to commercial industries when marine areas are protected versus the positive outcome of the conservation value (Allen Consulting, 2009). Allen Consulting (2009) reviewed the economic impact of introducing marine protected areas (no-take zones) within the south west marine region of Australia (namely the southern Western Australian coastline). The study found that while additional protected areas would result in direct economic losses to the fisheries industry in the order of tens of millions of dollars, the benefits to the fisheries industry, ecotourism and non-use values would be in the hundreds of millions (Allen Consulting, 2009). Table 1 provides a summary of these figures.

Table 1. Economic gain and loss for the south west marine region with increased marine protected areas (Allen Consulting, 2009).

+ Gain in economic surplus	
Spillover to commercial fisheries	Up to $2.4 million
Fishery buffer benefits	Not estimated
Ecotourism direct benefits	$5 - $10 million
Bio discovery	Not estimated
Environmental non-market values	$100 -$200 million
- Loss in economic surplus	
Displacement of commercial fisheries	$9 million
Displacement of recreational fishing	$1.8 million
Displacement of charter fishing	$0.75 - $1.25 million
Reduced demand for fisheries support services	Not estimated

*Estimates were calculated from previous studies (i.e. no new primary data was collected) which may limit the confidence of these figures; however the study provides a starting point for discussion and future investigation.

The study highlights the need to understand the total economic value of marine resources to ensure appropriate tradeoffs are made during management decisions. Understanding these values will assist in developing sustainable practices within coastal industries.

Two further studies that relate to marine parks have been undertaken, one at Cape Byron Marine Park (Julian Rocks) and another at Ningaloo Marine Park in Western Australia.

The study at Julian Rocks (within Cape Byron Marine Park) was highlighted in a report on the coastal values of Byron Shire (Byron Shire Council, 2000). Davis (1996) applied the travel cost method to study the non-market use of Julian Rocks as a dive site. A figure of $14.95 (1992 $) per dive was calculated, with a total value of $4 million (1992 $) (cited in Byron Shore Council, 2000).

A more recent study of people's value of marine parks was undertaken at Ningaloo Marine Park and the proposed Ngari Capes Marine Park in Western Australia. This study employed choice modelling to determine willingness to pay for ecological improvements in terms of a specified fee (McCarthy, 2009). Examples of the results include a willingness to pay of $8 for improvements that would lead to a 5% increase in turtle populations and $19 for an increase of 10% and $46 and $52 for a 5% and 10% increase in fish populations (Allen Consulting, 2009).

5.3 Beaches

Australian beaches are a highly valued natural resource for both amenity and use. The NSW Government placed beaches as one of the four most valuable natural resources in the state (NSW Government, 2006a). On a worldwide scale, Australia is synonymous with surfing and beach culture; with places such as Kirra and Bells Beach hosting international surfing contests, and companies such as Roxy, Billabong and Quiksilver being at the forefront of surf and beach culture apparel. However, many of Australia's beaches are under threat from increased development, beach erosion and sea level rise. In most cases retreat of development is unlikely, which places extreme pressure on the management of beaches as they potentially become a scarcer resource (Anning et al., 2009).

Beaches provide goods and services to many stakeholders, with a range of market, non-market and non-use values. A number of studies have been undertaken that investigate a range a values associated with beaches. Blackwell (2005) compiled several of these studies to estimate an overall value of Australia's beaches. Drawing on four recreation/tourism based studies (including one related to turtle preservation), Blackwell (2005) surmises a figure of $9-10 million per square kilometre per year for willingness to pay and $1 – 502 million in consumer surplus. Including studies of amenity and storm protection, Blackwell (2005) estimates a figure of $3.8 – 13 million per kilometre per year in market values. Blackwell (2005) goes on to point out that these figures do not capture all the potential provided by beach environments, including services such as social and cultural values. There are limited studies in Australia that capture the goods and services provided by beaches, however a number of recent studies have been undertaken that capture the values of beach visitation for both residents and tourists.

5.3.1 Visitation

Australian people value the coast. In a survey undertaken of Victorian residents it was noted that people are placing higher values on the coastline, since previous surveys, with a majority of residents (87%) visiting the coast at least once within the 12 month period (IPSOS, 2007). It was also recognised that placing a monetary figure against these values was never going to be simple (Smith and Piggot, 1989). In an early attempt of beach valuation, Smith and Piggot (1989) provided a crude estimate by multiplying the estimated visitation rates to Gold Coast (Queensland) beaches in 1983

with the average hourly salary rate. It was reported that the Gold Coast beaches were worth $24 million overall per year and $6 million per kilometer (1983 $) (Smith and Piggot, 1989). Although this figure was very much an estimate, the study provided insight into the potential value of the beach.

In another early study, the South Australian Coast Protection Board undertook an assessment of Adelaide's beaches. The travel cost method was applied to beach visitation data (day visitors) from 1986 and using shadow prices from previous studies estimated a value ranging from $2 to $3.60 (1986 $) per visit (South Australian Coast Protection Board, 1993 and references therein). A recently developed strategy titled Adelaide's Living Beaches placed the value of Adelaide's beaches to day visitors at $23 million (Burgan, 2003 cited in DEH, 2005), with nine million visitors per year (McGregor Tan Research, 2003 cited in DEH, 2005)

In recent years, valuation techniques have become more consistent and commonly use survey techniques to directly determine the respondent's willingness to pay to visit the beach. A study undertaken on the Gold Coast, by Raybould and Lazarow (2009), involved a mailed survey in which 1,862 residents responded. The results provided an estimate of 40 million beach visits on the Gold Coast annually (Raybould and Lazarow, 2009).

The study of Raybould and Lazarow (2009) also estimated the economic value of these visits to residents using the travel cost method. This method was used as the data indicated that the distance residents lived from the beach influenced their visitation rate and residents tended to travel via private car (Raybould and Lazarow, 2009). The study found that residents spent between $0.05 and $7.66 per trip per adult depending on the method used: Method 1 used the RACQ travel running costs and Method 2 included additional vehicle costs such as depreciation, registration and insurance. Residents between 1 and 5km from the beach spent between $0.40 and $1.82 (method 1 and method 2, respectively) and residents over 10km from the beach spent between $1.92 and $7.66 per person per visit (method 1 and method 2, respectively). In addition, a further question asked respondents how much money they spent on goods during their last visit to the beach. The mean expenditure was then estimated at $5.26 per person, with over 75% spent on food and beverage (Raybould and Lazarow, 2009).

Similarly, a survey of residents travel costs to the beach at Mooloolaba, QLD (Queensland's Sunshine Coast) were estimated at $2.39 per visit (Blackwell, 2007b). The data presented was collected as part of a larger study on the Economics of Coastal Foreshore and Beach Management (Blackwell, 2003). Again, Blackwell (2007b) applied the individual travel cost method to survey 250 beach users in face-to-face interviews. The results concluded that at a minimum (car running costs) resident's spending was $0.49 to $2.39 (2000 $) per person per visit and $3.58 to $17.41 (2000 $) when travel time costs were included (time costs were calculated at 40% of the individuals hourly pay rate).

The travel cost method was also used during the economic assessment of the Victoria coastline (URS, 2007). Over six hundred residents were surveyed via telephone during the study in 2007 and of these a subsample group of 429 were asked travel cost questions (URS, 2007). Four models were developed to include variations between car running costs, car operational costs, and travel time. A conservative model was chosen that incorporated the running costs of a car and travel time. The results showed that approximately $48 per person per day was spent visiting Victoria's coastline and $154 per person per trip. Results also indicated that the average trip length was 1.7 overnight stays likely due to the average distance of 154km travelled (the study excluded residents that live in close proximity to the beach whose distance travelled was considered short) (URS, 2007).

Recently, Anning et al. (2009) reported on the recreational value of Sydney's beaches. This study included a survey of 530 beach users, using face-to-face interviews and internet-based surveys. The analysis employed the travel cost method to determine the visitor dollar value per person per day and additional on-site purchases. Although the full results are yet to be published, a value of approximately $6 per visit for travel costs and $5 for on-site purchases has been provided as preliminary results available on the Sydney Coastal Council's website (SCCG, 2011), a major partner of the project.

The data collected in the above studies were also translated into annual travel costs expenditure. For the Sydney study, there were some limitations in determining a reliable number of beach visits for all three sites studied, however, using visitation rates at Manly Beach, the total annual travel expenditure was estimated at $25 million with a further $25 million for on-site expenditure (SCCG, 2011). Similarly, Blackwell (2007b) used annual visitor estimates provided by the local council lifeguard service to estimate an annual expenditure of $153 million for residents (2000 $) visiting Mooloolaba's beaches. Raybould and Lazarow (2009) estimated the annual value for the use of Gold Coast's beaches between $21.5 million and $91 million. For the Victorian coastline, the overall recreational use was valued at $1.9 billion per year (URS, 2007). The results are summarised in Table 2, below.

Table 2. Summary of beach valuation studies for Australian beaches

Study	**Location**	**Method**	**Residents/ Tourist**	**Cost/visit***	**Additional spending**	**Cost/yr* ($million)**	**Notes**
SA Coast Protection Board (1986)	Adelaide	Travel cost method	Unspecified	$2.00 - $3.60			
Smith & Pigget (1989)	Gold Coast, Qld	Visitation rate*salary	Unspecified			$24	
Cited in DEH (2005)	Adelaide	Unspecified	Day visitors			$23	
Blackwell (2007b)	Mooloolaba, Qld	Travel cost method	Residents	$0.49 - $2.39		$153	Dollar value for year 2000
Blackwell (2007b)	Mooloolaba, Qld	Travel cost method	Residents	$3.58 - $17.41			Incl. travel time
Raybould & Lazarow (2009)	Gold Coast, Qld	Travel cost method	Residents	$0.05 - $7.66	$5.26	$21.5 - $91	
Anning et al. (2009)	3 Sydney beaches (Manly, Collaroy-Narrabeen, Hawkesbury River foreshores)	Travel Cost Method	Unspecified	~$6.00	~$5.00	$25	Cost/yr estimated for Manly beach only

*dollar values have not been adjusted and are per date of publication apart from Blackwell (2007b).

The results discussed above should be considered as minimum values as the total economic value of the beaches, including both use and non-use (e.g. existence, option and bequest values), were not estimated (SCCG, 2011; Anning et al., 2009; Raybould and Lazarow, 2009). The travel cost method is a tool to measure the use-values and therefore does not take into account non-use values. The study by Anning et al. (2009), however, used a mix-mode technique that also included an assessment of the non-use values using the contingent valuation technique. During the survey, respondents were asked whether they would provide a donation to a project in place to reduce the impacts of beach erosion and resultant loss of the sandy beach due to sea level rise that would hypothetically lead to beach closures or 'loss of beach days' (Anning et al., 2009). This method calculated the willingness to pay for beach protection. Preliminary results provided by SCCG (2011) indicate that 70% of respondents believed sea level rise would have an impact on Sydney's beaches and approximately half would give 'in-principle' to a fund for beach protection. There are some limitations in these estimates as respondents were not actually required to pay and therefore may overestimate their willingness to pay.

The studies discussed above emphasise the value that people place on the beaches and coastline for recreational purposes. Raybould (1998) recognised that little was known of how both residents and tourists actually value the beach. More recently, attitudes towards the beach and its management were also incorporated into the survey of Gold Coast residents (Raybould and Lazarow, 2009) to assist in further understanding the origins of a respondent's willingness to pay. The study found that residents place great importance on the beaches and felt a sense of pride. In terms of use, activities focussed on passive recreation with being outdoors, walking/jogging and being with family and friends were also considered important (Raybould and Lazarow, 2009). In Victoria, the study found that simply being at the beach, with family and friends and experiencing a change of scenery were the most important values for use of the coastline (IPSOS, 2007). Important activities also included short walks, relaxing, and visiting seaside cafés and restaurants (URS, 2007).

Beach residents are often very active in the improvements of their beach environment, which is reflected in the number of CoastCare groups currently active in Australia. A key example of community action and pride is Gold Coast's Tallebudgera Beach being awarded Australia's Cleanest Beach in Keep Australia Beautiful's Clean Beaches Competition (2010). The award recognises community pride, participation and action and highlights the strong values that people place on the beach environment. Community members are active in improving the local environment at this site and are immensely proud of this award.

The provision of a clean and healthy coastline, in additional to the provision of adequate infrastructure, is a key motivator for beach usage.

The above studies reveal that the recreational value of an individual city's beach can be worth millions of dollars per year and in the case of a state coastline, billions of dollars. In many cases these values far outweigh the costs of maintaining and managing the beaches. The Victorian study concluded that the estimated recreational value of the Victorian coastline far exceeded the value of the coastal dependent industries that were considered within the study (URS, 2007) and highlights the risk of undervaluing natural coastal assets in favour of tradeoffs for industry and development. The above-mentioned studies are a stepping-stone to both understanding these values and placing a monetary figure on the use of beaches.

What does this mean under climate change? These studies provide a convincing argument towards investment, at both Local and State Government levels, in the recreational values of our beaches and coastline. As climate change further increases pressures on our coastline, managers will need to consider adaptation measures to ensure that the recreation opportunities meet the expectations of the community.

5.3.2 Visitation – Tourists

Australia offers endless sandy beaches of world-renowned quality and a strong tourism market. There is a high dependency of beaches on tourism economically (Moreno and Amelung, 2009) and in a document published in 2008 by Gold Coast City Council, it was noted that 56% of all overnight visitors and 30% of day-trippers visit the beach (GCCC, 2008). Tourism is a major component of the economy, for example one in every five dollars generated on the Gold Coast is directly related to the tourism industry. Tourism is a competitive world-wide market with a broad measure of economic activity including being a major employer (Houston, 2008). Tourism is also difficult to offshore, in comparison to many other industries, meaning that much of the revenue stays within the country (Houston, 2008). Tourist destinations are, on a larger scale, unique, however on a small scale if destinations do not meet the expectation of the tourist they may move to another destination taking the revenue inter-state or to another country (Stronge, 1994). The management of our beaches is therefore paramount in retaining the tourism dollar that they generate.

Coastal tourism often relies heavily on weather conditions and the consistency of weather (Moreno and Amelung, 2009). Climate change poses a threat to the coastal tourism industry, particularly in the use of beaches. The predicted changes in weather patterns include increased storm activity that will result in increased occurrence of beach erosion and coupled with sea level rise will lead to increased pressure on the coastline. The recent flooding in South East Queensland and destruction from cyclone Yasi in North Queensland have emphasized concerns regarding the impact extreme weather events can have on tourism, with numerous articles currently presented in the media. These concerns were reinforced when the Minister for Resource and Energy and the Minister for Tourism, The Hon. Martin Ferguson AM PM initially announced a $10 million Tourism Industry Support package for Queensland in February 2011 which was later increased, via the Gillard and Bligh Governments, to $12 million (http://www.minister.ret.gov.au/index.html). Tourism is a key component of the Queensland economy, directly contributing $9.2 billion annually (Tourism Queensland, 2010) and an increase in such events will potentially lead to a long term negative impact on this industry.

The economic impact of the loss of beaches (by erosion) was experienced on the Gold Coast (Queensland) after the major erosion events of 1967, when a sequence of seven major storms resulted in the temporary loss of an iconic Australian symbol (Smith, 1994). Furthermore, the sensationalism of the disaster by the media was thought to exacerbate the reduction in visitation to the Gold Coast into the early 1970s (Smith, 1994). Still today, the media sensationalises minor erosion events on the Gold Coast and go to length to print images taken at obscure angles to highlight the erosion scarp (Tomlinson, pers.comm., 2011).

After the Gold Coast's experience of the erosion events of 1967, the Queensland State Government and Gold Coast City Council commissioned an economic appraisal of the capital works required to restore Gold Coast's beaches (GCCM, 2010). This report by Maitra and

Walker (1972) became known as the Shrapnel Report and provided an analysis of tourism related statistics including visitation numbers and employment via the tourism industry. The study then went on to relate the potential value of tourism to the Gold Coast with the beaches restored via a major capital works program in comparison in an attempt to lobby the Federal Government to fund a percentage of the costs (GCCM, 2010; Maitra and Walker, 1972).

The study included an assessment of visitation by tourists via the Coolangatta airport (Gold Coast) and the data showed that within the first half of 1967 airplane arrivals fell by 14.3% followed by a further 11.8% in the first half of 1968. During the same period the figures for air travel in Australia had risen by 12.5% along within an increase of 12.7% in the Australian GNP (Maitra and Walker, 1972). This reduction in air travel to the Gold Coast was seen as directly related to the storm impacts. Considering the average amount spent per tourist was calculated at $6.80 per night (1970 $) and with the average length of the visit at 6.9 nights, a significant contribution to the local economy was lost (Maitra and Walker, 1972). Additionally, it is likely that these figures underestimated the true impact to the tourism industry as the focus was on air travel without inclusion of the many day-trippers travelling by vehicle (Smith, 1994). Smith (1994) suggested that the figures were underestimated by possibly 20-30%. In a further study by Smith (1994) a tourism loss was estimated in terms of tourist numbers that was calculated at between 400,000 (11%) and 650,000 (26%) people between 1966 and 1970.

More recent studies have been carried out that take into account the value of beaches to tourists. A US study by Stronge (1994) in Florida found that tourists who were beach oriented on average stayed longer and therefore spent more money per visit (USD$367.03 compared to USD$311.27 for non-beach oriented tourists). In the aforementioned studies by Raybould and Lazarow (2009) and Blackwell (2009) an assessment of visitation value of tourist was also included.

Raybould and Lazarow (2009) applied the benefit transfer method to draw on benchmark evaluation studies to estimate the total beach value associated with tourism. The benchmark studies were selected from the US literature as few relevant studies have been undertaken in Australia. The total number of beach visits was estimated from a number of sources including data collected by Tourism Research Australia, which questioned tourists in regards to the types of activities undertaken during their travel (e.g. beach visits) (Raybould and Lazarow, 2009). A conservative number of 7 million visits per year were estimated for beach visits by domestic overnight, international and day tourists (Raybould and Lazarow, 2009).

From this visitation rate a travel cost approach was used, based on the benchmark studies selected, to estimate the costs incurred by a beach visit for tourists. Values of $15 (lower limit) and $45 (upper limit) were selected and a range of $106 million to $319 million (2006 $) per year was estimated for the total annual beach value for Gold Coast beaches. The authors emphasise that these figures are based on estimates and assumptions only (Raybould and Lazarow, 2009), however, they do establish a foundation for further studies and again reinforce the value that beaches provide to the economy.

In Blackwell's (2007b) study of beach visitation to Mooloolaba Beach, the value of tourists visiting the beach was also calculated. The travel cost method was separately applied to survey respondents who were deemed to be tourists. Blackwell (2007b) estimated that tourists to Mooloolaba beaches spent between $11.86 and $107.75 (2000 $) per person per

visit. The total annual visits were estimated and it was calculated that $205 million (2000 $) was annually spent by tourists.

In 2000 a study of coastline values was undertaken by Byron Shire Council to estimate ecological, social and economic values. Economic use values (non-use values were not included) were estimated using the benefit transfer method and a figure of $55.5 million was estimated for Byron Shire beaches based on Pitt's study of the recreational use of beaches (Byron Shire Council, 2000). Pitt estimated an individual benefit of $150.85 per person[2] and this figure was then applied to tourism statistics collected during a survey in 1996/97 to calculate the final figure (cited in Byron Shire Council, 2000). The overall figure was calculated based on the assumption that 70 per cent of tourists visiting the shire use the beach.

Tourism associated with our beach culture is of a great benefit to the economy. In a time of increased wealth and spending, it is imperative to local and state economies that this opportunity is captured through the provision and maintenance of natural assets. Sea level rise and threats from climate change such as increased storm intensity will provide additional pressures to maintain these environments. Local and state government will need to invest in their natural assets to ensure a strong tourism culture and further investigate opportunities to diversify the tourism image for destinations that are specifically beach focussed.

5.3.3 Surfing

Surfing is embedded in the Australian beach culture and forms a part of our beach identity (Lazarow 2007, Walsh 2002). The economic benefits of surfing have been recognised in several studies focussing within the USA (e.g. Nelson, et al., 2007). Lazarow (2007) also draws attention to the social benefits of surfing including the inter-generational relationships between surfers and the provision of an outdoor activity. There is inherent difficulty in estimating the total economic value of surfing, with the inclusion of non-use values, and studies generally considering the money spent by surfers related to equipment and access for a surfing session. In addition to spending directly on a surf session, there are also major industries in surf wear, with a number of key manufacturing companies located in Australia (Lazarow et al., 2007), and a large surf tourism industry (Buckley, 2002).

There is little data regarding the economic value of surfing in Australia (Lazarow, 2007). Based on the Sweeney Report, a study by Surfing Australia (2006), Lazarow (2007) estimated that over 2.5 million Australians surf regularly (with the likelihood that this figure is underestimated as the report only took into account capital cities). Therefore, the sport of surfing has the capacity to have considerable economic value. Surfing is also at risk from the impacts of climate change due to modifications to the coastline through coastal engineering works in response to the impacts of climate change (e.g. seawall, groynes, berms and artificial reefs) (Lazarow, 2010). With competing issues in mind, understanding the value of surfing will assist in justifying decisions associated with the coastline.

Given this considerable number within the surfing community, there can be competition between both surfers at specific breaks (resulting in 'surf rage') and other users of the beach and coastline (Lazarow, 2007). Case studies at South Stradbroke Island (Gold Coast, Qld), and Bastion Point (Mallacoota, Vic) highlight the issue of competing uses of the coastline

[2] The study did not take into account local residents' use of the beach.

between surfing and a proposed economic development and coastal engineering works, respectively (Lazarow, 2007).

These case studies presented by Lazarow (2007) at South Stradbroke Island and Bastian Point provide valuation assessments of surfing to highlight the potential loss associated with the proposed development. These studies involved face to face and internet based surveys (mixed mode method) of surfers to determine the gross market expenditure of surfing at each specific site. The access to and features of the surf break at South Stradbroke Island were likely to have been impacted upon by the notional cruise ship terminal at the Southport Spit that was proposed by the Queensland State Government in 2006. At Bastion Point, a proposed groyne, as part of a major upgrading project for the local area was seen to likely have negative impacts to the surfing conditions (Lazarow, 2007). The sites were selected due to the aforementioned conflict in users and the study aimed to identify the value of surfing to these two specific sites to encourage the consideration and discussion of surfing interests during associated decision making (Lazarow, 2007). The surveys were carried out at events held in protest to the proposed infrastructure, with 73 surveys completed for South Stradbroke Island and 37 at Bastion Point, in addition to further community engagement with stakeholders at Bastion Point.

The number of surfers and surf sessions (defined as a surf by an individual that has a distinct start and end point (Lazarow, 2009)) were estimated at 11,500 surfers per year at South Stradbroke Island and equated to 64,000 surf sessions per year. At Bastion Point the average number of surfers was 75 (which is relative to the small population of the region) (Lazarow, 2007). The average dollar amount spent per surfer per year on surfing was estimated through specific questions on market expenditure within the survey. It was estimated that surfers at South Stradbroke Island spend an average of $4,365 on surfing per year with $1,775 specifically spent at this site. Surfers at Bastion Point spend $4,397 annually on surfing and $3,078 specifically at the site (Lazarow, 2007). The total amount spent on surfing each year at South Stradbroke Island was estimated at $20,000,000 and $230,850 at Bastion Point.

A larger scale study was undertaken estimating the value of surfing along the Gold Coast where 471 surveys were completed using the mix mode method of face to face interviews and an internet survey (Lazarow, 2009 and Lazarow et al., 2007). The survey included a range of socio-economic questions and 363 surveys were deemed usable to provide estimates of the dollar value of surfing to the Gold Coast (Lazarow, 2009). From the results of the survey, it was estimated that there were approximately 120,000 surfers on the Gold Coast (this included residents and visitors) and over 12.4 million surf sessions per year. An estimate of expenditure directly related to surfing was calculated through equipment purchases and travel costs. Travel costs included fuel and food, as a conservative approach. Per surf session, surfers spend between $18.67 and $30.36, which compared to US studies, is at the lower end of the range (Lazarow, 2009). This equates to $1,950 per surfer per year and almost $4000 per surfer per year if accommodation was included (Lazarow, 2009). Based on the former figure a total expenditure of $126 - $233 million dollars was estimated (the range in values was determined via three different methods of estimating the total number of surfers).

These studies provided a basis for understanding the economic value of surfing. They do not, however, represent a total value as non-use values (such as option, existence and bequest) were not included within the studies (Lazarow, 2007). Given the general attitudes surrounding surfing as a sport and the considerable number of surfers, there is likely to be

significant non-use values associated with surfing sites leaving opportunity for further studies to allow the total value to be captured.

Lazarow (2010) highlights the potential conflict between surfing and adaptation measures associated with climate change. Modifications to our coastline, such as hard engineering infrastructure, can result in changes to the natural surf conditions. The loss of a surf break will have flow-on effects that will be felt both economically and socially within a community. In some cases, surfers may choose another location, but often the locations are limited due to the very nature of the coast. As discussed above, surfing provides a significant input into the economy, along with social values such as health and well-being. With a future under climate change, it is important that adaptation measures take into consideration surfing and its value wherever possible.

5.4 Coral reefs

Coral reefs are known for their biodiversity, aesthetics and recreational appeal. Coral reefs are highly valued and provide many goods and services, including:

- Recreational fishing
- Commercial fisheries
- Habitat
- Recreation opportunities (e.g. diving, boating)
- Tourism
- Aesthetics
- Storm protection
- Bio-prospecting (medical research for pharmaceutical drugs)
- Minerals (e.g. limestone)
- Aquarium fish trade
- Nutrient storage and recycling

(Mooney et al., 2006; PDP Australia, 2003)

It is well understood that coral reefs are under threat from a number of anthropogenic and natural impacts (including agricultural runoff, increased suspended sediment from land clearing and development and pollution). The risks associated with climate change predictions further intensify the anthropogenic threats. Predicted climate change scenarios include an increase in storm intensity, resultant flooding, sea level rise, increased sea temperatures leading to coral bleaching and loss of corals due to ocean acidification. These threats can be both direct and indirect, for example increased storm intensity may have a direct impact upon the structure of the reef along with a further impact from pollution associated with increased runoff during flooding. Adding to this, increasing population and urbanisation will further exacerbate these threats.

There are great concerns regarding the impacts of increasing sea surface temperatures and coral bleaching. A mass global coral bleaching event in 1998 led to a worldwide mortality rate of 16% along with 75% of coral reefs being affected (Cesar et al., 2003). There is a risk that coral bleaching will become an annual event within 50 years under current climate change scenarios (Cesar et al., 2003). Such events will lead to significant impacts to coral reef systems and have major secondary effects on the communities that rely on their use.

In addition to natural pressures, there are also many well known anthropogenic threats to coral reef systems including:

- Pollution from land based activities (e.g. increased nutrients leading to algae blooms)
- Sedimentation (increased suspended sediment load from land based activities)
- Over fishing
- Tourism including diving (over visitation and subsequent degradation to the fragile reef)

Unfortunately, there is often limited compatibility between the goods and services provided (Cesar, 2000): the use of one will limit use by another. This comes about due to externalities where people are benefiting from the natural system without paying the full cost of their impact (Cesar, 2000). This may include the impact of overfishing on future fish stocks, poor land management causing sedimentation or tourism damaging the reef leading to a loss of future tourism and impacting local businesses. In some cases, these externalities can be managed through economic tools (e.g. licensing and exemption zones) (Davis and Gartside, 2001), however it is innately difficult to provide strategies that meet the needs of all users and ensure a sustainable future. There is also strong competition between uses such as tourism, commercial entities and conservation (KPMG, 2000) adding a further complexity to their management.

Coral reefs are a vital component of the economy and welfare of many countries in tropical regions. Many island nations, particularly those of developing countries, rely heavily on coral reef systems, notably for food and tourism. The economic value of coral reefs have been studied worldwide in a number of contexts mainly in regards to fisheries and tourism and in some cases coastal protection, biodiversity and carbon sequestration (Conservation International, 2008). Costanza et al. (1997) included coral reef systems in their assessment of ecosystem services and valued the world's reefs at USD $6,076 per hectare per year. Cesar et al. (2003) placed an overall figure of USD $800 billion on the world's coral reefs (discounted at 3% over a 50 year timeframe). These figures highlight the immense value of coral reef systems to many people of the world.

However, many studies likely underestimate the total value as they generally don't take into account the full economic value of the resource. Studies often focus on one component of the reef's resource provisions such as fishing, tourism or mining, etc (Moberg and Folke, 1999). Additional values are difficult to estimate and include the non-use or indirect values that are unpriced and not found in the market place (existence, bequest and options values – see Section 3.1).

The world's coral reef systems are on a steady decline due to the many anthropogenic threats (Hoegh-Guldgerg, 2011). In many countries they are poorly managed and exploited. Understanding the total economic value of reef systems will aid in establishing effective and sustainable management strategies and support appropriate resource allocation.

Australia is home to several coral reef systems, most famously the Great Barrier Reef and also smaller reef systems such as Ningaloo Reef in Western Australia. Cesar et al. (2003) estimated an annual value of USD $168 billion per year for Australian coral reefs based on a previous study of coral reefs in Hawaii (Cesar et al., 2002 cited in Cesar et al., 2003) and an area of 49,000 km^2. However, Oxford Economics (2009) highlights that this area is over twice the size of the Great Barrier Reef and therefore the result may be limited. Nevertheless, the estimate emphasises a high value may be placed on Australia coral reefs as natural assets.

The Great Barrier Reef is an iconic coral reef system extending over 2000 km in length along the North Queensland coastline. There are over 300 fringing and platform reefs and with its vast size is the largest coral reef system in the world (Hopley 1982 cited in Mooney et al., 1996). The Great Barrier Reef region is also well known as a tourist destination particularly for diving. Approximately 1.1 million people visit the reef annually (Oxford Economics, 2009) and reef tourism provides Queensland with its second largest industry valued at $1.5 billion (Mooney et al., 1996).

The Great Barrier Reef has been well studied in economic terms and most studies are commissioned economic reports targeting specific uses. Stoeckl et al. (2011) provides a very useful review of a range of relevant studies. Several of these studies are discussed below. The earliest of these was a study by Hundloe et al. (1987) looking at the economic impact of the Crown of Thorns Starfish to the reef (cited in Stoeck et al., 2011 and Oxford Economics, 2009). This was one of the few studies to estimate non-use values and using the contingent valuation method surveyed Australian resident's (geographically distanced from the Great Barrier Reef) willingness to pay for research and management to control the Crown of Thorn Starfish (Ruitenbeek, 1999). The survey asked respondents if they would be willing to pay an entrance fee and an additional fee for research and control (Oxford Economics, 2009). The results were extrapolated to the Australian population and an estimated benefit of $98 million per year (converted to 2003 $) was calculated (PDP Australia, 2003). This study by Hundloe et al. (1987) has been used during several other studies as base data for further economic valuations (see below) and this reliance highlights the lack of current research associated with non-use values for the Great Barrier Reef.

Choice modelling was employed for a study of non-use values of biodiversity conservation of Ningaloo Reef in Western Australia (Gazzani and Marinova, 2007). Two hypothetical scenarios, representing levels of conservation, were provided to surveyed respondents in addition to the current reef status. Willingness to pay was calculated at $26.12 to increase the conservation area of Ningaloo Reef.

Carr and Mendelsohn (2003) estimated annual recreational benefits of the Great Barrier Reef by applying the travel cost method to domestic and international air travel. The study estimated the recreational value to range from USD $700 million to $1.6 billion per year, with an average of between USD $350 to $800 per person per visit. Carr and Mendelsohn (2003) concluded that there are very high economic values associated with the Great Barrier Reef and conservation and appropriate management is warranted.

In a study of recreation divers and snorkelers, Kragt et al. (2006) used the contingent behaviour approach to assess the impact a decline in quality of the Great Barrier Reef may have upon visits by this user group. The study adopted both revealed and stated preferences of reef trip demand. Interviews were carried out on commercial dive boats within the Port Douglas region and respondents were asked their maximum willingness to pay to continue visiting the reef in the future (Kragt et al., 2006). Additionally, respondents were presented with a scenario of future reef degradation and asked whether this would influence their future trip numbers. Consumer surplus was estimated at $62.50 per reef trip with an annual figure of $96 million for all Great Barrier Reef visitors. Under a scenario of reef degradation, a 59% decrease in visits was determined which would lead to a loss of $23.50 per person or $57 million for all visitors (Kragt et al., 2006). The study also highlighted that a reduction of 59% in reef visits would lead to a potential profit loss to tourism of approximately $136 million per year (before considering flow-on effects) (Kragt et al., 2006).

A number of studies have been carried out that focus on specific uses such as tourism and fisheries and utilise market values for estimating the overall economic value of the Great Barrier Reef. For example KPMG (2000) presented a study of the direct uses of the Great Barrier Reef; namely tourism, commercial fisheries and recreational fishing and boating (the figures update a previous report by Driml (1997). The assessment considered market values and estimated the gross financial value[3], output effects and employment effects. Tourism was estimated using passenger expenditure accommodation and spending at resorts, etc. Commercial fisheries were estimated by the size of the commercial catch and the gross value of the catch, with recreational fishing and boating estimated through use of previous data. Table 3 provides a summary of the results.

Table 3. KPMG results for the Great Barrier Reef for 1997-98 (KPMG, 2000).

	Gross Financial Value	Output effects (total impact) ($ millions)	Employment effects (total impact)
Tourism	$454,836,000	$844.4	$12,888
Commercial fisheries	$136,180,000	$193.3	$2,720
Recreational fishing/boating	$107,572,000	$254.9	$2,008
Total	$698,588,000	$1,293.2	$17,616

In 2003, PDP Australia (2003) undertook an economic and social impact assessment of the Great Barrier Reef in relation to rezoning that took place to modify a number of zoned areas. The modification reflected an increase in the size of protected areas and expansion of the 'no-take' zones (PDP Australia, 2003). The assessment included tourism, commercial fisheries, recreational fishing and also explored social and cultural values and considered the potential changes in value associated with the proposed rezoning. The estimated values presented were in terms of value added and gross financial value based on market figures.

Tourism expenditure was estimated through the combined data of the Great Barrier Reef Marine Park Authority Environmental Management Charge and OESR (2002) at $274 per visit and $589.4 million per year (based on reef visitation charges, land and island based accommodation) (PDP Australia, 2003).

Commercial fisheries were estimated at $24.6 million per year value added[4] and $130.1 million per year for gross value product (1996-2002) (PDP Australia, 2003). Estimates were derived from previous reports by ABARE referred to in the Productivity Commission (2003). The assessment also considered the economic cost of the rezoning to fisheries. A loss of between $0.52 and $2.59 million per year was estimated as a value of forgone activity (equivalent to 4.1 cents to 10.2 cents per year for each Australian) (PDP Australia, 2003). PDP Australia (2003) also discussed the potential for adaptation of the fisheries industry through mobility and flexibility of their activities, to reduce the potential of this loss.

Several previous studies were used to establish a range of values for recreational fishing. Expenditure data of $5,000 (2002 $), estimated by Blamey and Hundloe (1993) (expenditure included travel and accommodation costs and sundries), and vessel registration data were combined to give a total expenditure for 2002 of $201 million (although it was recognised that this may be an overestimate as fishing also occurs outside of the marine park) (PDP Australia, 2003). Alternatively, an expenditure of $80.7 million per year was estimated based

[3] Gross financial value - the economic worth of the total quantity harvested
[4] Value added – output after deducting the value of inputs.

on a survey by Henry and Lyall (2003) that calculated average expenditure per person of $407 and an estimated 198,327 recreational fishers (cited in PDP Australia, 2003).

A series of annual economic contribution studies of activities within the Great Barrier Reef catchment area have been undertaken by Access Economics from 2004/05 to 2006/07. These studies focussed on the use values of tourism, commercial fisheries and recreation activity in terms of added value, gross product and employment and consider only market transactions (Access Economics, 2005; 2007; 2008). Social, ecological and non-use values were not included. A further limitation when considering the values of the Great Barrier Reef, is these studies cover the entire catchment area and include activities that may not be specifically or directly related to the reef system itself (Oxford Economics, 2009)

Access Economics (2007) provide the most recent results for the Great Barrier Reef Catchment area, these are summarised in Table 4 (bearing in mind these results are for the catchment area, and the values would be smaller for the reef and marine park) (Access Economics, 2007).

Table 4. Direct and indirect value added contributions to the Great Barrier Reef catchment 2006/07 (Access Economics, 2007).

Direct + Indirect contribution	
Tourism	$3,344 million
Commercial fishing	$117 million
Recreational fishing	$61 million
Other recreational activities	$36 million
Total contribution	$3,558 million

The methods employed for these assessments used the Tourism Satellite Account[5] and tourism survey data for tourism and recreational use and conventional supply-side analysis for commercial fisheries (Access Economic, 2008).

A more recent report by Oxford Economics (2009) assessed the cost of permanent coral bleaching of the Great Barrier Reef within hypothetical scenarios. Unlike previous studies, this assessment more effectively considered the approach of total economic value and included:

- direct use – tourism and fisheries
- indirect use – coastal protection
- non-use values – option, existence and bequest; i.e. willingness to pay for continued existence

The total value of the Great Barrier Reef was estimated with a present value[6] of $51.4 billion and the cost of permanent bleaching of corals within the Cairns area was estimated at $37.7 billion (Oxford Economics, 2009). In comparison to several other economic studies of the Great Barrier Reef, this study focussed on values that can be more directly related the Great Barrier Reef itself (as opposed to the catchment or region) (Oxford Economics, 2009).

Table 5 below provides a summary of the estimates provided during this study along with a brief summary of the methods used. In determining the non-use values, this study (similar to

[5] Tourism Satellite Account – measures the total inbound economic value of tourism to gross domestic product

[6] Present value – benefits are estimated considering their value into the future

several before) relied on the previous work by Hundloe et al. (1987) in addition to the more recent work by Windle and Rolfe (2005).

Table 5. Present value of the Great Barrier Reef (GBR) and value of bleaching costs (from Oxford Economics, 2009).

	Present value of GBR ($ billion)	Present value of bleaching costs ($ billion)	Methods
Tourism consumer surplus	16.6	16.6	Travel cost method (survey data of tourists from Bureau of Tourism Research) Travel cost method (survey data applied to domestic and international visitors collected by James Cook University)
Tourism producer surplus (profit)	3.6	3.6	Regional expenditure values derived from Bureau of Tourism Research data
Recreational fishing consumer surplus	2.5	0.0	Use of previous studies of recreational fishing in the Great Barrier Reef Catchment (Blamey and Hundloe, 1993)
Recreational fishing producer surplus (profit)	0.3	0.0	Sales of fishing equipment, boats, including hire and fuel based on estimates provided by Access Economics (2008)
Commercial fisheries producer surplus (profit)	1.4	0.4	Derived from Gross Value of Production figure for "wild harvest" fisheries and the gross value added figure for commercial fisheries provide by Access Economics (2008)
Indirect use values (coastal protection)	10.0	0.0	Minimum cost value of shoreline protection based on cost of construction of revetment walls at $2,300 per metre
National non-use values	15.2	15.2	Derived from Hundloe et al. (1987) study using contingent valuation method to determine willingness to pay for entrance fees and research and Windle and Rolfe (2005) estimated Brisbane resident's willingness to pay for changes in water quality of the Fitzroy estuary (see Section X).
International non-use values	1.9	1.9	Benefit transfer method, data derived from Pearce (2007) study of willingness to pay for rainforests in the US
TOTAL	51.4	37.7	

The aforementioned studies highlight the immense value of coral reefs systems, namely the Great Barrier Reef, and the goods and services they provide to the Queensland and Australian economy and people. Given that a range of methods has been used and assessments of both direct use (market values) and non-use values have been considered, comparison across the studies can be somewhat difficult. Oxford Economics (2009) criticises previous studies where non-use values were not included. Non-market values, including non-use values, are inherently difficult to determine and require time consuming methods such as surveys. This is reflected in the small number of these studies available and the reliance on previous studies such as Hundloe et al. (1987) to provide a basis for further economic valuation. Table 6 provides a summary of all values provided for the Great Barrier Reef.

Climate Change and the Great Barrier Reef

More recent studies (Miles et al., 2009; Oxford Economics, 2009) assess the potential threats of climate change on the values of the Great Barrier Reef. Climate change is likely to have significant impacts on the coral reef ecosystems of Australia and management to facilitate resilience and recovery will be of growing importance (Access Economics, 2006). A recent report card for the marine environment reported that parts of the Great Barrier Reef have experience coral bleaching and decline due to warmer sea surface temperature and a reduction in coral growth rates of the Porites corals have been linked with ocean acidification (Poloczanska et al., 2009).

Access Economics (2006) included a qualitative assessment of the implications of climate change on the industries dependent on the Great Barrier Reef. Tourism will be directly affected through the loss of coral from increased incidents of coral bleaching (increased sea surface temperatures) and ocean acidification. Access Economics (2006) concluded that if the reef is well managed (improved sustainability) and human impacts reduced then it may be more resilient to climate change induced events. A long term trend may be that tourism moves away from reef-specific to other tourism opportunities within the region (Access Economic, 2006). However, given that tourism is such an important industry within the Great Barrier Reef catchment, generating $4.2 billion annually (in 2003) (Miles et al., 2009), consideration of the impacts of climate change to tourism is important.

Miles et al. (2009) undertook a survey of businesses to understand their attitudes to climate change with the following results:

- 40% of respondents thought the Great Barrier Reef was important to their business
- 50% of respondents believed that climate change would have a considerable impact on the Great Barrier Reef.

However, one third thought climate change would have no major impact on their business, therefore, respondents believe that climate change will affect the reef but not necessarily impact their business (Miles et al., 2009). In some cases, respondents felt they had capacity to diversify their business to accommodate for climate change. Interestingly, the survey revealed a lack in respondents understanding in regards to climate change adaptation. When asked questions about adaptation to climate change, most respondents answered with mitigation type responses (i.e. reduce carbon). As most respondents obtain their information from the media (Miles et al., 2009) this highlights the media's focus on climate change mitigation and emphasises the need for more available information regarding climate change adaptation.

5.5 Coastal lakes

Coastal lakes are picturesque features of the Australian coastal zone providing many social, cultural and economic benefits to coastal communities. These habitats are under great pressure from urban

development and population growth, particularly via increased pollution, changes in overland flow, stormwater and use, as well as management strategies such as artificial opening to the ocean. In addition to these threats are the potential threats related to climate change. These include sea level rise and increased coastal erosion (a result of increased storm intensity) and saline water intrusion.

Growing concerns regarding the sustainability of coastal lakes led to the development of an assessment tool: the Coastal Lake Assessment and Management (CLAM) (NSW Government, 2006b). The CLAM tool is managed by the Integrated Catchment Assessment and Management Centre at The Australian National University. The main purpose is to assess the sustainability of coastal lake catchment areas. The program uses Bayesian networks to develop an integrated model framework, which allows for the inclusion of both qualitative and quantitative data (Ticehurst et al., 2006). The model aims to integrate existing knowledge on the ecological, social and economic functions of coastal lakes, identify tradeoffs and provide decision support tools.

A CLAM tool will be developed for 27 coastal lake catchments within NSW with eight already completed (Cudgen, Myall, Wollumboola, Narrawallee, Burrill, Coila, Back and Merimbula). Ticehurst et al. (2006) provides an overview of Bayesian networks and a case study of Cudgen Creek and Ticehurst et al. (2008) provides a description of the decision support tool with a case study of Merimbula Lake. An outcome of the model is the provision of the expected value of utility for each 'scenario run', for example a scenario run with a development buffer of 50m will lead to a 6% increase in fishing revenue (estimated at $1 million) (Ticehurst et al., 2008). These results support an improved understanding for tradeoffs to be made during decision making in the management of these coastal lakes.

5.6 Intertidal – Wetlands, Salt Marsh, Mangroves, Estuaries, and Seagrasses

A number of Australian studies have been undertaken to assess the economic values of coastal wetlands, salt marshes, mangroves, estuaries and seagrasses.

5.6.1 Coastal wetlands – salt marshes and mangroves

The intertidal area of the coastline supports a wide range of habitats and provides for a number of direct and indirect uses. Costanza et al. (1997) placed a value for ecological services of US$9,990 per hectare per year on wetlands – specifically tidal salt marshes and mangroves and an annual global value of US$1,648 billion. Blackwell (2007a) calculated a value for Australia's tidal wetlands based on these figures of $1,796,364 (2005 $) per square kilometre (tidal salt marshes and mangroves) with a total annual value of $39.1 billion (2005 $). As previously mentioned, these figures may have limitations but provide a useful basis in understanding the value of natural coastal assets.

Australia has some of the most pristine and diverse mangrove forests and wetlands in the world, with areas in North Queensland having almost half the number of species in the world (PDP Australia, 2003). Although significantly cleared in the past, mangroves in Australia are now protected which is a reflection of the high values they contain. Mangroves are one of the most productive ecosystems in the world and their values include:

- habitat for commercially important fish species
- habitat for juvenile fish and prawn species
- nutrient cycling
- sediment accumulation
- wave dissipation
- storm protection and erosion buffer.

Given the high value of wetlands and mangroves, there are few studies in Australia that investigate their economic value or contribution. Morton (1990) sampled total fish biomass in the mangroves of Moreton Bay, Queensland. The study estimated the value of mangroves at $8,380 per hectare based on the market value of the fish caught (not taking into account juvenile fish of commercially important species). Additionally, a study by Thomas and Connolly (2001) found that 14 of 23 fish species inhabiting a subtropical salt marsh in northern Moreton Bay (Queensland) were of commercial and recreational significance, highlighting the potential value of these ecosystems.

An assessment of non-market values for the coastal wetlands of Moreton Bay (which includes mangroves) was undertaken by Clouston (2002). Economic values of these wetlands are both direct (fisheries, recreation) and indirect (habitat, storm protection, water quality, waste assimilation) and include non-use values (cultural, conservation). Moreton Bay supports a wide range of flora and fauna, including turtles and dugongs leading to additional non-use values associated with conservation. The study assessed whether non-use value methods, namely the contingent valuation method, can be used to determine the ecological value that survey respondents held for the wetlands of Moreton Bay and whether their values can be influenced by how much information they are provided with (e.g. no additional information, ecological information, use value information and non-use value information (Clouston, 2002).

Respondents were asked their willingness to pay for a hypothetical conservation trust fund to undertake management options to improve water quality. Of those that were willing to pay, respondent that were provide with 'non-use' information were willing to pay $11.41 and those that were provided with 'use' information were willing to pay $19.22. The survey results found that between 39.6% and 51.6% of respondents (depending on the information provided) indicated that they would be unwilling to pay (mostly on the basis of not being able to afford it). Once these 'protest bids' were removed, the study found that the remainder of respondents were, on average, willing to make a 'one off' payment of $22.74 (Clouston, 2002).

5.6.2 Estuaries

Estuaries are also seen as having many direct and indirect use values in addition to non-use values. These include ecosystem services such as breeding grounds and habitats for juvenile species, provision of habitat, nutrient cycling and water filtration (Robinson, 2001b), in addition to goods such as those linked to the fisheries industry. Estuaries also provide additional services including sheltered water for shipping movement, shoreline protection, waste disposal and tourism activity (Robinson, 2001b). In many cases, the use of these goods and services is likely to come into conflict.

Costanza et al. (1997) valued the world's estuary systems at USD$22,832 per hectare per year and an annual global figure of USD$4,110 billion. Using Costanza et al. figures, Blackwell (2007a) placed an indicative value of $4,105,563 per square kilometre on Australian estuaries and an annual value of $68.1 billion ($A 2005). Within this study, estuaries were the most valuable natural assets per square kilometre of the Australian ecosystems that were included (followed by floodplains and seagrasses) (Blackwell, 2007a). In their assessment of values of the Victorian coastline, URS (2007) also noted that estuaries provided the most ecological services of all the coastal habitats.

Blackwell (2007a) also undertook a more detailed assessment of estuaries collating a range of Australian and overseas studies. This assessment provided a figure of $2,063,060 (1995 $) per square kilometre per year for willingness to pay; a consumer surplus of $32,125 per square kilometre per year based on a recreation boating study by Driml and McBride (1982); and a market value of $27,072 per square kilometre per year based on food, recreational fishing and port services (Blackwell, 2007a).

Robinson (2001b) provides a review of economic values associated with commercial and recreational fisheries of species that rely on estuaries at some point within their life cycle (oyster, prawn, barramundi, and crabs). The study is limited in that only market values (direct use values) were included, as there are few studies available of the indirect use and non-use values relative to Australian estuaries. The study found that the total market value of commercial fisheries linked to estuaries was $432 million per year. The fisheries included rely on an unmodified estuarine system for the successful lifecycle of the fish catch (thereby supporting the values of the natural environment). Robinson (2001b) also assessed the value of the commercial fisheries of species that are not totally dependent on estuaries but benefit from the protection of estuaries when available (e.g. bream, mullet, snapper, tailor and whiting). With several caveats in consideration, the total value was estimated at $40 million per year. Several examples of the estimated values of recreational fishing undertaken in estuarine environments were also provided. For example, using data from a Department of Primary Industry survey in Queensland in 1997, Robinson (2001b) concluded that a contribution of $528 million per year is made by recreational fishers in estuaries to the Queensland economy. This was based on fishers spending approximately $1,000 per year on goods related to fishing (i.e. tackle, boats, travel and accommodation).

A more detailed non-use values study of the Fitzroy estuary was undertaken by Windle and Rolfe (2005). This study employed choice modelling to survey Australian resident's willingness to pay to improve water quality in the Fitzroy estuary (being within the Great Barrier Reef catchment). The study was used as a means to understand how people value improved estuary conditions that are linked to the iconic Great Barrier Reef. Respondents were geographically removed from the Great Barrier Reef catchment (i.e. Brisbane) and were provided with a number of scenarios and choice sets. The sets included environmental issues such as healthy vegetation, healthy waterways, health of the estuary and protection of aboriginal cultural sites. Respondents were asked to include how much they were willing to pay for each option. The results of the study found that respondents were willing to pay $3.21 per household per year for a one per cent improvement in the health of the Fitzroy estuary.

The method of choice experiments (choice modelling) was used in a study by Kragt and Bennet (2009) to determine the values of river and estuarine health within the George catchment in North East Tasmania. This data was further developed into an integrated catchment modelling project that utilised Bayesian network modelling techniques to integrate hydrological, ecological and economic features of the catchment (Kragt et al., 2011). The study received a total of 586 returned surveys. To determine willingness to pay, respondents were asked if they would make a 'one off' payment as a levy within their rates. The survey included attributes of both the river and estuary and a bed of seagrass was used as an indicator to assess the value of estuarine health. Results showed that while respondents were willing to pay between $2.47 and $4.46 per kilometre for riverside vegetation, respondent's willingness to pay for seagrass protection was much smaller at $0.13 per hectare for one model. Overall the study found the respondents preferences for seagrass ambiguous with feedback implying that some may see seagrass beds as a nuisance (Kragt and Bennet, 2009).

5.6.3 Seagrass

Seagrass meadows are equally important in the goods and services they provide to human welfare, for example:

- nutrient sink
- habitat for many species forming a complex ecosystem
- nursery area for juvenile species including several of commercial value
- high rates of productivity

- stabilisation of coastal sediments
- influence on longshore sand transport.

A study of seagrass beds along the coastline of Adelaide highlights the influence seagrass has on coastal sediment transport. The study recorded a reduction in seabed elevation and increased erosion blow-outs where seagrass loss had occurred with evidence of the redistribution of inshore sediments (DEH, 2005). Furthermore, the loss of seagrass has lead to increased wave energy reaching the shoreline and a change in the degree of wave refraction (DEH, 2005).

Although these valuable services are recognised from a qualitative view, there seems to be few studies that estimate the economic contribution made by seagrasses and their habitat. In Australia, two studies have been undertaken that link a specific species dependent on seagrass to their marketable economic value. Watson et al. (1993) provide a study on the value of commercial Penaeid prawns that reside in seagrass in North Queensland and McArthur and Boland (2006) modelled the link between seagrass dependent species and a reduction in catch due to seagrass decline.

Watson et al. (1993) placed an average value of $1.2 million per year on the three major commercial prawn species dependent on seagrass within the Cairns Harbour. Unsworth and Cullen-Unsworth (2010) used this figure in a comparative study of international literature and calculated a value of USD$3,500 per hectare per year.

The study by McArthur and Boland (2006) considered another aspect of seagrass value, being the secondary production rates related to seagrass in South Australia. The study modelled a number of seagrass dependent species (e.g. southern calamari, blue swimmer crab, southern sea garfish, King George whiting, snapper, tommy ruff and yellowfin whiting) relative to their catch rate and potential reduction in catch if seagrass habitats were degraded. The results showed that a loss of 16% in seagrass would result in an economic loss of up to $235,000 per year (McArthur and Boland, 2006). The study also estimated that the seagrass habitats of South Australia have an economic contribution of $114 million per year (in terms of secondary production). Unsworth and Cullen-Unsworth (2010) further expand on this figure to give an estimate of USD$133 per hectare per year.

Costanza et al. (1997) also include seagrass in their global assessment of ecological services. An annual value of US$19,004 per hectare was estimated along with a global value of US$3,801 billion. Blackwell (2007a) estimated an indicative value of seagrass to the Australian economy of $3,417,227 per square kilometre per year and an overall estimation of $175.3 billion annually.

6.0 CONCLUSION

This paper has highlighted the immense value of natural coastal assets to human welfare; from both a market and an ecological point of view, our coastal assets are worth billions of dollars annually. Economic valuation is a growing field in Australia and the recent broad scale study of the values of the Victorian coastline highlights interest and commitment to improve management decisions. If coastal assets are valued in monetary terms, local Council's will be in a better position to ensure appropriate management strategies are in place, and that they are prepared for further tradeoffs as our coastal communities experience climate change. With the climate change adaptation question looming over us, managers will be better able to argue for funding for protection and maintenance of their assets.

There are of course limitations in providing this level of assessment and much discussion regarding the validity of methods involved. Many of the studies do not assess the total economic value and are

likely to be underestimating the overall value of the goods and services provided. However, the figures, overall, provide a convincing argument of the value of our natural assets and a starting point for many conversations.

Population growth within our coastal cities and towns will provide yet further pressures on our environment and an increased need for infrastructure and urbanisation. Many of our State coastal plans and policy recognise the importance of understanding economic, social and environmental values and incorporating them into planning. This emphasises the need for further future research into understanding the total value of our natural coastal assets.

Part 2 of this paper will investigate the value of built coastal assets, with the following key points:

- Increased vulnerability under a changing climate
- Tradeoffs between coastal protection and environmental changes
- Cost benefit analysis
- State coastal management plans – e.g. interim net benefit
- Limitations in economic analysis – cost for small projects
- Hedonic pricing methods and property values related to coastal views
- Value of beach nourishment provided to protect property
- Value of infrastructure that provides a key element in a coastal community and is highly vulnerable to SLR, e.g. surf lifesaving clubs
- Value of recreational infrastructure at risk under climate change
- Economic values and policy

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APPENDIX

Summary table of values for each natural asset type.

Study	Natural asset	Description	Value	Value of dollar (if stated as different to year study published)
Coastal and Marine Ecosystems				
Costanza et al., 1997	World's coastal ecosystems		US$20,949 billion per year US$577 per hectare per year	1995
URS, 2007	Victorian coastline	Annual output value	$2,796 million per year	
URS, 2007	Victorian coastline – recreational value	Consumer surplus Travel cost method	$48 per day $154 per person per visit $1.9 billion per year	
Blackwell, 2005	Marine ecosystems		$1,359.3 billion per year	
Davis, 1996	Non-market value use of Julian Rocks (Cape Byron Marine Park)	Travel cost method	$4 million per year	1992
Beaches				
Blackwell, 2005	Beaches	Willingness to pay (from previous studies)	$9-10 million per km^2	
Blackwell, 2005	Beaches	Consumer surplus (from previous studies)	$1-502 million per year	
Blackwell, 2005	Beaches – amenity/storm protection	Market values (from previous studies)	$3.8-13 million per year	
Smith & Piggot, 1983	Gold Coast beaches	Visitation and salary	$24 million per year $6 million per km	
South Australian Coast Protection Board, 1993	Adelaide's beaches	Visitation rates	$2-3.60 per visit	

Study	Natural asset	Description	Value	Value of dollar (if stated as different to year study published)
Raybould & Lazarow, 2009	Gold Coast Beaches (QLD) (residents)	Travel cost method	$0.05-7.66 per trip $21.5-91 million per year	2006
	Gold Coast beaches (QLD) (tourists)	Travel cost method	$15-45 per visit $106-319 million per year	2006
Blackwell, 2007b	Mooloolaba Beach (QLD) (residents)	Travel cost method	$0.49-$2.39 per visit costs $3.58-17.41 per visit incl. time costs $153 million per year	2000
Blackwell, 2007b	Mooloolaba Beach (QLD) (tourists)	Travel cost method	$11.86-107.75 per visit $205 million per year	2000
Anning et al., 2009	Sydney's beaches		$6 per visit $5 for onsite purchases	
	Manly Beach (NSW)		$25 million per year travel $25 million per year onsite purchases	
Surfing				
Lazarow, 2009	South Stradbroke Island (Gold Coast – QLD)	Travel cost method	$4,365 per year on surfing $1,775 per year at this site $20 million per year at this site	
Lazarow, 2009	Bastion Point	Travel cost method	$4,398 per year on surfing $3,078 per year at this site $230,850 per year at this site	

Study	Natural asset	Description	Value	Value of dollar (if stated as different to year study published)
Lazarow, 2009	Gold Coast (QLD)	Travel cost method	$18.67-30.36 per surf session $1,950 per surfer per year $126-233 million	
Coral Reefs				
Costanza et al. 1997	World's coral reefs		US$6,076 per hectare per year US$800 billion per year	1995
Cesar et al. 2003	Australia's coral reefs		US$168 billion	
Hundloe et al. 1987*	Research & control of Crown of Thorn Starfish (Great Barrier Reef, QLD)	Contingent valuation method	$98 million per year	2003
Gazzani & Marinova, 2007	Non-use value at Ningaloo Reef (WA)	Choice modelling	$26.12 to increase conservation	
Carr & Mendelsohn, 2003	Great Barrier Reef	Travel costs (air travel)	US$700 million to US$1.6 billion per year US$350-800 per person per visit	
Kragt et al., 2006	Great Barrier Reef (decline)	Contingent valuation method	$62.50 per reef trip $96 million per year -$23.50 per person if degraded -$57 million per year if degraded	
KPMG, 2000	Great Barrier Reef	Gross Financial Value	$455 million – tourism $136 million – commercial	1997/98

Study	Natural asset	Description	Value	Value of dollar (if stated as different to year study published)
			fisheries $108 million – recreational fishing/boating	
PDP Australia, 2003	Great Barrier Reef	Tourism expenditure Value added Gross value product	$274 per visit $589.4 million per year $24.6 million per year $130.1 million per year	2002 1996-2002
Blamey & Hundloe, 1993*	Great Barrier Reef - fishing	Travel cost method	$5,000 per year $201 million per year	2003
Henry & Lyall, 2003*	Great Barrier Reef - fishing		$407 per person per year $80.7 million per year	
Access Economics, 2008	Great Barrier Reef	Value added	$3,344 million – tourism $117 million – commercial fisheries $61 million – recreational fishing $36 million – recreational other	2006/07
Oxford Economics, 2009	Great Barrier Reef – cost of coral bleaching	Present value	$51.4 billion	
Intertidal – Wetland, mangroves, estuaries and seagrass				
Costanza et al., 1997	Global wetlands – tidal marshes and mangroves		US$9,990 per hectare per year Us$1,648 billion per year in total	1995

Study	Natural asset	Description	Value	Value of dollar (if stated as different to year study published)
Blackwell, 2007a	Australia's wetlands – tidal marshes and mangroves		$1,796,364 per km^2 per year $39.1 billion per year	2005
Morton, 1990	Mangroves of Moreton Bay (Qld) based on market value of fish	Market value	$8,380 per hectare	
Clouston, 2002	Non-market values of Moreton Bay (Qld) wetlands	Contingent valuation method	$11.41-$19.22 as a one off payment	
Costanza et al., 1997	World's estuaries		US$22,832 per hectare per year $US4,110 billion per year	1995
Blackwell, 2007a	Australia's estuaries		$4,105,563 per km^2 per year $68.1 billion per year	2005
Blackwell, 2007a	Australia's estuaries	Willingness to pay (from previous studies) Consumer surplus (from previous studies) Market value (from previous studies)	$2,063,060 per km^2 per year $32,125 per km^2 per year $27,072 per km^2 per year	1995
Robinson, 2001b	Estuaries through value of estuarine fish	Market value of estuarine fish (dependent of estuaries) Market value of partially dependent fish species Market value of recreational fishing in estuaries	$432 million per year $40 million per year $528 million per year ($1000 per year per fisher)	

Study	Natural asset	Description	Value	Value of dollar (if stated as different to year study published)
Windle & Rolfe, 2005	Non-market value of estuary health (Fitzroy estuary, Qld)	Choice modelling	$3.21 per household per year	
Watson et al., 1993	Value of seagrass	Market value of commercial prawn species dependent on seagrass	$1.2 million per year	
McArthur & Boland, 2006	Value of seagrass in South Australia	Market value of seagrass dependent fish species	$114 million per year	
Costanza et al., 1997	World's seagrass		US$19,004 per hectare per year US$3,801 billion per year	1995
Blackwell, 2007a	Australia's seagrass		$3,417,227 per km^2 per year $175.3 billion per year	2005