Economic Values of the Northern Territory Marine and Coastal Environments

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Foreword

Ecosystem Services and the Sustainable Wellbeing of Humans and the Rest of Nature

Humanity is finally rediscovering an important relationship – the interdependent relationship between humans and the rest of nature. The industrial revolution and some religious traditions have emphasized the distinctions between humans and 'nature' – that humans are somehow above, apart from, or fundamentally different from the rest of nature. In fact, the more we learn about the way the world and its complex interconnected systems function, the more we recognize that homo sapiens is, and has always been, an integral component of the ecosystems it is embedded within. Humans are not apart from nature but are a part of the natural world and their health and wellbeing cannot be understood or managed separately from that complex and evolving context.

The concept of ecosystem services makes this interdependence with the rest of nature more apparent and quantitative. It does this by analysing, modelling, quantifying, and valuing the degree to which humans are connected with and benefit from the ecosystems that enclose them. Ecosystems provide a range of services that are of fundamental importance to human well-being, health, livelihoods and survival (Costanza et al., 1997; Daily, 1997; MEA, 2005; de Groot et al., 2014).

The idea that preserving the environment as an asset, rather than an impediment to economic and social development, is both very old and very new. For most of human history, at least until the start of the Industrial Revolution, the benefits humans derived from the rest of nature were well recognized and embedded in various cultural rules and norms, including those of indigenous Australians. Parts of forests, lakes, wetlands, or mountains were often deemed sacred and off limits. But it is no coincidence that these sacred natural assets also supplied essential life-support services for the communities involved. This is in stark contrast to the post-industrial view in much of the Western world that nature is merely a pretty picture – nice to enjoy if you can afford it but not essential to the more important business of 'growing the economy'. Too often, when the issue of conservation of the environment has entered public or political discussions, it has been purported to come at a cost, and the discussion has been framed as 'the environment versus the economy'.

Probably the most important contribution of the widespread recognition of ecosystem services is that it reframes the relationship between humans and the rest of nature to be more consistent with what we know. A better understanding of the role of ecosystem services emphasizes our natural assets as critical ingredients to inclusive wealth, well-being and sustainability. Sustaining and enhancing human well-being requires a balance of all of our assets – individual people, society, the built economy and ecosystems. This reframing of the way we look at 'nature' is essential to solving the problem of how to build a sustainable and desirable future for humanity – a goal that we all share.

The ecosystem services concept makes it abundantly clear that the choice of 'the environment versus the economy' is a false choice. If the environment contributes significantly to human well-being, then it is a major contributor to the real economy and the choice becomes how to manage all our assets, including natural and human-made capital, more effectively and sustainably (Costanza et al., 2000).

Interest in ecosystem services in both the research and policy communities has grown rapidly (Braat and de Groot, 2012). As of this writing, over 18,000 journal articles have been published on this topic, according to SCOPUS, and the number is growing exponentially. The most highly cited of these (with over 7,000 citations in SCOPUS as of this writing) is one that I and 12 co-authors published in Nature in 1997 that estimated the value of global ecosystem services to be in excess of US$33 trillion per year, a figure larger than global gross domestic product (GDP) at the time (Costanza et al., 1997). This admittedly crude underestimate, and a few other early studies, stimulated a huge surge in interest in this topic. In 2005, the concept of ecosystem services gained broader attention when the United Nations published its Millennium Ecosystem Assessment (MEA, 2005). The MEA was a 4-year, 1300-scientist study for policymakers. In 2008, a second international initiative was undertaken by the UN Environment Programme, called The Economics of Ecosystems and Biodiversity (TEEB, 2010). The TEEB report was picked up extensively by the mass media, bringing ecosystem services to a broader audience. Hundreds of projects and groups are currently working toward better understanding, modelling, valuation and management of ecosystem services and natural capital. In 2012 The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established. IPBES is an intergovernmental body (similar to the IPCC) which provides information on the state of biodiversity and ecosystem services for decision making purposes. Its current membership includes 126 national governments. Global, national and regional networks, like the Ecosystem Services Partnership (www.es-partnership.org) have also emerged. Ecosystem services are now poised to provide real solutions to the problem of how to sustainably manage our critical natural capital assets.

From the perspective of ecosystem services, marine and coastal systems are among the most important and valuable ecosystems in the world (de Groot et al. 2012). The recognition of this value is a far cry from the situation not that long ago (and still prevalent in some places) when coastal wetlands were considered to be 'wastelands' and every effort was made to drain, fill, and convert them to other land uses. The Northern Territory contains relatively unspoiled marine and coastal ecosystems, including wetlands, which have managed to escape the ravages of excessive development.

If we are to build the sustainable and desirable future we all want, we need to be able to understand, model, and value complex social-ecological systems in the comprehensive way this report exemplifies. The Northern Territory has the opportunity to make better decisions by recognising the full value of its marine and coastal ecosystems.

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Executive Summary

Here we estimate the values of ecosystems and the industries they support in the marine and coastal waters of the Northern Territory. The marine waters of the Northern Territory extend from the high water mark out to 3 nautical miles (approximately 5.5km) and include the 88,400 ha Limmen Bight Marine Park and the 229,000 ha Garig Gunak Barlu (formerly Cobourg) Marine Park. Also relevant are many terrestrial protected areas which contain coastal ecosystems, including the Charles Darwin and Kakadu National Parks, the Dhimurru Indigenous Protected Area which takes in land and sea country, and the Yanyuwa, Anindilyakwa, Laynhapuy, Djelk, south-east Arnhem Land, Marthakal and Marri-Jabin Indigenous Protected Areas which have coastal boundaries.

Protecting ecosystem health is essential

Ecosystems provide a range of services that are of fundamental importance to human health and well-being. Ecosystem services are a bridge between healthy and functioning ecosystems and the social and economic benefit we subsequently derive. Marine and coastal ecosystem services of clear economic benefit include recreational fishing catches and fisher activities, tourism, climate regulation via carbon stores, storm protection, and breeding grounds for marine life. There are other ecosystem services more difficult to value, and which are generally overlooked, but which are very important to society and the economy, such as Indigenous connection to country and sea, and aesthetic and educational values. The supply of ecosystem services will be severely compromised in ecosystems that are unhealthy and have lost their functional integrity, resulting in lost value and reduced benefit to society. It is essential therefore to protect ecosystem health and integrity to maintain the supply of ecosystem services.

Marine and coastal waters in the Northern Territory support over 6,000 jobs and directly contribute 4% to the economy

- Recreational fishing is estimated to have direct economic value of $21.3m annually, with total contribution to the Northern Territory economy worth about $76m annually.
- Marine and coastal tourism is estimated to have a direct economic value of $156m annually, with a total contribution to the Northern Territory economy worth about $691m annually.
- The value of mangroves, seagrasses and tidal saltmarshes for the NT coastal waters is estimated at $65m/yr.
- The annual sequestration of blue carbon in the Northern Territory marine and coastal waters is worth $39m to $468m annually; while the total stock of carbon is valued in the order of $23.9 billion to $198.5 billion, with the large bulk of this being the stock of carbon in mangroves.
- Although in many regards they are priceless, Indigenous cultural values are worth about $52.5 to $412m annually.

Overall, we estimate that the Northern Territory marine and coastal ecosystems contribute about $1billion per year to the Territory economy (Table ES1). The Gross State Product (i.e. Territory-level GDP) in 2015-16 is $23.6 billion[1], meaning the marine and coastal ecosystems contribute around 4% to the Territory economy. These ecosystems also support about 6,300 jobs. But only some of the ecosystem services provided by the Northern Territory's marine and coastal ecosystems are bought and sold in the market. The value of ecosystem services can thus be thought more broadly in terms of the contribution that they make to economic

[1]ABS (2016). 5220.0 - Australian National Accounts: State Accounts, 2015-16.

welfare (wellbeing) – we estimate these values at between $875m and $1.9b per annum. The large range is explained by the different assumptions used to estimate the values.

Table ES1. Summary of all ecosystem service values in the Northern Territory marine and coastal ecosystems. The large ranges are explained by the various assumptions used to estimate value.

Ecosystem services	Contribution to the NT economy (direct and indirect economic impact)		Economic value ($m/yr)
	$m/yr	Jobs	
Provisioning services			
Commercial fishing & Aquaculture	174.0	424	124.3
Recreational fishing	76	N.A.	21.3
Pearl cultivation	48	100	24.1
Crocodile cultivation	106	264	64.4
Regulating services			
Blue carbon	No direct market value	-	39 – 468
Storm protection	No direct market value	-	109.1
Cultural services			
Tourism	691	5,530	156
Aesthetics, amenity and other recreational values (residents)	No suitable studies for benefit transfer found	-	2.5 – 40.3
Bequest/existence	No direct market value	-	217 - 414
Indigenous cultural values	N/A since Indigenous cultural values not bought/sold in the market	-	52.5 - 412
Habitat services			
Genepool of habitat types	N/A since genepool not bought/sold in the market	-	65.2
Total	**1,095.0**	**6,318**	**875.4- 1,898.7**

The value is found in the many ecosystem services supplied by the marine and coastal ecosystems. Marine and coastal tourism makes the biggest contribution to the economy ($691m/yr), supporting over 5,500 jobs. For every dollar spent by tourists, extra income is generated in other regional business. The size of these additional (indirect) impacts varies according to the size of the region/economy, with the indirect impacts in urban areas being much larger than in remote locations. For the whole of the Northern Territory, indirect impacts of tourism have been estimated at approximately the same size as direct impacts (i.e. for every dollar of tourist expenditure, there is an additional dollar of regional benefit created).

Provisioning services that directly supply people with many goods extracted from the marine and coastal ecosystems also make a substantial contribution to the economy ($404.4m/yr). Carbon sequestration (up to $468m/yr), (non-Indigenous) existence and bequest values (up to $414m/yr) and Indigenous cultural values (up to $412m/yr) make large contributions to overall economic welfare (wellbeing). Carbon storage in marine and coastal ecosystems offers a substantially more efficient sequestration option than terrestrial forests because blue carbon accumulates without reaching saturation and the carbon is stored for thousands of years.

We acknowledge that our assessment of cultural ecosystem services, presented in Table ES1, may not reflect the true value that Indigenous and non-Indigenous people in the NT may hold for their coastal and marine systems, however it does offer an additional argument to understand the value of such resources and to influence policy decision-making.

Marine parks protect and supply ecosystem services

Expanding the current network of marine parks in the Northern Territory's marine and coastal waters will ensure the $billions in economic value continue to flow into the Territory economy. Marine parks provide many economic benefits, including eco-tourism and commercial fisheries by protecting fish species' breeding grounds. Marine parks also ensure the protection and provision of many other ecosystem goods and services which we show in this report to have considerable economic value. The economic benefits of expanding marine parks is between 3 to 20 times greater than the costs. Marine parks with permeable boundaries also have positive spill-over effects on adjacent fisheries which experience increases in catch per unit of effort, compensating for impacts to fishing from the establishment of marine parks.

1 Introduction

Marine and coastal ecosystems provide a wide range of values to Australians. Recent estimates state that the values provided by Australia's oceans are worth about $69 billion each year. But only $44 billion of that value is formally recognised in our economic accounts (Eadie and Hoisington 2011), comprising marine-based industries such as commercial fishing and aquaculture, shipping and ports, offshore oil, gas and renewable energy, and marine and coastal tourism[2]. The other $25 billion in value is realised outside of traditional economic markets via the many ecosystem goods and services provided by marine and coastal ecosystems. These goods and services include recreational fishing catches and fisher activities, climate regulation via carbon stores, breeding grounds for marine life, and pest and disease control. There are other ecosystem services more difficult to value, and which are generally overlooked, but which are very important such as Indigenous connection to country and sea, and aesthetic and educational values.

This report documents the values of marine and coastal ecosystems and the marine industries they support in the marine and coastal waters of the Northern Territory. All values we present in this report are Australian Dollars (2015 prices) unless otherwise stated. The marine waters of the Northern Territory extend from the high water mark out to 3 nautical miles (approximately 5.5km) and include the 88,400 ha Limmen Bight Marine Park and the 229,000 ha Garig Gunak Barlu (formerly Cobourg) Marine Park. Several land-based parks and reserves, namely the Charles Darwin National Park, Berry Springs Nature Park, Casuarina Coastal Reserve, Shoal Bay Coastal Reserve, Tree Point Conservation Area and Kakadu National Park include marine and coastal areas. Also included is the Dhimurru Indigenous Protected Area which takes in land and sea country, and the Yanyuwa, Anindilyakwa, Laynhapuy, Djelk, south-east Arnhem Land, Marthakal and Marri-Jabin Indigenous Protected Areas which have coastal boundaries. We include the full extent of mangroves, estuaries, and any other areas subject to storm surges along the Northern Territory coastline.

We take an *Ocean Economy* approach whereby we identify and estimate the value of the many ecosystem goods and services that directly underpin marine-based industries and that provide other values not traditionally recognised in the economy. This chapter defines the *Ocean Economy* and explains the ecosystem services framework and the concepts of 'value' used in the report.

1.1 The *Ocean Economy*

The international Organisation for Economic Cooperation and Development (OECD) defines an *Ocean Economy* as the sum of the economic activities of ocean-based industries, and the assets, goods and services of marine ecosystems (OECD 2016). It is often the case that marine ecosystems provide intermediate inputs to ocean-based industries, and the activities of ocean-based industries can have significant impacts on marine ecosystems – marine ecosystems and ocean-based industries are inextricably linked (Figure 1).

[2] Globally, these marine-based industries are estimated to be worth US$ 1.5 trillion annually, a third of which is from offshore oil and gas, and a quarter from marine and coastal tourism (OECD 2016). In 2010 the marine industries contributed 31 million direct full-time jobs (OECD 2016).

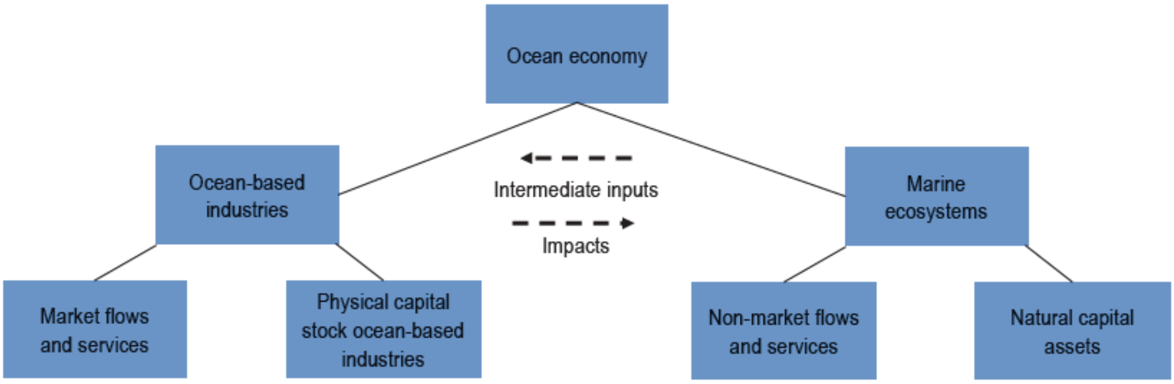

Figure 1. The full value of the *Ocean Economy*.

Source: OECD (2016)

The *Ocean Economy* is a refinement of the *Green Economy,* which is an economy that is resource and energy efficient, promotes human wellbeing (current and future generations) and social equity, reduces environmental risks and invests in environmental sustainability. A *Green Economy* aims to provide greater protection for natural capital to ensure continued provision of ecosystem services. The idea emerged in the 1960s, and by the late 1980s economists were writing in detail about a new economic model. Pearce et al. (1989) led the way with their *Blueprint for a Green Economy*. There is now widespread global acceptance of Inclusive *Green Economy* models, with about 50 countries developing national *Green Economy* plans (UNEP 2015). A prominent example is China which is integrating economic, social, ecological, political and cultural dimensions of development into its Eco-Civilisation approach to economic growth (UNEP 2016).

Core to an *Ocean Economy* is the adoption of metrics of economic performance that consider the scarcity and the condition of natural capital. *Ocean Economy* frameworks provide opportunity to incorporate sustainability criteria into common metrics of growth such as GDP. In 2012, the UN Statistical Commission adopted a standardised accounting method for integrating statistics on the environment and its relationship with the economy (United Nations Statistical Division 2014). This System of Environmental-Economic Accounting (SEEA), also includes an experimental ecosystem accounting framework for measuring and valuing changes to ecosystem services within a nation (United Nations Statistical Division 2013). A centrepiece of the United Nations Sustainable Development Goals (SDGs) and underpinning targets is the protection of ecosystem services, which requires measurement and valuation of the full range of ecosystem goods and services from which people derive benefit. The ocean features prominently in the UN SDGs, with Goal 14 to 'Conserve and sustainably use the oceans, seas and marine resources for sustainable development', and Target 14.2 to sustainably manage and protect marine and coastal ecosystems using ecosystem-based (i.e. ecosystem service) approaches[3].

1.2 Ecosystem services framework

Ecosystem services are the benefits people obtain from ecosystems (Millennium Ecosystem Assessment 2005). In marine ecosystems these include:

- 'provisioning services' such as fish and crustaceans.
- 'regulating services' such as regulation of storm surges, pests and disease, climate.

[3]All targets and indicators for the marine-based Sustainable Development Goal 14 are described at https://sustainabledevelopment.un.org/sdg14

- ‘cultural services’ such as recreational, spiritual, religious and other non-material benefits.
- ‘supporting services’ such as nutrient cycling.

The term ecosystem services first appeared in the early 1980s (Ehrlich and Ehrlich 1981). It was popularised by two publications in 1997 – the book Nature's services (Daily 1997) and a paper on valuing the services provided by global ecosystems published in Nature (Costanza et al. 1997). Ecosystem services were employed by the Millennium Ecosystem Assessment (MEA) – a four-year global effort involving more than 1300 experts – to develop its conceptual framework to assess nature’s essential contribution to human wellbeing (Millennium Ecosystem Assessment 2005).

More recently, The Economics of Ecosystems and Biodiversity (TEEB 2010), another major international initiative, also used the ecosystem services framework to draw attention to the global economic benefits of ecosystems and to highlight the growing costs of biodiversity loss and ecosystem degradation. The TEEB project disentangled the pathway from ecosystems and biodiversity to human wellbeing. Figure 2 shows the pivotal link provided by ecosystem services between human wellbeing and ecosystems and how decisions by people, governments and the private sector can drive change to ecosystems which in turn impact human well-being. Ecosystem services bridge the divide between healthy and functioning ecosystems and the social and economic benefit we subsequently derive. An ecosystem that is unhealthy and has lost its functional integrity will supply few ecosystem services, resulting in lost value and benefit to society. It is essential therefore to protect ecosystem health and integrity to maintain the supply of ecosystem services to people.

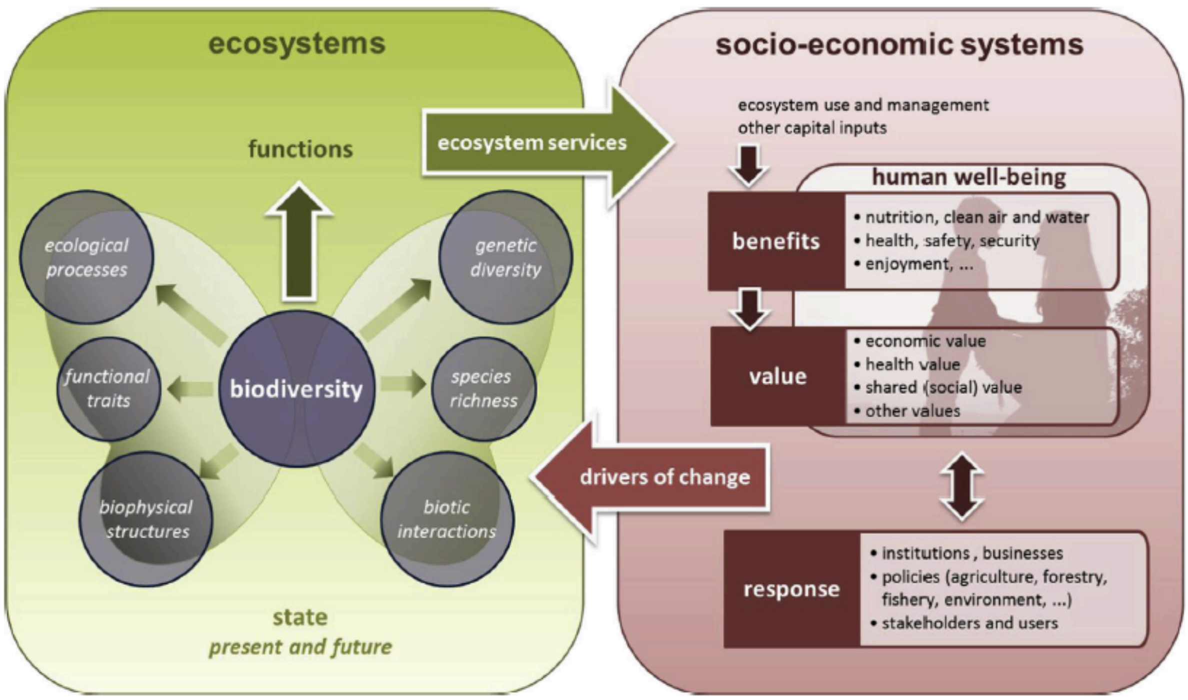

Figure 2. Conceptual framework linking ecosystem to socio-economic systems.

Source: Maes et al. (2016)

In Figure 2, functions are the abilities of ecosystems to deliver services, which in turn depends on the properties of ecosystems such as structure, processes, and biological richness and diversity. Through governance, policy and management, the private and public sectors make decisions that influence ecosystem processes, functions or services. The difference between processes, functions and services can be demonstrated with examples of marine ecosystems. The process of photosynthesis and primary production of seagrasses and plankton is required to maintain viable herbivore and carnivore populations (function) which can be harvested to provide food (a type of provisioning service). Photosynthesis and primary production of mangrove species is needed for stable mangroves (function) to provide protection against storm surges (a type of regulating service). Photosynthesis and primary production sequester carbon which regulates atmospheric greenhouse gases and climate (another regulating service).

There has been exponential growth in studies that quantify and value ecosystem services since the 2005 MEA, but the focus has be mostly on terrestrial ecosystems; marine and coastal ecosystems have received considerably less attention (Liquete et al. 2013). The role of Marine Parks (also referred to as marine protected areas and marine reserves) in protecting and supplying ecosystem services is a subject of increasing interest (Rice et al. 2012, Miteva et al. 2015, Boulton et al. 2016). The creation of Marine Parks demonstrates the interconnectedness between marine ecosystems and ocean-based industries, the fundamental premise of an *Ocean Economy* (Figure 1). Although Marine Parks were previously developed with the primary or sole goal of protecting unique marine biodiversity, they are now recognised as providing many economic benefits, including eco-tourism (Brander et al. 2007, Potts et al. 2014, Wells et al. 2016, Viana et al. 2017). For example, the annual revenue from eco-tourism in the Great Barrier Reef Marine Park is 36 times greater than the revenue from commercial fisheries (McCook et al. 2010).

Marine Parks also ensure the protection and provision of many other ecosystem goods and services which have considerable economic value. The economic benefits of expanding Marine Parks was recently shown to be 3 to 20 times greater than the economic costs (Brander et al. 2015).

Table 1 provides examples of ecosystem services provided by Marine Parks, and the ecological mechanisms and functions underlying the services. The continued supply of these ecosystem services is predicated on there being areas within Marine Parks that have a relatively high level of habitat protection to allow a build-up of biomass and species diversity, and where use of natural resources is not permitted (e.g. IUCN Protected Area Categories I & II; sanctuary zones; no-take zones). It's important to note that Marine Parks can contain a mixture of high level habitat protection and mixed-use zones. There is growing evidence that Marine Parks with permeable boundaries can have positive spill-over effects on adjacent fisheries which experience increases in catch per unit of effort, often compensating for the potential loss of fishing grounds within the high protection zones of Marine Parks (Goñi et al. 2010, Halpern et al. 2010, Leenhardt et al. 2015).

Table 1. Examples of the effects of Marine Parks on ecosystem services and the process and functions underlying service provision.

Ecosystem service category ((Millennium Ecosystem Assessment 2005)	Ecosystem service	Mechanism by which Marine Parks provide the service	Species, Community Attribute, Functional Trait, or Functional Group Underlying Effect	Reference
Provisioning services	Food	Increased production/ stabilization of target species biomass	Large size of target species, recovery of top predators and food web complexity	Goñi et al. (2010)
	Ornamental resources	Increased production/ stabilization of ornamental fish biomass	Species diversity	Williams et al. (2009)
	Raw materials	Algal and sand production	Predators controlling herbivory, bioeroders, corallivores	Karnauskas and Babcock (2014)
	Genetic resources	Protection of genetic diversity, adaptation to climate change	Response diversity, genetic diversity	Miller and Ayre (2008)
	Medicinal resources	Protection of molecular diversity	Chemically defended species, biological diversity	Schröder et al. (2004)
Regulating services	Carbon sequestration and climate regulation	Protection of plants and calcifying organisms (e.g., mangroves, sea grass, corals)	Species that have high carbon sequestration capacity (primary producers, calcifying species, bio-constructors)	Gonzalez-Correa et al. (2007)
Cultural services	Cultural heritage	Maintenance of traditional community-based natural resource management	Charismatic species (e.g., sharks, sea turtles, large molluscs)	Clarke and Jupiter (2010)
	Spiritual and historical heritage	Maintenance of traditional community-based natural resource management	Charismatic habitat (e.g. coral reef, kelp forests)	n.a.
	Recreational activities	Creation of nature-based eco-tourism opportunities (scenic beauty and emblematic species)	Charismatic species, large species, and habitat-forming species	Ríos-Jara et al. (2013)
	Science and education	Creation of opportunities for research and education in places of reduced human impacts	Biological diversity, complex food webs	n.a.
Supporting services	Primary production	Protection of primary producers	Primary producers, habitat- forming species	Milazzo et al. (2002)
	Coastal protection	Protection of habitat formers (e.g., corals, sea grasses, mangroves) providing attenuation of wave intensity	Habitat-forming species	Mumby and Harborne (2010)

Source: Leenhardt et al. (2015)

1.3 Measuring the economic impact and value of ecosystem services

Many studies place a monetary 'value' on ecosystems services. But the values estimated in different studies are not always comparable, since they focus on different things. As outlined in the foreword, all ecosystem services contribute to human wellbeing (MEA 2005) but only some are closely associated with market activities, making measurable contributions to employment and GDP. Some valuation methods measure the contribution that ecosystem services make to the economy (i.e. their economic impact) and other methods measure the contribution that ecosystem services make to human wellbeing (i.e. their economic value (welfare)).

To avoid confusion and double-counting, our report presents impact and value estimates separately. The different approaches, are summarised in Figure 3 with an explanation below, using tourism as an example.

1) Contribution to the economy - economic impact

   Tourism creates a 'direct' economic impact when tourists spend money in the area they are visiting. If businesses that benefit from the direct expenditure by tourists then spend at least some of their newly earned income with other local people and businesses (e.g. paying staff, buying stock), then additional indirect[4] benefits are created. Together, these direct and indirect impacts describe the total economic impact (or contribution) of an activity (left, Figure 3). These impacts are generally measured using computable general equilibrium models, input output models, or by using multipliers.

2) Contribution to human wellbeing - economic value (welfare)

   If a tourist doesn't have to pay anything to enjoy a marine area (e.g. a free day at the beach), there will be no measured economic contribution (expenditure is zero), but there is still value. The difference between how much a tourist is willing to pay to enjoy the marine environment, for example, and how much they actually pay, is what economists call consumer surplus (middle, Figure 3).

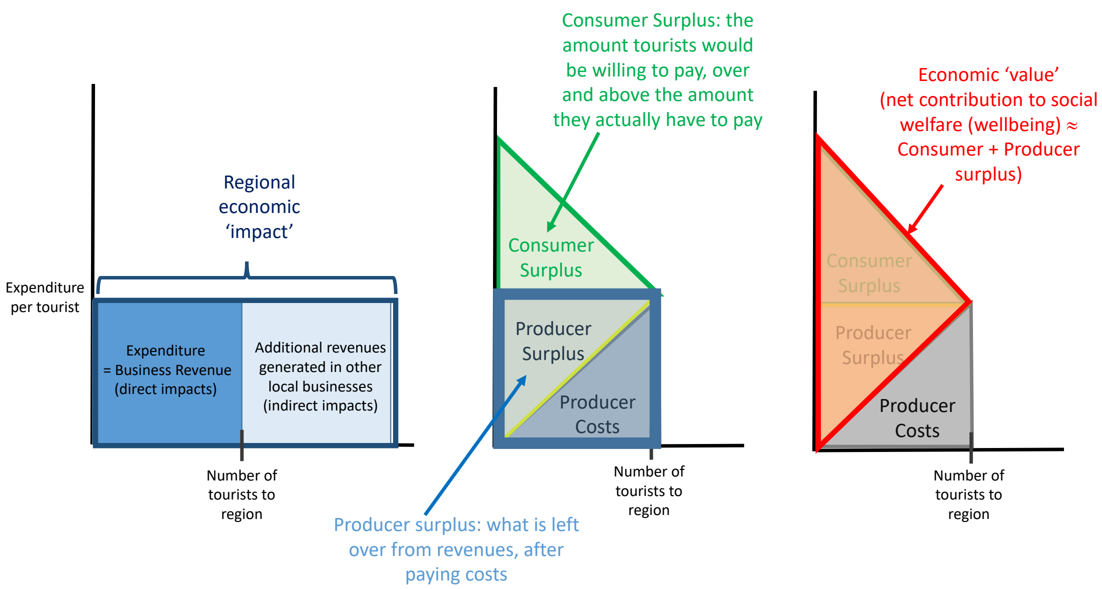

Figure 3. The difference between studies that estimate economic impact (left) and studies that estimate economic value (middle, right).

[4] Some also refer to induced effects – those associated with salaries and the expenditure of individuals instead of only business expenditure.

Similarly, tourism operators are not able to personally benefit from all the money they earn from tourists because they have costs of running their business. The difference between the minimum income needed to cover costs and their actual income is termed producer surplus (middle, Figure 3).

The contribution that marine ecosystems make to social welfare (one measure of human wellbeing), can be thought of as the sum of consumer and producer surplus, which is labelled economic value (right, Figure 3). This is the value that marine ecosystems generate for households and businesses, above and beyond the money actually paid (or received). These values are difficult to estimate but numerous methods are used. Most methods are only able to estimate value for particular types of ecosystem services, hence the need for different approaches. The different methods for economic valuation of ecosystem service include:

- Direct market pricing, Expenditure, Replacement Cost, Avoided Cost, Mitigation Cost, Restoration Cost (none of which capture true value, since they essentially look at Price * Quantity, rather than consumer and producer surplus).
- Hedonic Pricing, Hedonic Wages, Travel Costs.
- Contingent Valuation; Contingent Behaviour, Choice Modelling.

Another method, called Benefit Transfer, is used to transfer value estimates from one context to another when it is not possible to generate new estimates of value (particularly if working within tight timeframes or budgets). Benefit transfer simply uses unit value estimates (e.g. $/ha; $/kg) calculated for a specific ecosystem service at one location to value the same ecosystem service but in a different location. For credible valuation using benefit transfer the socio-economic and biophysical conditions at the original study location and the new study location should be very similar. This report relies predominantly on benefit transfer, although great care is taken to ensure that the estimates transferred were generated from studies undertaken in contexts relevant to the Northern Territory's marine and coastal ecosystems and economy.

2 Values of biodiversity

> *Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.* (CBD 1992)

Valuing biodiversity is a topic of much discussion in the ecological and economic sciences. The Millennium Ecosystem Assessment (2005) highlights how biodiversity plays an essential role in supporting human well-being through maintaining the functioning of terrestrial, freshwater and marine ecosystems that underpin the delivery of a range of ecosystem services. Ecological research tends to focus on ecosystem functions and processes, however extending that to ecosystem services demonstrates how biodiversity underpins benefits that people obtain from their natural systems, which can help improve peoples' connections with natural ecosystems. Overall, more than 95% of experimental studies suggest a positive relationship between biodiversity and ecosystem services (UNEP-WCMC 2015) . A framework showing the connections between biodiversity and ecosystem services is presented in Chapter 1. This chapter begins by briefly describing the diversity of Northern Territory's coastal and marine ecosystems. We then provide an assessment of the monetary value of the biological genepool. Our assessment of the contribution biodiversity makes to Indigenous well-being is provided in Section 5.4.3, which focuses on Indigenous cultural values (acknowledging their inextricable links to other values).

2.1 Biodiversity in the coastal and marine ecosystems of the Northern Territory

The Northern Territory coastal and marine ecosystems support a diverse variety of flora and fauna including ancient and unique species such as crocodiles, dolphins, dugongs, turtles, whales, and seabirds. The coastal and marine environments of the Northern Territory have been identified as some of the least impacted and most intact marine ecosystems in the world (Seagrass-Watch 2008, NT Government 2017). The economic importance of the resources obtained from these waters is outlined in subsequent chapters.

The Northern Territory coastal and marine waters extend three nautical miles from the coast and contain two Marine Parks where the natural resources can be used sustainably (IUCN category VI), the 88,400 ha Limmen Bight and 229,000 ha Garig Gunak Barlu (previously named the Cobourg Marine Park) and an Indigenous protected area (IPA), Dhimurru, the first IPA that includes sea country (Figure 4). Beyond the Territory water limits are six Commonwealth Marine Reserves—Oceanic Shoals, Limmen, Arafura, Arnhem, Wessel, and Joseph Bonaparte Gulf. In addition, there are several land-based parks, reserves, conservation areas and IPAs that directly and indirectly support the rich biodiversity of the Northern Territory's coastal and marine ecosystems. The IPAs connected to coastal and marine environments include the Yanyuwa IPA, Anindilyakwa IPA, Laynhapuy IPA, Djelk IPA, south-east Arnhem Land IPA, Marthakal IPA and Marri-Jabin IPA. Appendix 1 lists the terrestrial parks, reserves and conservation areas connected to marine and coastal waters.

Some of the key unique features of the Northern Territory's coastal and marine waters are pristine mangroves, turtles[5], dugongs, and large populations of shore- and sea-birds, including species that use the mangrove and coastal systems as part of international migratory routes (Lilleyman et al. 2014). These birds depend on coastal resources found in nationally and internationally significant wetlands, such as Kakadu National Park and the Pellew Islands. There are strong Indigenous cultural affiliations and connections to the saltwater country and the species it contains, both as an important food source, and for spiritual and totemic reasons (Barber 2015), which are discussed in detail in Chapter 5.

[5] https://nt.gov.au/environment/animals/wildlife-in-nt/marine-turtles

Mangroves in the Northern Territory, with more than 50 species occupying 11,000 km of coastline, represent 35% of total mangroves in Australia and 2.5% worldwide (Lee 2003). They are among the most carbon-rich ecosystems in the world (see Chapter 4). The NT mangroves have high diversity and endemism. For example, *Avicennia integra* is only found in the NT at 15 sites with fewer than 5,000 trees (Duke 2010). Mangroves and the tidal mud-flats offer habitat for many species, including the migratory birds, fish, particularly barramundi, prawns, molluscs and mud-crabs. They also protect the coastline from storm surges, high speed wind and waves, tsunamis and floods and hold the unstable soil and provide nutrients to many organisms that inhabit the mud in which they stand (see Chapter 4). A recent incident of massive mangrove die-off from 1,000 km of coastline in the Gulf of Carpentaria caused significant concern, demonstrating the importance of these ecosystems (Australian Broadcasting Corporation 2017).

Other important habitats in the Northern Territory marine and coastal waters are seagrasses, tidal mudflats and wetlands. Seagrass, mudflat and wetland habitats are significant hotspots for biodiversity. Seagrasses are prime feeding areas for turtles and dugongs, and support commercially valued species including prawns. Other high-value commercial and recreational fishing species such as mud crab and barramundi also depend on these marine and coastal habitats.

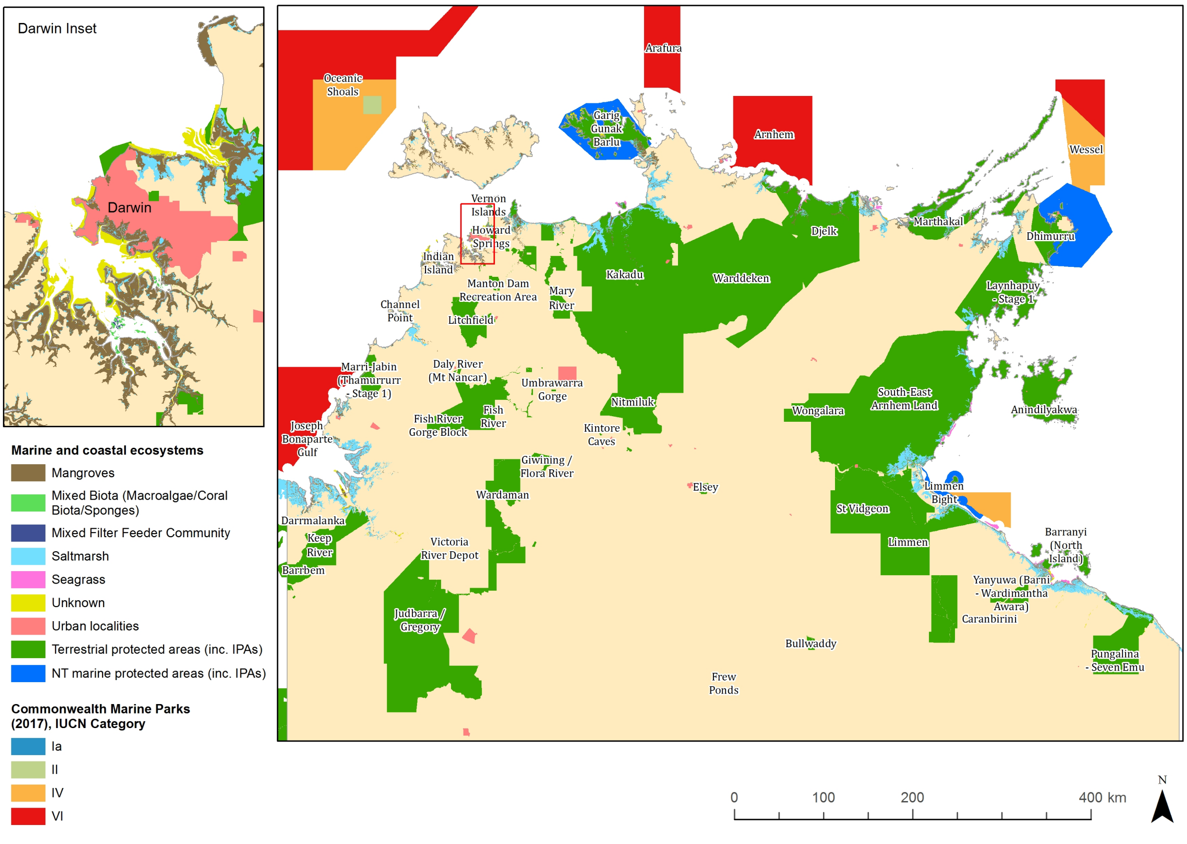

Figure 4. Terrestrial and marine protected areas. All terrestrial and NT marine protected areas were extracted from CAPAD 2016 database. Marine reserves in Commonwealth waters are from the Australian Marine Parks (draft) 2017 database.

The Northern Territory coastal and marine waters support six of the world's seven marine turtle species - the leatherback, loggerhead, green, hawksbill, flatback, and olive ridley. Marine turtles are an iconic species and are an example of an important threatened species dependent on the coastal and marine habitats of the Northern Territory. They are ancient animals that have lived in the oceans for more than 100 million years but are now threatened due mainly to habitat modification and pollution.

2.2 Assessing the value of the biodiversity genepool

Biodiversity is an integral part of an ecosystem supporting a wide range of ecosystem functions and processes (Figure 2), but there is no price tag for an entity such as 'biodiversity'. However, biodiversity has intrinsic and option value and should be valued for present and future generations. Biodiversity values underscore other values estimated in this report, so here we only explicitly discuss genepool values to avoid double counting. Other biodiversity values are discussed in Chapter 5 (e.g. biodiversity contribution to Indigenous wellbeing as an integral part of Indigenous cultural values). The values we provide here are a first pass and use the benefit transfer approach.

Habitats such as coastal mangroves, seagrasses, tidal saltmarshes or open oceans provide the required environment for species to survive and to pass on genes from one generation to another, which maintains the continuity of ecological processes and functions, and hence the services to people. To estimate the value of the genepool we used a benefit value transfer method to transfer values of similar services from the relevant studies to our study area. We selected from a global ecosystem service database of 1,310 values (van der Ploeg and de Groot 2010) the genepool or nursery values from entries in the database that best match the characteristics of our study area (comparable economic and ecosystem conditions). Four case studies (Turpie et al. 2003, McArthur and Boland 2006, Beaumont et al. 2008, Chang et al. 2009) were chosen for genepool values. These values were adjusted and updated ($ values in year 2015) using the World Bank exchange rate database.

Two values were used to estimate the value of the Northern Territory's coastal and marine biodiversity's genepool service. For the 334,000 ha of mangroves and 70,000 ha of seagrasses in the Northern Territory coastal and marine waters, a unit value of $99.76/ha/yr was applied, and for the 500,000 ha of tidal saltmarshes, a unit value of $49/ha/yr was applied. The derivation of the areas for each habitat type is described in Chapter 4. The total genepool value is then estimated at $65m/yr. Although this is an imprecise measure of the value of biodiversity's genepool service, it demonstrates the importance of the genepool towards maintaining the continuity of services for supporting human well-being. These resources are not currently bought/sold in the market, so the genepool does not make a direct contribution to the Northern Territory's economy.

2.3 Summary of biodiversity and habitat values

The total value of the biologically diverse genepool of the Northern Territory marine and coastal ecosystems (mangroves, seagrasses and tidal saltmarshes) is worth $65.2m per year (Table 2).

Table 2. Value of biodiversity's genepool of the NT's coastal and marine waters.

Biodiversity benefit	Valuation technique	Value ($m/yr)
Conserving and valuing biodiversity for its genepool	334,000 ha area of mangroves; 70,000 ha of seagrasses; and 500,000 ha of tidal saltmarshes[1].	$65.2

[1]Using TEEB database ES value for genepool and nursery for mangrove and sea grasses. These values were first adjusted to USD for the year of study, converted to AUD and then updated to year 2015 using Official Exchange Rates from the Worldbank database (https://data.worldbank.org/indicator/PA.NUS.FCRF?type=points&view=map&year). An average value of $99.76/ha/yr was used for mangroves and seagrasses and $49/ha/yr was used for tidal saltmarshes.

3 Values of provisioning services

Provisioning ecosystem services are the material benefits such as food that people obtain from ecosystems. The Northern Territory coastal and marine waters supply a diverse range of provisioning services including fish, oysters, shellfish, mud crabs, prawns, crocodiles, mangroves and other sources of food, leather, jewellery and recreational importance. This chapter considers the economic impact and value of provisioning services of the Northern Territory's coastal and marine waters towards supporting key industries that are based in the region and support local development, as listed below:

- Commercial fishing.
- Recreational fishing (although often categorised as a cultural service, this is considered here alongside commercial fisheries; recreational fishing also provides an important protein source).
- Other coast and marine businesses: crocodiles and pearl cultivation.

3.1 Commercial fishing

The coastal and marine waters of the Northern Territory contain many fish and crustacean species of high importance and worth to commercial and recreational fishers. In 2015-16, commercial fishing was the third largest contributor to the primary industries sector in the Northern Territory, comprising about 17% of total production (Department of Primary Industry and Fisheries 2016). The two largest contributors to Northern Territory primary production are cattle (44%) and horticulture (30%). The commercial fisheries include harvesting of wild catch fisheries and aquaculture, as well as the processing, trade and retailing of seafood and other products. The main commercial species are barramundi, prawns, mud crabs, goldband snapper, Spanish mackerel, threadfin salmon, barramundi, prawns, squid and sea cucumbers.

The NT commercial fisheries generate an economic output of $124.3 m/yr (Table 3) with an additional output value for the rest of the economy worth $49.7m/yr (Department of Primary Industry and Fisheries 2016). Excluding aquaculture, the commercial fisheries are worth $99.8m/yr. Impact is estimated at $174.0m ($124.3 direct plus $49.7 indirect). Additionally, the commercial fisheries, including aquaculture, support about 51 sole-trader businesses and 22 small (1-19 employees) businesses (Department of Primary Industry and Fisheries 2016). Assuming the average small business has 10 employees, the jobs commercial fishing directly supports is about 270. Using the employment multiplier of 0.57, a further 154 jobs are indirectly supported by commercial fishing – these are in other, non-fishing industries (Department of Primary Industry and Fisheries 2016).

Table 3. Value of output from commercial fisheries in the Northern Territory, 2015-16.

Product	**2015-16 ($m/yr)**
Fin Fish	$31.6
NT Crustaceans	$3.0
Aquaculture	$24.5
Molluscs & Echinoderms	$0.3
NPF Crustaceans (NT catch)	$64.9
Total	**$124.3**

Source: Department of Primary Industry and Fisheries (2016).

3.2 Recreational fishing

Recreational fishing can be considered a cultural ecosystem service because the activity is a recreational pursuit. However, we include recreational fishing in this provisioning ecosystem services chapter because a substantial proportion of the fish caught are consumed and therefore provide a direct source of protein to anglers.

Iconic species such as barramundi, golden snapper and mud crab are important contributors to recreational fishing. Recreational fishing across all the Northern Territory supported around 30,500 (non-Indigenous) fishing trips in 2009-10 (Northern Territory Government 2012). This includes fishing in inland waters. A detailed survey by the Northern Territory Government (2012) during 2009-2010 found that 80% of the fishing activity is within marine areas. Over 770,000 organisms are caught over a year, of which 46% are retained, and the rest are either released or discarded (Northern Territory Government 2012). Assuming each organism weighs about 3kg, and sells in the market place for an average of $20/kg[6], the substitute value of the protein consumed by anglers from their catch equals about $21.3m annually (Table 4). The additional (cultural) values associated with recreational fishing are discussed in chapter 5.

Although fish caught by recreational anglers is not traded in the market, anglers spend money on fishing equipment, food, transport and accommodation; recreational fishing thus has an economic impact. Here we exclude anglers from outside the Northern Territory (considered in chapter 5, which looks at cultural services). Anglers who are residents of the Northern Territory spend $47m annually on goods and services directly related to recreational fisheries, equating to $1,500 spent per year per fisher (Table 4). About 93% of this fishing related expenditure occurs in the Northern Territory, and with 80% being confined to marine areas, means the marine and coastal ecosystems are worth $38m per year in recreational fishing value from Northern Territory-based fishers. Additionally, expenditure on the main fishing asset, vessels (mostly powered/trailer boats), contributes about $194m/yr, averaging about $18000/boat. Almost 60% of the NT anglers own their boats. In the absence of other information regarding the additional (indirect) impacts of this expenditure, we use a multiplier of two, which matches that for the tourism industry[7]. This indicates that recreational fishing has an economic impact of about $76m per annum (omitting boat values, since they will accrue over time). The number of jobs supported by recreational fishing in the Northern Territory is elusive. The best figures available are from an ABS 2002 Year Book, which reported about 90,000 jobs Australia-wide, with no state or territory breakdown.

There are also recreational fishers travelling to the Northern Territory from interstate and overseas. There are an estimated 150,000 visitor fishing days each year from interstate and international fishers, roughly equating to 21,400 visitors if each visitor spends about a week on fishing. If 21,400 visitors spend 50% of the expenditure that the Northern Territory fishers spend ($750 per angler per year), an estimated $18m per annum is spent in the Northern Territory by interstate or international recreational fishers. An undated study by the Northern Territory Government tourism agency estimates the value of the Territory's fishing tourism from interstate and international visitors at $22m per annum, using fishery tourism industry data from 2012 (Tourism NT n.d.). To avoid double counting we do not report this as a separate value because it is very likely to be included in the tourism value reported in Chapter 5.

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[6]Although organism sizes and market prices are highly variable, recent online sizes and prices of whole barramundi are about 3kg and $20/kg, respectively, e.g. https://seafoodhomedelivery.com.au/product/barramundi-whole/. Using barramundi for the average size estimate is likely to be conservative given many fish caught are large (http://northernterritory.com/things-to-do/outdoor-activities/fishing/fish-species); however, barramundi is the most common fish caught according to the DPIF 2010 survey.

[7]State Tourism Satellite Accounts 2015–16, Tourism Research Australia, Canberra

3.3 Other provisioning services

3.3.1 Crocodile cultivation

Australian saltwater, or estuarine, crocodiles (*Crocodylus porosus*) are iconic species which inhabit brackish waters in mangrove and estuarine ecosystems. They are a key attractor for Northern Territory tourism, supporting tour companies such as crocodile-watching cruises, Jumping Crocodile Tours, Crocodylus Park and Crocosaurus Cove. There are eight commercially operated crocodile farms in the NT. These farms export 90% of their skins to Japan, France and Italy, and finished products to USA. According to the Crocodile Farmers Association of the Northern Territory and the Northern Territory Government (2015), crocodiles support a $25m industry that has scope to double in the next five years. A recent report by Ernst and Young and Department of Trade Business Innovation (2017), in association with the Crocodile Farmers Association of the NT, reported that the industry is worth $106m per year, consisting of $64.4m of direct and $42m of indirect value to the NT economy annually.

The industry also provides significant employment opportunities for 264 people in the region, including in remote locations where employment opportunities are usually very limited (Table 4). For example, a project called 'Croc in a box' in Ramingining, now in its fourth year, has successfully installed two crocodile raising facilities where rangers and local community members work together (Crocodile Farmers Association of the Northern Territory and the Northern Territory Government 2015). The project is under consideration to be rolled out in another eight communities. Crocodile farming contributes $4.2m/yr to the remote and regional economies and provides job opportunities for the local indigenous people (Ernst and Young and Department of Trade Business Innovation 2017).

3.3.2 Pearl cultivation

Commercial pearling industry has been present in the Northern Territory since the late 1800s. There is only one target species in this fishery, the silver lipped pearl oyster, Pinctada maxima, which is collected by highly trained divers. The most recent figures we could find reported that the value of annual production of molluscs in the NT (with pearly oyster the only species with data) was $24.1m in 2014/15 (ABARES 2016), with Paspaley the dominant producer based in Darwin (Pearl Producers Association 2008). Pearls are farmed mostly around Bynoe Harbour, Beagle Gulf, Cobourg Peninsula and Croker Island, and around the islands north west of Nhulunbuy[8]. We were unable to find a study that estimated indirect impacts from pearl farming, so using a multiplier of two, pearl farming is likely to contribute up to $48m/yr to the NT economy.

3.4 Summary of provisioning ecosystem services values

We have estimated the provisioning services that are directly extracted from the Northern Territory marine and coastal waters. We use information from industry and government market analyses to estimate that the annual direct and indirect value to the Northern Territory of commercial fishing is $124.3m and $49.7m, respectively (Table 4). These activities also support about 424 jobs in the Northern Territory, made up of 270 direct and 154 indirect jobs. Recreational fishing is estimated to have direct economic value of $21.3m annually, with total contribution to the Northern Territory economy worth about $76m annually. The other provisioning services we valued are pearl and crocodile cultivation, whose contribution to the economy are, respectively, $42m and $106.7m and they support about 364 jobs (Table 4). The total direct and indirect value to the local economy of provisioning services from the Northern Territory marine and coastal ecosystems is over $400m per annum, supporting nearly 800 jobs. The 'value' of these industries (in terms of contribution to

[8] https://nt.gov.au/marine/aquaculture/aquaculture-species

economic welfare) is estimated at approximately $234m (their direct value, except for recreational fishing where we infer the value of catch).

Not included here is the tourism value of recreational fishing (i.e. 'tourism fishing'), which is estimated to be in the order of $21m annually. These values are captured by the value of the tourism cultural ecosystem service estimated in Section 5.2, and they would be double-counted if included here.

Table 4. Value of provisioning ecosystem services from the NT coastal and marine waters towards NT economy (in 2015 $ values) followed by the number of jobs in each sector.

Provisioning services	**Economic 'value' (estimated as direct market value unless otherwise indicated)**	**Contribution to NT Economy (direct + indirect impacts)**	
	$m/yr	$m/yr	Jobs
Commercial fishing & Aquaculture (Aquaculture)	124.3[1] (24.5)	174.0	424[2]
Recreational fisheries (NT residents)	21.3 (value of fish caught)[3]	76[4]	NA
Pearl cultivation	24.1[5]	48	100[6]
Crocodile cultivation	64.4[7]	106.4[8]	264
Total value	**234.1**	**404.4**	**788**

[1]DPIF 2016 ($124.3m/yr including aquaculture, and $99.8m/yr excluding aquaculture).

[2]DPIF annual report 2015-16 and outlook 2015; ABS Catalogue no. 5220.0 (cited in DPIF report 2015-16); and ABS 2011 census data suggesting 149 jobs in the relevant Agriculture, Fisheries and Forestry sectors (assuming 1/2 of those jobs exist in the fisheries).

[3]Assuming annual catch of 770,000, with 46% retained, and average weight of 3kg per fish, @ $20/kg

[4]DPIF 2012 (2009-10 survey); a total estimate of expenditure on good and services: $1500/angler*93% of that expenditure on recreational fisheries*no. of visitors 30,358 = $43m/yr. Since 80% of the fishing activities occurs in the marine waters so discounted that value to 80%, i.e. $34m/yr in 2010 or $38.1m/yr in year 2015.

[5]Pearl Producers Association (2008); and ABS (2012) suggesting $19m/yr during 2009-2010.

[6]Pearl Producers Association (2008). In total 600 jobs are created by the Paspaley Company with six distribution centres, we assumed 1/6th of those will be in the NT due to its base in the region.

[7]CFANT and the NT Government (2015) Strategic plan 2015-2021; Ernst and Young (EY) and the Department of Trade, Business and Innovation (DTBI) 2017.

[8]Ernst and Young (EY) and the Department of Trade, Business and Innovation (DTBI) 2017

4 Values of regulating services

Regulating ecosystem services are the benefits provided by ecosystem processes that moderate natural phenomena. Marine and coastal ecosystems provide many basic services that make life possible for people. For example, coastal vegetation holds sand and sediment in place to prevent erosion and mitigate impacts of storm surges. Coastal and marine vegetation and sediments provide water filtration services, and also contain large stores of carbon that regulate climate and mitigate climate change. This chapter calculates the value of two major regulating ecosystem services provided by marine and coastal ecosystems: i) carbon sequestration for climate regulation (referred to as blue carbon), and; ii) protection against storms and coastal erosion. Other regulating ecosystem services provided by marine and coastal ecosystem, such as pest and disease control and waste assimilation, are not valued here because of an absence of robust data for tropical Australia. Figure 4 shows the distribution of the vegetated ecosystems providing regulating ecosystem services valued in this chapter, and the extent of the marine parks in the Northern Territory waters. A very large proportion of the vegetated marine and coastal ecosystems are outside of formally protected areas (Figure 4).

Although terrestrial carbon sequestration and water quality improvements are emerging as products tradeable in the market, regulating ecosystem services are not traditionally traded in the market and do not contribute directly to the economy. Instead, their value is found in their contribution to human wellbeing. We therefore consider these services only for their economic value.

4.1 Blue carbon

Blue carbon is a generic term that refers to the carbon sequestered in the biomass and soils of vegetated coastal ecosystems, namely mangrove forests, seagrass meadows and tidal saltmarshes (McLeod et al. 2011, Pendleton et al. 2012). Unlike land-based vegetation, these ecosystems can accumulate carbon without reaching saturation and they can store the carbon for thousands of years; blue carbon ecosystems are one of the most efficient bio-sequestration systems on Earth (McLeod et al. 2011). Because of their long-term carbon storage potential, the carbon emissions from the loss of one hectare of blue carbon ecosystems is equivalent to the loss of 10 - 40 hectares of native terrestrial forest (McLeod et al. 2011). Mangroves in tropical regions are especially important because they are the most carbon-rich forests in the tropics, storing on average 3-4 times more carbon that tropical terrestrial forests (Donato et al. 2011, Ahmed and Glaser 2016). Mangrove carbon stock can exceed 1,100 t/ha, with some tropical mangroves containing over 3,000 t/ha of carbon (Donato et al. 2011, Ezcurra et al. 2016). Recent work has shown that the un-vegetated mudflats and sandbars within the inter-tidal coastal vegetated 'blue carbon' ecosystems also contain significant sediment organic carbon, of amounts comparable to seagrass meadows (Phang et al. 2015).

Globally, the current rates of loss and degradation of coastal vegetated ecosystem are estimated to release between 0.15 – 1.02 billion tons of carbon dioxide annually from the standing carbon pool (previously sequestered and stored carbon) in the biomass and top metre of sediments (Pendleton et al. 2012). The conversion of coastal vegetation to other uses (e.g. aquaculture, built infrastructure) contributes up to 19% of all emissions from deforestation globally. The estimated economic damages from the release of this carbon is in the range of US$ 6 – 42 billion, using a mid-range estimate of the social cost of carbon of US$ 41 per ton of CO2 (in 2007 dollars) (Pendleton et al. 2012). The wide range is due to the uncertainty in the extent of the habitats being lost and degraded globally.

The Australian Government has shown considerable interest in blue carbon because of its potential to contribute to Australia's emission reductions targets, and intends to include blue carbon in its national greenhouse gas inventory (Macreadie et al. 2017). However, the understanding of the stocks and rates of accumulation of carbon in vegetated coastal ecosystems in Australia is patchy, especially in the more remote tropical regions. The mapped extent of these ecosystems is likewise patchy. We draw from the best available

Australian research into the carbon stocks, carbon accumulation and spatial extent of the vegetated coastal ecosystem in Northern Australia to estimate the value of the blue carbon in the Northern Territory marine and coastal waters. We supplement this with Australian and international analogues from elsewhere in the tropics. We use two prices for carbon: i) $60 t/CO2e, the social costs of carbon (SCC), and ii) $12 t/CO2e, the average price recently paid for carbon dioxide equivalents (CO2e) through Australian Clean Energy Regulator Emissions Reduction Fund. The SCC is the marginal value of economic damages of climate change (e.g. from sea level rises and increased frequency and intensity of droughts and floods) attributable to an additional tonne of CO2 in the atmosphere in 2020 and is an estimate of the environmental damages that can be avoided by reducing emissions. The SCC will not necessarily equal the market price paid for carbon sequestration credits (e.g. through the Emission Reduction Fund) because this market price is the avoided cost of regulatory controls on carbon emissions and not avoided damages.

The total value of the stocks of blue carbon in the Northern Territory marine and coastal waters is in the order of $23.9 billion to $198.5 billion, with the large bulk of this being the stock of carbon in the ~350,000ha of mangroves in the Northern Territory (Table 5). This is a very large value and is dominated by the carbon rich sediment and above ground biomass of mangroves. The value of the blue carbon sequestered each year in the Northern Territory marine and coastal waters ranges from $39 million to $468 million, consisting of $2 million – $11 million in seagrass ecosystems, $26 million - $292 million in mangroves, and $11 million - $165 million in tidal saltmarshes (Table 5).

Table 5. Blue carbon stocks and economic value, Northern Territory, Australia.

Vegetation type	Extent ('000 ha)	Carbon stock (t C/ha)	Annual sequestration rate (t C/ha/yr)	Total value[1] (AU$ million, 2015 dollars)	
				Stock	Annual sequestration
Mangroves	334[2] – 380[3]	1,500[7] – 2,139[8]	1.74[8] – 3.5[11]	$22,211 – $178,690	$26 - $292
Seagrasses	70[4] – 90.6[5]	50.8[9] – 610[7]	0.54[8]	$158 – $12,150	$2 – $11
Tidal saltmarshes	500.5[6]	69.77[10]	0.55[10] – 1.5[8]	$1,546 – $7,676	$11 – $165

[1]Total C estimates were converted to CO2e by multiplying C by 3.664. Price of $AU 12.10 per tCO2e average carbon price from previous three auctions held by Australia's Clean Energy Regulator from Macreadie et al. (2017). Price of US$ 42 is central estimate of social cost of carbon (CO2e) for 2020, at 3% discount rate (in 2007 USD; equals US$ 48 in 2015 (AU$ 60), at inflation of 14.3%), derived from (Interagency Working Group on Social Cost of Greenhouse Gases 2016)
[2]Australian Government (2013)
[3]Northern Territory Government factsheet https://nt.gov.au/__data/assets/pdf_file/0012/204204/mangrove-forest-factsheet-english.pdf
[4]Roelofs et al. (2005)
[5]Estimate of seagrass habitat along 671km coastline of Gulf of Carpentaria, all in the Northern Territory, from Kirkman (1997)
[6]Bucher and Saenger (1991)
[7]Howard et al. (2014)
[8]Estimates from a global database in Alongi (2012)
[9]Estimates for tropical Australia from Lavery et al. (2013)
[10]Estimates for soil only from Macreadie et al. (2017). Soil OC comprises about 95% of total carbon in tidal salt marshes
[11]Lovelock and Ellison (2007)

4.2 Storm protection and erosion prevention

Mangroves can provide protection against storms, tsunamis and coastal floods with their ability to attenuate waves, buffer winds, and accrete sediment through reduced turbulence (Sandilyan and Kathiresan 2015), and there are a growing number of studies that estimate the value of this benefit (Barbier 2015, 2016). Tsunami waves, typically 3-18m in height above mean sea level, can reach up to 48m, as was found with the 2004 Indian Ocean tsunami (Choi et al. 2006). Storm surges from cyclones can see waves reach up to 9m above mean sea level, with 3-5m the norm (Marois and Mitsch 2015). Although it's been demonstrated that mangrove forests of at least 100m in width can significantly reduce the wave flow pressures (Alongi 2008), and the presence of mangroves between the sea and human settlements can reduce casualties by up to 8% (Das and Vincent 2009, Laso Bayas et al. 2011), isolating the exact role mangroves play in protecting against storms and tsunamis is complicated by other marine and coastal characteristics that also contribute to storm protection. The shape of near-shore bathymetry, the presence of coral reefs offshore, distance inland, elevation above sea level of potentially impacted areas, differences in root and trunk structure, and the composition of mangrove ecosystems all influence the level of wind and wave attenuation and erosion benefits (Marois and Mitsch 2015). The presence of communities and built infrastructure in areas at risk of storm and tsunami damage also determine the level of benefit provided by mangroves (Costanza 2008).

Studies that have valued the storm protection services of mangroves arrive at a wide range of values. For example, Barbier (2007) used 1975-2004 data on frequency of storm events and value of damage in Thailand to show that the marginal effect of a loss of mangroves would increase expected storm damages by US$ 1,879 – US$ 5,850 per hectare per year. Coastal wetlands, of which mangroves are a large component, were estimated by Costanza et al. (2008) to provide protection against hurricanes in the USA of an average US$ 8,240 per hectare per year. The protection value of intact mangroves in Odisha state, India, from an intense cyclone that killed almost 10,000 people in October 1999 was estimated at US$ 8,700 per hectare per year (Das and Vincent 2009). These methods employed the damage costs avoided (and expected damage function) to estimate the value mangroves provide to areas at risk.

Other studies have used the replacement cost method where the cost of built infrastructure to replace protection provided by mangroves is estimated. Using this method, (Sathirathai and Barbier 2001) calculated the present value over 20 years of mangrove protection and stabilisation in Thailand at US$ 12,263 per hectare. However, the replacement cost method has been criticised because the replaced built alternative is rarely the most cost-effective way to provide the service, resulting in much higher value estimates than if using the expected damage cost function (Barbier 2016). A third approach to valuation used in some mangrove valuation studies is benefit transfer, whereby the value of the benefit provided by the service in the studied location (the *study* site) is transferred to the location of interest (the *policy* site). Two prerequisites should be met for robust benefit transfer: i) the ecosystems at the study and policy site are comparable, and; ii) the beneficiary populations are similar in income levels, ecosystem benefits received, preferences, employment and economic opportunities and household characteristics (Plummer 2009). The greater the differences in ecosystems and beneficiary population between the study and policy sites, the less reliable the valuations.

The Northern Territory is at risk from cyclones and coastal flood inundation, with the region experiencing a severe (category 3, 4 or 5) cyclone about every 2 years[9]. The annual costs of these natural disasters in the Northern Territory was estimated in 2001 at $142.6 million based on a 1967-1999 national database of natural disasters (Gentle et al. 2001). This cost is dominated by the 1974 Cyclone Tracy which caused an estimate $837 million in damage (1974 dollars)[10] and is Australia's most damaging cyclone[11]. Here we estimate the value of the storm protection and erosion prevention service using two methods: i) benefit transfer, and; ii) replacement cost. The expected damage function is outside the scope of this report because using this approach requires an analysis of the amount and value of the built infrastructure at risk if coastal mangroves were removed from the Northern Territory coastline.

[9] http://www.bom.gov.au/cyclone/about/northern.shtml
[10] https://en.wikipedia.org/wiki/Cyclone_Tracy
[11] http://www.bom.gov.au/cyclone/about/extremes.shtml

The area or extent of mangroves valued is limited to the mangroves that are between built-up areas and the coast. Other areas where there are few or no people are excluded because there are few beneficiaries of the storm protection and erosion prevention service. All mangroves located within 1km of urban localities were selected and assumed to provide protection. The urban coastlines where mangroves are present were also selected to estimate the replacement cost of the mangroves assuming a sea wall would need to be built to protect these urban areas from storm surges. We identified 9,327ha of mangrove habitat that are within 1km of urban areas along the coast of the Northern Territory. With these mangroves providing an annual economic value of $11,696 per hectare per year in storm protection service, the total annual storm protection value of coastal urban mangroves is estimated at $109.1m per year (Table 6). We identified 45km of coastline where mangroves exist along urban localities. Replacing these mangroves with a sea wall would cost between $45m and $396m depending on the cost of the sea wall construction (Table 6).

Table 6. Valuation of storm protection and erosion prevention services provided by mangroves, Northern Territory, Australia.

Valuation method	Area/extent of mangroves	Unit value (AU$, 2015 dollars)	Economic value
Benefit transfer	9,327 ha[3]	$11,696 per hectare per year[2]	$109.1m/yr
Replacement cost	45km[4]	$1 m - $8.8 m per km[1]	$45m – $396m

[1]Based on two values: i) 125-metre seawall being built at Palm Beach (Gold Coast) near 27th Avenue and the Esplanade at a cost of AU$ 1.1 million (2015 dollars); ii) proposal to build seawall at $AU 1 million per km. See https://www.brisbanetimes.com.au/national/queensland/gold-coast-beach-erosion-plan-is-the-plan-on-the-right-track-20150705-gi5cz2.html
[2]Mid-point between unit value estimates of mangroves from Costanza et al (2008) and Das and Vincent (2009) is $US 8,470. Converted to 2015 is $9357. In AUD equals $11,696 at an exchange rate of 0.8 USD to 1.0 AUD
[3]Area of all mangroves mapped in the Geoscience Australia Coastal Waterways Habitat Mapping within 1km of Urban Localities, as mapped by the ABS 2016.
[4]Length of coastline of urban localities along the coast and containing mangroves

4.3 Summary of regulating ecosystem services values

The regulating ecosystem services provided by the Northern Territory marine and coastal ecosystems that we were able to value are blue carbon and storm protection. They have an annual economic value of around $148.1m - $577.1m, consisting of storm protection worth $109.1m and carbon sequestration worth $39m – $468m. A number of other regulating ecosystem services are provided by the marine and coastal waters of the Northern Territory, including pest and disease control and waste assimilation (via water filtration), but it was not possible to place a value on these because of the absence of data for northern tropical Australia.

5 Values of cultural services

Haines-Young and Potschin (2012) define cultural services “as the physical settings, locations or situations that give rise to changes in the physical or mental states of people, and whose character are fundamentally dependent on living processes; they can involve individual species, habitats and whole ecosystems”. The cultural ecosystem services are classified as[12]:

Division 1: Physical and intellectual interactions with ecosystems and land-/seascapes

- Physical and experiential, e.g.
    - Non-extractive recreation and tourism;
    - Extractive recreation and tourism (covered in Section 3.2 on provisioning services);
    - Aesthetic Values.
- Intellectual and representational, e.g.
    - Inspiration for culture, art and design;
    - Research and other forms of knowledge sharing for individual and social development;
    - Other ways of creating and sharing knowledge.

Division 2: Spiritual, symbolic and other interactions with ecosystems and land-/seascapes

- Spiritual and/or emblematic;
- Other cultural outputs (which can include Bequest and existence (non-use) values).

5.1 Important note about valuing cultural ecosystem services

All of the cultural ecosystem services contribute to wellbeing (MEA 2005) but only some are closely associated with market activities (Figure 5) and contribute directly to the macro-economy via contributions to GDP and to employment. Although there are tools to value (in monetary terms) some cultural services outside of markets (Figure 5), many important services, particularly those that generate complex inter-related benefits for society as a whole, cannot yet be readily valued (Stoeckl et al. 2018). In many societies it is unethical to value some types of cultural services (particularly the spiritual) (Daw et al. 2015). This chapter groups cultural ecosystem services in three ways:

1. Services that have strong links to the market and thus make a direct contribution to the macro economy (darker oval in Figure 5). We estimate both the economic contribution these services make to the macro economy and their economic value.
2. Services which do not have strong links to the market, but which can be valued using traditional non-market valuation methods such as contingent valuation, and choice modelling (lighter oval in Figure 5).
3. Services which do not have strong links to the market, and which cannot be valued using traditional non-market methods (services outside the dark and light ovals in Figure 5).

[12]According to the Common International Classification of Ecosystem Services, 2016, see https://cices.eu/

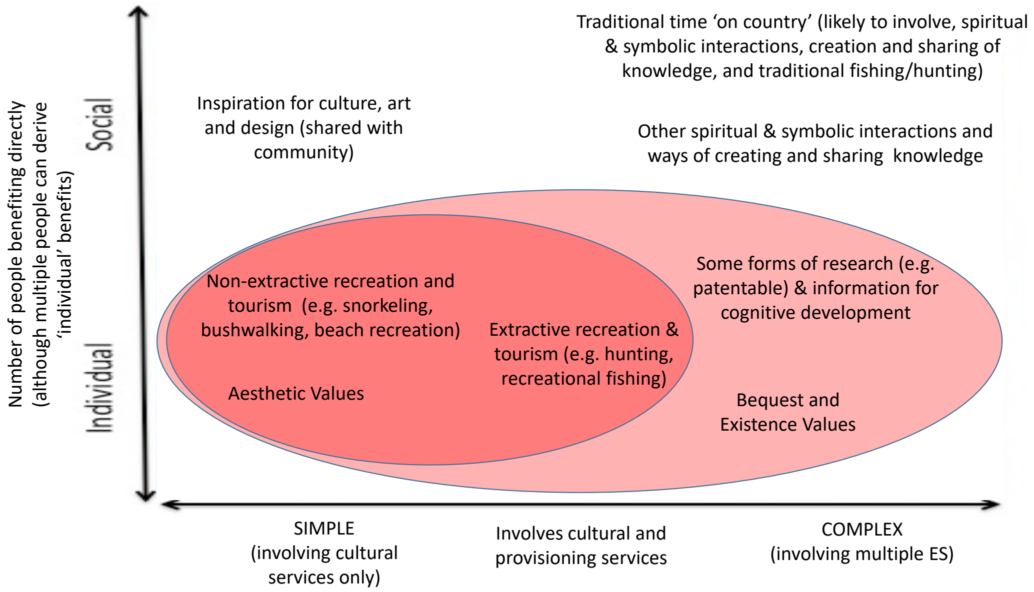

Figure 5. Cultural services relevant to the Northern Territory's marine and coastal ecosystems, categorised by (a) to whom most benefits accrue to (individuals or society more broadly), and (b) the number of other ecosystem services they relate to. Categorisation based on Stoeckl et al. (2018).

We acknowledge that our monetary estimate of cultural ecosystem services, wherever measured, will not reflect the full value of NT's marine and coastal waters that both Indigenous and non-Indigenous people may hold. However, the assessed monetary values can be used as an additional tool to support conserving the marine and coastal natural resources and their contribution to people's wellbeing.

Different ecosystem services have different spatial characteristics (Costanza 2008) and it is crucially important to consider scale when undertaking valuation exercises. For some of the cultural services discussed in this chapter, we have been able to use monetary estimates of the 'value' of cultural services from other studies to draw inferences about the likely 'value' of similar services provided by the Northern Territory's marine and coastal environments. We have converted 'value' estimates from the other studies into values per person and multiplied those per person values by estimates of relevant populations benefiting from the cultural ecosystem services. The spatial distribution of some of the core populations we consider relevant are shown in Figure 6 and include:

- Tourists visiting parts of the Northern Territory which are adjacent to the coast (used to estimate regional economic impact of marine tourism and the (tourism) recreation use values of marine environment) – with selected boundaries linked to those used by the Northern Territory's Tourism board;
- About 35,000 Indigenous people living within approximately 200km of the Northern Territory's coast (used for discussion of Indigenous cultural values) – with selected boundaries linked to those used by the Australian Bureau of Statistics (ABS) for their Indigenous Regions;
- About 120,000 non-Indigenous people living within approximately 200 km of the Northern Territory's coast (used to estimate (local resident) recreational use values – Indigenous Area boundaries also used here, since population counts from the ABS include both Indigenous and non-Indigenous people.

Populations relevant to other cultural services (specifically bequest and existence values) are global, although we have used local population estimates for calculations, thus ensuring final estimates unambiguously represent a 'lower bound'.

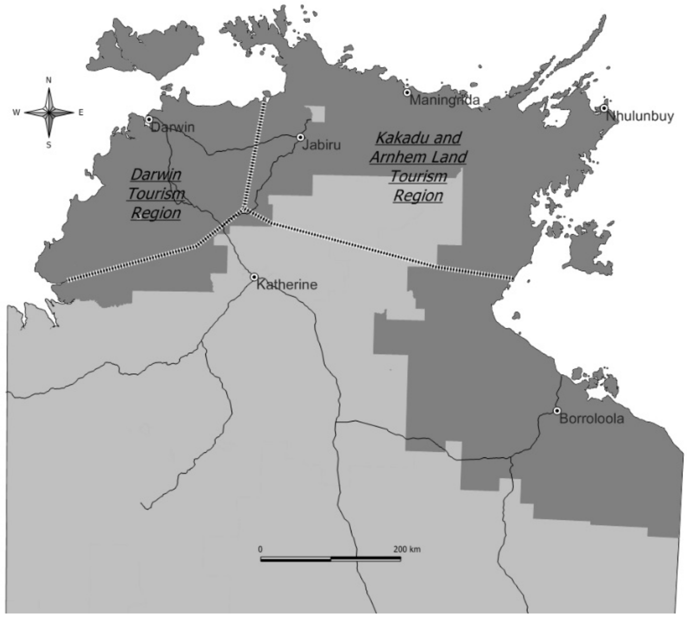

Figure 6. The NT's marine 'populations' - Tourism Regions (Darwin and Kakadu/Arnhem land) and ABS administrative regions adjacent to the coast. About 120,000 non-Indigenous and 35,000 Indigenous people reside in the dark grey regions (ABS 2011).

5.2 Tourism – a cultural service with strong links to the market

5.2.1 The economic contribution of marine tourism to the NT economy

Tourism employment multipliers (i.e. the jobs created per dollar earned within the industry) are often higher than the employment multipliers associated with other sectors of the economy (Carlsen and Wood 2004), highlighting that tourism is a particularly good way of growing regional job markets. Marine tourism, including consumptive (e.g. sports-fishing) (Barnett et al., 2016) and non-consumptive (e.g. diving, snorkelling, whale watching) activities, has been shown to makes substantial contributions to regional economies in many parts of the world, including Australia.

Tourism NT estimates that for the year ending March 2017, more than 1 million tourists visited the Darwin and Kakadu/Arnhem Land regions of the NT (on and adjacent to the coast), spending, on average, $1,215 and $868 per person, respectively, in each area. European studies have found that tourists are willing to pay a premium for accommodation in coastal areas (J. M. Hamilton, 2007), and Australian research has shown that visitors intent on interacting with iconic marine species in and around the Great Barrier Reef (GBR) are also willing to spend a premium. Although we could not find similar studies in the Northern Territory, a search of the Telstra Yellow Pages for fishing charters in coastal Northern Territory, revealed that these visitors are also likely to be enticed to spend considerably more than the 'average' visitor to experience remote and unique environments. Day trips fishing at local reefs may cost as little as $210[13], but some full-week fishing charters are quoted at more than $11,000 per person[14]. Here we use 'general tourism' estimates of expenditure ($1,215 and $868) to generate an estimate of the regional economic impact of marine tourism in the NT, noting that they will likely understate the expenditure of marine-focused tourists.

[13] https://www.yellowpages.com.au/nt/cullen-bay/equinox-fishing-charters-14883063-listing.html?referredBy=www.yellowpages.com.au&context=businessTypeSearch
[14] http://www.dhipirribarra.com.au/the-lodge/charters/

Approximately 50% of tourists to the greater Darwin region visit the Casuarina Coastal Reserve[15], although not all their expenditure can be directly attributed to marine and coastal ecosystems because a portion of tourists are likely to be visiting the region primarily for other reasons (e.g. to visit friends and relatives, to visit terrestrial environments). Across Australia, 40% of all domestic tourism and 19% of international tourism is assumed as 'marine' (DeloitteAccessEconomics 2016). Arguably, the Northern Territory's marine environment does not currently play as significant a role in attracting visitors to the region as it does in other parts of Australia such as the Great Barrier Reef[16].

In the Northern Territory it is terrestrial activities that attract tourists, and which are the major contributors to tourism expenditure. For the year ending March 2017, about half of all domestic visitors and two-thirds of international visitors to the Northern Territory visited inland regions (e.g. Uluru), rather than coastal areas. About 8% of all tourists (71,000 visitors) to the greater Darwin Region arrived on Cruise Ships[15]. Much tourism in the Top End is focused inland: 38%, 19.9% and 14.2% of International, Inter-state and Intra-territory visitor expenditure in the top end, respectively, has been attributed to the presence of Kakadu National Park (Tremblay 2007), although most tourist activities within the park occur in inland areas. Given the significance of terrestrial environments to Northern Territory tourism, we assume that 30% of domestic and 15% of international tourism in the NT's Top End is marine and coastal. As for estimates of per-person expenditure, this is likely an underestimate and will thus bias estimates of regional economic impact downwards.

For every dollar spent by tourists, extra income is generated in other regional business. The size of these additional (indirect) impacts varies according to the size of the region/economy, with the indirect impacts in urban areas being much larger than in remote locations (Stoeckl 2007). For the whole of the Northern Territory, indirect impacts of tourism have been estimated at approximately the same size as direct impacts (i.e. for every dollar of tourist expenditure, there is an additional dollar of regional benefit created, suggesting that the tourist 'multiplier' is about two)[17]. If only interested in Territory-wide impact of visitors to all regions (including remote areas in and around Kakadu/Arnhem Land), then a multiplier of two is thus likely appropriate. Here we assume a regional, rather than a Territory-wide interest, so use a multiplier of two for the Darwin area, and, a multiplier of 1.25 for the Kakadu/Arnhem Land region (Stoeckl 2007). Use of a lower multiplier for the remoter region is in line with previous analytical choices, ensuring that any biases are unambiguously downwards.

Our final estimates of the regional economic impact of the Northern Territory's marine tourism industry are presented in Table 7, where we also estimate the number of Northern Territory jobs associated with marine tourism, assuming the same ratio of jobs per $ contribution that is evident for all types of tourism across the Northen Territory[18] applies here.

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[15] http://www.tourismnt.com.au/~/media/files/corporate/research/tnt_darwin-profile_jun-17.ashx

[16] Empirical studies in the Great Barrier Reef (GBR) region, suggest that (a) between 80-90% of on-shore regional expenditure by live-aboard dive boat tourists would not have occurred if divers had not been able to go on the dive-boat (Stoeckl et al. 2010) and that (b) more than 90% of non-business visitors and 67% of business visitors to the GBR coast, came to the region for at least one nature-related reason, generally associated with the marine environment; fewer than 40-50% of visitors would still have come to the region, if the marine environment were seriously degraded (Mustika et al. 2016).

[17] State Tourism Satellite Accounts 2015–16, Tourism Research Australia, Canberra

[18] Deloitte Access Economics estimates that the tourism industry contributes $2.2b to the NT economy (2015-16), employing 17,300 people. So there is one job associated with every $127,167 contributed. Direct employment in tourism was 9,200, with GVA estimated at $1,108,000,000. So for every $120,434 dollars earned, there is one job. (TourismNT 2016). We use 1 job per $125,000 for our estimates.

Table 7: Estimates of the contribution marine tourism makes to the NT's Top End economy

	Darwin	Kakadu/Arnhem	Total coastal region - Top End (Darwin + Kakadu/Arnhem)
Domestic & International	864,000 visitors 240,100 'marine' visitors $1215 per visitor $291.7m marine visitors	222,000 visitors 62,100 'marine' visitors $868 per visitor $53.9m	1,086,000 visitors 302,200 'marine' visitors $1,144 per visitor $345.6m
Estimated economic contribution of marine and coastal tourism	$583.4m (2 times $291.7m)	$67.4m for the Kakadu/Arnhem economy (1.25 times $53.9m) $107.8 for all of NT	$691.2m (NT)
Estimated employment (FTE) associated with marine tourism (1 job per $125,000)	4,667	539 within Kakadu/Arnhem, 862 within the NT	5,530 (NT)

Notes:

- The distribution of jobs and income between Indigenous and non-Indigenous people is likely to be unequal (with a disproportionate share going to non-Indigenous people) unless tourism enterprises are specifically Indigenous and/or other measures are taken to redress structural problems that tend to skew the distribution of benefits (incomes and jobs) in favour of non-Indigenous people (Stoeckl et al. 2014, Barnett et al. 2016)
- Marine-focused tourists (e.g. those going on diving trips, or fishing charters) may spend more than terrestrial tourists (likely, at least partially because of the cost of boat trips). If the total number of visitors to the NT remain unchanged, an increase in the proportion of those engaged with marine activities, could generate an increase in the economic benefit of tourism.

5.2.2 Recreational use-values for tourists

Many studies have estimated the recreational value to tourists of coastal areas (middle, Figure 3) most often using the travel cost method. The money spent travelling to and from a natural environment such as a beach infers the value of the beach, an activity related to the beach, or the value of beaches that are of different environmental 'quality' (e.g. people will travel further and spend more to visit a pristine coast than a degraded one). This is a true value because it captures the amount that tourists would be willing to pay to visit an area, over and above that which is actually paid (often zero).

Although such a study has been undertaken for Kakadu (Knapman and Stoeckl 1995), we could not find a marine-specific example in the Northern Territory, so instead inferred values from studies undertaken elsewhere in the northern parts of Western Australia and in Queensland. The values are listed in Table 8.

We multiply the median of these estimates ($522 per person per visit) by our estimates of the number of 'marine' visitors (approx. 300,000 per annum), to generate an estimate of the recreation use value of the Northern Territory's marine and coastal ecosystems of about $156m per annum.

5.3 Non-market cultural services that can be valued

5.3.1 Aesthetic, amenity and recreational use values (non-Indigenous residents)

Aesthetic, amenity and lifestyle values associated with marine environments are not traded in markets but their value is often built in to other market prices. A house with an ocean view will generally sell for more than an identical house without one, and people who must live and work in unpleasant environments, often need to be offered higher wages for identical work than those living and working in more attractive locales. It can be difficult to disentangle effects, since aesthetic, amenity and lifestyle values are likely to simultaneously impact both house and labour markets (e.g. amenity values attracting people to region, expanding both labour supply and housing demand), but overall, it seems that house-price effects may dominate (Colombo et al. 2014). Rates paid by land-owners to local governments reflect property values (Pearson et al. 2002) meaning the aesthetic, amenity and 'lifestyle' values associated with marine environments also indirectly contribute to local government revenues (although we do not generate estimates of that contribution here).

Table 8. Relevant recreational use values for northern Australia.

Location	Value	Source
Kakadu National Park	$381 per person per visit	Estimated by dividing total value estimate ($40.8m -(Knapman and Stanley 1991))) by approximate visitors per annum (180,000 in 1987; 200,000 in 2000 (Buckley 2002)
Hinchinbrook Island	$972 per person per visit	(Stoeckl 1998)
Fraser Island	$1,853 per person per visit	Mean of reported range. (Fleming and Cook 2008)
Lake McKenzie, Fraser Island	$307 per person per visit	Mean of reported range (Fleming and Cook 2008)
Great Barrier Reef	1. $522 - $1177 per person per trip (mean $849) 2. $214 per trip diving 3. $662 per person per visit domestic visitors 4. $329 per person per visit (domestic & International)	1. Estimated by dividing total value estimates (710m-1.6b in 1992 dollars) by estimated visitors (2m). (Carr and Mendelsohn 2003) 2. Kragt et al. (2009) 3. (O'Mahoney et al. 2017) 4. Hundloe (1989) cited in (Hoagland et al. 1995)

Many studies have used the hedonic pricing method to estimate amenity values associated with the marine environment. The hedonic pricing method compares the value of real estate which are identical in all respects except for one: an ocean view. The difference between the price of real estate that has a view, and one that does not, provides an indication of the 'value' of the view. Application of the hedonic price method has shown that properties with sea views command particularly high prices with premiums of 15 - 30%. Proximity to the beach is also important, although prices fall off rapidly at relatively short distances from the sea. For example, a 30-50% decline in house prices has been observed over distances of less than 200 metres (Milon et al. 1984, Hamilton and Morgan 2010). There is also evidence highlighting that the 'quality' of the waterfront impacts property values. For example, Gopalakrishnan et al. (2011) found that beach width has a significant impact on house prices, with erosion capable of reducing house prices by up to 52%.

Near Sydney, properties close to the coast have been found to attract price-premiums of up to 40% compared to similar properties located away from the coast (Sydney Coastal Councils Group 2013), and in Noosa, on the Sunshine Coast of QLD, properties with ocean views had prices up to 76% higher than similar properties without views; those in walking distance of the ocean also attracted price premiums (Pearson et al. 2002). We found only one Northern Australian study, in Exmouth, which confirms these findings, noting the existence of price premiums for coastal properties, even when such properties were at risk from cyclones and storm surge (Roberts et al. 2015).

Observed property price premiums are likely to reflect enhanced recreational opportunities associated with a marine location. We thus omit these values altogether to avoid the risk of double-counting, instead using local-resident recreation use values, generated from travel cost studies. There are several studies of recreational use values of residents in marine environments. In the US the consumer surplus for beach, island and marine park visits by residents have been estimated, using the travel cost method, at between $31 and $610 per person per day (converted from US$ 1995 to AU$ 2010) (Hoagland et al. 1995). We could not find any studies of recreational values in marine areas for the Northern Territory, but note that there has been one study of recreational fishing values along the Capricorn coast of QLD, suggesting that the consumer surplus per fishing trip is $2,360 per angler per annum (Prayaga et al. 2010), with total estimated recreational fishing values of about $6m per annum (2015 values) for the entire Capricorn coast (≈ $24 per person[19]). There have been numerous empirical travel cost studies of the value of beach recreation in and around the Brisbane area (including Gold coast and Sunshine coast), with values ranging between $1.70 and $40 per person per visit, depending upon the beach.

The recreational values associated with southern beaches are unlikely to be readily transferable to the Northern Territory because: i) crocodiles and other marine hazards, together with the absence of 'surf', makes beach recreation a significantly different experience, and; ii) the socio-economic conditions are substantially different between the north and south. We suggest that the (residential) recreation use value of beaches in Northern Territory is likely to be at the lower end of the range of values compared to south-east QLD. We thus generate a range of what we feel are plausible estimates: selecting the per-person recreation use values that lie between QLD's reported minimum and median values ($1.70 to $40 per person per beach visit, which is broad enough to also include our estimates of recreational fishing values). For the approximately 120,000 non-Indigenous people living within 200 kilometres of the Northern Territory coast (Figure 6) we could not find information about the number of times per annum that people visit the beach so we use the beach visitation patterns of Queensland residents who visit the beach approximately once a month (Larson et al. 2015). We estimate that the aesthetic, amenity and recreation use-values associated with the Northern Territory's coastal and marine environment ranges from $20 to $336 per resident per annum, or $2.5m to $40.3m for all residents.

5.3.2 Bequest and Existence Values (non-Indigenous residents)

People do not have to use the environment to benefit from it (Weisbrod 1964, Krutilla 1967). Some people feel better knowing that the environment exists for its own sake (existence values), that it is preserved for future generations (bequest values), and/or that it is preserved if humans determine other uses for it in the future (option values). There are many studies seeking to quantify those values, most using stated preference techniques such as contingent valuation and choice modelling. Contingent Valuation (CV) involves the construction of 'hypothetical' markets. Individuals are asked to indicate if they are willing to pay, and how much, to, for example, improve water quality to enjoy swimming, snorkelling or diving. Choice modelling (CM) differs from CV, in that respondents are asked to choose between alternatives. CM involves the construction of numerous different 'choice-sets', each with different characteristics (e.g., differently levels of environmental amenity) and different prices. Individuals are asked to indicate which choice-set is preferred, and these preferences are used to estimate the value of the different characteristics described in the choice-sets.

Many CV and CM studies have been undertaken in marine environments globally and in Australia. Tasmanians, for example, are willing to pay to protect seagrass beds, estuarine vegetation and rare marine native plants and animals (Kragt and Bennett 2011). Residents of NSW are willing to pay to protect the Nadgee (coastal) nature reserve and people are willing to pay to improve the health of the Great Barrier Reef, and of related attributes (e.g. seagrass, fish, reef) (Rolfe and Windle 2012). Queenslanders are willing to pay about $100 per person per annum to protect Hawksbill turtles, a key marine species prevalent in the Northern Territory (Tisdell et al. 2007). The intent of these CV and CM studies has not been to generate an estimate of (total) non-use values, but rather to assess people's willing to pay to improve or to prevent degradation of the health

[19] The 2011 ABS census indicates that the federal division of Capricornia had a population of 233,000.

of ecosystems. These estimates usually tell us about people's willingness to pay for change in ecosystems, such as a 1% improvement in coral cover or a 5% increase in seagrass beds.

Care must be taken when transferring CV and CM estimates for use in other contexts because the changes specified in the scenarios used within the hypothetical questions or the scarcity of the environment to be improved are usually not relevant in other locations (Hsee and Rottenstreich 2004). To illustrate the care required, research suggests that QLD residents are willing to pay up to $9.36 per household per annum to 'improve' a hectare of seagrass. A basic benefit transfer would multiply this per hectare value by the number of hectare of seagrass in the Northern Territory's marine environment (70,000 - 90,000 ha), to generate a total estimate of willing to pay of $842,000 per household per annum which is implausibly high.

We therefore suggest that the existence/cultural value of the NT's marine environment (including, but clearly not limited to seagrass and reefs) is in the more conservative range of $5,000 - $10,000 per household per annum. Using an average household-size of 2.9 people[20], we estimate that the existence/bequest values to the 120,000 non-Indigenous population living near the coast are likely to be worth between $207m and $414m per annum.

5.4 Cultural services that are impossible to value using 'traditional' non-market valuation methods

5.4.1 Inspiration for culture, art and design

Techniques for valuing the contribution nature plays in culture, art and design are not well developed because valuation methods consider value in terms of the contribution that goods or services make to an individual's welfare/utility. Rather than making contributions to an individual's welfare, this group of ecosystem services are a type of complex social good, generating value at a broader social scale.

The Northern Territory's marine and coastal ecosystems provide an aesthetic background, with social and recreational opportunities that enhance the quality of life of those who live there, and they inspire creativity (e.g. local art); which contributes to economic growth (Florida 2014). These values are real and produce measurable economic value, although relevant empirical studies that quantify these types of value are elusive. They are crucially important values but are immeasurable with current available valuation methods. Omission of these estimates is equivalent to using a value of zero resulting in underestimates of total value.

5.4.2 Research

Measuring research values requires calculating the benefit to society of research undertaken minus the cost of undertaking the research. We could find no empirical studies of this value for the marine and coastal environment which likely reflects the difficulties of attempting to assess the benefits of research which are often intangible and may not be apparent until many years after the research has taken place. Research is a complex social good and its benefits not readily amenable to valuation. There are examples of studies that have calculated marine focused research expenditure which could be used to assess the economic contribution of marine research to the Northern Territory economy (DeloitteAccessEconomics 2013), but estimates relevant to the Northern Territory could not be sensibly transferred, and are thus omitted from our estimates of total values. As above, omission of these estimates is equivalent to using a value of zero resulting in underestimates of total value.

[20] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/7

5.4.3 Indigenous cultural values

For tens of thousands of years Australian Indigenous people have been doing many different activities on their land and sea country. Termed Caring for Country, activities are generally guided by the laws, customs and ways of life inherited from ancestors and ancestral beings (Weir et al. 2011). It involves caring for all values, places, resources, stories, and cultural obligations associated with an area, including the associated processes of spiritual renewal, connecting with ancestors, food provision and maintaining kin relations (Altman et al. 2007). Activities undertaken while out on country include (Hill et al. 2013):

- Collection, sharing and maintenance of customary or cultural and other resources (e.g. hunting, burning, knowledge sharing, firewood collection, management of water supplies);
- Commercial economic activities (e.g. pastoral, art, bush harvest for sale), and;
- Weed and feral animal control, fire management, revegetation.

Caring for Country thus simultaneously and interactively involves provisioning, regulating, maintenance and cultural services; generating benefits for individuals, families, the community and the environment itself. Chapter 3 identified several marine industries that Indigenous people are associated with, providing estimates of their 'provisioning' values, and highlighting that these industries do more than just provide food. They also provide medicines for Indigenous people. Amongst numerous other things, medicines are inextricably linked to Indigenous cultural values, to identity and to sense of place.

There exist inter-relations between provisioning and cultural services in Indigenous contexts, such as the cultural importance of traditional foods. Regulating and maintenance services also need to be considered. Caring for Country requires traditional biocultural knowledge (simplistic examples include knowing which medicines to use in which situations; how to ensure water at particular sites remains drinkable) which has made demonstrable contributions to ecosystem science and management (Ens et al. 2015). Indigenous people obtain significant benefit from provisioning and cultural services, while making a positive contribution to regulating and supporting services. Indigenous cultural values thus cannot be thought of as comprising separable benefits that flow in a single direction from an ecosystem to individuals. They are very much part of an entire complex and dynamic system, with benefits (and costs) flowing back and forth between parts of the system and with benefits accruing at multiple scales (e.g. at the individual, family and community level). Sangha and Russell-Smith (2017) provide a conceptual framework that highlights the tight connections between ecosystem services, Indigenous people and their well-being and livelihoods (Figure 7). Bark et al. (2016b) identify several different types of cultural values held by Indigenous people's fish-traps. Some values map to particular ecosystem services, some to parts of the total economic framework, some are entirely 'new'. Bark et al. (2016a) provides an overview of Indigenous cultural values in the Murray Darling basin and Jackson and Palmer (2015) critique mainstream economic approaches to Indigenous cultural valuation and pricing policy in environmental settings.

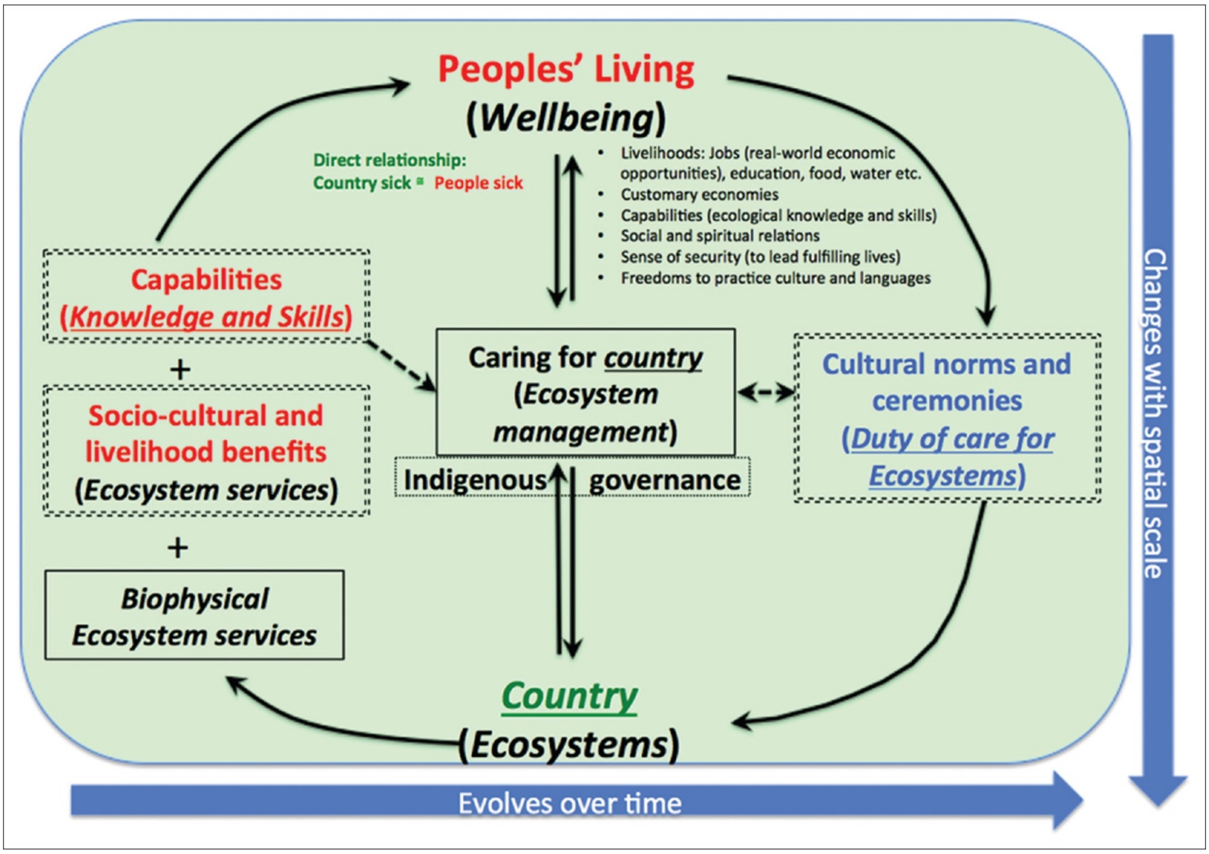

Figure 7. An Indigenous framework for valuing benefits (ES) from country. The green box denotes country of which people and their living are an integral part. In each text box, the normal font indicates Indigenous, and the italicized equivalent western, perspectives (except for country). The arrows denote the influence (benefits/knowledges) between the two systems. Red and blue text boxes indicate the key aspects lacking valuation in the current economic framework.

Source: Sangha and Russell-Smith (2017)

The majority of research about Indigenous cultural values is qualitative (Farr et al. 2016) because of the complex, inter-connected system (Figure 7). The valuation tools available today assume that benefits are separable (e.g. provisioning benefits are distinguishable from cultural benefits), that benefits flow in a single direction (from the environment to people) and that benefits accrue solely to individuals (with social benefits being, simplistically, the sum of individual benefits). That said, we use insights from the literature to indicate their likely value, compared to other values. The studies relevant to northern Australia from which we draw these insights are:

- Jackson et al. (2014) estimated that the value of the harvest of freshwater dependent aquatic species for bush foods in the Fitzroy (WA), Daly (NT) and Mitchell (QLD) river catchments had a replacement value of between $245 and $434 per person per annum (location specific) and comprised approximately 13% of household expenditure on food in the Daly River, and up to 22.7% in the Fitzroy.
- An assessment of people's willingness to pay to trade-off agricultural development against keeping waterholes in good condition for Aboriginal people (interpreted as being a proxy for Indigenous cultural values) estimated between $91 (all Australians) and $207 (northern Australians), per person to preserve the waterholes.

- A 'sustainable' livelihoods look at traditional harvest in the East Alligator River identifies important species and categorises them according to where they were caught (instream, bank, or on floodplains), the gender of the person catching and the method used to catch them (Ligtermoet 2016).
- An investigation of factors contributing to the wellbeing of residents in the Daly River Catchment by (Adams et al. 2014) finds that cultural factors are important to all people, although significantly more important for Indigenous people. Socio-cultural values for Indigenous people were also considered to be much more important than commercial values.
- A study of the history, attempts at development, and challenges faced by the trepang (sea cucumber) industry in Warruwi, NT (Gould 2016). The research highlights the numerous links between the provisioning services associated with the industry, and other socio-cultural values. An important point was made that parts of the NT are not suited to intensive agricultural development, and attempts to develop terrestrial ventures (e.g. cattle) have led to food shortages in some communities. This highlights the importance of the marine environment for Aboriginal residents of the Northern Territory.
- Barber et al. (2015) produce a qualitative model using data relating to the use of wild resources in coastal Arnhem land in addition to that used in the Fitzroy (WA), Daly (NT) and Mitchel River (QLD) catchments. The model highlights that although hunting/fishing is associated with less dysfunction, there is a strong and significant link between community well-being and subsistence activities: 'Community well-being cannot be maintained unless: the country itself is healthy; appropriate people are looking after it through practices that encompass subsistence effort; and the results of such productive labour are appropriately distributed' (page 59).
- An exploration of the motivations for, and importance of 'sharing' turtle and dugong (Watkin Lui et al. 2016) highlights the crucial importance of cultural values and practices – reiterating points apparent from the terrestrial literature: that harvesting/hunting &/or spending time 'on country' (sea or land) is about much more than providing food.
- Delisle et al. (2017) estimate the costs and benefits of turtle and dugong hunting in Torres Strait. They group perceived costs and benefits into separable groups, finding that benefits fell into three distinct categories: i) those directly associated with the market (food provisioning values); ii) individual values (health and sense of identity), and; iii) community benefits (cultural benefits including sharing, the maintenance of culture and the provision of food for ceremonial purposes). The replacement cost method was used to estimate the value of food harvested, and information about distance travelled, the number of people going on hunting trips, and fuel used, allowed for the calculation of harvesting costs. Harvesting costs were subtracted from food value to generate an estimate of the net benefit of harvested food of $206,000 and $108,000 per annum on Mabuiag and St Paul's, respectively (about $500 and $900 per person per annum). Community values were considered by respondents to be unambiguously more important (to wellbeing) than food values; individual values were considered to be of 'equivalent' importance to food values. Delisle et al. (2017) concluded that all values (food, individual and community) were collectively worth at least $1,500 - $2,700 per person per annum.
- A study of ecosystem service values on an Indigenous property in the Northern Territory (Sangha et al. 2017) considered trade-offs on Indigenous welfare expenditure to draw inferences about Indigenous cultural values. They used 50% of welfare payments (per person, per annum) to estimate values.
- A recent report by the Social Ventures Australia (SVA 2016) underscores the role of Indigenous Protected Areas for capability benefits along with socio-cultural and environmental benefits. Applying a replacement cost for a research position ($37,242/yr/head) for individuals aged between 15 to 45 years.

In the absence of other regionally relevant research, we use estimates from the last three studies to generate a range of 'plausible' estimates for use in the Northern Territory marine environment. For the lower-bound estimate, we multiply Delisle et al. (Forthcoming)'s lowest per-person estimate of the 'values' associated with the traditional hunting of dugong and turtle ($1,500) by the 35,000 Indigenous population living in regions that are adjacent to the coast (Figure 6). This gives us a 'minimum' estimate of value equal to $52.5m per annum.

For the upper-bound estimate, we first multiply $11,300 by 35,000 ($395m). This is 25% of the money spent by the Australian Government on Indigenous welfare (a total $45,201 per person per year, (Steering Committee for the Review of Government Service Provision 2014); which is one-half of the amount, per person, used by Sangha et al. (2017), when valuing the socio-cultural services of an inland terrestrial estate. The logic for substituting Indigenous welfare expenditure for the value of services people accrue from their coastal and marine resources is that services such as healthy lives, early childhood learning and development, secure environment and welfare directly link to the coastal and marine resources (provided there are appropriate mechanisms and support structures). We then include an additional allowance for the role the marine environment plays in building and enhancing capabilities of Indigenous people. For example, the availability of natural resources (e.g. sea country) ensures that Indigenous people can manage their country, learn and pass-on their knowledge, skills and cultural practices to the next generation (Sangha and Russell-Smith 2017). Capability benefits of using and valuing natural resources are very rarely accounted for in peoples' well-being because many valuation frameworks are based on western perspectives including the MA and TEEB frameworks (Sangha and Russell-Smith 2017). However, capability benefits are the real benefits that Indigenous people value, which are now well recognized and advocated by (Bockstael and Watene 2016, Sangha and Russell-Smith 2017). Using a replacement value for a research position ($37,242/yr), we infer additional socio-cultural values of $16.5 m per annum. This provides us with a total upper-bound estimate of $412m per annum.

We conclude that the Northern Territory's marine and coastal Indigenous cultural values, which differ significantly from non-Indigenous cultural values in that the cultural services are inseparable from provisioning and other services, are therefore worth between $52.5m and $412m per annum.

5.5 Summary of cultural ecosystem services values

Valuing cultural ecosystem services is difficult. Many of the values are beyond the reach of traditional economic valuation techniques because they are qualitative, less tangible and in many societies, it is unethical to value some types of cultural services (particularly the spiritual). In this chapter we grouped cultural ecosystem services in three ways based on their link to the market and their ability to be valued. The first group consists of tourism and recreation values which have a strong link to the market and thus make a direct contribution to the macro economy. We estimate tourism in marine and coastal ecosystems to contribute $691m per annum to the Northern Territory economy supporting 5,530 jobs. The economic benefit (value beyond price) of recreation accruing to tourists is estimated at $156m per annum (Table 9).

The second group consists of aesthetics, amenity and recreational values (residents) and bequest and existence values, which do not have strong links to the market, but which can be valued using well-established methodologies. We estimate the annual value of these to be $2.5 – $40.3m and $217m - $414m, respectively (Table 9). The third group of cultural ecosystem services are the services which do not have strong links to the market and which cannot be valued using traditional non-market valuation techniques. The services we discuss here are research for cognitive development, inspiration for culture, art, and design and Indigenous cultural values (Table 9).

While we cannot reliably value these, we estimate that the minimum value of Indigenous cultural values related to the Northern Territory marine and coastal ecosystems is $52.5m per annum, with upper bound estimates possibly reaching as high as $412m per annum.

Combined, the cultural ecosystem services contribute an estimated $691m per annum to the economy of the Northern Territory, with 5,530 jobs. Their economic value from their contribution to wellbeing is between $428m and $1,022.3m annually.

Table 9. Summary of cultural values.

Example	Contribution to NT's economy ($m/yr; jobs)	Economic value ($m/yr)
Tourism	$691m (5,530 jobs)	$156m
Aesthetics, amenity and recreational values (residents)	No suitable studies for benefit transfer found, but potentially significant since creative people attracted by social and environmental amenity. Also, attractive environments inflate property prices, and thus rates paid	$2.5m – $40.3m
Bequest/existence	No direct market value	$217m - $414m
Research / information for cognitive development	No suitable studies for benefit transfer found	Possibly immeasurable (with current methods)
Inspiration for culture, art, and design	No suitable studies for benefit transfer found, but potentially significant since creativity core for economic growth	Immeasurable with current valuation methods
Indigenous cultural values	No suitable studies for benefit transfer found; but few links to market, so would not expect 'impact' to be large.	Impossible to measure accurately. Indications that values fall between $52.5m and $412m

6 Summary and Recommendations

The Northern Territory marine and coastal ecosystems contribute in the order of $1 billion per year to the Territory economy (Table 10). The Gross State Product (i.e. Territory-level GDP) in 2015-16 is $23.6 billion[21], meaning the marine and coastal ecosystems contribute around 4% to the Territory economy. These ecosystems also support over 6,300 jobs[22]. But only some of the services provided by the Northern Territory's marine and coastal ecosystems are bought and sold in the market. The value of services can thus be thought of in terms of the contribution that they make to economic welfare (wellbeing) – we estimate these values at between $850m and $1.9b per annum (Table 10).

The value is found in the many ecosystem services supplied by the marine and coastal ecosystems, of which a few ecosystem services dominate. The services of marine and coastal tourism ($691m/yr), existence value (up to $414m/yr) and the underlying contribution of the biodiversity genepool to Indigenous well-being ($412m) make up a substantial portion of all the ecosystem service values we estimated. The provisioning services that directly supply people with many goods extracted from the marine and coastal ecosystems are worth $404m/yr. Also of high value is blue carbon, or carbon sequestration in marine ecosystems. Worth about $470m per annum, carbon storage in marine and coastal ecosystems offers a substantially more efficient sequestration option than terrestrial forests because blue carbon accumulates without reaching saturation and the carbon is stored for thousands of years.

There are other aspects of marine and coastal ecosystems that are very valuable, but these values are not easily quantifiable, e.g. the value of a healthy and intact landscape for Indigenous peoples. Although their monetary values are not able to be quantified, and so are not included, they should not be ignored because of their high intrinsic worth. These are important values and should be considered in decision making.

The ecosystem services concept makes it clear that the choice of 'the environment versus the economy' is a false choice and an outdated paradigm. The OECD calls for the new economic paradigm of an *Ocean Economy* that includes both the economic activities of ocean-based industries and the assets, goods and services of marine ecosystems. Marine and coastal ecosystems of the Northern Territory must be protected to maintain the flow of ecosystem goods and services, and ensure they continue to contribute over $1 billion annually to the Northern Territory economy and nearly $2 billion annually to the economic welfare of Territorians. Marine Parks are a tool by which ecosystem goods and services and their economic benefits can be maintained, provided they have a sufficient level of protection – all Territorians will benefit from enhanced protection of their marine and coastal ecosystems.

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[21]ABS (2016). 5220.0 - Australian National Accounts: State Accounts, 2015-16.

[22]By comparison, the mining, energy and resource manufacturing sector in the Northern Territory employs about 4,800people and is worth about $5.2 billion annually (see https://cmsexternal.nt.gov.au/__data/assets/pdf_file/0008/434546/economic-development-framework.pdf)

Table 10. Summary of all ecosystem service values in the Northern Territory marine and coastal ecosystems (AUD 2015).

Ecosystem services	Contribution to the NT economy (direct and indirect economic impact)		Economic value ($m/yr)
	$m/yr	**Jobs**	
Provisioning services			
Commercial fishing & Aquaculture	174.0	424	124.3
Recreational fishing	76	N.A.	21.3
Pearl cultivation	48	100	24.1
Crocodile cultivation	106	264	64.4
Regulating services			
Blue carbon	No direct market value	-	39 – 468
Storm protection	No direct market value	-	109.1
Cultural services			
Tourism	691	5,530	156
Aesthetics, amenity and other recreational values (residents)	No suitable studies for benefit transfer found	-	2.5 – 40.3
Bequest/existence	No direct market value	-	217 - 414
Indigenous cultural values	N/A since Indigenous cultural values not bought/sold in the market	-	52.5 - 412
Habitat services			
Genepool of habitat types	N/A since genepool not bought/sold in the market	-	65.2
Total	**1,095.0**	**6,318**	**875.4- 1,898.7**

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Appendix 1: Terrestrial reserves, parks and conservation areas with connectivity to the marine and coastal waters of the Northern Territory

Territory Parks and Wildlife Conservation Act
Adelaide River Foreshore Conservation Area
Baranyi (North Island) National Park
Casuarina Coastal Reserve
Channel Island Conservation Reserve
Channel Point Coastal Reserve
Charles Darwin National Park
Cobourg Marine Park
Djukbinj National Park
Garig Gunak Barlu
Limmen Bight Marine Park
Limmen National Park
Mary River National Park
Point Stuart Coastal Reserve
Shoal Bay Coastal Reserve
Tree Point Conservation Area
Vernon Islands Conservation Reserve
NT Fisheries Act 1988
Aquatic Life Reserves
East Point Aquatic Life Reserve
Doctor's Gully Aquatic Life Reserve
Stokes Hill Wharf
Reef Fish Protection Areas (temporary until 2019)
Batthurst Island
Melville Island
Charles Point Wide
Lorna Shoal
Moyle and Port Keats
Environment Protection and Biodiversity Conservation Act 1999
Kakadu National Park