Northern Gulf

Gulf Coast Regional NRM Assessment

2015

Prepared by:

NRM Planning

@ Northern Gulf Resource Management Group Ltd

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Australian Government

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1. INTRODUCTION

The South East Gulf of Carpentaria's coastal and marine zone is not widely recognized for its outstanding biodiversity; however it contains unique ecosystems of global significance.

Among such assets one can find breeding marine turtle populations, submerged patch reefs and extensive sea grass beds. The ecosystem also includes a significant proportion of the world's dugong population, endangered sawfish, river sharks and three species of rare inshore dolphin.

The coast comprises nationally important coastal wetlands, and is host for internationally recognised migrating shore birds and nationally significant breeding populations of water birds.

The health and productivity of the coastal and marine zone is also reflected in traditional, recreational and commercial fisheries that produce over $50m of crab, prawn and finfish product whilst supporting a growing tourist industry and providing material and cultural sustenance for Indigenous people.

Given a small population and limited intensive land use or industrial development, the status of most natural assets within the South East Gulf's coastal and marine zones are relatively well preserved. In fact, many such ecosystems are considered to be 'near pristine' when compared to more developed regions of Australia. However, what we know is far outweighed by what we don't know about the Gulf's coastal and marine zone due to limited scientific investigations and data collected in the region.

The condition of these valuable ecosystems is being negatively affected by grazing along the coastal zone, pests, weeds and an unmanaged fire regime. For marine areas, the most significant impacts are associated with commercial fishery catch including non-target bycatch species, disturbance of the environment via trawling and marine debris from Asia.

Locally, port operations and recreational fishing tourism engender significant impacts. More educational material regarding fisheries regulations and marine sustainability may be needed to target visiting anglers.

There is also an emerging issue due to the influence of turbid flood waters in big wet seasons, from erosion in Gulf river basins and elevated sediment loads impacting on the marine environment.

Given the Gulf region's naturally varied climate and its low lying coastline, projected climate change and sea level rise poses significant impact risks to the coastal zone and communities. Some impacts brought about by a rise in sea level are already evident as eroded beaches and salt water incursion into coastal wetlands.

Coastal areas will experience further changes in response to sea level rise. More extreme cyclones and storm surges with major disruption to coastal, near shore, marine and estuarine ecosystems are expected.

To be effective Natural resource managers, a much greater and integrated understanding of river basin, coastal and marine ecosystems is required. Currently, there is a lack of coordinated or ongoing system scale monitoring within the Gulf's coastal and marine environment.

This is in stark contrast to other coastal areas of Queensland with high value marine biodiversity assets. Obvious examples include the Great Barrier Reef and Moreton Bay catchments. The influence of sea grass meadows and catchment scale water quality on marine environments are priority for ongoing research.

The two main natural resource managers within the coastal Gulf are pastoralists and traditional owners. NRM activities are increasingly being led by Land and Sea Ranger programs.

Many of the identified NRM needs of the south east Gulf's coastal and marine zone are across jurisdictions of governments. Therefore, NRM strategies along the Gulf coasts will involve consultation and facilitation between regional

stakeholders, community members, state and commonwealth management agencies, industry bodies and research organizations.

The communities included in the Gulf coasts sub-region of the Northern Gulf include:

Normanton

Normanton is a small regional centre on the Norman River. The town's population is 1,100; 60% of whom are Indigenous Australians. The Aboriginal community is largely represented by three tribes- the Gkuuthaan, Kukatj and Kurtijar people. Normanton is the administrative centre of Shire of Carpentaria, and also includes other social services.

Karumba

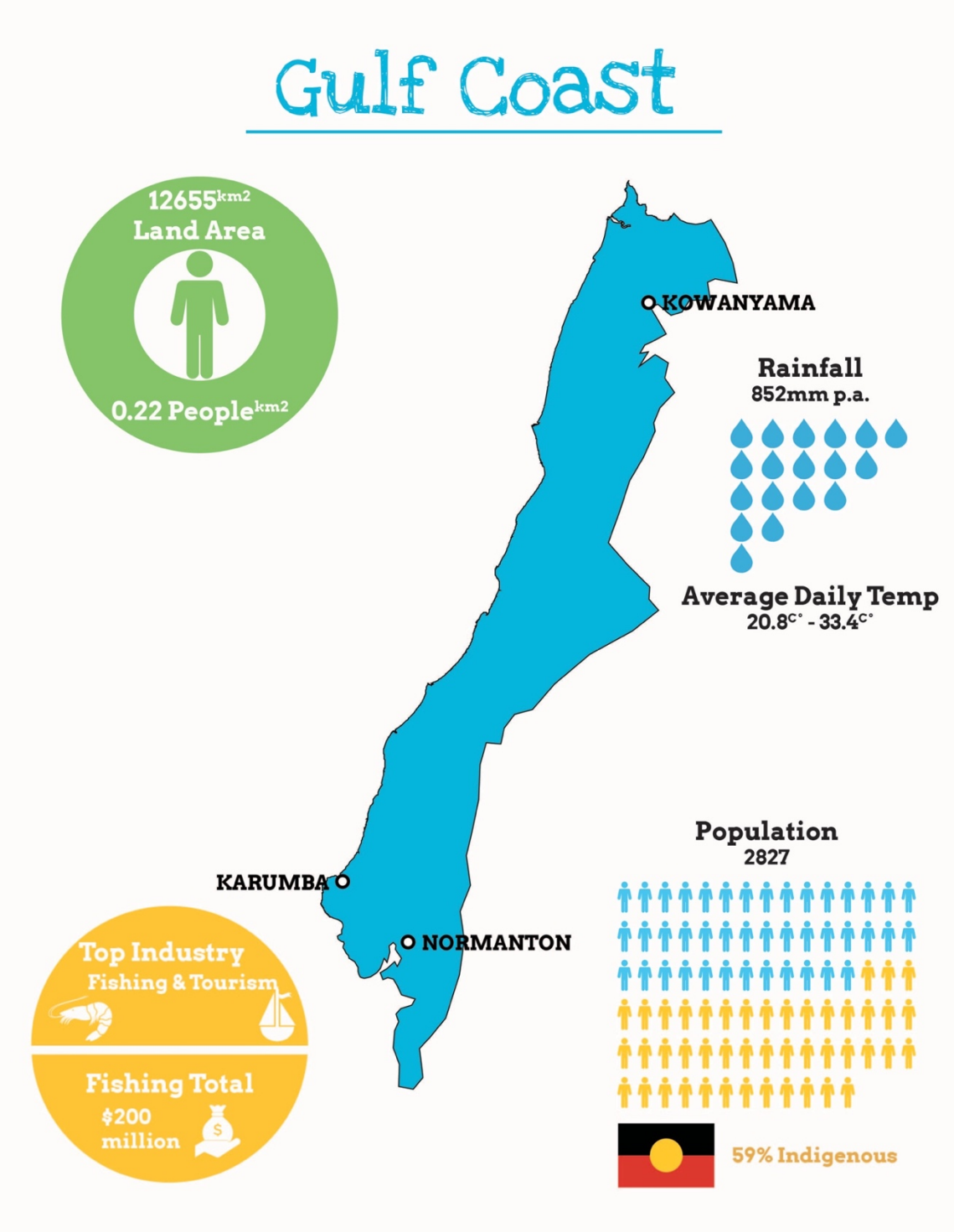
Karumba is a town in the Gulf Country region of Queensland, Australia, and 71km by road from Normanton. At the 2006 census, Karumba had a population of 518.The town is sited at the mouth of the Norman River, and enjoys the distinction of being the only town along the southern Gulf of Carpentaria that is within sight of the Gulf itself (the Gulf's extensive tidal flats prohibits settlement elsewhere along its shore). As such, the town's economy revolves largely around fishing. The Karumba port services the Century Zinc Mine (scheduled to close in 2016) and the live cattle export trade as well as the fishing industry.

Kowanyama

Kowanyama is a remote Aboriginal community with a population of 1,017. The Aboriginal people who live in this community include Kokominjena, Kokoberra and Kunjen groups, amongst others. In their overarching Yir-Yoront language, Kowanyama means "The place of many waters." The community is situated on the banks of the Magnificent, a tributary of the Mitchell River, 20 km (12 mi) inland from the coastline of the Gulf of Carpentaria.

The coastline also includes significant pastoral holdings, notably Delta Downs, also known as Morr Morr. The property is situated approximately 74 km north east of Karumba and 174 km south of Kowanyama in the Gulf Country of Queensland. Currently the property occupies an area of 4,000 square km and has approximately 126 km of frontage along the Gulf of Carpentaria. The station is an aggregation of three leases; Delta Downs, Karumba Downs and the Maggieville outstation. It is the focus of much of the Kurtijar people's cultural tourism and Aboriginal enterprise activities.

2. GULF COASTS DEMOGRAPHICS



3. SOCIAL ASSESSMENT

The Gulf Coastal communities are classed as "very remote" in the Accessibility and Remoteness Index Assessment (Queensland Government 2014). Carpentaria Shire and Kowanyama are within the top 10% of the most disadvantaged LGAs in Queensland (ABS 2011). Population growth in the region has been between 1.1 and 1.2%, which is half of the average for the state of Queensland (Queensland Government 2014).

Census data (2006) identifies 25% of the regional population of the entire Northern Gulf region as being of Aboriginal and Torres Strait heritage (compared with 3% average for Queensland), with the combined Indigenous populations of Kowanyama and Carpentaria Shire accounting for 70% of the entire region's Indigenous populations. It is noted however that Indigenous people are typically underrepresented in census counts and the real proportion of Indigenous people could be larger.

The towns of Karumba and to a lesser extent Normanton, also have very high numbers of itinerant, non-permanent residents. A report on angler tourism published ten years ago reported that 14,000 tourists visit Carpentaria Shire each year (this number may have increased since this report was published), resulting in a total of 280,000 tourist days per annum, the majority of whom visit Karumba. Stays are commonly up to ten weeks and ≤50% return visitors (Greiner et al. 2004b). Therefore, this itinerant group of angler tourists can legitimately be considered as a component of the community. In terms of equivalent population, this number of tourists represents a further 795 residents, which compares dramatically to the local resident population of Karumba, which is approximately 518 (2006 census).

While the Gulf coast suffers from relative isolation, limited economic and education opportunities and a highly dispersed population, Gulf coast communities continue to have strong and distinct cultural integrity around key locations and industries.

3.1 Income

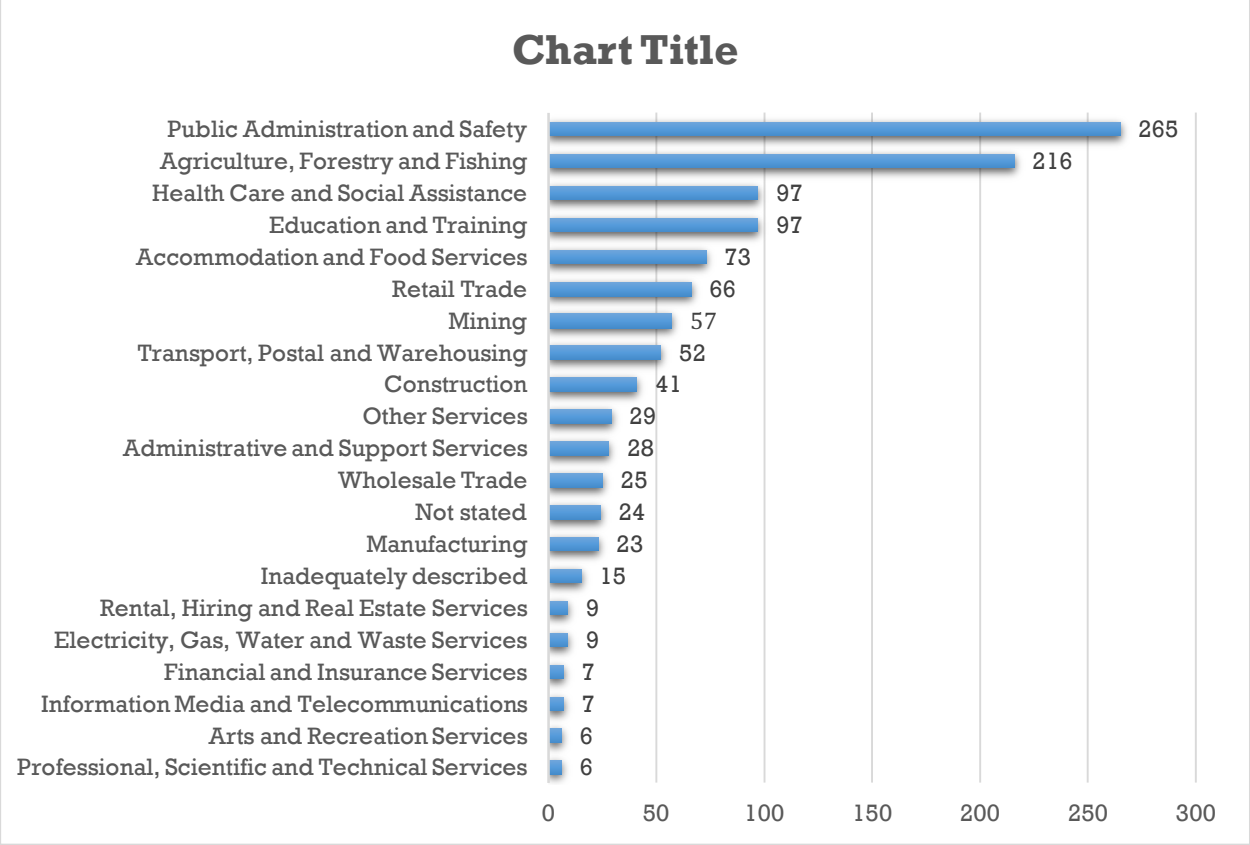
Gulf coast communities are characterised by welfare reliance, low skill levels, low education, low income and low levels of home ownership (GSD 2009). The total median income across the whole of the Northern Gulf in 2011 was $24,103, compared to a median income of $30,524 in Queensland as a whole. A total of 47.4% of people are in the most disadvantaged quintile. The region of Kowanyama has a particularly low median income, with 67.8% of people earning less than $20,800 per year and 100% of people in the most disadvantaged quintile (Queensland Government 2014). This means most residents in the Gulf coast sub-region are living below the poverty line, which is $234 per week (Dale 2014b).

3.2 Employment

The unemployment rate of Carpentaria Shire Local Government Area was 15.2% in 2012, which compares unfavorably to the Queensland average of 5.5% (OESR 2014). Under-employment is not well reflected in these figures, but youth unemployment remains high. Government-driven Indigenous community support programs such as the Commonwealth Jobs Program are a significant source of additional revenue for these communities (NGRMG 2008). However, high levels of illiteracy and lack of housing affordability affect the region (Dale, 2014).

At the 2011 Census, there were 1,152 employed persons in the Gulf Coast region. Industries of employment in the Gulf Coast region were as shown in Table 5 below:

Table 1: Gulf Coast, Employment by Industry, Employed persons (usual residents) aged 15yrs and over



Source: ABS 2011 Census, usual residents, Basic Community Profile

Of the people employed in Agriculture, Forestry and Fishing in the Gulf Coast region, the following were the top industries:

Table 2: Gulf Coast, Top Industries of Employment in Agriculture, Forestry and Fishing

Agricultural Industry of Employment	Persons
Sheep, Beef Cattle and Grain Farming	172
Fishing, Hunting and Trapping (not further defined)	18
Agriculture and Fishing Support Services	10
Fishing	7
Agriculture (not further defined)	6
Forestry Support Services	4
Agriculture, Forestry and Fishing (not further defined)	3

Please note: Anecdotal evidence indicates that Commercial Fisheries are thought to account for a much higher proportion of employment than these figures indicate, however this shortfall reflects a known difficulty in gathering accurate fishing data.

3.3 Health

While Gulf coast community health levels are average relative to international health levels, there are significant disparities between the community and rest of Australia. People in these remote areas are statistically more likely to suffer from lung cancer, chronic heart disease, stroke, suicide, injury, poisoning, road accidents, tobacco smoking as well as a higher and hazardous alcohol consumption (Qld Health in Kreger & Hunter, 2005). There is evidence that socioeconomic disadvantage is a key driver of these rural and remote health disparities (Beard et al. 2009).

Recent community engagement in this area by NGRMG (see chapter 6) highlighted widespread concerns about a growing methamphetamine or "ice" epidemic in the region, an issue which was addressed in a forum hosted by Carpentaria Shire Council in June 2015. Normanton Police Senior Sergeant Duane Amos, who is also a councillor with the Carpentaria Shire, said ice use had spiked significantly since he first came to the town in April 2011 (Thompson 2015).

Remote areas of Queensland like the Gulf coast comprise 3.1% of the state's total population, but account for 4.3% of the total suicide incidence from 2008-2011. The report *Suicide in Queensland 1999-2001* provided an indicator of the extent of variance in mental health status between metropolitan, rural and remote areas. Mortality rates for males in remote areas are 42.3 in 1,000, were significantly higher than suicide rates in males for metropolitan areas and Queensland averages. Regional rates for males and all persons were significantly higher than those from counterparts in metropolitan areas (De Leo & Heller 2004 in Kreger & Hunter, 2005). This suicide rate indicates a higher prevalence of mental health disorders in remote areas. This may be associated with isolation, social disadvantage and hardship incurred post-natural disasters. Furthermore, from 2008 to 2010, the highest number of suicides by Aboriginal and Torres Strait Islander people were in North and Far North Queensland. These indicators are a significant cause for concern for Gulf communities.

3.4 Education

There is a significant skills shortage, largely caused by lack of training and educational facilities (NGRMG 2008). Levels of formal education in Gulf coast communities are lower than Queensland averages. Between 2001-2011, the share of persons with a Bachelor degree or higher in the Northern Gulf increased from 16.4% to 17.8%, but is still well below the Queensland average. This rate may be lower for the Gulf coast communities (Queensland government, 2014).

There are four schools in the Carpentaria Shire and Kowanayama Aboriginal Council local government areas (Normanton state school, Gulf Christian College, Karumba state school and Kowanyama state school) and none offer secondary education beyond year 10. Many high school students in these remote areas rely on boarding schools for their final year of education (Stokes et al. 1999). Furthermore, after receiving a university degree, people who grew up in the region are unlikely to return. Departure of these children is a significant source of financial and emotional strain in these remote communities (Dale 2014b).

Few people in the Northern Gulf receive higher education in agriculture or environmental fields necessary to develop a sustainable natural resource base for the region: only 4.6% of non-school qualifications in the Northern Gulf are in these areas of study. The Normanton TAFE is currently fairly inactive, and mainly offers short courses in adult literacy, however there are currently negotiations with the Carpentaria Shire Council to take over the facility, which may provide opportunities for more education opportunities in a wider range of fields through this established institution (Pascoe, pers comm, 2015).

3.5 Housing

Access to housing is another significant cause for concern for the communities of Normanton, Karumba and Kowanyama. Lack of housing is also a limiting factor for attracting skilled professionals into these areas. Land availability for housing is poor within the region due to significant agriculture and mining land uses (BITRE 2011). A large discrepancy exists in the quantity and quality of housing between different areas of the Northern Gulf region. Efforts to improve housing accessibility are needed in areas such as Kowanyama and Normanton. If this accessibility does not improve, it will hinder efforts to attract a year-round workforce and long-term residents (Dale 2014b). Up until recently, Karumba has been effectively land locked by tenure constraints of large leaseholder

properties surrounding the established residential area of the town, however the Carpentaria Shire Council has recently negotiated a solution to this issue which will release more residential land (Turner, pers comm, 2015).

3.6 Social Services

The reduction in Frontier Services capacity within the region has notably diminished coordinative capacity and flexibility within the services sector (Dale 2014). Data shows that numbers of aged care, child care and hospital services are also significantly lower than numbers across Queensland (OESR 2014). Kowanayma also does not currently have a fire station (Queensland Government, 2014). However there are a large number of social service providers in Normanton, most notably Bynoe which provides social housing as well as a delivering other community services (www.bynoecacs.org.au).

4. INDIGENOUS CULTURAL HERITAGE

The Indigenous people of the Gulf coast continue to have strong and distinct cultural connections to the land and sea, and retain custodial responsibilities to ensure their protection.

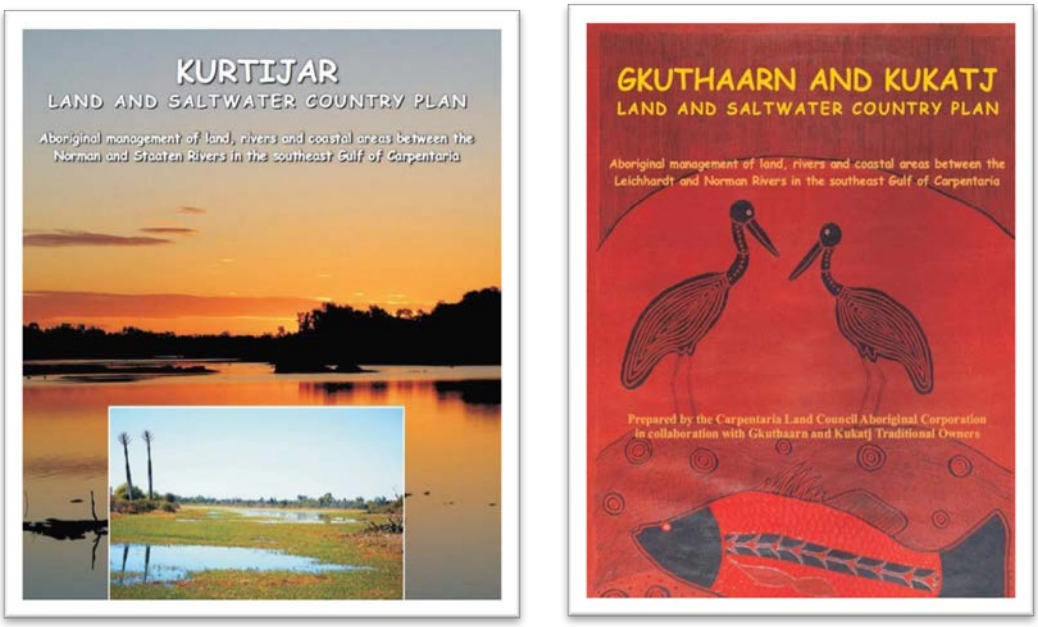
The main cultural groups represented in this area include:

The Gkuuthaan and Kukatj people, many of whom live in Normanton although their traditional country descends down into the Southern Gulf NRM region including parts of the Bynoe and Flinders catchments. The northern boundary of their traditional country is the lower reaches of the Norman River.

The Kurtijar people, whose traditional country starts at the northern bank of the Norman River mouth and goes up to the southern bank of the Staaten River, close to Kowanyama, and includes the Indigenous-run coastal cattle station of Delta Downs.

The Kokoberrin, Koko berra, Olkola , Kunjen, Yir Thangedlan Yir Yoront Traditional Owners all converge in the Kowanyama township. Their traditional country extends to the coast, inland or up into Cape York, depending on the group. For the purposes of this report, these different groups and the cultural diversity they represent are referred to simply as Kowanyama community.

4.1 Gkuuthaarn/ Kukatj & Kurtijar



Images: two NRM plans for Kurtijar (left) and Gkuthaarn and Kukatj (right) produced by Carpentaria Land Council Aboriginal Corporation and the Traditional Owners.

The Carpentaria Land Council Aboriginal Corporation (CLCAC) engaged Dermott Smyth to conduct the Land and Saltwater Country planning for the Gkuthaarn/Kukatj and the Kurtijar peoples, whose traditional lands comprise a large part of the South East Gulf of Carpentaria coastline. The three tribes converge in the centre of Normanton and most Gkuthaarn/ Kukatj and Kurtijar people live in this community, which has a 59% Indigenous population.

The Northern Gulf region only encompasses a corner of the Gkuuthaarn/Kukatj traditional lands, which do come into the Norman river catchment from the south, however Kurtijar lands are entirely contained within the Northern

Gulf NRM region. The Kurtijar people also manage Delta Downs station, which is about 74km north of Karumba and 174 km south of Kowanyama and occupies an area of over 4,000 km^2.

The key NRM messages from these two planning exercises which relate to NRM Planning are the following:

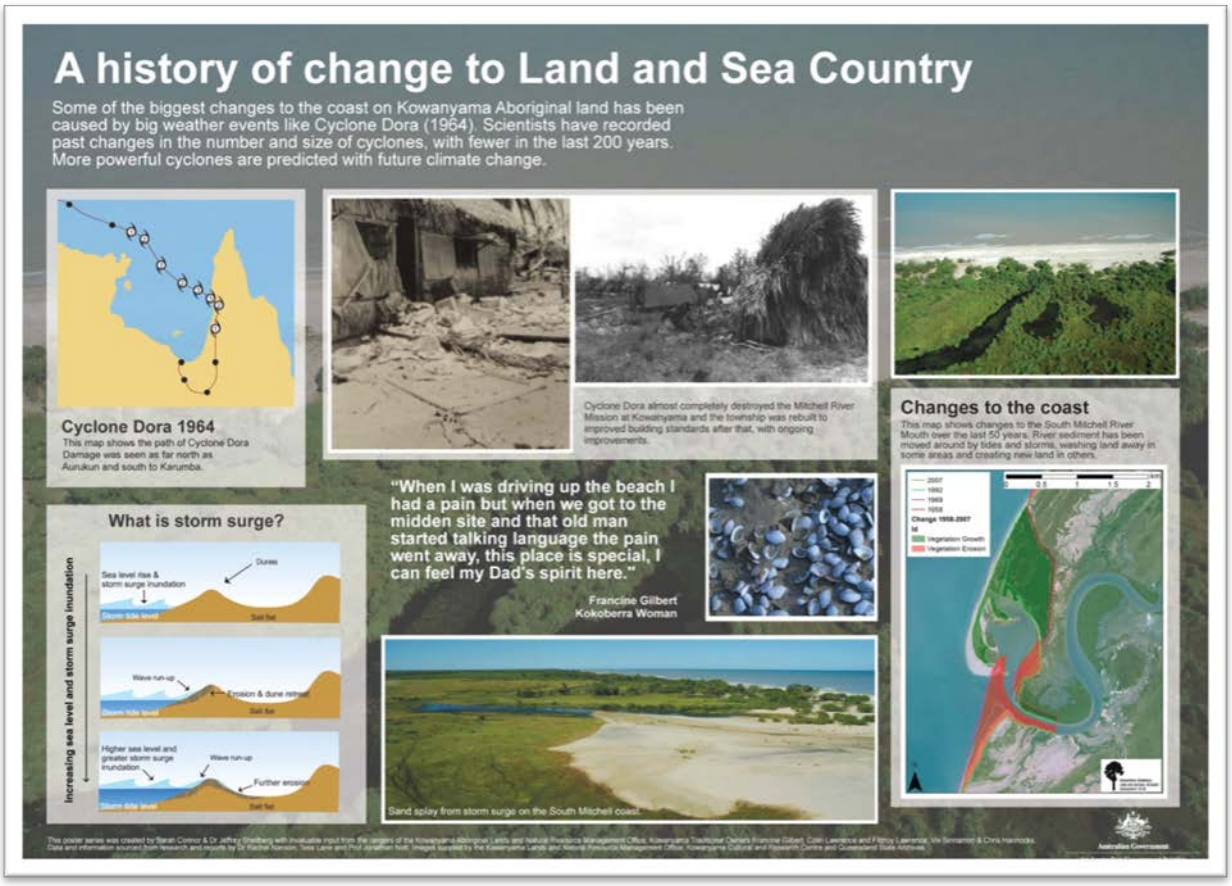
1. Water resource development higher in Gulf catchments is a great concern to Indigenous communities along the coast. Currently they feel they have not been adequately consulted;
2. Indigenous people want to be more involved in fisheries management, and are concerned about the impacts of recreational and commercial fishing;
3. Biodiversity research is highlighted as an ongoing need;
4. Coastal wetlands are threatened by climate change, and these wetlands are an important cultural asset. In particular, Mutton Hole Wetlands Reserve (behind the Normanton township) was highlighted in both plans as an important asset, with ongoing opportunities for cultural interpretive tourism;
5. Indigenous ranger programs are seen as primary mechanisms for NRM delivery, particularly addressing pests and weeds.

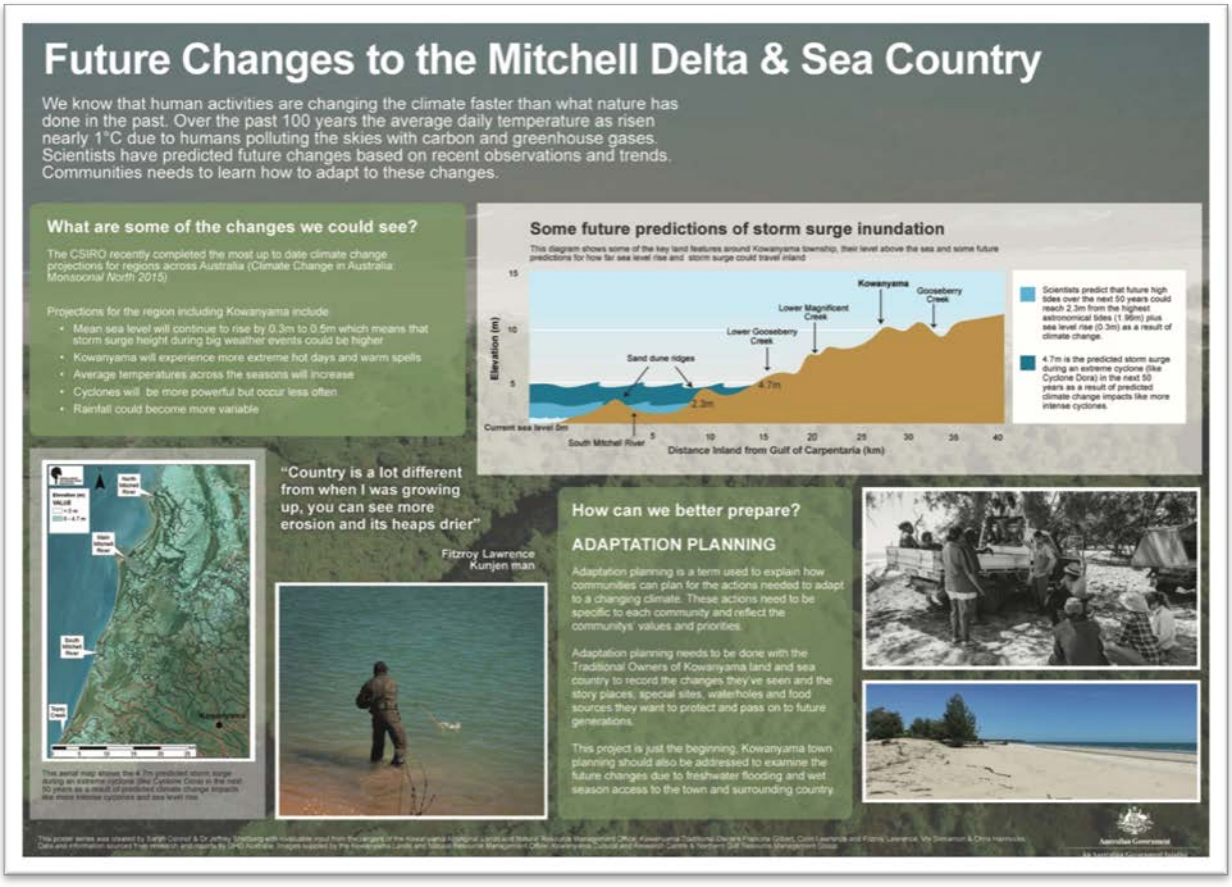
4.2 Kowanyama

The Kowanyama Aboriginal Lands and Natural Resource Management office (KALNRMO), has conducted a significant strategic planning exercises in 1994, which resulted in the Strategic directions document (Dale 1994).

More recently the planning team visited Kowanyama for two projects: the Northern Gulf NRM Planning engagement, and the Monsoonal North, Stream 2 Project - Understanding Indigenous climate knowledge: A case study with Kowanyama Aboriginal Community (A sub-project of Indigenous knowledge of climate change to improve adaptation planning).

The primary objective of this project is to improve the understanding of Indigenous knowledge of climate change by following a Country-based methodology and providing an opportunity for Kowanyama Traditional Owners to tell their story.


A history of change to Land and Sea Country
Some of the biggest changes to the coast on Kowanyama Aboriginal land has been caused by big weather events like Cyclone Dora (1964). Scientists have recorded past changes in the number and size of cyclones, with fewer in the last 200 years. More powerful cyclones are predicted with future climate change.
Cyclone Dora 1964
This map shows the path of Cyclone Dora Damage was seen as far north as Aurukun and south to Karumba.
Cyclone Dora almost completely destroyed the Mitchell River Mission at Kowanyama and the township was rebuilt to improved building standards after that, with ongoing improvements.
Changes to the coast
This map shows changes to the South Mitchell River Mouth over the last 50 years. River sediment has been moved around by tides and storms, washing land away in some areas and creating new land in others.
What is storm surge?
Increasing sea level and storm surge inundation
Sea level rise & storm surge inundation
Dunes
Wave run-up
Erosion & dune retreat
Higher sea level and greater storm surge inundation
Further erosion
"When I was driving up the beach I had a pain but when we got to the midden site and that old man started talking language the pain went away, this place is special, I can feel my Dad's spirit here."
Francine Gilbert
Kokoberra Woman
Sand splay from storm surge on the South Mitchell coast.


Future Changes to the Mitchell Delta & Sea Country
We know that human activities are changing the climate faster than what nature has done in the past. Over the past 100 years the average daily temperature as risen nearly 1°C due to humans polluting the skies with carbon and greenhouse gases. Scientists have predicted future changes based on recent observations and trends. Communities needs to learn how to adapt to these changes.
What are some of the changes we could see?
The CSIRO recently completed the most up to date climate change projections for regions across Australia (Climate Change in Australia: Monsoonal North 2015)
Projections for the region including Kowanyama include
Mean sea level will continue to rise by 0.3m to 0.5m which means that storm surge height during big weather events could be higher
Kowanyama will experience more extreme hot days and warm spells
Average temperatures across the seasons will increase
Cyclones will be more powerful but occur less often
Rainfall could become more variable
Some future predictions of storm surge inundation
This diagram shows some of the key land features around Kowanyama township, their level above the sea and some future predictions for how far sea level rise and storm surge could travel inland
Kowanyama
Gooseberry Creek
Lower Magnificent Creek
Lower Gooseberry Creek
Sand dune ridges
4.7m
2.3m
Current sea level 0m
South Mitchel River
Elevation (m)
Distance Inland from Gulf of Carpentaria (km)
Scientists predict that future high tides over the next 50 years could reach 2.3m from the highest astronomical tides (1.96m) plus sea level rise (0.3m) as a result of climate change.
4.7m is the predicted storm surge during an extreme cyclone (like Cyclone Dora) in the next 50 years as a result of predicted climate change impacts like more intense cyclones.
"Country is a lot different from when I was growing up, you can see more erosion and its heaps drier"
Fitzroy Lawrence
Kunjen man
How can we better prepare?
ADAPTATION PLANNING
Adaptation planning is a term used to explain how communities can plan for the actions needed to adapt to a changing climate. These actions need to be specific to each community and reflect the community's values and priorities.
Adaptation planning needs to be done with the Traditional Owners of Kowanyama land and sea country to record the changes they've seen and the story places, special sites, waterholes and food sources they want to protect and pass on to future generations.
This project is just the beginning. Kowanyama town planning should also be addressed to examine the future changes due to freshwater flooding and wet season access to the town and surrounding country.

5. REGIONAL DRIVERS

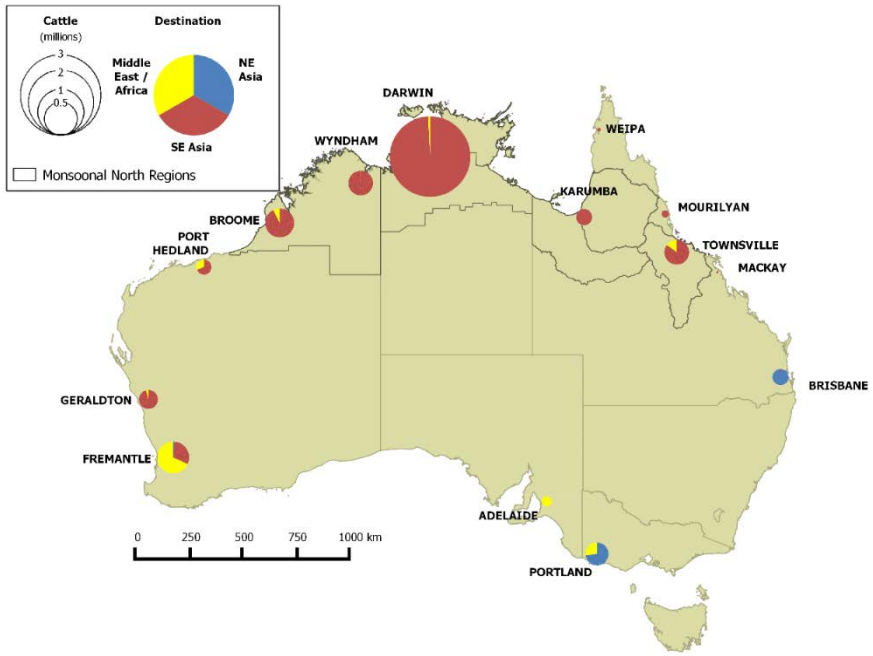
The Gulf coast's economy is limited by its geographical isolation, which is exacerbated in the annual wet season, and the small size of the highly dispersed communities (GRPAC 2000).

5.1 The Port of Karumba

The Karumba Port services the region's pastoral industries, particularly through the export of live cattle. It also supports mineral exports and is strategically positioned to facilitate more trade and export to Asia and the Pacific from the Gulf region (GSD 2009; GSD 2011). The Port's ability to service the region's pastoral and mining industries' product exportation is also constrained by the region's poor road infrastructure and inadequate port facilities (GRPAC 2000).

Figure 5.1.1. Number of cattle exported from Australian ports 2002-2014

SOURCE: (MLA 2014; NORRIS ET AL. 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)



5.2 Commercial Fisheries

The fisheries industry is a key regional driver of the Gulf coast. In the Gulf of Carpentaria, fisheries is worth $250 million per annum. The largest sector is the prawn industry (based in Karumba), which is worth approximately $40 million per annum to the Gulf. However the dollar return to the community is low because of the use of motherships for supplying and processing in the Gulf rather than in Karumba (GRPAC 2000). A multi-species bio-economic and stochastic model examined the Australian Northern Prawn Fishery, and found that the current strategies for diversifying catch across sub-regions require a compromise between expected performance and risk. Furthermore, the increasing fleet size in current economic conditions will increase both expected economic performance and increase variability of performance (Gourguet et al. 2014).

Prawn wild catch showed its largest decline in the real value of production in outback fisheries over the past decade, reducing by $51 million and $58 million respectively. A large proportion is exported and the appreciation of the exchange rate since 2000-01 has had a significant effect on the value of exports of these products.

Competition from imported prawns in the domestic market has also placed significant downward pressure on prices in recent years (ABARES 2014).

The industry is also competing for resource use with National Marine Park objectives. A marine protected area (MPA) has been proposed for approximately 22,000km2 of the North Marine Region (which includes the Gulf of Carpentaria) to protect threatened marine and bird species. If this MPA is successful, commercial fisheries will be unable to access this area, however tourism, recreational and charter operations will still maintain their access (DoE 2014; DSEWPC 2011).

More investigations are required to assess the impact of proposed water extraction from the Gilbert and Flinders catchments on the Gulf fishing industry, as there is a strong correlation between streamflow and Gulf fishery catches (TWS, 2014). Preliminary investigations from the Queensland Department of Natural Resources and Mines indicate that impacts on Gulf fisheries from water extraction for agriculture will be very significant, and the government has downscaled water available for future allocations through the Gulf Water Resource Plan (2014) for this reason (Dempster, pers comm; 2015).

Gulf commercial fisheries have made significant progress towards sustainability objectives, and are generally considered to be relatively sustainable, particularly within a global context (Dale 2014a).

However due to the reasons listed above, the Gulf fisheries' resilience to projected climatic variation and changed environmental conditions may be low.

5.3 Tourism

Tourism is another significant regional driver for the Gulf Coast, which is estimated to be 19% of gross regional product throughout the Northern Gulf, and is primarily based on self-drive tourists (Cummings 2010; Greiner et al. 2004a). This has been further promoted by the "Savannah Way", an adventure drive from Cairns to Broome which passes through most of the Gulf communities and connects with Normanton and Karumba (Gray, 2010; Savannah Way 2014).

Much of this tourist traffic is generated by recreational fishing opportunities in the Gulf of Carpentaria, and is focused on the town of Karumba (Greiner et al. 2013). Some regional concerns remain about the intensifying impact of these numbers on recreational fishing stock (Gunn, pers comm 2015). The cumulative impact of angling tourists may threaten the sustainability of both recreational and commercial fisheries, if it is unmanaged (Greiner et al. 2013).

5.4 Energy

There are significant gas reserves in the Gulf of Carpentaria, however these are closer to the town of Burketown in the Southern Gulf NRM region. However the Normanton Solar Farm is in development, and Infigen's Forsayth wind farm proposal has an expected installed capacity of 70-80 MW. This proposal will provide energy to the towns of Normanton and Karumba from a 100% renewable source, if successful (Boland, pers comm 2015)This development will be a significant advance for energy security in the future, as currently the region is highly dependent on fossil fuels transmitted from Central Queensland. The coastal communities will remain dependent on liquid fuels which are transported to the region through poorly maintained and flood-vulnerable roads (Dale et al. 2014).

5.5 Mining

The closure of Century Mine at Lawn Hill is likely to have significant regional impacts on local workforce participation (Everingham et al. 2013). After 16 years of production, Century Mine and the Port facility at Karumba will cease operations in 2015. Rehabilitation will become the main focus of activities at Century, with a workforce of less than 160 people. One of the indirect economic disadvantages of this closure is that dredging of the channel from Port of Karumba by MMG will cease, which will also impact of other port users such as the live cattle export trade (Rutherford, pers comm, 2015).

6. ENGAGEMENT OUTCOMES

The 2015 Gulf Coast community engagement process included the following activities:

11-13 May	**Kowanyama visit**
6-7 June	Normanton Rodeo
8 June	Sausage sizzle at Gulf country Caravan Park, Karumba
9 June	Stall outside Karumba supermarket
9 June	Gulf Coast NRM Dilemma's workshop, Karumba Civic Centre
10 June	Market stall at Gulf point caravan park, Karumba
18 August	Meeting with key staff, Carpentaria Land Council, Normanton
19 August	Deputation to Carpentaria Shire Council, Normanton
19 August	Meeting with Kurtijar Traditional owners, Normanton
21 August	Meeting with key staff, Carpentaria Land Council, Normanton

Furthermore, a full assessment of the Sea East Gulf of Carpentaria coastal and marine areas was undertaken by Jim Tait (Econcern Consulting) in 2014, which was also underpinned by consultation with Traditional owners, Coastal pastoralists, conservation groups, local government, port users, recreational fishers, commercial fishers and the tourist industry. The outcomes of this engagement are included in Appendix 1 of this report.

Engagement efforts, which focused on Karumba, particularly targeted the recreational angling community, based in the town's main caravan parks. Three days were also spent in Kowanyama, including one day in the Kowanyama Aboriginal Land and Natural Resources Management Office (KALNRMO) office with Indigenous rangers, and one day touring the coastal area and wetlands around Kowanyama with rangers and Traditional Owners. A further three days were spent in Normanton, engaging the Carpentaria Shire Council, Carpentaria Land Council and Kurtijar Aboriginal Corporation. NGRMG also contributed to the Gkuuthaan/Kukatj Land and Sea Plans, and the Kurtijar Land and Sea Plans, which were coordinated by the Carpentaria Land Council.

6.1 Kowanyama Visit

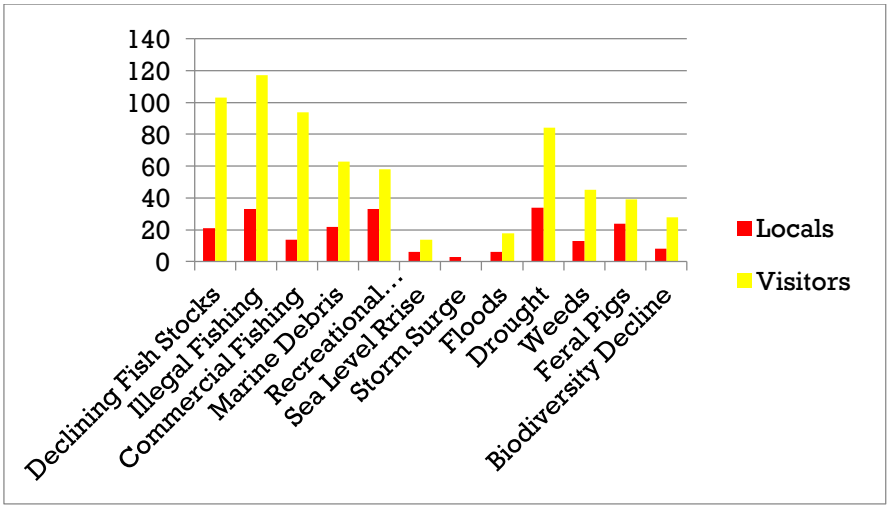
The Planning team's visit to Kowanyama represented a combination of two projects: the Northern Gulf NRM Planning engagement, and the Monsoonal North, Stream 2 Project - Understanding Indigenous climate knowledge: A case study with Kowanyama Aboriginal Community (A sub-project of Indigenous knowledge of climate change to improve adaptation planning). Details and outcomes are on page 17.

Photos: NGRMG Planning team visit to Kowanyama Indigenous land and sea rangers at their office (left) and meet with rangers and Kokoberrin Traditional Owners on the beach front near Kowanyama (right).

6.2 KARUMBA VISIT

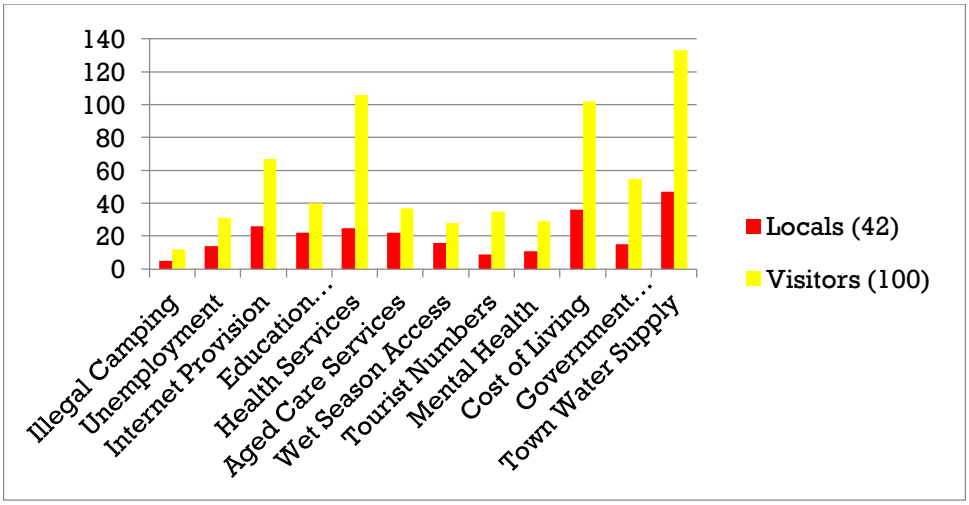
While visiting the town of Karumba to determine the greatest environmental and community concerns for the people of that region, we conducted rapid surveys in three locations. These surveys engaged local residents, visitors who spend the majority of the winter months living and fishing in the area and genuine tourists, i.e. short stay visitors. We also conducted a workshop to tease out some of the major dilemmas of the region in more detail. From this we discovered one major NRM project that NGRMG should facilitate, a feasibility study that NGRMG could drive and several other concerns that NGRMG and Gulf Horizons can support.

FIGURE 6.2.1: ENVIRONMENTAL ISSUES, KARUMBA



Of greatest environmental concern was the sustainability of fishing in the immediate Karumba area (68% overall including drought impacts on fish stocks). This was developed into a project that is outlined in more detail on the next page.

FIGURE 6.2.2: COMMUNITY ISSUES, KARUMBA



Regarding community concerns cited, many were beyond the scope of Gulf Horizons to be able to respond to, e.g. cost of living, Internet provision, boat ramps etc. The majority of community concerns that did relate to Karumba were within the remit of the Carpentaria Shire Council and many of these are being addressed by the Council e.g. the boat ramps with adjacent parking. One concern that was voiced was the quality and access to other activities apart from fishing in the town such as lawn bowls. There is potential here for Gulf Horizons to be involved in a small way (e.g. grant writing).


GULF COAST
STICKER DOT SURVEY
NORTHERN GULF RESOURCE MANAGEMENT GROUP
Let us know with 5 stickers what your priority issues for the ENVIRONMENT are.
Declining Fish Stocks
Illegal Fishing
Commercial Fishing Impacts
Marine Debris
Recreational Fishing Impacts
Sea Level Rise
2050
sea level
Storm Surge
Floods
Drought
Weeds
Feral Pigs
Biodiversity Decline


STICKER DOT SURVEY
NORTHERN GULF RESOURCE MANAGEMENT GROUP
Let us know with 5 stickers what your priority issues for the COMMUNITY are.
NORTHERN GULF RESOURCE MANAGEMENT GROUP
Illegal Camping
Unemployment
Internet Provision
Education Opportunities
Health Services
Aged Care Services
Wet Season Access
Tourist Numbers
Mental Health
Cost of Living
Government Regulations
Town Water Supply

6.2.1 Gulf Coast's NRM Dilemmas Workshop, 9 June 2015, Karumba

Photo: Workshop participants in Karumba, June 2015

Dilemma: How do we share a limited resource between competing sectors?

There are three sectors in the greater Karumba region who rely on fishing as an integral part of their livelihoods and culture. These are defined as the Recreational, Commercial (inshore net and crab fisheries) and Indigenous fishing sectors. Each sector raised the "lack of fish" as a concern, especially in drought conditions as experienced now (sticky dot survey, see Figure 6.2.1). Each sector considers that the answers to the dilemma involves large changes by the other sector(s), not themselves.

Influencing factors

There are strong but opposing views as to the sustainability of Gulf inshore fish resource based on:

- Anecdotal evidence (size and number of fish captured by recreational fishers)
- Perception of high levels of illegal fishing by both the recreational & commercial sectors (sticky dot survey)
- A paucity of accurate data from the recreational and Indigenous sectors although good data from the commercial sector
- Conflicting reports between the Department of Primary Industries' stock assessments (Barramundi) and research by Dr Romy Greiner (Banded Grunter)
- Kurtijar and Gkuuthaan/ Kukatj Sea Country Plans.

At the core of the dilemma is a high degree of rumour and misinformation. There is a perception that the recreational fishing sector, being a continual influx of people from outside the region, has no stewardship of the resource therefore impossible to educate. Additionally, there is a general consensus that the enforcement of regulations is inadequate for the size and scope of all sectors, hence there is a lot of illegal activity.

Consequences if nothing is done

If the fishery is unsustainable, the local economy will be devastated. Karumba relies on commercial fishing and tourism from recreational fishing as staple incomes. This reliance will increase after 2016 when the Century Mine closes. Additionally, there may be increased "effort creep" as fishers explore further afield to maintain the level of expected catch.

Even if the fishery is sustainable, continued conflict between commercial and recreational fishing sectors can cause damage to all sectors. Commercial fisheries already operate under a cloud of misinformation about the impacts

created by their industry, as indicted by the results of their sticker dot surveys, while the tourism industry will be damaged as Karumba will be seen as not a particularly friendly town to visit. This is central to the visitor experience, as many stay for up to four months (recorded interviews at Gulf Country Caravan Park).

6.2.2 Community Survey, Gulf Coast

NGRMG conducted an online and phone survey of the Northern Gulf community. A total of 141 people in the region completed this survey. The results have been separated into Gulf Coast, Grazing lands and Tablelands for the purposes of the NRM Plan. There were 21 responses from the Gulf Coasts.

Of the 21 respondents, 30% identified as graziers and 35% identified as small business owners, which we assume are mainly associated with the tourism sector. It also reveals that the Gulf coast area is still heavily influenced by grazing, which occurs along the coastal areas to the beach front.

The key words explaining community values about the Gulf coast sub region were *fishing*, *environment* and *people*. For 'what's changing', *climate* came up strongly, as did references to changes in the tourism industry. For 'what is causing the changes', *tourists* were also cited several times, which is assumed to be a reference to over-fishing in the recreational sector. For 'what you would like to see done about it', one response was "A better balance between rate payers and tourists in sharing and caring for our resources" and another was, "Educate the wider community, so they gain an affinity & understanding of the importance as custodians of our land", which reveal something of the tensions between locals and visitors, and Indigenous people and non-Indigenous visitors, in this part of the world.

The NGRMG projects which received the most support were water quality monitoring in the Norman River; which further emphasised the importance of this environmental asset to both the Normanton and Karumba communities, followed by valuing ecosystem services and school programs. The latter two ranked in the top three of all sub-regions.

7. COMMUNITY RESILIENCE TO CLIMATE CHANGE

The Gulf Coast was severely affected by the floods Between January and March 2009. Over 10,000,000ha of the Gulf plains in the Southern Gulf of Carpentaria were flooded, with 1,000,000ha underwater for 3 months. This was an unprecedented even in the historical record (NGRMG 2015). The towns of Normanton, Kowanyama and Karumba are all less than 15m from sea level, situated in the extensive Gulf plains bioregion. They are all situated on the lower reaches of large river catchments, and are highly exposed to flooding ancyclonic events which form in the Gulf of Carpentaria, as evidenced by recent natural disasters in the last decade. Karumba is also exposed to sea level rise and storm surge.

The aftermath on the community of the 2009 floods is still being felt, as evidenced by a recent community survey which revealed that 58% of respondents from the Gulf coast said they had been affected by natural disaster; of these, 50% cited flooding and 40% cited drought as the natural disaster which affected them. Remarkably, 100% of respondents said that they did not receive adequate support post-natural disaster, and only 20% said NGRMG had provided any post-disaster support to them at all, despite being recipients of a grant of almost $1 million to provide support to these communities after the 2009 floods (NGRMG 2015).

Further, 100% of respondents said they had experienced loss of income after this disaster, followed by loss of stock, land degradation and pasture damage. These results reveal the extent of the heavy toll the 2009 floods took on these coastal communities, which is apparent in a survey result six years after they occurred. As more of these extreme flood events are projected under current climate change scenarios, this highlights a real vulnerability in our regional community and current systems to respond to natural disasters (NGRMG 2015).

Having been through significant recent disasters and high debt level, the general community may be more vulnerable and prone to depression, suicide risk and have lowered resilience to change when there is a lack of adequate support networks (Dale, 2014).

There is potential for major port disruptions from extreme weather events. Coastal port assets are generally durable but also vulnerable to flooding and cyclone risk. Regional housing stock could be vulnerable to more intense cyclones that penetrate further inland, and there are low levels of community input into Indigenous housing design standards (Bird et al. 2013).

The region is also exposed to drought, as fisheries in the Gulf rivers and the adjacent marine environment relies on monsoonal flushes down Gulf river catchments for recruitment of marine biodiversity. Currently there have been three failed wet seasons, fisheries catch are declining (Ward, pes comm 2015). There is a 70-80% chance that rainfall will be below the median for the region from November 2015 to January 2016 and a 65-80% chance that maximum temperatures will be above the median (BOM, 2014).

There is no link between emergency management and land use planning in the Gulf. Neither climate change adaptation measures nor responsive design strategies are included in land use planning. Land use planning systems do not use their planning legislation effectively to create disaster-resilient communities. Better mechanisms for sharing data and knowledge accumulated by emergency management systems and for integrating into land use planning systems need to be developed as a matter of urgency (Bird et al. 2013).

New airline deregulation policies could decrease regional services. The cost of living will increase in the region due to increased freight and consequently product costs if roads are flooded more frequently and fuel prices continue to rise.

Post Cyclone Yasi (2010) and the 2009 floods, communities have a heightened awareness of the impacts of intense cyclonic and flooding events, if not an understanding of potential links to climate change. People may recognise that changes are happening, but not necessarily because of climate change. Ongoing periods of high variability provide an opportunity to build awareness about climate change and natural resource sustainability (Dale, 2014).

Identified barriers to improving resilience included:

1. The transient nature of emergency service personnel
2. The centralisation of services leading to further marginalisation of remote locations;
3. Inconsistencies in emergency management procedures in urban compared with remote locations;
4. Limited funding from governments for disaster preparedness and mitigation works;
5. Limited access to remote locations;
6. The lack of capability for evacuation from these areas in an emergency.

(Dale, 2014).

More positively, Normanton and Kowanyama both have multi-purpose recreational centres which double up as evacuation centres.

8. NATURAL ASSETS AND STATUS: COASTAL AND MARINE

The coastal zone is the interface between the land and the ocean. Coastal zones are comprised of dynamic and constantly changing landscapes due to the competing and interacting influences of terrestrial and marine land formation processes. In the case of the Gulf of Carpentaria the dynamic nature of the coastal zone is accentuated by a lack of landscape equilibrium due to recent changes in sea-level in the geological timescale (Hydrobiology Pty Ltd 2005). Since the end of the last post-glacial sea-level high about 6,000 years ago, sea level in the Gulf has declined by as much as 2.2 m (Rhodes 1982; Woodroffe et al. 1993), resulting in the very recent formation of the extensive Karumba plains and other low-lying coastal floodplains. The low-lying position of the extensive flat plains of the Gulf coastal zone makes it particularly vulnerable to sea-level changes (Burrows 2003). Current increases in sea level of approximately 3.1mm per annum (Moise 2014) now provide a contemporary driver for further dynamic landscape change within the Gulf coastal zone.

For the purposes of this NRM Plan, the Gulf coastal zone has been defined by reference to a combination of land zones recognised to have been formed by coastal processes (Sattler et al. 1999). These include Land zone 1 – *Marine tidal clay plains* and Land zone 2 – *Coastal sand dunes and swales*. Due to the low-lying nature and dynamic recent history of the Gulf coast, some inland land forms e.g. those associated with Land Zone 3 – *Near level alluvial plains with riverine patterns, wetlands and lakeside dunes* (Sattler & Williams 1999), are also subject to coastal processes e.g. saline inundation, and have been included in the defined 'coastal zone'. Spatially this coastal zone is captured by the defined *Karumba Plains* province of the *Gulf Plains* Bioregion (Sattler & Williams 1999). The marine zone definition utilised for this report has been based on an approximate 160 nautical mile arc extending out from Karumba as an epicentre into the marine environment. This figure has been used as a rule of thumb for this assessment, and does not comply with any formal, defined regional boundaries.

FIGURE 8.1

COASTAL AND MARINE ZONE DEFINED BY COMBINATION OF KARUMBA PLAINS AND WELLESLEY ISLANDS PROVINCES OF THE GULF PLAINS BIOREGION (SATTLER & WILLIAMS 1999) AND AN APPROXIMATE 160 NAUTICAL MILE ARC EXTENDING OUT FROM KARUMBA AS AN EPICENTRE INTO THE MARINE ENVIRONMENT.

8.1 ASSETS AND STATUS

COASTAL LANDS

The defined coastal zone within the southern Gulf includes a range of land forms. Shorelines are backed by dunes and beach ridge systems and/or saline mud flats (salt pans) that comprise the most extensive marine plains in Australia (Sattler & Williams 1999). Marine plains are dissected by mangrove-lined tidal estuarine channels including those associated with large meandering river systems. More elevated areas of the marine plains are vegetated by succulents and salt marsh species including marine couch. Dune areas include intervening swale swamps and support a range of vegetation from sedgelands to woodlands, vine thickets and paperbark wetlands. Areas above tidal range extending across the coastal zone to its inland margins are comprised of low elevated

grassy plains with woodlands and include remnants of prior river channels which now support seasonal freshwater wetlands (Sattler & Williams 1999).

The predominant land use across most of the coastal zone is rangeland grazing of unimproved pastures on pastoral leasehold lands (SGC 2005; NGRMG 2008). Significant areas are also under Aboriginal ownership, some of which is utilised for pastoral operations e.g. Delta Downs and Karumba Holdings on Kurtijar country (CLCAC 2014c). A small area of the coastal zone are also included in the Staaten-Gilbert River declared fish habitat areas (FHAs) and one Conservation Park, Mutton Hole Wetlands, occurs adjacent to Normanton.

Human population density throughout the Gulf coastal zone is extremely low and other than isolated Cattle Stations and Aboriginal outstations is concentrated in a small number of population centres including Kowanyama, Karumba and Normanton. Karumba is served by an industrial shipping port which exports both zinc concentrate and live cattle.

8.1.1.1 Beaches

The occurrence of beaches is controlled by shore line exposure to prevailing wind direction and associated wave energy (SKM 1996). Representing a higher energy interface between the ocean and the land, beach environments are particularly vulnerable to sea level rise and storm surge. Evidence of beach foreshore retreat in response to sea level rise is already emerging at sites around the Gulf coastal zone, especially the human settlements of Karumba and Kowanyama (Bell 2009) as well as being the receiving environment for much marine debris including ghost nets (Wilcox et al. 2013).

Beach shorelines are important habitat for listed threatened species including nesting marine turtles and migratory shore birds (CLCAC 2014a).

Beaches are a focal area for tourism and visiting recreational fishers and are subject to disturbance by 4WD vehicle traffic (CLCAC 2014a). Beach campers, total grazing pressure, unmanaged fire regimes, weeds and feral animals (pigs, wild horses, wild dogs) also provide sources of disturbance for beach fauna and foreshore vegetation in the Gulf coastal zone (CLCAC 2013b; CLCAC 2014a).

8.1.1.2 Beach Ridges / Coastal Dunes

Within the Gulf coastal zone, beach ridge dune systems are found adjacent to the contemporary shoreline and also as more inland secondary systems, some of which have naturally degraded via erosion to form low sandy ridges (Sattler et al. 1999). Both types of beach ridge system are believed to have formed as barrier island features during different periods of higher sea level, the more inland ones during the earlier Pleistocene period ~120,000 years BP, and the more coastal ones during the more recent Holocene period ~6000 – 4000 years BP (Smart 1976). Beach ridges support a range of vegetation types including grasslands, eucalypt and acacia woodlands and semi-deciduous vine thickets. Intervening swale depressions also support a range of vegetation and wetland types including sedgelands and paperbark swamps and collectively contribute to high habitat and biodiversity values being associated with beach ridge systems.

In addition to their ecological values, beach ridges are also culturally important areas for Aboriginal people, being used traditionally and contemporarily as seasonal camping sites (Smyth et al. 2004). Shell midden deposits and other significant cultural heritage features are often associated with coastal beach ridges.

Across the coastal Gulf the main ecological pressures affecting beach ridge and dune areas are total grazing pressure and weed infestation. Wind erosion of disturbed areas and tourism (camping and vehicle use) are also significant issues in some areas (CLCAC 2014a). Being relatively elevated areas, beach ridge systems are often used as flood refuges by cattle during wet season floods (Tait 2005).

Significant weeds on beach ridge and dune areas include: rubber vine *Cryptostegia grandiflora*, calotrope *Calotropis procera,* buffel grass *Cenchrus ciliaris* and chinee apple *Ziziphus mauritianus* (Sattler & Williams 1999; Tait 2005; NGRMG 2008; CLCAC 2014a). Grazing pressure and shade generating weed canopies both contribute to low fuel loads and reduced opportunities for beneficial controlled burns in or adjoining these systems. Some beach ridge vegetation communities e.g. vine thickets are fire sensitive and can be damaged by uncontrolled wild fire (CLCAC 2013a).

Secondary beach ridge systems provide suitable elevated landforms for establishing fencing infrastructure that can be used to manage coastal marginal areas separately from the remainder of Gulf coastal pastoral properties.

Wet season spelling, conservative stocking densities, stock exclusion from sensitive wetland areas and fuel load management have all been nominated as potentially beneficial management approaches in these areas (Tait 2005).

8.1.1.3 Coastal and Marine Plains

Significant areas of the marine plains within the Gulf coastal zone are subject to sustained wet season inundation and/or more regular high spring tidal inundation and are therefore also described under aquatic habitats below. Both seasonally and tidally inundated areas and more elevated coastal plains are managed as integrated 'land resources' and most are subject to use for pastoral grazing. More elevated areas support a range of grassland types including Mitchell grassland on calcareous clays but aquatic associated species are more typical. These coastal plain include shallow seasonal wetland basin and open woodlands comprised of eucalypts, broad leaf tea tree, beefwood, gutta percha and pandanus (Sattler &Williams 1999; CLCAC 2014a).

Total grazing pressure, weed infestation and uncontrolled fire regime present the main risks to the condition of these coastal grassland plains. Sustained grazing pressure particularly around watering points promotes infestation of woody weeds such as prickly acacia, mimosa and Parkinsonia (Tait 2005). Unmanaged late dry season fires have the capacity to degrade the productivity of these grasslands which can take several years to recover from such events (CLCAC 2013a). In recent years sustained inundation of these coastal grassland by exceptionally large (extreme) rainfall events has resulted in pasture degradation that had not recovered until up to greater than 12 months following the event (NGRMG 2008).

8.1.2 Aquatic Ecosystems

The Gulf of Carpentaria is a shallow semi-enclosed sea which receives a substantial portion of the continental run off of Australia, primarily via wet season-associated flood flow pulses from contributing river basins across a flat and low-lying coastal landscape. Consequently the Gulf coastal and marine zone includes a diverse mix of marine, estuarine, brackish and freshwater aquatic ecosystems, although many of the latter are highly seasonal and dry for the majority of the year.

8.1.2.1 Saltpans and Salt Marsh

Seasonally inundated marine plains form the most extensive aquatic habitat in the Gulf coastal zone, particularly the central southern Gulf (Bruinsma et al. 2000). Referred to as 'salt pans', they are a consequence of extensive low coastal plains and a seasonally dry climate that creates a hypersaline environment where very little vegetation is able to survive. Saltpans are comprised of clays laid down in sheltered depositional environments and have been exposed by relatively recent sea level regression (Smart 1976; Woodroffe et al. 1993). Salt pans are predominantly unvegetated though more elevated areas support a samphire community comprised of succulent chenopods (e.g. *Halosarcia spp.*) and salt-tolerant sedge and grass 'marsh' species including salt couch. Extensive seasonally inundated *Eleocharis spp* sedgelands occur in areas with a greater freshwater influence. Most saltpans are dissected by intricate dendritic tidal drainage networks. Larger drainage systems are fringed by mangroves and subject to regular tidal exchange. More elevated drainage systems only operate on spring tides, lack mangroves and can generate hypersaline conditions between tidal inflows (Blackman et al. 1999). During the wet season local catchment run off or large overbank flow events from adjoining river systems can inundate entire marine plain systems (Hydrobiology 2004). Storm surge, particularly in conjunction with high tide events, can also inundate these areas with sea water (Smith et al. 2013). Given the variable supplies of water to these marine plains, water bodies occurring on them can vary spatially and temporally from fresh to hyper saline.

The saltpans of the coastal Gulf have enormous biodiversity values, including the provision of critically important habitat for migratory shore birds and are included in several large wetland aggregations listed in the Directory of Important Wetlands in Australia (DIWA) (Blackman *et al.* 1999; EA 2001; CLCAC 2014a). Saltpans have also been shown to be significant productivity and recruitment drivers for coastal fisheries. When seasonally inundated, fishery benefits are provided by their functioning as important nursery habitat for both prey and predator fish species including mullet and barramundi (Bruinsma et al. 2000; Halliday et al. 2012).

More recently saltpans have been identified to be an important source of carbon, nitrogen and phosphorus nutrients for estuaries and near shore areas. These nutrients become available via algal growth when saltpans are inundated and via dissolved forms released directly to the water column (Burford et al. 2010). Wet season outwelling of nutrients and saline waters from coastal salt flats are also recognised to nourish sea grass beds in adjoining inshore areas (Harris et al. 2004; Wolanski 1993). Due to their carbon content saltmarsh areas, as well as mangroves and seagrass, have benefits in climate change mitigation (via what is referred to as 'blue carbon') through sequestration and storage of carbon in sediments (Lawrence 2015).

Due to the extreme nature of saltpan and marsh environments, land use is limited, though what does occur can generate ecological pressures. Salt couch grasslands occurring on the margins of salt pan areas are favoured as productive pastoral resources and excessive cattle access to it can lead to over-grazing and disturbance of marine plain areas including via pugging and grazing pads and tracks altering tidal ingress paths (Tait 2005). Vehicle access to marine plain areas adjoining the coast can also generate habitat and fauna disturbance. Uncontrolled late dry season burning has the capacity to impact salt marsh habitats (CLCAC 2013b). In other regions these types of habitats have also been degraded by construction of tidal bunds and introduction of ponded pastures (Tait 2013), though this has not yet occurred in the Gulf coastal zone.

Given the low-lying and near coastal location of salt pan ecosystems they are extremely vulnerable to changes driven by sea level rise (Bustamante et al. 2012). Alteration of river basin flow regimes due to water resource development also poses an as yet unrealised threat to the functioning and fishery productivity benefits of these systems (Burford et al. 2010; Halliday et al. 2012; Petheram et al. 2013b). Excessive grazing leading to soil erosion of more elevated plains adjoining salt pan systems can also lead to degradation of water quality of wetlands hosted by salt pan areas (Tait 2005).

8.1.2.2. Mangroves, Estuaries and Intertidal Flats

The estuarine ecosystems of the coastal Gulf are extensive and functionally include the salt pan habitats discussed above, tidal creeks and river channels, mangrove forests and extensive intertidal flats fronting the Gulf coastline. Relative to the rest of Queensland and Australia coastal Gulf estuarine ecosystems retain high levels of integrity (Bruinsma et al. 2000; Danaher et al. 1995). In the National Land and Water Resource Audit's national assessment of estuary condition, the majority of estuaries within the Gulf of Carpentaria drainage division were assessed as near pristine (NLWRA 2002).

Compared to other northern Australian regions, mangrove communities of the coastal Gulf are restricted in extent and zonal diversity by the Gulf's low tidal range. Mangrove forests are predominantly confined to foreshore environments and river and drainage channels through the extensive salt pans (Bruinsma & Duncan 2000). At least 27 species of mangroves occur within coastal and estuarine ecosystems of the Gulf coastal zone with individual species occurrence and dominance determined by geomorphic setting, substrate type, tidal range position and freshwater influence (SKM 1996; Bruinsma & Duncan 2000). Foreshore mangrove forests up to 1 km wide dominated by *Avicennia* form the most extensive mangrove stands in the Gulf coastal zone. Closed *Rhizophora spp* forest is also significant often occurring at the mouths of major river channels; while *Ceriops spp* closed forest occurs in zones more removed from active channels (Bruinsma & Duncan 2000).

Being a semi-enclosed sea that receives significant freshwater discharge during the wet season, and having current patterns that help maintain the separation between clearer oceanic water and more turbid and brackish coastal waters, salinity within much of the near shore area of the southern Gulf can be depressed for extended periods and may be considered to be estuarine in nature (SKM 1996). Due to the low gradient coast near shore, waters are generally very shallow and expose extensive areas of inter tidal flats during low tide. Significant areas of these flats support seagrass communities (discussed below). Other areas are comprised of relatively bare sandy substrates in exposed and higher current areas or mud substrates in more sheltered bays and river estuaries. Due to a higher retention of organic matter muddy substrates generally support a more diverse and abundant biota including crabs, other crustaceans, gastropods, bivalves and marine worms (SKM 1996).

The Gulf's estuarine ecosystems including its mangrove forests have exceptionally high production and biodiversity values. They support a range of commercial, recreational and traditional fisheries (discussed below). The fisheries productivity of Gulf estuarine and marine ecosystems has been found to be closely linked to rainfall and flows in contributing catchments. A range of mechanisms are believed to underpin these linkages including nutrient exports from catchments, inundation of nutrient generating coastal flats, promotion of recruitment facilitating habitat linkages, freshwater displacement of estuary populations and inundation of nursery functioning wetlands (Burford *et al.* 2010; Halliday *et al.* 2012). This relationship is referred to by Gulf coastal residents and fishers as 'drought on the land equals drought in the ocean.'

Mangrove estuaries and intertidal flats of the Gulf provide significant feeding, roosting and rookery areas for waterbirds and migratory sea birds and host a range of threatened fauna species including sawfish and marine mammals (CLCAC 2014a). They also have a coastal protection role acting as a buffer against extreme climatic events such as cyclones and associated storm surge (Smith & Harper 2013).

Given the general integrity of Gulf estuarine ecosystems, currently nominated threats are mainly associated with the sustainability of fishing practices and inappropriate tourist behaviour. Threats posed to non-target species by commercial and illegal gill netting practices, high levels of commercial and recreational fishing take and inappropriate vehicle use and camping disturbance have all been identified as threats to estuarine system values (CLCAC 2014a). Other issues of concern identified by coastal stakeholders include fishing gear discarded within estuaries i.e. crab pots, or that has drifted into them as marine debris. Bank erosion risks associated with dredging operations used to maintain the industrial port at Karumba has also been nominated as a specific estuary management concern (Appendix 1).

Potential threats to estuarine ecosystems have also emerged in relation to the potential impact of water resource development proposals on river basin flow regimes (Hydrobiology 2005; Petheram *et al.* 2013), and in association with pollution risks posed by current and past mining operations in contributing catchments (NGRMG 2008; CLCAC 2014a).

While estuarine ecosystems and mangrove forests are highly dynamic they are vulnerable to potential impacts associated with climate change and sea level rise. Any climate change impacts affecting regional rainfall and river basin flows will potentially impact estuarine salinity regimes and productivity (Burford *et al.* 2010; Halliday *et al.*

2012). Elevated rates of soil erosion and river basin sediment loads possible under the emerging climate change scenarios of extended dry seasons potentially followed by more intense wet season rain events (Moise 2014) also have the capacity to alter the form and function of Gulf estuarine ecosystems. Subject to the rate of sea level rise, mangrove forests may expand in extent as newly inundated areas become available for colonisation.

In many mangrove forests rates of surface accretion (increase in the elevation of the soil surface) matches or exceeds current rates of sea level rise (Lovelock et al. 2012). If rates of sea level rise continue to increase as predicted, at some point the surface accretion ability of mangrove forests will be surpassed and mangrove forest will be lost to inundation stress particularly where their resilience is undermined by extreme events such as cyclones or storm surge (Lovelock *et al.* 2012).

Due to their carbon content, mangroves have potential benefit in climate change mitigation (via 'blue carbon') through sequestration and storage of carbon in sediments (Lawrence 2015).

8.1.2.3 Coastal Freshwater Wetlands

The Gulf coastal zone is by definition a marine and coastal process-dominated landscape. Consequently freshwater wetlands represent only a small though ecologically important component of the zone's mainly marine and estuarine wetland aggregations (Blackman *et al.* 1999). More extensive freshwater wetland systems with features unique to the south east (SE) Gulf and western Cape York occur on the landward boundary of the defined coastal zone including:

1. Large fluvial megafans (distributary deltas) including Australia's largest (Mitchell River) and their associated distributary and often anabranching floodplain stream systems which are unique to western Cape York Peninsula and the SE Gulf of Carpentaria and found nowhere else in tropical Australia;
2. The greatest density of ox-bow lake systems in northern Australia found on the floodplain of the Mitchell River (a feature shared with the Fitzroy River floodplain in Western Australia);
3. The greatest density and areal extent of palustrine (vegetated swamp) systems in northern Australia found on Cape York Peninsula and in the SE Gulf of Carpentaria (Cook et al. 2011).

The defined coastal zone freshwater wetlands include the Southeast Karumba Plain Aggregation.

Water supply to these wetlands is variable depending upon landform setting. Supply includes local catchment run in, overbank flows from adjoining river systems during flood events and shallow groundwater aquifer discharges e.g. in the case of wetlands hosted within beach ridge swales, alluvial or sandy landforms. Due to the highly seasonal rainfall of the coastal Gulf, extended dry season and the generally shallow nature of most coastal freshwater wetlands, the majority are highly seasonal and only a small subset of deeper channel hosted or aquifer supplemented water bodies are perennial (*Blackman et al.* 1999). Given their proximity to the coast, many of these wetlands are also subject to high spring tide ingress or storm surge during cyclonic events. These marine influences and the common occurrence of underlying saline plain sediments means that many freshwater wetlands also undergo a high degree of water quality seasonality, with some trending to brackish or even hyper saline conditions during some stage of their seasonal or inter annual cycles.

Freshwater wetlands within the coastal zone support a range of values. They form critical parts of wetland aggregations that host significant populations of more than 22 species of migratory shorebirds which visit the Gulf each year (CLCAC 2014a). They also provide breeding, roosting, feeding and moulting habitat and drought refuges for a range of waterbird species including nationally and internationally significant populations of some species (Blackman *et al.* 1999). Several threatened species across a range of plant and animal taxa depend on freshwater wetland habitats within the Gulf coastal zone (CLCAC 2014a). Both permanent and seasonal wetlands also provide high value nursery habitats for fishery-associated species including barramundi (Bruinsma and Duncan 2000). Freshwater wetlands of the coastal zone also host sites and animal and plant resources of great cultural importance to Traditional land owners, including longneck turtles, waterfowl and water lilies (Monaghan 2001; CLCAC 2014a; CLCAC 2014b; CLCAC 2014c).

While there has been no comprehensive assessment of the condition of freshwater wetlands within the Gulf coastal zone, available information including data collected from a range of sites indicate that condition is variable and that there are a range of operating threats (Blackman *et al.* 1999; Tait 2005; CLCAC 2014a). The majority of the coastal zone falls within pastoral leases, and under pastoral land use, freshwater wetlands are generally utilised as watering points and pasture resources for grazing stock. The potential and observed impacts of grazing stock on Gulf coastal freshwater wetlands have been described by Burrows (2004) and Tait (2005). They included

pugging of the beds and banks of water bodies, grazing and trampling based removal of riparian and emergent vegetation on wetland margins, accelerated soil erosion and scalding of frontage areas, associated water quality impacts (elevated turbidity) and promotion of woody weed species. Impacts of this nature have the capacity to seriously undermine the productivity and habitat values of coastal freshwater wetlands.

There is evidence that increases in the Gulf's cattle herd in recent decades and associated changes to fencing configurations and watering point availability has placed additional pressure on freshwater wetland frontages (Shellberg et al. 2010; Tait 2005). However, stocking density and grazing management practices on coastal pastoral leases vary across the coastal zone, with some properties utilising fencing configurations, seasonal spelling and conservative stocking regimes that reduce stock associated impacts on coastal freshwater wetlands (Tait 2005, Appendix 1).

Another common wetland disturbance associated with pastoral land use is the bunding and/or excavation of wetlands basins and drainage lines to increase their water-holding capacity and functional value as stock watering points (Tait 2005). While wetland habitat values can sometimes be accentuated by artificial increases in site perenniality, such developments can also significantly impact riparian and marginal wetland vegetation communities and affect aquatic habitat connectivity.

Commercial grazing land use has been excluded from significant areas of the Gulf coastal zone including the Mutton Hole Wetlands Reserve near Normanton (CLCAC 2014a; CLCAC 2014b; CLCAC 2014c). In terms of wetland habitat resources and water quality the better condition of wetlands within these ungrazed areas contrasts markedly with commercial pastoral leases (Tait 2005). However, even in areas lacking commercial grazing operations, feral cattle, horses and pigs still provide a significant source of impact to freshwater wetland habitats (Tait 2005, CLCAC 2014a). Pigs are particularly destructive to freshwater wetlands due to their targeted feeding on wetland aquatic plants such spike rushes *Eleocharis spp.* and predation of wetland fauna including freshwater turtles, mussels, frogs and the eggs of waterbirds and turtles (Doupé et al. 2008).

Cane toads are another feral animal species, common within freshwater wetlands of the coastal Gulf, that generates significant impacts to native fauna. While exotic fish have not yet colonised coastal Gulf freshwater habitats, several exotic species that could occupy such habitats have been recorded in the upper catchments of contributing river basins (Mitchell and Leichardt) including tilapia, guppies and mosquito fish (Burrows 2004).

The threats posed by global warming including both climate change and sea level rise present significant risks for the Gulf's coastal freshwater wetlands. Freshwater wetland ecosystems are particularly vulnerable to climate change because the persistence and quality of aquatic habitats depend heavily on climatic and hydrologic regimes (Morrongiello et al. 2011). In low gradient landscapes such as the coastal Gulf of Carpentaria, sea level rise exacerbated by storm surges associated with greater intensity cyclones is anticipated to generate impacts to coastal floodplains and floodplain obligate biota over vast spatial scales (Pusey et al. 2009).

8.1.2.4 SEAGRASS

The Gulf's seagrass ecosystems provide critically important nursery habitat for a range of commercial prawn and fin fish species and are also the primary food resource for endangered dugong and green sea turtles (Hill et al. 2002; Poiner et al. 1987; Taylor et al. 2007). Commercial fish catch has been observed to correlate with the extent of available seagrass habitat between years (McKenna et al. 2013) and caused offshore commercial prawn catches to decline following destruction of seagrass beds by cyclones (Hill *et al.* 2002). In recent years there has also been an increased appreciation of the broader ecosystem services provided by seagrass ecosystems particularly their role in the sequestration and storage of carbon into coastal sediments (Connolly 2012) and carbon storage (Lawrence 2015).

The earliest aerial survey of seagrass extent in the Gulf of Carpentaria produced a total estimate of 906 km^2 of seagrass habitat along 671 km of shoreline (Poiner *et al.* 1987). The majority of this seagrass extent occurred in large patches in the western Gulf in NT waters, although substantial areas were also mapped within the coastal Gulf planning area around the Wellesley Islands and along the adjoining mainland coast to the NT border.

While Poiner *et al.* (1987) only mapped small patches of seagrass in the eastern Gulf, mainly north of Archer Bay, subsequent surveys have identified low density sea grass communities at several eastern Gulf sites that are only visible from the air when exposed at low tide due to high water turbidity, including 10km^2 in the Karumba area (SKM 1996). These Karumba seagrass beds have subsequently been the focus of a long term and ongoing monitoring program associated with port dredging operations (McKenna & Rasheed 2013).

Seagrass meadows in the Gulf are best developed in depths of less than 20 m and are comprised of up to eleven species which represents about 20% of the known seagrass species in the world (Poiner *et al.* 1987). Most occur along open coastline in depth zoned communities with *Halodule uninervis* and *Halophila ovalis* common in the intertidal zone, *Syringodium isoetifolium* and *Cymodocea serrulata* dominant in sub tidal areas, *H. ovalis* and *H. spinulosa* predominant offshore, *Thalassia hemprichii* dominates mixed stands on reef flats and *Enhalius acoroides* is often common in front of mangroves in small sheltered embayments (SKM 1996).

The density, standing biomass and compositional make up of seagrass communities can change in response to climatic and water quality factors including rainfall, water and air temperature, turbidity, sediment stability, solar irradiance and nutrient levels and also due to grazing pressure by fauna such as dugongs (Bruinsma et al. 2000; McKenna et al. 2013; Taylor et al. 2007).

Within the Great Barrier Reef (GBR) catchments on Queensland's eastern seaboard elevated sediment loads and other contaminants sourced from developed river basins are recognised to be responsible for critical water quality events causing significant impacts to the extent and condition of seagrass meadows (Brodie et al. 2012; Brodie et al. 2013a; Brodie et al. 2013b).

Evidence that Gulf river basins are now experiencing a significant elevation in soil erosion rates and associated sediment loads (Brooks et al. 2008), combined with predicted and emerging patterns of climate change-influenced extreme weather events (Moise 2014), present an increased potential for catchment run off-associated impacts on seagrass meadows and other vulnerable near coastal aquatic ecosystems including fringing reefs (below). Given the generally clockwise coastal currents associated with the Gulf's gyre (DSEWPC 2012), it is possible that turbid plumes discharged from the SE Gulf's major river basins could ultimately be distributed toward the main areas of sea grass occurrence in the south west.

In the Karumba area elevated river discharges associated with flooding in the largely undeveloped Norman River result in increased productivity and density in coastal seagrass meadows (McKenna et al. 2013). Long term monitoring of the Karumba seagrass communities has also identified that the biomass of the dominant species at this location, *Halodule uninervis*, was lower after periods of high ambient air temperatures. Elevated sea surface and air temperatures are a recognised source of potential climate change impact to seagrass communities, as are rising sea levels and potentially more intense cyclone events (Connolly 2012).

8.1.2.5 Reefs

Inshore areas of the SE Gulf are generally not suited to coral growth due to coastal waters being macrotidal, turbid and experiencing substantial depressions of salinity during the wet season (SKM 1996). Local sea surface temperatures near the coast range from 15 to 32°C and salinity ranges from 0 to 39 parts per tonne, which are outside the range of temperatures and salinities best suited for reef growth (Harris et al. 2004). In such environments, corals are unable to compete with fleshy algae for habitat, which explains their absence in the Gulf's shallow coastal waters.

Prior to the recent discovery of 80 km^2 of submerged patch reefs using multi-beam sonar mapping in the SE Gulf (Harris *et al.* 2004), scientists thought the Gulf contained only fringing reefs and isolated coral colonies but no patch or barrier reef bioherms like those found in the GBR. Most of the known occurrences of fringing reefs are outside the SE Gulf coastal and marine planning areas (e.g. in the north western and north eastern Gulf). It is now recognised that submerged patch and barrier reefs form an offshore broken margin around the perimeter of the Gulf of Carpentaria and provide complex habitats in an otherwise largely featureless basin (DSEWPC 2012).

The morphology and depth of the submerged patch reefs indicate that they were formed when sea level was 25–27m below its present position most likely in the late Quaternary when such low sea level periods coincided with cooler and drier climatic conditions than present (Harris *et al.* 2004). Seabed sampling in areas with patch reefs has identified that they occur in regions of low turbidity lacking mud and containing hard substrates of corals or coarse carbonate sediments. These coarse carbonate sediments are an example of how reef growth can armour the seabed thereby reducing fine sediments sources which limit resuspension and reduce turbidity.

The presence of both fringing and patch reefs within the Gulf contributes to its marine biodiversity values and supports a range of reef-associated fishery species (DSEWPC 2012; Zeller & Snape 2006). Within the northern prawn fishery, submerged reefs are recognised as 'untrawlable grounds' but are observed to correlate with the distribution of prawns, with some of the areas of highest prawn density found near these grounds (Haywood et al. 2005). Besides concerns of the potential impact of trawling on isolated reef habitats, the other main threat currently

recognised for coral reefs ecosystems in the Gulf planning area is overfishing by line fisheries and the recreational sector (CLCAC 2013a).

Coral reefs in the Gulf exist on the margins of suitable habitat boundaries determined by water quality and temperature and within the latitudinal belt (10–15˚) predicted to be most affected by seas surface temperature warming and coral bleaching (Harris *et al.* 2004). Sea surface temperatures in the central Gulf range from 28 to 30˚C annually. The thicker water column above submerged reefs filters out harmful solar radiation and ameliorates diurnal over-heating of the uppermost surface waters. It is believed the submerged reefs of the Gulf may provide an important refuge for corals and larvae for reseeding during the next few decades when near-surface reefs are threatened by widespread coral bleaching due to warmer global sea surface temperatures (Harris *et al* 2004).

Gulf fringing reefs in shallower water will be extremely vulnerable to any further increase in temperature associated with climate change (Anthony et al. 2012). Superimposed on the risks posed by global warming is the growing threat of ocean acidification, which is expected to reduce rates of reef accretion critical for reef maintenance and ecological function. Models of reef calcification under business-as-usual carbon emission paths predict that net rates of reef growth may become negative by the middle of the century (Anthony & Marshall 2012). Ocean acidification will impact submerged patch reefs as well as shallow fringing reefs.

Sea level rise, increased intensity of storms, floods driving further reductions in water quality and more extensive freshwater plumes in coastal zones, and altered oceanic circulation are important additional climate change-associated factors threatening reefs (Anthony & Marshall 2012). In the Gulf, increased soil erosion rates in contributing catchments combined with the likelihood of both extended dry seasons and more extreme wet season rainfall events (Moise *et al.* 2014), could potentially generate turbidity plumes that extend to some areas hosting reefs on the margin of the Gulf basin.

8.1.2.6 Other Benthic Marine Habitats

Across the Gulf marine planning area the composition of benthic sediment varies from 80% to 100% sand (versus mud) in the north east and extending west to the Wellesley Islands, down to 50-80% sand in the south west coast, and down to 20-50% sand around the mouths of major river systems (SKM 1996). Benthic surveys, including some conducted as part of impact assessment investigations for port operations and the Northern Prawn Fishery have identified a diverse range of benthic communities associated with these sediment types under differing conditions of water depth and clarity. This includes areas dominated by seagrasses, relatively bare sediments, macro algae, and sponges (SKM 1996; Haywood *et al.* 2005).

For infaunal surveys conducted using benthic grabs, scavengers/carnivores (44%) and deposit feeders (43%) have been shown to be the most numerically dominant, with suspension feeders (13%) and herbivores (<1%) less well represented. Suspension feeders were found to be dominant on muddy sand substrates of the south eastern Gulf while deposit feeders were found to be dominant in muddy sediments (SKM 1996). A broad spectrum of benthic infauna taxa are present, with species' numerical dominance in descending order being crustaceans, polychaetes, molluscs, echinoderms, sipunculids, coelenterates, nemertea, Platyhelminthes, chaetognatha and ascidians, although the dominance of different taxa varies in relation to site sediment type.

In beam trawl based surveys of epibenthic communities in offshore waters of the Wellesley Islands, wide regional variations in community composition were found with some areas dominated by sponges and others by seagrasses. The taxa caught with the highest efficiency by trawl nets were crustaceans (123%)*, sponges (Desmospongiae; 22%), crinoids (19%) and cephalopods (18%) (Haywood *et al.* 2005).

* *The greater than 100% efficiency comes from it being a comparison with another method which (epi benthic sled) is considered more representative of the bottom fauna.*

While the fisheries productivity and ecosystems service values of these benthic communities are not fully understood they are recognised to be important components of the marine ecosystem with roles in primary production, nutrient cycling and habitat provision that need to be managed sustainably. Prawn trawling poses the greatest current threat to these benthic communities. Impact assessments studies estimate a 12% depletion rate for benthic biota from a single pass of a trawl net and found targeted prawns represent only 20% of the catch by weight of a trawl net (Hill et al. 2002). The greatest impacts occur to more sessile biota such as crustaceans, bryozoans and sponges while more mobile taxa such as bivalves are less impacted.

Besides the threat posed by trawling, marine benthic communities are also subject to impacts from port channel dredging operations and threats posed by climate change. Climate change associated threats include: sea level rise and altered rainfall which has the capacity to affect light penetration and sediment deposition patterns, changing ocean currents and sea temperatures that will drive distributional shifts in biota, extreme weather events including more intense cyclones that can generate sustained disturbance and ocean acidification that is already impacting biota with calcium carbonate shells and exoskeletons (Bustamante et al. 2012; Howard et al. 2012; Poloczanska et al. 2012).

8.1.3 Fisheries

8.3.1 Commercial

The Gulf of Carpentaria is renowned for its fishery values which extend across freshwater, estuarine and marine environments, include commercial, recreational and traditional sectors and are based on fin fish, crustaceans, molluscs and a host of other taxa, including reptiles (e.g. turtles) and mammals (e.g. dugong) harvested as part of traditional 'fisheries'.

One Commonwealth and five Queensland-managed commercial fisheries operate within the Gulf coastal and marine zone (**Error! Reference source not found.** 8.1). These fisheries utilise a suite of methods including: gill netting, trawling, line fishing, and baited pots and target a host of fin fish and crustacean species (Zeller et al. 2006).

TABLE 3 COMMERCIAL FISHERIES OPERATING WITHIN THE SOUTH EAST GULF

Fishery	Management Authority	Main Target Species	Gross Value Annual Production $ **
L4/L5 Line Fishery	Qld Govt (DAFF)	Spanish mackerel, tropical snappers, cods and emperors	~$1.3 M
***Developmental Gulf Finfish Trawl Fishery**	Qld Govt (DAFF)	Red emperor, crimson snapper and saddletail snapper.	~$4.1 M
N9 Offshore Net Fishery	Qld Govt (DAFF)	Tropical shark and grey mackerel	~$17 M
N3 Inshore Net Fishery	Qld Govt (DAFF)	Barramundi, king and blue threadfins	
C1 Crab Pot Fishery.	Qld Govt (DAFF)	Mud crabs	~$2.64 M (Gulf component)
Northern Prawn Fishery (NPF)	Aust Govt (AFMA)	Nine commercial species of prawns	~$40.7 M (Qld component catch (Barwick 2011)).

* Largely outside the defined coastal and marine zone ** from DAFF (2013)

Gulf commercial fisheries are commonly promoted as sustainable 'wild caught' fisheries. Management reviews of Gulf fishery sustainability issues has been accredited under the Commonwealth's *EPBC Act* in terms of Ecological Sustainable Development and fishery guidelines (Zeller et al. 2006; DAFF 2013a; AFMA 2013).

An ecological risk assessment of Queensland-managed Gulf fisheries (including recreational and traditional sectors) examined forty-seven retained species components, 45 non-retained species components and 44 general ecosystem components for relative levels of risk (Zeller et al. 2006). Two target species in the Gulf net fishery (guitarfish in the N3 fishery and grey mackerel in the N9 fishery) were assessed to have a high risk to their sustainability compared to other retained species. Ten other species groups were considered to have a moderate risk to their sustainability including Spanish mackerel, red snappers, barramundi, threadfin salmons, sharks and mud crabs. For species interacting with, but not-retained by a fishery, there were no species considered to be at high risk to their sustainability. Six species groups from the net fishery were considered to have a moderate risk to their sustainability (bottlenose dolphins, speartooth sharks and sawfishes), and the trawl fishery (sharks, rays and sawfishes). There was no fishery impacts considered to be high risk factors to the sustainability of the marine ecosystem supporting Gulf fisheries. However some fisher camps were considered to have a moderate risk to the local terrestrial ecosystem (Zeller et al. 2006).

Amongst such reviews and the broader NRM stakeholder community concerns remain regarding the sustainability and potential impacts of Gulf commercial fisheries including gill netting and trawling, on non-target species such as

turtles, dugong, inshore dolphins and saw fish, sea grass and other benthic habitats, juvenile fish stocks and broader stock sustainability (Hill *et al.* 2002; Haywood *et al.* 2005; SGC 2005; CLCAC 2006; CLCAC 2013a; CLCAC 2014a; NGRMG 2008; McDonald 2011, Appendix 1). Many of these sustainability issues are also examined under the *Coastal and Marine Biodiversity* sections.

Across several stakeholder sectors, including from within the commercial fishing industry there are perceptions that some elements of the gulf fishery are overfished including via recreational sector pressure. Investment warnings regarding further fishing effort have been in place for some commercial fisheries operating in the Gulf (i.e. Mud Crabs) since the nineties (Ryan 2003), and have recently been extended to all commercial fisheries. Comparisons are made with the Northern Territory where the number of commercial crab and inshore gill netting licences for equivalent areas of costal habitat are an order of magnitude lower than the Queensland Gulf fishery (Appendix 1).

An ongoing challenge for fishery sustainability assessments is the availability of reliable catch data. Most fishery assessments are conducted by reference to commercial catch log books. Concerns exist regarding the accuracy of such data and the need has been identified for more fishery-Independent monitoring of both targeted stocks and non-targeted species (Appendix 1). Relative to commercial fisheries, the catch of the recreational and traditional fishery sectors is even more poorly quantified as is the impact of illegal fishing activities (Zeller et al. 2006).

While the potential impacts of commercial fisheries on other sectors and the environment provide a focal area for NRM, issues potentially affecting commercial fishery productivity and sustainability also provide a conduit and need for engagement of this valuable commercial industry in regional NRM. These issues include: the potential impact of river basin water resource development on river flows and coastal productivity, water quality risks posed by catchment development including agriculture and mining, fish passage barriers, and competition with other fishery sectors and industries. Climate change also poses a range of potential impacts to Gulf commercial fisheries given the strong productivity and dependent habitat linkages with climate (Creighton et al. 2013; Hill et al. 2002; Hobday et al. 2008).

8.1.3.2 Recreational fishing

Recreational fishing pressure in the Gulf coastal and marine zone is targeted at both estuarine and marine waters although some effort also occurs in freshwater in lower rivers reaches and lagoons occurring within the defined coastal zone. A wide range of estuarine, pelagic and reef species are targeted by recreational fishers including barramundi, threadfin and blue salmon, grunter, mangrove jack, Spanish mackerel, black jewfish, coral trout, fingermark, cod, queensfish, bream, trevally and mud crabs (Greiner 2013; Zeller et al. 2006). Some catadromous (estuarine breeding) species (e.g. barramundi, cherabin) that occur in the Gulf coastal zone also recruit to freshwater recreational fisheries outside the zone.

Given the low resident population density of the Gulf coastal zone the most significant recreational fishing pressure is exerted by visiting tourist fishers. Recreational anglers make up the vast majority of tourist visitors to the Gulf of Carpentaria (Greiner et al. 2009). Tourist access to coastal fishing resources in the Gulf is highly restricted by land tenure and road access. Unless visitors make private arrangements with coastal pastoralists or traditional land owners, the only legally accessible mainland coastal areas available to recreational fishing are Burketown, Normanton, Karumba, Kowanyama and Pormpuraau, with the latter two subject to a limited season, local council permits and 4WD road access only (CYSF 2014). Unpermitted access of recreational fishing tourists to coastal lands and associated site impacts remains an issue of concern for coastal landholders (CLCAC 2014a).

Tourists can seasonally swamp resident numbers in mainland Gulf communities accessible by sealed roads e.g. Normanton and Karumba, particularly the latter which has the most established tourism industry and infrastructure. Recreational fishing pressure is consequently spatially and temporally concentrated to the most accessible sites and season which is the northern winter or dry season (April – October). While no specific statistics for the defined coastal planning region are available, annual visitor numbers to the Carpentaria shire alone were 14,000 in 2002/3 (Greiner 2013), and recreational fisher numbers for the entire Gulf were assessed to be around 100,000 in 1999 (Zeller et al. 2006).

There are a wide range of visiting recreational angler types and motivations for fishing in Gulf waters. They span non-exclusively across those seeking primarily consumptive benefits i.e. fishing for food and to take sea food resources home to share with friends and family, those for which fishing is primarily an outdoor recreation and social activity and those motivated by trophy 'big fish' sport fishing experiences (Greiner et al. 2013). The travelling

retiree or 'Grey Nomad' demographic constitutes the most significant component of the Gulf tourist recreational fishery, although younger family groups are also prominent. Most tourist fishers come equipped with their own boats to access coastal areas, although there is a growing commercial charter boat segment that also caters for visitors.

Amongst the recreational sector, there is often a perception that levels of take by the sector are much smaller than that of commercial fisheries, however available recreational fishing survey data indicates that catches are still substantive and may exceed the commercial catch for a number of species (Greiner et al. 2013; Taylor et al. 2012; Zeller et al. 2006). The retained Gulf recreational catch for barramundi alone has been estimated at approximately 180 tonnes or 12% of the Qld commercial catch (Taylor *et al*. 2012), although other estimates for the entire Gulf have placed it equivalent to the commercial catch (Clarke *et al*. 2009). The recreational fishery for grunter *Pomadasys kaakan* at Karumba is the most widely cited example of a heavily exploited and potentially vulnerable Gulf recreational fishery with annual (retained) catch rates at Karumba alone estimated to be > 13.5 tonnes, or 600-800% of the commercial catch (Greiner et al. 2013), or in the order of 40-50 tonnes / year for the entire recreational fishery (cf. 30 t/years for the commercial fishery) in the eastern Gulf (Zeller et al. 2006).

As indicated by this range of figures, the availability of reliable recreational fishery catch data remains an outstanding issue with regard to quantifying fishery status and one that continues to be nominated as a management priority (Greiner et al. 2013). Coastal Gulf residents' concerns for the sustainability of the Grunter fishery are based on: the witnessed high recreational fishing pressure e.g. >90 recreational dinghies fishing on the water at one time (Appendix 1); the targeting of grunter breeding aggregations; observations that fish size and bag limit regulations are flouted and that 'consumptive' anglers take large volumes of frozen fish from the region; anecdotal information that banks that previously hosted breeding aggregations no longer do and that catch rates have declined; and concerns that collapse of the fishery would spell disaster for the local tourist industry and economy.

Concerns over local depletion of grunter stocks in areas readily accessible to recreational fishers have not been supported by the available tag/recapture data from tagging studies done at these locations (Zeller & Snape 2006). However, evidence that: grunter juveniles are taken as by-catch within the northern prawn fishery; that the commercial inshore N3 gill net fishery may have a detectable impact on the population size of grunter stocks; and that the species has regionalised genetic stocks in the Gulf all mean that the additional impact on stocks from recreational and indigenous fisheries might require closer management (Zeller & Snape 2006).

Amongst Gulf coastal residents one of the main nominated needs for addressing recreational fishery sustainability concerns is the provision of more accessible information concerning fishing regulations, appropriate fisher behaviour and biological aspects of the fishery related to its vulnerability. These local suggestions dovetail with research findings that locally available hard copy communication remains the preferred source of information particularly for consumptive-oriented anglers (Greiner *et al*. 2013). Specific recommendations have included provision of signage at local boat ramps and establishment of 'fishcare' volunteers or an equivalent program within the long term resident populations of Karumba caravan parks (Appendix 1). Other management approaches that have been identified in relation to the vulnerability of Karumba's recreational fishery-dependent tourism industry include: the promotion of alternative nature based tourism activities; increased support for less-consumptive recreational fisher experiences; and increased tightening, enforcement and possibly licensing of the recreational fishery (Greiner *et al*. 2013).

Beyond Karumba and the sustainability of the recreational grunter fishery, there are a number of other NRM issues relevant to the Gulf's coastal and marine recreational fishery assets. Competition with the commercial sector for access to fishery resources remains an issue of contention for recreational fishery representatives. The NT example of significantly reduced commercial fishing pressure and a more valuable recreational fishing sector is often cited as a management model for the coastal Gulf, as are cost benefit analyses that indicate bigger returns to the community and economy from recreational based fisheries in comparison to commercial fisheries (McDonald 2011).

The use of environmental offset dollars or other sources of funding to buy back commercial fishing licences and/or to create recreational fishery only areas in the coastal Gulf is favoured by some representatives within the recreational sector (Appendix 1). Under the existing regulations governing the commercial net fisheries of the Gulf (Queensland Government 1999), there are already 12 exclusion areas within the Gulf coastal and marine planning area where commercial gill net fishing is prohibited, including on the Mitchell River, Staaten River, Gilbert River and Norman River. Many of these areas have limited access for recreational fishers. Concerns have also been expressed that targeted fishing pressure immediately outside of net exclusion areas negates much of their value to recreational fisheries and to the improvement of overall stock size (McDonald 2011).

As identified above, recreational fisher access to coastal fishery resources is a double edged issue in that increased access opportunities could reduce effort on existing pressure spots but generate additional management issues elsewhere. In the past recreational fishing lodges or paid access opportunities provided by coastal Gulf pastoral properties (e.g. Dunbar) provided additional access options for recreational fisher tourists to the Gulf and enterprise diversification for pastoral operations. Ultimately the management burden of such operations has weighed against their commercial sustainability. Traditional land owners have also expressed interest in providing tourists access to coastal lands under a ranger-regulated camping permit system as a form of economic enterprise (CLCAC 2014a).

Potentially important areas of investigation required, to support nature-based sustainable development opportunities in the coastal Gulf, include: issues surrounding existing access opportunities for recreational fishers (and other tourists); opportunities to increase access and the economic benefits and management costs associated with such initiatives. The potential of such recreational fishery development for providing employment and economic development opportunities for Indigenous communities has been identified by previous studies in the eastern Gulf (McDonald 2011).

The aspirational goal expressed by Indigenous Land and Sea ranger programs to obtain enforcement powers under the Qld Fisheries Act (CLCAC 2014a), provides a possible source of enhanced fisheries enforcement capacity to better support existing and any future recreational fishery development. Beyond the bag and size limit issues identified for the Karumba grunter fishery, other identified enforcement issues include illegal use of fishing apparatus and potential interactions with endangered and protected fauna such as freshwater sawfish.

Broader basin scale NRM issues relevant to the recreational fishery of the Gulf coastal zone include those identified for other fishery sectors i.e. the potential impact of river basin water resource development proposals on flows and fishery productivity (discussed under *River Basin Management* below) and fish passage barriers that limit access to freshwater habitat and potentially reduce overall population size of catadromous species that form part of both coastal and freshwater fisheries, such as barramundi.

Culturing and stocking of key recreational species that are perceived to have undergone stock reduction due to fishing and other pressures i.e. barramundi is conducted within the coastal planning area. This activity is supported by both recreational and commercial fishing sectors and is currently undertaken by a facility operated by the Carpentaria Shire Council with support from James Cook University. Post stocking assessments previously conducted by state fishery agencies as a means of monitoring the outcomes and justification for stocking efforts, are no longer undertaken. Recreational fishing representatives and both stocking and conservation advocates have nominated such activities as a priority for improved management of stocking programs (Appendix 1).

8.1.3.3 Traditional fishing

The first broad-scale survey of traditional fisheries in northern Australia included four Indigenous communities within the Gulf coastal and marine planning area: Gununa (Mornington Island), Doomadgee, Kowanyama and Pormpuraau (Coleman et al. 2003). More specific detail of the traditional fisheries, management practices and customs of specific Indigenous groups within the area is provided by literature reviews and consultations undertaken as part of the Northern Regional Marine Planning Process (Memmott et al. 2004; Smyth et al. 2004).

While there is overlap between traditional and recreational fisheries in terms of methods used and species taken, there are also significant distinctions in that traditional fisheries: have much higher participation rates; target a much broader range of taxa including species legally protected from take by non-indigenous fishers; utilise a broader suite of methods including a much greater dependence on hand collecting, spears, and nets; are more subsistence based with lower rates of release; are not directly subject to *Fisheries Act* regulations (when conducted for traditional purposes), and usually have additional educational, social and cultural motivations for participation including fulfilment of community responsibilities and obligations and strengthening of cultural identity (Coleman et al. 2003; Jackson et al. 2011). Beyond provisioning and recreation, one of the key values attributed to fishing by Indigenous people in northern Australia is its role as an educational activity that teaches young people about their country, responsibilities under customary law, as well as the social act of cooking and consuming fish with family (Jackson *et al.* 2011).

Results from the northern Australia survey indicated participation rates in Indigenous fisheries in north Queensland were greater than 93% and less than 2% of catch was returned (Coleman *et al.* 2003). In northern Australia including the coastal Gulf, customary fishing, hunting and harvesting activities contribute significantly to Indigenous

household income and diet (Jackson *et al*. 2011). In surveys in Cape York it was found customary production was very significant in meeting people's nutritional needs, including up to 80% of protein which came from wild resources (Altman et al. 2009).

Of species targeted by indigenous fishers in north Queensland and the Gulf, numerically prominent fin fish include mullet, bream, sea perch/snapper, catfish, trevally, grunters, threadfin salmon, cod and barramundi, many of which have direct dependencies on riverine or estuarine habitats. Significant non-fin fish components of the surveyed Indigenous fishery included prawns, mud crabs, oysters, mussels and other bivalves and species whose take is prohibited for non-indigenous people including crocodiles, dugong, turtle eggs, marine turtles and freshwater turtles (Coleman *et al*. 2003). Other important non-fishery materials forming part of the customary harvest from aquatic ecosystems in northern Australia coastal areas include Magpie geese and lotus lilies (Jackson *et al*. 2011), and material for utensils, fuel, medicines, arts and crafts (Altman *et al*. 2009).

A range of issues concerning traditional fisheries management and threats have been identified by Indigenous groups in the Gulf coastal and marine zone through the North Marine Regional planning process, Indigenous Protected Area management planning and recent consultative efforts (Memmott & Channells 2004; Smyth & Monaghan 2004; CLCAC 2006; CLCAC 2013a; CLCAC 2014a, Appendix 1).

From a management perspective a key aspiration of Indigenous groups is to gain greater management authority and autonomy for traditional sea country. Land and Sea Ranger Programs, with a logistical capacity to monitor sea country marine resources and fishery operations ideally with some fisheries regulation enforcement capacity, are seen to be the most viable means by which to empower traditional management aspirations (Memmott & Channells 2004; CLCAC 2013a, 2014a).

Conflict with other fishery sectors (commercial, recreational) remains a key concern for Indigenous fishers. Issues include: the impact of commercial gill and trawl fisheries on non-target species (including via non-compliance with regulations i.e. net attendance rules) that form a culturally important component of traditional fisheries i.e. marine turtles and dugong, excessive take of commercially targeted species e.g. barramundi from some areas, waste of fishery resources in the form of discarded by-catch, and the accessing of culturally sensitive coastal areas including islands, by commercial or recreational fishers without following appropriate protocols. While Native Title determinations have recognised the legal rights of commercial fishers to operate on sea country claimed under Native Title, the rights of Traditional Owners to expect fishers to notify them of operations on country and to follow cultural protocols is also recognised (DEEDI 2011), but not always followed.

Other identified concerns regard the potential impact of catchment management and pollution on traditional coastal and marine fishery resources. In recent years the loss and reduction of important coastal seagrass beds following large wet season flood events has been attributed to elevated rates of soil erosion in catchment areas impacted by grazing pressure (CLCAC 2013a; CLCAC 2014a, Appendix 1). Loss of seagrass is perceived to threaten the carrying capacity and health of dependent dugong and turtle populations and other fishery resources. Concerns regarding potential marine pollution associated with unsecured mining contamination sources in the catchment, such as Redbank mine (CLCAC 2013c), and zinc concentrate and tailwater spills in Gulf coastal and marine areas have also been heightened by traditional fisher observations of sick turtles and dugong with tumors and unusually-colored and smelling fat (CLCAC 2013a, Appendix 1).

Consultation with Traditional Owners of sea country and Indigenous Protected Area management plans (CLCAC 2013a; CLCAC 2014a) also identify concerns regarding the sustainability of fishing and other practices conducted by the Indigenous community. Concerns included the impact of beach vehicle traffic and excessive harvesting of sea turtle eggs and the sustainability of community take of adult turtles and dugong in specific hunting areas, given worries about external pressures on populations. The impact of traditional fishers on protected fauna such as turtles and dugong is also a concern to the broader Australian community with some dugong hunting rates in northern Australia assessed to be unsustainable (Heinsohn et al. 2004). There is little quantitative information available regarding Indigenous harvest of turtle and dugong in the North Marine Regional Planning Area. However, research in the Borroloola region indicates that the harvest of 40 to 50 dugongs per year in that area is well below the estimated maximum sustainable harvest of 400 animals per year, out of an estimated total local dugong population of 8000 (Smyth et al. 2004).

Whether dugong populations and harvest rates of this size remain viable in the coastal Gulf requires current assessment given the emergence of more recent concerns for seagrass beds and dependent fauna. An aspiration of Land and Sea Ranger and IPA management programs in the coastal Gulf is to establish and maintain monitoring programs for seagrass, dependent turtle and dugong populations and traditional fishery take. Better monitoring

and quantification of the take of the traditional fishery, including for fish species would serve to address one of the main information gaps identified for its effective management (Zeller & Snape 2006).

An emerging issue that may present management challenges for the Gulf indigenous community and traditional fishery management is the desire by some community members to explore economic development and employment opportunities presented by participation in the commercial fishery sector.

8.1.4 Coastal and Marine Biodiversity

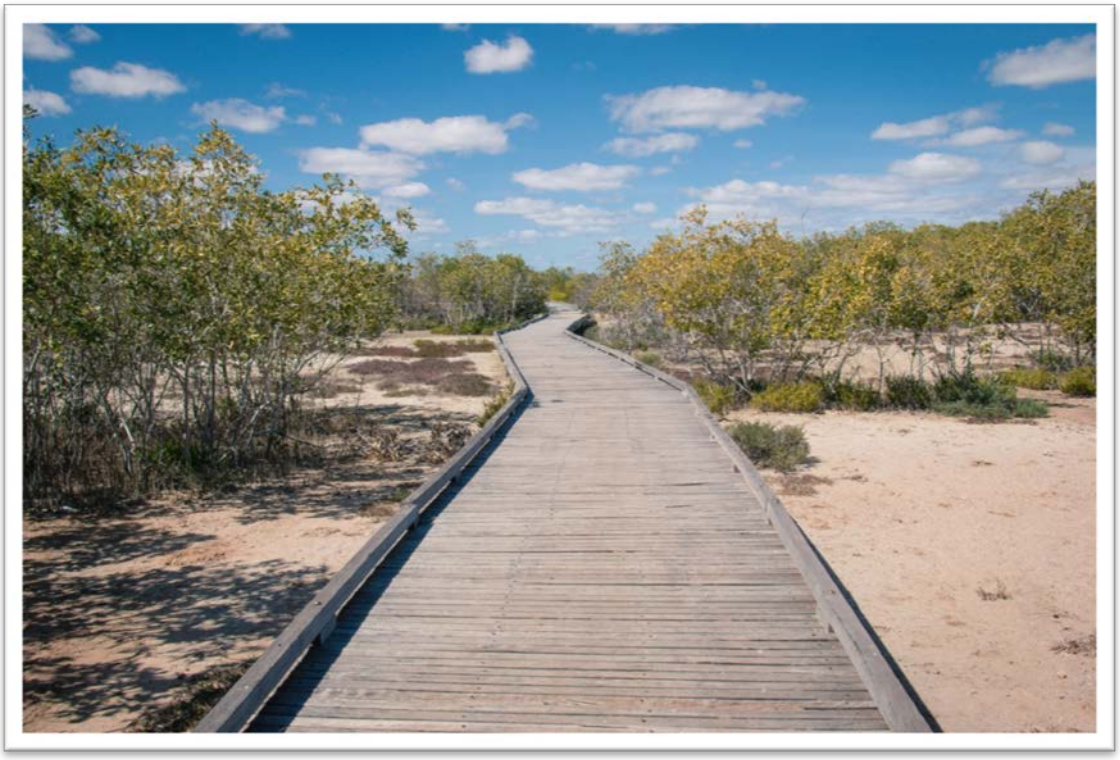
Biodiversity by its simplest definition means 'life in all its forms'. The Gulf of Carpentaria's coastal and marine zone is renowned for supporting biodiversity that is of global conservation significance including six of the seven species of marine turtles in the world, a significant proportion of the world's dugong population, five species of endangered elasmobranchs (sawfish and river sharks), three species of inshore dolphin, major aggregations of internationally migrating shore birds and nationally significant breeding populations of water birds (Blackman *et al.* 1999; DSEWPC 2012; CLCAC 2014a).

8.1.4.1 Marine Biodiversity and Threatened Species

The Gulf of Carpentaria's marine biodiversity values including threatened species have been comprehensively assessed as part of the Commonwealth Government's recent preparation of the Marine bioregional plan for the North Marine Region under the auspices of the *EPBC Act* (DSEWPC 2012). The objectives of the plan are:

1. Conserving biodiversity and maintaining ecosystem health;
2. Ensuring the recovery and protection of threatened species;
3. Improving understanding of the region's biodiversity and ecosystems and the pressures they face.

This plan applies to the entire Commonwealth marine area between western Cape York Peninsula to the NT/WA border. While the Commonwealth marine area starts at the outer edge of state waters, usually 3 nautical miles (5.5 kilometres) from the shore (territorial sea baseline), and extends to the outer boundary of Australia's exclusive economic zone, several of the key ecological features and most of the regional priority conservation values identified by the plan occur within the SE Gulf planning zone. Many also have ecosystem process and dependent habitat linkages to the coastal zone and contributing river basins.



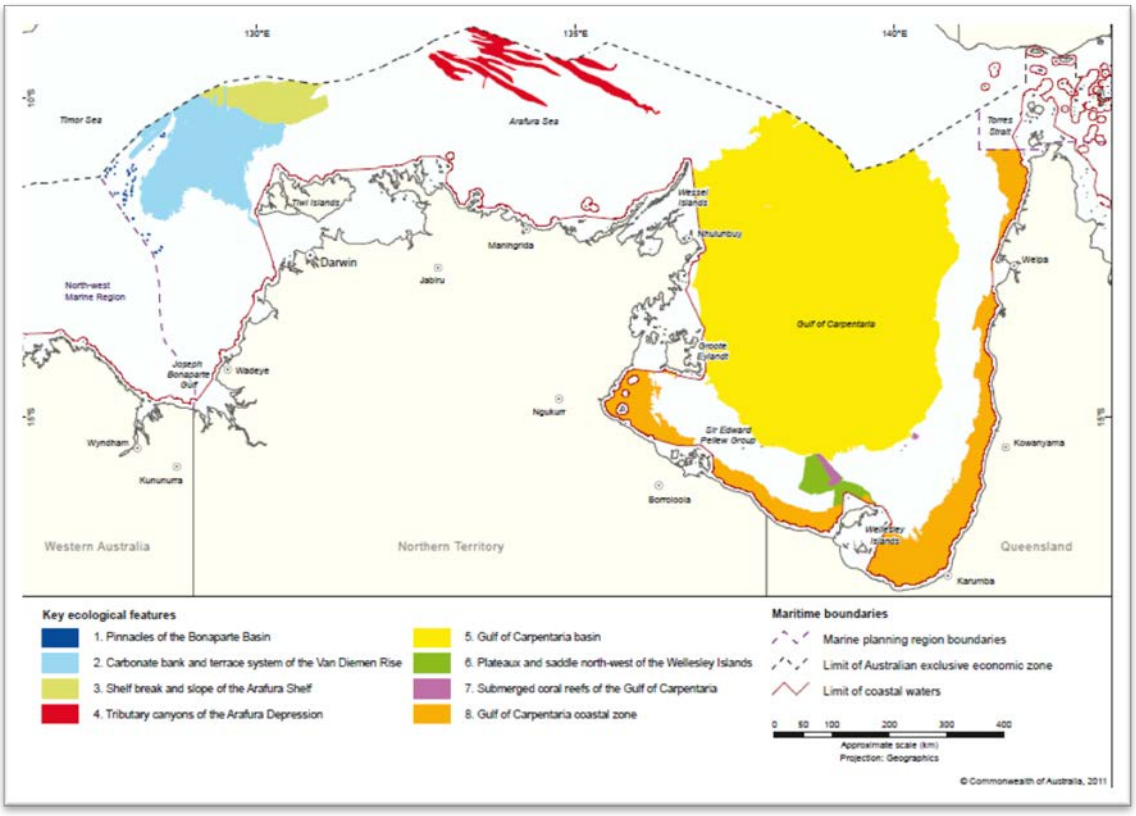


FIGURE 8.2 KEY ECOLOGICAL FEATURES IN THE NORTH MARINE REGION (SOURCE DSEWPC 2012)

By global standards, the marine environment of the North Marine Region is known for its high diversity of tropical species but relatively low endemism which is attributed to it being part of a vast species-rich biogeographic ocean zone that stretches from the western Pacific to the east coast of Africa but has few physical barriers to promote speciation (DSEWPC 2012). Areas within the North Marine Region that are nominated as being particularly rich in biodiversity all occur within the SE Gulf marine planning area and include three of the four key ecological features that occur in the planning area (Figure 8.2 Table 8.2) including: the Gulf of Carpentaria coastal zone, plateaux and saddle north-west of the Wellesley Islands, and the submerged coral reefs of the Gulf of Carpentaria (DSEWPC 2012). Key ecological features are defined as elements of the marine environment that, based on current scientific understanding, are considered to be of regional importance for either the region's biodiversity or ecosystem function and integrity.

TABLE 4: DESCRIPTION OF KEY ECOLOGICAL FEATURES WITHIN THE SOUTH EAST GULF NRM PLANNING AREA (SOURCE DSEWPC 2012).

Feature	Description
Gulf of Carpentaria basin	Values: Regional importance for biodiversity and aggregations of marine life. The Gulf of Carpentaria basin is one of the few remaining near-pristine marine environments in the world. Primary productivity in the Gulf of Carpentaria basin is mainly driven by cyanobacteria that fix nitrogen, but is also strongly influenced by seasonal processes. The soft sediments of the basin are characterised by moderately abundant and diverse communities of infauna and mobile epifauna dominated by polychaetes, crustaceans, molluscs and echinoderms. The basin also supports assemblages of pelagic fish species including planktivorous and schooling fish, with top predators such as shark, snapper, tuna and mackerel.
Plateaux and saddle north-west of the Wellesley Islands	Values: High aggregations of marine life, biodiversity and endemism. Abundance and species density are high in the plateaux and saddle as a result of increased biological productivity associated with habitats rather than currents. Submerged reefs support corals that are typical of northern Australia, including corals that have bleach-resistant zooxanthellae; and particular reef fish species that are different to those found elsewhere in the Gulf of Carpentaria. Species present include marine turtles and reef fish such as coral trout, cod, mackerel and shark. Seabirds frequent the plateaux and saddle, most likely due to the presence of predictable food resources for feeding offspring.
Submerged coral reefs of the Gulf of Carpentaria	Values: High aggregations of marine life, biodiversity and endemism. The submerged coral reefs of the Gulf of Carpentaria are characterised by submerged patch, platform and barrier reefs that form a broken margin around the perimeter of the Gulf of Carpentaria basin, rising from the sea floor at depths of 30–50 m. These reefs provide breeding and aggregation areas for many fish species including mackerel and snapper, and offer refuges for sea snakes and apex predators such as sharks. Coral trout species that inhabit the submerged reefs are smaller than those found in the Great Barrier Reef and may prove to be an endemic subspecies.
Gulf of Carpentaria coastal zone	Values: High productivity, aggregations of marine life, biodiversity and endemism. Nutrient inflow from rivers adjacent to the North Marine Region generates higher productivity and more diverse and abundant biota within the Gulf of Carpentaria coastal zone than elsewhere in the region. The coastal zone is near pristine and supports many protected species such as marine turtles, dugongs and sawfish. Ecosystem processes and connectivity remain intact; river flows are mostly uninterrupted by artificial barriers and healthy, diverse estuarine and coastal ecosystems support many species that move between freshwater and saltwater environments.

Protected species are those that are protected under the *EPBC Act* that occur within the planning area and fall into four non-exclusive categories:

1. *Threatened species* – species that have been identified as being in danger of becoming extinct and are listed under a range of categories dependent upon their status including vulnerable, endangered and critically endangered.
2. *Migratory species* – species of birds or other fauna listed under international conventions to which Australia is a signatory (discussed in a following section)
3. *Cetaceans* – all whales, dolphins and porpoises
4. *Marine species* – belong to taxa that the Australian Government has recognised as requiring protection to ensure their long term conservation.

The North Marine Region Bioregional Plan identifies twelve regional priorities, which include a mix of conservation values comprised of both protected species and key ecological features and pressures that represent regional priorities. Conservation values of regional priority (in no particular order) include:

1. Marine turtles
2. Inshore dolphins (3 species)
3. Sawfishes and river sharks (5 species)
4. Dugong
5. Sea snakes
6. Gulf of Carpentaria coastal zone.

These are described in greater detail below. Pressures of regional priority include:

1. Marine debris
2. Bycatch
3. Extraction of living resources (illegal, unreported and unregulated fishing)
4. Physical habitat modification
5. Climate change
6. Changes in hydrological regimes.

These are described further in the summary of threats to coastal and marine zone assets in the following section.

MARINE TURTLES (6 SPECIES)

Flatback turtle, Green turtle, Hawksbill turtle, Leatherback turtle (EPBC Act listed as vulnerable, migratory and marine) *Loggerhead turtle, Olive ridley turtle* (EPBC Act listed as endangered, migratory and marine)

Six of the seven species of marine turtle in the world are known to inhabit the North Marine Region. All six species are listed as threatened under the EPBC Act, and have important breeding, nesting and/or feeding areas in or adjacent to the North Marine Region. In particular, the region supports globally significant populations of green, hawksbill, olive ridley and flatback turtles. In the North Marine Region, the pressures assessed as *of concern* for marine turtles are invasive species and marine debris. The pressures assessed as *of potential concern* for marine turtles are sea level rise, changes in sea temperature, bycatch (commercial fishing), extraction of living resources (Indigenous harvest), noise pollution (seismic exploration) and light pollution (offshore activities). The conservation status of marine turtles, the significance of the North Marine Region to their recovery and the pressures facing them in the region make the species group a priority for conservation effort (DSEWPC 2012).

Coastal waters of the SE Gulf planning area support major populations and breeding site of marine turtles (Wilcox *et al*. 2012; CLCAC 2013a; CLCAC 2014a). The Gulf's population of green turtles has been found to be genetically distinct from east coast populations and to warrant specific management arrangements (CLCAC 2013a).

Marine turtles are an important cultural and subsistence resource for sea country Traditional Owners (Memmott & Channells 2004; CLCAC 2013a; CLCAC 2014a). In recent decades Traditional Owners have expressed major concerns regarding the apparent reduction in regional turtle populations and observations of sick and poor condition individuals. While there is an acknowledgement that traditional take of both adult turtles and eggs may be contributing to population decline in specific areas (CLCAC 2013a), much greater concern is directed at larger scale pressures. These include the impact of turbid river flood plumes on seagrass beds, mortality associated with bycatch of the commercial trawl and gill net fisheries, entanglement in marine debris, pig and native animal predation of turtle nests, weed infestation of nesting sites, vehicle traffic on nesting beaches and the potential impact of metals and other contaminants sourced from industry (CLCAC 2013a; CLCAC 2014a). Sea level rise is also recognised as an emerging threat to turtle nesting beaches and rising temperatures a threat to hatchling sex ratio outcomes. Inundation of nest sites by high tides has been observed in adjoining coastal areas in the NT (CLCAC 2014a).

Turtle conservation management activities have been a primary focus of Land and Sea Ranger programs in the SE Gulf since their inception in 2007 (CLCAC 2013a). Conducted activities have included turtle tagging and tracking,

nest site monitoring for hatchling success and sex ratios, feral pig control and exclusion fencing, nest beach weed control, vehicle beach access management, marine debris clean up, quantification of traditional take and community education programs (CLCAC 2013a; CLCAC 2014a).

While significant progress has been made in tackling some key threats to turtle such as defining strategic approaches for managing marine debris (Wilcox et al. 2013), and the development of turtle excluded devices for the commercial trawl fishery (Burke et al. 2012), major outstanding pressures require further investigation and/or implementation of more effective management solutions particularly commercial gill net fishing bycatch and the apparent impact of climate change exacerbated extreme flood events on sea grass beds. Other consequences of climate change associated impacts on turtles (sea level rise, temperature increases) while acknowledged to be potentially significant have not yet been resolved at a fine enough level to identify possible mitigative needs or opportunities.

INSHORE DOLPHINS (3 SPECIES)

Australian snubfin dolphin, Indo-Pacific humpback dolphin (EPBC Act listed as cetacean and migratory), *Indo-Pacific bottlenose dolphin* (EPBC Act listed as cetacean and migratory [Arafura/Timor Sea populations])

The Australian snubfin dolphin, Indo-Pacific humpback dolphin and Indo-Pacific bottlenose dolphin are known to occur in the North Marine Region. All three species are listed as migratory and cetacean under the EPBC Act. These species rely on the waters of the North Marine Region and adjacent coastal areas for breeding and foraging. The Australian snubfin dolphin and Indo-Pacific humpback dolphin occur mostly in shallow waters up to 10km from the coast and 20km from the nearest river mouth. Indo-Pacific bottlenose dolphins tend to occur in deeper, more open coastal waters, primarily in continental shelf waters (up to 200m deep), including coastal areas around oceanic islands. The species' vulnerability to pressures is intensified due to their life history characteristics (they are long-lived, females take many years to reach sexual maturity and they have a low rate of reproduction) and their small and fragmented populations. In the North Marine Region, the pressure assessed as *of concern* for inshore dolphins is physical habitat modification (onshore and offshore construction). The pressures assessed as *of potential concern* for inshore dolphins are bycatch (commercial fishing), marine debris, noise pollution (onshore and offshore construction; shipping), changes in sea temperature, ocean acidification, sea level rise (Australian snubfin dolphin only), chemical pollution (onshore and offshore mining) and physical habitat modification (dredging). The conservation status of inshore dolphins, the significance of the North Marine Region to their survival (especially given their limited and fragmented ranges) and the pressures facing them in the region make the species a priority for conservation effort (DSEWPC 2012).

Of the listed concerns for dolphin conservation the most relevant to the SE Gulf planning area are commercial fishing bycatch, marine debris, habitat modification (dredging) and those associated with global warming i.e. sea level rise and ocean acidification. Of these, the most significant currently recognised threat is considered to be commercial gill net fishery bycatch. Significant mortality of dolphins due to gill netting bycatch is observed particularly in association with the offshore gill net fishery (McDonald 2011), and Bottlenose dolphins are considered to have a moderate risk to their sustainability due to the Gulf gill net fishery (Zeller & Snape 2006). Enforcement of fishery regulations and improved surveillance and reporting of bycatch represent opportunities for better managing fishery impacts on dolphins. Alternatively, seasonal or permanent closures of areas important to (particularly breeding) dolphins to commercial fisheries provides another strategy for reducing commercial fishing bycatch pressure on conservation values such a cetaceans (DSEWPC 2012).

SAWFISHES AND RIVER SHARKS (5 SPECIES)

Dwarf sawfish, Freshwater sawfish, Green sawfish (EPBC Act listed as vulnerable), *Northern river shark* (EPBC Act listed as endangered), *Speartooth shark* (EPBC Act listed as critically endangered)

Five species of sawfish and river shark listed under the EPBC Act are known to occur in the North Marine Region. While relatively little is known about the distribution and abundance of sawfishes and river sharks in northern Australian waters, the North Marine Region is considered an important area for the species group as the region and adjacent waters contain nationally and globally significant populations of sawfish and river shark species. Biologically, sawfishes and river sharks are characterised by their late age at maturity, slow growth rate, low fecundity, longevity and low rate of natural mortality, all of which result in low rates of reproduction and capacity to withstand human-induced pressures. In the North Marine Region, the pressures assessed as *of concern* for sawfishes and river sharks are bycatch (commercial fishing; recreational fishing), extraction of living resources (illegal, unreported and unregulated fishing) and changes in hydrological regimes. The pressures assessed as *of potential concern* for sawfishes and river sharks are sea level rise, changes in sea temperature, marine debris, extraction of living resources (commercial fishing [freshwater sawfish only]; Indigenous harvest) and chemical pollution (onshore and offshore mining). Research into the distribution, population size, population trends and factors influencing recovery of these species has been undertaken but significant gaps in knowledge on sawfish and river shark species in northern Australia remain. These knowledge gaps, along with the conservation status of sawfishes and river sharks, the significance of the North Marine Region to their recovery, and the pressures facing them in the region, make the species group a priority for conservation effort (DSEWPC 2012).

All three species of sawfish nominated as regional conservation value priorities are recorded within the SE Gulf planning area. Northern River and Speartooth sharks have not been recorded specifically within the planning area (SPAT 2014), although this may primarily reflect a lack of dedicated survey effort and the challenges associated with identifying these species. Perennial river estuarine habitats such as that provided by the Nicholson and the Mitchell River estuaries would appear to provide suitable habitat for these shark species and warrant targeted survey.

While the Gulf represents a global stronghold for sawfish populations, anecdotal observation by regional stakeholders would suggest that Gulf populations have undergone significant reductions in recent decades (CLCAC 2014a). Commercial fishery bycatch is identified as the principle threat to sawfish, particularly entanglement in gill nets in near shore and estuarine waters which few survive. As discussed for Dolphins (above) in the absence of more effective impact mitigation practices, seasonal or permanent area closures may represent the only viable method for reducing net impacts on sawfish and this option is supported by key regional stakeholders including Traditional Owners (CLCAC 2014a). Recreational fishers are also recognised to impact sawfish populations either via taking as unintended bycatch on baited lines or due to targeted fishing by those seeking sawfish rostrums as a trophy (DoE 2014).

Quantitative assessment of sawfish population status is hampered by a lack of survey effort and effective methods and variable reporting of bycatch by commercial fishery operators (DSEWPC 2012). Since the introduction of Turtle Exclusion Devices, captures of sawfish within the Northern Prawn Trawl fishery are reported to have reduced by 73% (Burke *et al.* 2012). In sustainability assessments undertaken for Gulf fisheries, sawfish were assessed to have a moderate risks to their sustainability due to the Gulf gill net fishery (Zeller & Snape 2006).

Threats posed by fish passage barriers may also be significant for Freshwater sawfish which are an amphidromous species that move between marine and freshwater habitats. (GBRMPA 2011; DoE 2014). Historically Freshwater sawfish were recorded hundreds of kilometres inland in some of the larger Gulf river systems such as the Gilbert-Lynd, Flinders and Nicholson (Allen et al. 2002; Petheram et al. 2013a; Petheram et al. 2013b). Regional stakeholders familiar with these river systems report that encounters with sawfish in freshwater reaches are less frequent than historically (Appendix 1). In addition to fishery bycatch pressures on estuarine and coastal sawfish populations, fish passage barriers in the form of road crossings and water infrastructure constructed on Gulf rivers in recent decades (Marsden et al. 2005), may also be impacting populations. Further assessment of the potential impact of fish passage barriers on freshwater sawfish within SE Gulf river basins and means of mitigating their impact is a nominated priority within the planning area.

Most fish surveys conducted in Gulf freshwaters utilise techniques unsuited to the capture of sawfish and seldom record them despite concurrent landholder reports or evidence of their presence at surveyed sites (Burrows et al. 2006; Hogan et al. 2005). There is a need to develop suitable non-destructive method for surveying freshwater sawfish populations.

As for most species with dependencies on freshwater, estuarine and nearshore habitats and connectivity between each, the threats posed by global warming and climate change including sea level rise-driven inundation of coastal habitats, altered rainfall and river flow patterns, extreme weather events and rising temperatures pose a range of concerns to sawfish habitat and population sustainability (DSEWPC 2012).

SEA SNAKES

(EPBC Act listed as marine)
The North Marine Region is an important area for sea snakes. Nineteen species are known to occur in the region; all are listed as marine species under the EPBC Act. Sea snakes are vulnerable to human-induced pressures because of their slow growth rates and low fecundity. In the North Marine Region, the pressure assessed as *of concern* for sea snakes is bycatch (commercial fishing). The pressures assessed as *of potential concern* for sea snakes are physical habitat modification (dredging), changes in sea temperature and ocean acidification. The conservation status of sea snakes, the significance of the North Marine Region to their survival and the pressures facing them in the region make the species a priority for conservation effort (DSEWPC 2012).

The commercial prawn trawl fishery poses the most significant threat to this conservation value within the SE Gulf planning area. Fishery collected data indicates captures of the order of 7000 - >9000 sea snakes per year by the fishery of which 50 – 80% are released alive (Burke et al. 2012). Recent trials of a Popeye FishBox bycatch reduction device (BRD) demonstrated a reduction of 87% in sea snake captures suggesting enhanced adoption of this BRD design throughout the fleet may further reduce the frequency of seasnake interactions in the Northern Prawn Fishery (Burke *et al*. 2012). Other means for improving management of impacts on sea snake include better species specific reporting of bycatch, and potential closures of areas to the fishery, including by possible declaration of a marine reserve network (DSEWPC 2012).

Assessments of the susceptibility of sea snakes to impacts associated with climate change have identified that they have a range of vulnerabilities including upper thermal tolerance boundaries, limited dispersal ability, and dependence on feeding habitats and/or prey vulnerable to storm disturbance and/or elevated sea temperatures (Fuentes et al. 2012). While there is a lack of quantitative data to provide causal linkages, there is some speculation that climate change-associated impacts may be responsible for precipitous declines and local extinctions of sea snake populations that have been recorded in other northern Australian marine regions (Fuentes *et al*. 2012).

DUGONG

(EPBC Act listed as migratory and marine)
A significant proportion of the world's dugongs occur in the North Marine Region and adjacent coastal waters. Dugongs are vulnerable to human-induced impacts as a result of their biological characteristics, such as their longevity (up to 70 years), long gestation (12–14 months), litter sizes of one, long intervals between births (up to 2.5 years) and late age at sexual maturity (6–17 years). In the North Marine Region, the pressures assessed as *of potential concern* for dugong are bycatch (commercial fishing), extraction of living resources (Indigenous harvest; illegal, unreported and unregulated fishing), marine debris, sea level rise, changes in sea temperature and physical habitat modification (storm events). The conservation status of dugongs, the significance of the North Marine Region to their survival and the pressures facing them in the region make the species a priority for conservation effort (DSEWPC 2012).

As a regional conservation value priority there are many parallels between dugong and marine turtles discussed above. Coastal waters within the SE Gulf planning area including those surrounding the Wellesley Islands and adjacent mainland support a large population of dugongs. Dugongs are extremely important for sea country Traditional Owners as a food resource and as a source of cultural identity having specific dreaming, site and totemic associations (Memmott & Channells 2004; CLCAC 2013a; CLCAC 2014a).

As per marine turtle populations Traditional Owners have expressed major concerns regarding the apparent reduction in regional dugong populations and observations of sick and poor condition individuals including underweight animals that appear to have an unusually coloured fat layer. The most recent survey of population numbers in 2007 indicated a relatively stable population with numbers recorded similar to previous surveys (CLCAC 2013a). However, since the 2007 survey was conducted Gulf river basins experienced an extreme flood event in 2009.

Other principle sources of threat for dugong within the planning area are bycatch associated with gill net fisheries, marine debris, traditional owner harvest and extreme weather impact on seagrass beds either via sediment laden freshwater flood plumes and/or cyclonic disturbances. Most of these threats have been addressed to some degree by previous regional NRM management activities particularly programs collaboratively conducted by Land and Sea Rangers and state and commonwealth agencies. However most require further investment and some require major new initiatives.

Evidence of drownings of dugong in Gulf commercial fishery gill nets is widely cited by regional coastal Gulf stakeholders, particularly sea country Traditional Owners (Appendix 1) and recreational fishers (McDonald 2011). The need for greater surveillances and enforcement of net fishery regulations intended to minimise fishery and dugong interactions provides one option for mitigating these impacts, as do the creation of seasonal or permanent fishery closures in important foraging areas for dugong (CLCAC 2014a). On the Queensland east coast Dugong Protection Areas provide an additional management framework for the protection of dugong (Coles *et al*. 2002), not utilised in Gulf commercial fisheries.

Programs quantifying Traditional Owner harvest of dugong have been initiated by Wellesley Island sea rangers (CLCAC 2013a) and require further investment effort to produce current data. This work is required to identify possible localised areas of overharvest of concern to the community but also to demonstrate total harvest lies within sustainable boundaries claimed by sea country traditional owners and to place it within a broader impact context relative to other dugong population pressures (CLCAC 2013a; CLCAC 2014).

Potentially the most significant and as yet most poorly understood or quantified source of potential impact on dugong populations concerns the inter-annual status of seagrass beds and their impact and recovery responses to extreme weather events including cyclones, flood events and extended droughts. To understand these impacts there is a need for greater integrated system understanding of the Gulf coastal zone that incorporates catchment condition and climatic drivers. These include the implications of elevated sediment loads in river basins draining to the Gulf coastal zone, other sources of contaminants associated with past and current mining industry development and the impact exacerbating potential of rising sea level and greater rainfall variability associated with climate change (Moise 2014). This need is discussed further in relation to the Gulf of Carpentaria coastal zone conservation value (below).

Gulf of Carpentaria coastal zone

(Key ecological feature)

The Gulf of Carpentaria coastal zone is a key ecological feature of the North Marine Region due to its productivity, presence of aggregations of marine life (including several endemic species) and comparatively high biodiversity. Nutrient inflow from rivers leads to higher productivity and more diverse and abundant biota in this area than elsewhere in the North Marine Region. In the North Marine Region, the pressure assessed as *of concern* for the Gulf of Carpentaria coastal zone is marine debris. The pressures assessed as *of potential concern* for the Gulf of Carpentaria coastal zone are physical habitat modification (offshore construction), extraction of living resources (illegal, unreported and unregulated fishing), changes in hydrological regimes, sea level rise, changes in sea temperature, ocean acidification and physical habitat modification (storm events). The Gulf of Carpentaria coastal zone is a priority for conservation efforts because it is a key ecological feature that supports diverse marine life, that is facing pressures assessed as *of concern* and *of potential concern*, and about which there is a lack of data (DSEWPC 2012).

This key ecological feature comprises most of the marine planning area of the SE Gulf NRM planning area. Identified pressures affecting the Gulf coastal zone are common to most of the preceding regional conservation value priorities.

While marine debris is described as a *of concern* pressure, as discussed above, an improved understanding of the origins of marine debris and its behaviour within the Gulf now provides the opportunity to progress more strategically targeted management programs (Wilcox *et al.* 2012).

Illegal, unreported and unregulated fishing affects most priority regional conservation values. As previously identified, improved management of this pressure requires more direct engagement with fishing activity via greater surveillance; reporting incentives to better quantify bycatch impacts and/or exclusion of the fishing activity by declaration of protected areas or closures that are effectively managed. The option of fishery closures or declared reserves/protected areas may represent the most viable options for limiting many fishery associated impacts and is supported by a range of regional stakeholders including conservationists, recreational fishers and sea country Traditional Owners (Appendix 1).

To better address the remaining set of pressures identified for the Gulf coastal zone i.e. changes in hydrological regimes, sea level rise, changes in sea temperature, ocean acidification and physical habitat modification associated with storm events, requires much greater integrated ecosystem understanding than currently exists for the Gulf coastal zone. This need was also previously identified in relation to the management of regional seagrass ecosystems and dependent dugong and turtle populations (above).

In recent years concerns about the potential impact of water resource development proposals within Gulf River basins have driven improved understanding regarding the linkages between basin flows and fisheries productivity. This new understanding has been utilised to improve Northern Prawn Fishery management (Burford *et al.* 2010; Halliday *et al.* 2012; Petheram *et al.* 2013a; Petheram *et al.* 2013b; Buckworth *et al.* 2013). While this understanding has progressed the capacity to examine some of the likely impacts associated with water resource development on coastal ecosystems it is still insufficiently resolved to assess flow on impacts of altered climate and rainfall patterns including extreme flow events on receiving marine environments and dependent coastal ecosystems such as seagrass. This is in contrast to eastern Queensland where integrated models of catchment condition and behaviour in conjunction with strategic river and end of system coastal monitoring has been used to progress advanced system understanding and an impact-predictive capacity for receiving coastal ecosystems of GBR catchments (Brodie *et al.* 2012; Brodie *et al.* 2013a; Brodie *et al.* 2013b).

The Gulf is unlikely to ever enjoy the level of management investment afforded to more populated and developed GBR catchments. However, the conservation and cultural values of its marine biodiversity assets and the direct economic values of its fishery assets warrant further investment in building the systems understanding required to sustainably manage its ecosystems in the face of challenges being presented by emerging land use impacts, development proposals and global warming driven climate change and sea level rise. As previously identified, predicted climate change and sea level rise (Moise 2014), poses significant impact risks to the Gulf coastal zone given natural levels of climatic variability and its low lying, low gradient coastline which is going to experience relatively rapid changes in response to seas level rise and more extreme storm events i.e. cyclones and storm surge (Pusey & Kennard 2009).

A key area to progress further understanding concerns the impact of catchment condition particularly observed elevated rates of soil erosion (Brooks et al. 2008), on basin sediment loads, coastal geomorphology and flood plume impacts on vulnerable receiving environments (e.g. seagrass). Other than periodic programs examining seagrass extent (Taylor *et al.* 2007) and localised long term monitoring conducted for industry and port operations (e.g. McKenna & Rasheed 2013), there is currently no coordinated ongoing monitoring of the Gulf coastal zone's marine environment, physical parameters or ecosystem condition. Seasonally stratified monitoring of these elements, including during extreme weather events is required to progress macro system understanding and to support more effective basin scale NRM.

8.1.4.2 Remnant Vegetation and Threatened Terrestrial Species

Examining the status of regional ecosystems within the coastal zone provides a broad indication of the condition of terrestrial biodiversity and a means of identifying threatened components that can be targeted with tailored management efforts. Unlike other regions of Queensland or Australia, a very limited extent (<0.5 %) of the Gulf's coastal zone native vegetation has been cleared (Accad *et al.* 2013).

Of 34 individual regional ecosystems (RE) of the Gulf coastal zone, only one (RE 2.2.1 'beaches and fore dunes', see Table 5) is listed as being 'of concern' in terms of its vegetation management class due to having an areal

extent less than 10,000 ha, although 89% of the pre-clearing extent remains. This RE is of particular importance to Gulf coastal and marine biodiversity assets due to its seasonal value for nesting marine turtles and the role is plays in stabilising the coastline. Twelve of the 34 regional ecosystems within the coastal zone have an 'of concern' biodiversity status due to threatening processes other than vegetation clearing (Table 8.3).

The majority of these coastal regional ecosystems with an 'of concern' biodiversity status are woodlands and wetlands including riparian forests. A range of special values are associated with them including nesting areas for marine turtles, bioregional or provincial refugia for woodland fauna and flora, significant habitat for arboreal mammals, breeding, feeding and moulting sites for waterbirds and sites important for the movement of birds, fish and reptiles (Table 8.3).

The most common threatening processes affecting coastal regional ecosystems with an 'of concern' biodiversity status are those identified in the earlier sections examining coastal land assets. For eleven of the twelve regional ecosystems high total grazing pressure is listed as a common threat. For half of the twelve regional ecosystems, invasive weed species particularly rubber vine *Cryptostegia grandiflora* is a common.

Identified threatened species include 2 wetland plants, 1 grass, 4 woodland birds, 3 wetland birds, 4 birds of prey, 1 freshwater turtle, 1 shire bird and one mammal (Table). Nominated threats affecting these listed species that are relevant to the coastal Gulf overlap significantly with those identified for host regional ecosystems and include high grazing pressure, weed infestation, feral animals, inappropriate fire regime and vehicle access / human disturbance.

Although climate change and sea level rise have not been identified during herbarium assessments of threats to the Gulf's coastal regional ecosystems, on the basis of existing observations and predictions it is apparent that both will serve to threaten these coastal vegetation communities (Church *et al*. 2012; Smith & Harper 2013; Moise 2014). These threats will be realised via accelerated retreat and increased disturbance of beach foreshores by sea level rise and extreme weather events, salinisation of near coastal wetlands via greater tidal ingress, exacerbation of grazing pressure during periods of extended dry season and failed /late wet seasons, creation of disturbance regimes and native vegetation stress favourable to weed infestation, accelerated erosion rates in conjunction with more intense storm rainfall events and elevated temperatures and extended dry periods conducive to destructive fires.

In recent years emerging evidence of global warming and climate change associated impacts on Gulf coastal zone vegetation communities have already begun to emerge. This has included breaching of freshwater coastal swale swamps by storm surge and associated die back of overstorey vegetation and greater ingress of tidal flows to freshwater wetlands (Tait 2005; Bell 2009; CLCAC 2014a). Late and failed wet seasons have also been noted to increase grazing impacts and exacerbate scalding on wetland frontages (Tait 2005), and extreme soil erosion has been attributed to more intense wet season rainfall events (CLCAC 2014a).

TABLE 5 REMNANT VEGETATION REGIONAL ECOSYSTEMS OF THE GULF COASTAL ZONE WITH 'OF CONCERN' BIODIVERSITY STATUS (SOURCE QLD HERBARIUM REDD DATABASE)

RE	Short description	Special values	Threatening Processes
2.2.1	Beaches and fore dunes	Seasonally significant for turtle nesting.	Threatening process is infestation by *Cryptostegia grandiflora* (rubber vine), *Calotropis procera, Parkinsonia aculeata, Urochloa, Cenchrus* and the impact of high total grazing pressure, high vehicle use and camping use.
2.3.9	*Eucalyptus microtheca, Lysiphyllum cunninghamii* low open woodland and *Aristida spp.* on plains and low rises of texture contrast soils and earths		Subject to high total grazing pressure during wet season leading to wind erosion and scalding.
2.3.16	Deepwater lagoons with water lilies and sedges	Permanent and seasonal wetlands. Important breeding and feeding and moulting sites for water birds and nesting sites for freshwater crocodiles.	Threatened by introduction of ponded pasture species, and by high total grazing pressures around margins particularly during dry season.
2.3.17	*Eucalyptus microtheca* woodland on channels in fine textured alluvial plains	Bioregional refuge for fauna, including macropods.	Subject to very high grazing pressure. Widespread erosion and habitat loss. Extensive invasion by buffel grass *Cenchrus ciliaris* on sandier soils. Commonly heavily invaded by *Cryptostegia grandiflora* (rubber vine).
2.3.18	*Atalaya hemiglauca and Grevillea striata* low woodland on low rises and plains on red loamy soils		Prone to scalding and wind erosion. Widespread degradation due to high total grazing pressure and invasion by exotic species.
2.3.20	*Corymbia bella, Corymbia polycarpa, and Eucalyptus pruinosa* woodland on low rises and plains on pale sandy soils	Provincial refuge for some woodland flora and fauna.	Subject to high grazing pressure, particularly during wet season and invasion by exotic species. Buffel grass *Cenchrus spp.*, displacing native species.
2.3.21	*Eucalyptus leptophleba and Corymbia spp.* woodland on low rises and plains on fine sands and red earths	Significant habitat for arboreal mammals and for animals using hollows.	Subject to degradation from high total grazing pressure, particularly in the wet season. *Cryptostegia grandiflora* (rubber vine) and *Mesosphaerum suaveolens* (hyptis).invading some areas.
2.3.24	*Melaleuca spp.* woodland-open forest on sands in channels and on levees	Provincial refuge for some fauna and flora. Important sites for feeding and movement of birds, fish and reptiles.	Subject to invasion by *Cryptostegia grandiflora* (rubber vine). Subject to high total grazing pressure leading to habitat loss and erosion. Includes within channel aquatic ecosystems.
2.3.26	*Eucalyptus camaldulensis and Nauclea orientalis* open forest fringing major tributaries	Significant provincial refuges for fauna. Includes areas of permanent water with high habitat values for aquatic and other species.	Being disturbed by feral pigs, *Cryptostegia grandiflora* (rubber vine), fishing, tourism and high total grazing pressure.
2.3.29	*Melaleuca spp.* woodland fringing depressions and broad valleys on solodised soils	Provides wetland habitat for a flora and fauna.	Floristic changes occurring due to high grazing pressure. More information required to confirm conservation status.
2.3.33	*Eucalyptus microtheca* open woodland and sedges in circular depressions in sand plains, on cracking clays	Seasonal wetland. Important feeding and moulting sites for water birds.	Subject to degradation from high total grazing pressure and damage from feral pig diggings.

2.5.16	*Melaleuca foliolosa* shrubland on dissected plains on alkaline earths and texture contrast soil	Gully erosion usually active.

TABLE 6 THREATENED SPECIES LISTED UNDER THE QLD NATURE CONSERVATION ACT (NCA) OR COMMONWEALTH ENVIRONMENTAL PROTECTION AND BIODIVERSITY CONSERVATION ACT (EPBC) RECORDED OR PREDICTED* TO OCCUR WITHIN THE COASTAL LANDS OF THE NIJINDA DURLGA IPA (CLCAC 2014A)

Wetland Plants	**Bog Figwort (*Rhamphicarpa australiensis*): a herb to 0.4m – near threatened under the NCA** ***Fimbristylis adontocarpa*: a sedge – near threatened under the NCA**
Grass	*Ectrosia blakei* – vulnerable under the NCA
Woodland Birds	Gouldian Finch (*Erythrura gouldiae*) – endangered under the NCA and EPBC Purple-crowned Fairywren (*Malurus coronatus*) vulnerable under the NCA *Pictorella Manikin (*Heteromunia pectoralis*) – near threatened under the NCA *Golden-backed Honeyeater (*Melithreptus gularis laetior*) – near threatened under the NCA
Wetland Birds	Little Tern (*Sternula albifrons*) – endangered under the NCA Jabiru (*Ephippiorhynchus asiaticus*) – near threatened under the NCA *Australian Painted Snipe (*Rostratula australis*) –vulnerable under the NCA and EPBC; *Radjah shelduck (*Tadorna radjah*) – near threatened under the NCA.
Birds of Prey	*Red Goshawk (*Erythrotriochis radiatus*) – endangered under the NCA *Grey Goshawk (*Accipiter novaehollandiae*) – near threatened under the NCA *Grey Falcon (*Falco hypoleucos*) – near threatened under the NCA *Square-tailed Kite (*Lophoictinia isura*) – near threatened under the NCA
Shorebirds	Beach Stone Curlew (*Esacus magnirostris*) – vulnerable under the NCA *Eastern Curlew (*Numenius madagascariensis*) – near threatened under the NCA
Freshwater Turtle	Gulf Snapping Turtle – endangered under the NCA and EPBC
Mammal	*Northern Quoll (*Dasyurus hallucatus*) – endangered under the EPBC

8.1.4.3 Waterbirds and Migratory Shorebirds

Wetlands within the SE Gulf planning area seasonally host globally significant aggregations of migratory shore birds and nationally significant populations of breeding water birds (Kingsford *et al*. 2013), and provide another example of SE Gulf regional biodiversity assets that carry national and international conservation responsibilities.

The concentration of migratory shorebirds found within wetland aggregations of the SE Gulf represent the largest in the East Asian-Australasian Flyway and are higher than anywhere else in Queensland (CLCAC 2014a). At least half of the state's shorebirds pass through or spend extended time in the area from September to April each year and, importantly, high numbers of young birds or non-breeding adults also over-winter here (Garnett 198; Driscoll 2001). Many of the recorded species are listed under international agreements including 22 species under JAMBA *Japan–Australia Migratory Bird Agreement* and 31 species listed under CAMBA *China-Australia Migratory Bird Agreement* (Blackman *et al*. 1999). Listing under these agreements protects these species under the Commonwealth's EPBC Act provisions afforded to migratory species (DSEWPC 2012).

The Gulf Plains supports the main (and perhaps only) breeding populations of the vulnerable Sarus Crane and more than 1% of the global population of twelve species (Brolga, Black-tailed Godwit, Great Knot, Eastern Curlew, Sharp-tailed Sandpiper, Lesser Sand Plover, Grey-tailed Tattler, Little Curlew, Pied Oystercatcher, Broad-billed Sandpiper, Red-necked Stint and Black-winged Stilt), the near-threatened Australian Bustard and nine savannah biome restricted species (CLCAC 2014a).

The significance of bird populations within SE Gulf wetlands means they meet the Ramsar criteria for wetlands of International importance (Blackman *et al*. 1999), and provides an impetus for Australian Governments both state and Federal to provide for their protection. A National Plan for Shorebird Conservation in Australia, recognised by the Federal Government, identifies the SE Gulf of Carpentaria as being of outstanding importance to shorebirds (Watkins 1993). For regional NRM bodies this provides opportunities for securing Government funding support toward targeted bird conservation management initiatives which can also be used to serve broader wetland management outcomes.

Most of the significant wetland aggregations hosting these bird populations have been identified via their description and listing in the *Directory of Important Wetlands in Australia* (DIWA) discussed below, although suitable wetland habitats are also more widely distributed across the coastal zone. Management actions targeting the protection and sustainable management of DIWA wetlands (below) and wetland habitat generally provide a suitable focus for meeting many of the conservation needs of water birds and migratory shore birds (Tait 2005). In the SE Gulf, none of the wetlands supporting these globally significant populations of shorebirds and waterbirds are protected within conservation areas and "protection of these sites should be given the highest priority" by Governments (CLCAC 2014a).

The primary protective management needs for SE Gulf DIWA wetlands (discussed below) are initiatives that will decrease the pressures they face from the impact of high total grazing pressure and associated weed infestation, soil erosion and water quality impacts. Feral animals also present significant threats to wetland habitat quality (Tait 2005). Specific threats to coastal shoreline and beach habitats utilised by threatened resident species include predation and trampling of eggs and nests by feral animals and disturbance by beach traffic and tourist campers (CLCAC 2014a). Sea level rise is also predicted to place shorebird habitats at risk (Chambers *et al.* 2012), and will impact low-lying and near coastal wetland habitats of dependent species though the full implications for dependent water birds species in terms of habitat resource availability are hard to predict.

During consultations with regional tourism operators, the SE Gulf's significant shorebird, waterbird and woodland bird populations were nominated as regional biodiversity values that present significant opportunities for eco-tourism development. Development of these values may provide synergistic opportunities for projects and programs that also serve to deliver improved protection outcomes for the wetland and woodland ecosystems on which they depend.

8.1.4.4 Directory of Important Wetlands in Australia (DIWA) Wetlands

The Northern Gulf NRM region contains 3 DIWA wetlands, of the 851 listed wetlands in Australia (**Error! Reference source not found.**). A further 18 DIWA wetlands occur in the broader Gulf plains bioregion (Blackman *et al.* 1999).

TABLE 7: CRITERIA MET BY DIWA WETLANDS WITHIN THE SE GULF COASTAL AND MARINE PLANNING AREA

Basin(s)	DIWA wetland	Criteria
Norman - Mitchell	Southeast Karumba Plain Aggregation	1,2,3,4,5,6
Settlement - Norman	Southern Gulf Aggregation	1,2,3,4,5,6
Gilbert	Macaroni Swamp	1,2,3

The most significant DIWA wetland aggregations within the SE Gulf planning area are Southeast Karumba Plain Aggregation, which has been described as '*the best developed coastal wetland aggregation in Queensland, possibly Australia*' (Blackman *et al.* 1999). This wetland exerts a major influence on nutrient flow into the Gulf coastal zone (Wolanski 1993).

The ecological values of this coastal wetland include:

- Provision of habitat for threatened marine mammals (dugong) and reptiles (sea turtles);
- Seasonally rich post breeding roosting and feeding habitat for waterbirds;
- Largest winter populations of migratory shore birds in northern Australia;
- Cultural significance to traditional owners;
- Nursery habitat for commercial and recreational fish, crab and prawn fisheries.

An important aspect of these marine influenced coastal wetland aggregations is the role of catchment flows in the maintenance of their geomorphological and ecological character. While some receive water supply from local run off, the majority depend on river discharge and overbank flows for surface supply, groundwater aquifer replenishment and the maintenance of required salinity regimes (Hydrobiology 2005). This means their values and character is vulnerable to changes to hydrological regimes that may be associated with proposed river basin water resource

developments (Petheram *et al*. 2013a; Petheram *et al*. 2013b) or predicted changes in rainfall behaviour associated with climate change (Moise 2014). Being low-lying, most will also be subject to significant impacts and changes of character due to sea level rise currently predicted to be in the order of 0.28–0.83m by 2090 (Moise 2014). Evidence of sea level rise and storm surge impacts affecting the character of DIWA wetlands is already being observed within the Southeast Karumba Plain Aggregations (Tait 2005; Bell 2009).

8.1.4.5 Protected Areas

Australia is a signatory to the International Convention on Biological Diversity which has a 2020 target of 17% representation of member country area in protected areas (NRMMC 2009). Australia currently has 15.45 % and Queensland 7.49% of its area represented in protected areas (CAPAD 2012). However representation of the Gulf of Carpentaria Drainages Division within protected areas is only 3.8%, the third lowest of all Queensland drainage divisions. Nationally, SE Gulf aquatic and terrestrial biogeographic regions have been found to be some of the most poorly represented in protected areas and the Karumba Plains subregion that comprises the terrestrial component of the coastal zone has been assessed as a high priority area for consolidating Australia's protected area system, with only one Conservation Park - the Mutton Hole Wetlands, adjacent to Normanton (NLWRA 2002c; Tait *et al*. 2003). Operating under the auspices of the Northern Australia Aquatic Ecological Assets Project, Kennard *et al* (2010; 2011) and Hermoso *et al* (2011) produced systematic conservation planning based assessments of protection priorities within the Northern Australia Water Futures Assessment (NAWFA) area. This assessment identified numerous high value aquatic biodiversity conservation assets outside the existing protected area network in the Gulf drainage division including sites within the SE Gulf planning area.

Securing and improving the condition of existing protected areas is a prudent biodiversity investment priority for regional NRM plans. Identifying further opportunities to protect high conservation value biodiversity assets and ways to improve the comprehensiveness, adequacy and representativeness of marine and terrestrial protected areas within the Gulf coastal and marine zone would also serve the effective delivery of biodiversity conservation.

The protection of areas for biodiversity conservation provides an opportunity to reduce a range of anthropogenic pressures including those associated with commercial activities such as total grazing pressure, commercial fishing, vegetation clearing and development. However, pervasive threats associated with feral animals, weeds, fire regime management and climate change do not recognise land tenure boundaries and require ongoing management to secure biodiversity within 'protected areas'. Protection of terrestrial and marine ecosystems within protected areas is however recognised to provide enhanced resilience against a range of pervasive threats and is recommended as an adaptive strategy for emerging climate change pressures (Kingsford 2011; Williams *et al*. 2012).

8.2 SUMMARY OF THREATS TO COASTAL AND MARINE ZONE ASSETS

The aims of this section are to summarise the identified key threats across assets, and to identify thematic needs and priorities that provide opportunities to progress strategic regional NRM responses.

8.2.1 River Basin Management

The management of river basins that drain to the coastal and marine zone has a potentially important influence on receiving ecosystem condition due to dependent biophysical processes that link inland ecosystems with coastal and marine ones (GBRMPA 2012b). These processes include landscape water balance and associated flow patterns, soil erosion and associated sediment and nutrient loads, primary production, nutrient cycling and associated material exports and biota recruitment and movement. Key drivers of these processes include vegetation cover and condition, land use patterns and practices and entrained landscape degradation (NLWRA 2002a).

Most of the river basins draining to the SE Gulf coastal and marine zone originate hundreds of kilometres inland. Extensive rangeland grazing on native pastures is the dominant land use and there has been very limited clearing of native vegetation cover (Accad *et al*. 2013). There has also been only limited water resource development in terms of dam construction and water extraction from these Gulf River basins (Hydrobiology 2005; Queensland Government 2011), although current proposals exist to develop water resources for irrigated agriculture (Petheram 2013a). Intensive (although spatially constrained) development in the form of metalliferous mining also occurs within most SE Gulf river basins (SGC 2005; NGRMG 2008).

The principle threats to coastal and marine zone assets emanating from existing and proposed patterns of river basin land use, development and management include:

- Elevated rates of soil erosion driven by total grazing pressure, reduced ground cover and entrained gully erosion. Erosion resulting in increased basin sediment loads and associated river and receiving environment water quality decline and geomorphic changes;
- Alteration of river basin flow patterns due to water resource development and/or impacts to landscape water balance;
- Degradation of river or receiving ecosystem water quality due to elevated turbidity (above) or contaminants associated with mining or agricultural industry in contributing river basins;
- Instream barriers associated with water infrastructure, road or rail crossings or reach conditions limiting migratory biota access between coastal and marine and riverine habitats; and
- Distribution of feral animal or weed species from upper catchment source localities to the coastal and marine zone (discussed under invasive and feral species below).

Current information on the extent and severity of many of these threats is limited for SE Gulf river basins (discussed below). One of the principle needs identified to better inform river basin management is greater system understanding. While understanding of the linkages between river basin management and the condition of assets in the receiving coastal and marine zone has been progressed for other regions of Queensland e.g. Moreton Bay (Denninson & Abal 1999) and the GBR catchments (Brodie *et al*. 2012; Brodie *et al*. 2013a; Brodie *et al*. 2013b), such understanding is still rudimentary for the SE Gulf despite the significant value of its natural resource assets.

8.2.1.1 Soil Erosion and Sediment Loads

There has been long standing recognition that soil erosion is a significant land degradation issue within SE Gulf river basins (DPI 1993). More recent assessments have served to quantify the extent of the issue at basin scales, the importance of gullies and sub-soil profiles as sediment load sources and the initiation and exacerbation of the problem

in conjunction with increases in regional cattle herds and total grazing pressure (Tait 2005; Brooks *et al*. 2008; Shelberg *et al*. 2010).

While soil erosion is in itself a significant land degradation issue that can directly impact asset condition (i.e. wetland and riparian frontage habitats – discussed below), it is its contribution to increased sediment loads conveyed by river flows that define it as a significant threat to coastal and marine zone assets. Increased sediment loads have the capacity to drive a range of geomorphic changes in receiving environments, but more importantly contribute to turbid flood plumes being discharged to and impacting on coastal ecosystems during wet season flood events (Brodie *et al*. 2012; Brodie *et al*.2013a; Brodie *et al*. 2013b).

Seagrass meadows and fringing coral reefs are widely recognised for their sensitivity to increased water turbidity. The distribution of fringing reefs within the Gulf coastal zone is partially attributed to coastal water turbidity regimes and flood plume reach (SKM 1996). In the SE Gulf, turbid flood plumes linked to catchment erosion and extreme weather events have been implicated in the loss of coastal sea grass meadows and flow on impacts to dependent dugong and green sea turtles (CLCAC 2013a; CLCAC 2014a, Appendix 1). Given its potential to affect other biota (i.e. algae), primary productivity and nutrient dynamics, changes in basin sediment load and turbidity regimes in coastal Gulf receiving environments could also impact other aquatic ecosystems e.g. freshwater and estuarine habitats and fisheries productivity.

Currently there is insufficient understanding or monitoring of soil erosion and sediment loads within Gulf river basins, or of turbidity and ecosystem responses within the coastal zone to draw firm conclusions on the significance of the threat it poses to coastal and marine assets. The relationship between current levels of threat and the historical context and how this may be affected by predicted increases in extreme weather events and sea level rise (Moise 2014), are other important questions that need to be addressed to inform strategic NRM responses.

8.2.1.2 River Flows

Following on from the discussion above regarding risks posed to coastal and marine assets by turbid flood plumes, river basin flows have long been demonstrated to be a key driver of coastal and marine ecosystem processes and asset condition. Knowledge of the linkages between Gulf river flows and coastal processes has primarily been driven by a desire to better understand the flow dependent quotient and mechanisms driving coastal fisheries production and by concerns of the potential impact of water resource development proposals within Gulf River basins (Burford *et al*. 2010; Halliday *et al*. 2012; Petheram *et al*. 2013a; Petheram *et al*. 2013b; Buckworth *et al*. 2013). Predicted impacts of climate change on climatic variability and the hydro cycle, including the increased possibility of both extended droughts and more intense rainfall events (Moise 2014), also raise the likelihood that some climate change impacts will be realised via altered river flow regimes.

Water resource development proposals for SE Gulf river basins include proposals for the Flinders River Basin that could result in a reduction of 14 % of mean annual and 28 % of median flows (Petheram *et al*. 2013a), and two proposals for the Gilbert River basin that could result in (1) reductions of up to 14 % of mean annual or 20 % of median flows (Petheram *et al*. 2013b), or (2) reduction of 8.8% of mean annual flow at the Gulf (IFED 2013).

Reductions of this magnitude in river mean annual flows to the Gulf of Carpentaria are likely to impact on estuarine and coastal fisheries production, a risk acknowledged by proponents and natural resource assessments conducted for these proposals (IFED 2013; Petheram *et al*. 2013a), and supported by research findings on linkages between wet season flows and Gulf fishery production (Burford *et al*. 2010; Halliday *et al*. 2012; Buckworth *et al*. 2013).

Both the magnitude and duration of flows has been identified as important to fisheries and modification of either is likely to impact fisheries productivity (Burford *et al*. 2010). The importance of flood-generated inundation of coastal salt flats providing a source of carbon and nutrients to fuel productivity in estuaries and near shore areas is a relatively new finding (Burford *et al*. 2010), and one that needs to be included in flow impact assessments. Given the ultra-low gradient of Gulf rivers, small changes in flood flows could translate into significant changes in areas of floodplain and/or coastal flat inundation (Petheram *et al*. 2013a).

Fishery production responses to reduced flows are unlikely to be linear. Examination of catch statistics for the Northern Prawn Fishery (NPF) indicate the *Bold* catch statistical area recorded the greatest annual Banana Prawn catch within the entire NPF in 2010-2011, representing approximately 20% of the entire catch (Barwick 2010). The *Bold* statistical area coincides with the *Karumba* sub stock of Banana prawns (Buckworth *et al*. 2013), and covers the mouths of the Gilbert, Flinders and intervening Norman River basins. Collectively these three river basins contribute 43% of mean annual flow to the southern Gulf (NLWRA 2000). Potential impacts to the prawn fishery associated with any reduction of flows in the Flinders and Gilbert Rivers may therefore have a disproportionate impact on the NPF as a whole.

Considerations of potential future impacts on river flows also need to be cognisant of the likelihood of cumulative effects of climate change exacerbating those associated with water resource development. More extreme patterns of rainfall including extended periods of drought predicted and being observed in association with climate change is recognised to impact fisheries production (Gillson 2011).

While this discussion on the potential threat posed by altered river flows has primarily considered fishery assets, identified causal linkages operate by ecosystem processes that affect other aquatic ecosystem and biodiversity assets e.g. freshwater wetlands, estuaries and sea grass systems and dependent biota. A Queensland government project has examined critical flows needed to maintain both spatially defined wetland assets and more broadly defined hydro-ecological processes within these SE Gulf river basins (Clayton & Talbot 2010). This project found that technical understanding of most of the examined ecosystems assets (wetlands and processes), and of the mechanisms and consequences of the flow related threats was too immature to develop current notions of asset and threat into ecological threshold and planning outcomes (Kennard *et al*. 2011). For a small number of flow related threats where further interpretation and assessment depended on available data (gauged hydrological data, flood modeling, water quality), opportunities to progress ecological thresholds as a planning tool were identified (Clayton & Talbot 2010).

These findings point to the need for further development of an ecosystems-based understanding of Gulf river basin flow regimes and downstream flow-dependent asset condition that incorporates not only direct flow based linkages but also indirect linkages that occur via water quality, productivity and geomorphic effects.

8.2.1.3 WATER QUALITY

At least three sources of water quality threat to SE Gulf coastal and marine assets have been identified through the examination of asset status. These include:

1. Increased turbidity (and possibly bound nutrients) associated with elevated rates of soil erosion and sediment loads within contributing regional or local catchments (discussed above);
2. Metals and other mining industry associated contaminant loads sourced from past or current mining development and infrastructure including mine sites, waste retention facilities and concentrate transporting and processing facilities;
3. Contaminant loads in run-off from existing (currently limited to upper Mitchell and Gilbert basins) or proposed agricultural development including nutrients and agri-chemical residues.

As identified previously, (1. above) increased turbidity in receiving coastal waters presents potentially the greatest threat to coastal and marine assets, though concerns regarding (2) mining industry sourced contaminants, are consistently raised by stakeholders and warrant concern given regional (albeit localised) examples of chronic water quality impacts e.g. Redbank Mine and regional scale inundation and breaching of multiple mining waste retention facilities associated with the 2009 wet season floods (CLCAC 2014a). Localised water quality impacts associated with issue (3) have been demonstrated in the upper Mitchell Basin (NGRMG 2008), but generally this issue is more a potential concern associated with proposed development (particularly for the Gulf's '*clean green wild caught fisheries*') rather than a realised one.

Existing water quality monitoring programs, data or available information to serve the quantification of water quality threats to coastal and marine assets is currently very limited (Burrows 2004: SoE 2011). Providing relevant, accurate and trusted water quality data and accessible information is a role that has been nominated for regional community NRM organisations by regional stakeholders (Appendix 1). To fulfill this role would require both collation of existing data and information from government, industry and community sources and targeted investment in new monitoring

activities. While collation of existing data into a GIS database is recommended as a priority action for regional NRM bodies, the resources required to implement additional water quality monitoring activity across such a vast region including marine areas is beyond that available to community NRM organisations. However, regional NRM bodies such as SGC and NGRMG have a valuable role to play in identifying strategic monitoring needs and brokering government agency and industry support for further targeted investment in catchment and coastal water quality monitoring efforts. Previous studies e.g. Burrows (2004), have identified water quality monitoring approaches and parameters that could be used to address some of the key information needs for the SE Gulf region.

8.2.1.4 CONNECTIVITY

Aquatic habitat connectivity is a threat to both fishery and biodiversity assets of the Gulf coastal and marine zone. Unlike many other more developed regions of Australia where river barrages and tide gates present connectivity impacts within the coastal zone, most of the connectivity threats in the form of fish passage barriers identified within the SE Gulf region occur on river reaches inland of the defined coastal zone (Marsden & Stewart 2005; Tait 2005).

The principle threat posed by passage barriers is reduced access to suitable upstream habitat and consequent reduction in population size of migration-dependent species. The main amphidromous species associated with the coastal zone identified to be at risk from passage barriers include two key fishery species barramundi *Lates calcarifer* and Giant river prawn AKA Cherabin *Macrobrachium spinepes,* and the protected and vulnerable freshwater sawfish *Pristis pristis*. However, many more freshwater fish species recorded from SE Gulf river basin have estuarine or marine life stage dependencies and consequently barriers also present threats to their populations (Allen *et al.* 2002; Hydrobiology 2005; Hogan & Valance 2005; Burrows & Perna 2006).

While the impacts of passage barriers and potential mitigation options are well understood for some species such as barramundi, for larger-bodied species such as sawfish and other taxa such as freshwater crustaceans, understanding and mitigation option are less well developed. For sawfish this limitation can partially be attributed to a lack of effective survey methods and/or effort for freshwater populations including above potential passage barriers. For cherabin the lack of understanding stems from a failure to recognise them as a catadromous species or one that may be threatened by passage barriers. Anecdotal reports from regional stakeholders suggest that cherabin populations in the upper reaches of river systems affected by passage barriers have reduced in the period since the construction of barriers (Appendix 1).

Many of the passage barriers identified within SE Gulf river basins have been rectified to some extent by incorporation of fishways (Marsden & Stewart 2005; CLCAC 2014a). However, stakeholder concerns remain regarding the effectiveness of these fishways (particularly for large-bodied species such as sawfish), barriers that have not been rectified by fishways and the potential for creation of additional barriers in conjunction with water resource development (Appendix 1). One of the identified limitations of existing assessment methods for fishway success is that it is usually focused on counting rates of fish movement through fishways (e.g. Stuart & Berghuis 2002) rather than through stream reaches above and below fishways, that could be used to inform the success of passage rates in terms of background natural system levels.

Strategic areas for further investment in the management of the threat posed by connectivity barriers to coastal and marine assets include:

- GIS based inventory of all passage barriers within SE Gulf river basins and development of a regionally prioritised works program for rectification, equivalent to what has been done for other north Queensland NRM regions i.e. NQ Dry Tropics (Carter *et al.* 2007);
- Barrier independent monitoring of fish (and amphidromous crustacean) passage rates in reaches above and below barrier structures;
- Development and implementation of survey methods for freshwater sawfish populations, including within suitable habitats stratified across systems affected or not affected by potential passage barriers;

- Further assessment of the barrier passage capacity, behavior and fishway design requirements of large-bodied fish species particularly freshwater elasmobranchs, including the vulnerable freshwater sawfish *Pristis pristis*.

8.2.2 Coastal Land Use and Management

While river basin management issues that pose potential threats to the coastal and marine zone (discussed above) include management of land resources extending to the inland margin of the SGC and NGRMG planning regions, coastal land use and management within the defined coastal zone represent a specific NRM focus for the protection of coastal and marine zone assets.

As identified in the description of coastal land assets the predominant land use in the coastal zone is extensive rangeland grazing on unimproved native pastures, with a significant area also dedicated to Indigenous Protected Areas or IPAs (CLCAC 2013a; CLCAC 2014a). NRM strategies that contribute to both the improved ecological sustainability of coastal grazing enterprises and the sustainable management of IPAs will collectively serve the delivery of NRM over much of the defined coastal zone. While the threat posed by total grazing pressure is associated with pastoral lands, most others including fire regime, weeds and feral animals are pervasive and common to all coastal lands.

Lands of the coastal zone also host limited areas of more intensive land uses including settlements, industrial ports and tourism. The management of these activities also provides a focus for regional NRM planning albeit on focused nodes of the region.

8.2.2.1 Total Grazing Pressure

Issues surrounding the sustainable management of grazing land use are covered within other sections of the regional NRM plan. The specific focus here is on identifying coastal and marine zone assets threatened by total grazing pressure and strategic NRM responses applicable to the coastal zone.

High total grazing pressure has been identified as an active direct threat to the condition of all coastal land types (*Section* 8.1.1), half of the described aquatic ecosystem types (*Section 0)* and half of the identified coastal and marine biodiversity assets (*Section 0)*. High total grazing pressure on coastal lands also presents indirect threats to many other aquatic ecosystem and biodiversity assets via its contribution to soil erosion and increased turbidity in receiving waters and by its promotion of weed infestation.

It is generally accepted that the size of the cattle herd within the SE Gulf region has increased substantially over the last half century and that management measures pursued in recent decades to more evenly distribute grazing pressure on properties e.g. land type fencing and watering point provision have also facilitated an overall increase in total herd size and grazing pressure (Tait 2005; Shellberg *et al.* 2010).

There are at least two broad non-exclusive NRM strategies that could be pursued to reduce the threat posed by high total grazing pressure on coastal and marine zone assets.

1. Reductions in overall herd size and total grazing pressure; and
2. Reduction of total grazing pressure on identified high value assets.

Some grazier stakeholders within the coastal zone have nominated reductions in herd size as an economically viable strategy that can reduce pressure on pasture and land resources while facilitating increased weight gains for individual beasts and overall enhance enterprise profitability (Appendix 1). Conduction and promotion of case studies that documented the economic merits of such management strategies on coastal land types could provide an incentive for broader adoption of reduced stocking rates on coastal pastoral properties. The provision of material or financial incentives for targeted asset protection benefits could also have a role to play in the uptake of herd size reduction based management strategies.

Within coastal pastoral properties some regional ecosystems types including wetlands, beach ridges, salt couch grasslands and beach foreshores and their dependent biota are spatially or seasonally more susceptible to total grazing pressure impacts than the remainder of the property. Such assets can potentially be afforded protection via

fencing configurations and seasonally varied and conservative stocking regimes and spelling (Tait 2005). In the past, regional NRM bodies have provided material and financial incentives for stock excluding riparian fencing on Gulf River systems. Extending such incentive programs to the fencing of higher value coastal land assets would serve their protection and as a program proposal has indicative support from consulted coastal graziers (Appendix 1). Ideally such a program would be progressed in conjunction with other management measures that integratively addressed other pervasive threats including fire regime, weeds and feral animals.

To strategically deliver such a program, resource assessment and planning could be undertaken by regional NRM bodies to target incentives and program support at pastoral properties identified via GIS based mapping and data collation to host:

- DIWA wetlands (*Section* 0)
- Threatened fauna populations (*Section* 8.1.4.1)
- 'Of concern' regional ecosystems (*Section* 0)
- Significant population of water birds or migratory shore birds (*Section* 0), or
- Highly vulnerable/degraded (actively eroding) land types.

Participatory learning/monitoring programs that engage pastoral landholders in actively monitoring the condition of assets vulnerable to total grazing pressure could also provide a useful tool for building their capacity to better manage vulnerable biodiversity assets. A simple wetland assessment and monitoring pro-forma (SWAMP) utilising digital camera-based photo point monitoring of wetland systems was proposed by Tait (2005) for this purpose and warrants re-examination for current management needs.

8.2.2.2 FIRE

General issues concerning sustainable fire regime management are covered within other sections of the regional NRM plan. The specific focus here is on identifying coastal and marine zone assets threatened by inappropriate burning and strategic NRM responses applicable to the coastal zone.

Inappropriate fire regimes particularly hot, late dry season burns are recognised to pose threats to a number of threatened coastal terrestrial species (*Section* 0), fire-sensitive regional ecosystems including swale vine thickets, riparian, wetland, saltmarsh, marginal mangrove and beach foreshore communities (CLCAC 2013b, *Section* 0), and impacts the resilience of coastal plain grasslands (*Section* 0). Inappropriate burns can also generate secondary impacts via increased exposure of affected lands to soil erosion, destabilisation of beach foreshore, and dune areas, increasing grazing pressure on residual fire refugia, and by altering beach sand temperature regimes (potentially affecting marine turtle egg incubation) via impacts to overstorey canopies.

Fortunately appropriate fire management guidelines have been developed for the SE Gulf coastal savannahs to help land managers plan hazard reduction burns and for undertaking planed burns for improved production and conservation outcomes (CLCAC 2013b). Indigenous Land and Sea Ranger programs have initiated controlled burning-based management of IPAs and other accessible traditional country areas (CLCAC 2014a; CLAC 2014b; CLAC 2014c). Further adoption of these guidelines and implementation of appropriate burning practices across the coastal Gulf would significantly reduce the threat posed to coastal assets by fire. Impasses to further adoption of controlled burning include conflict with pastoral production objectives e.g. burning can reduce the availability of late dry season pasture reserves. Conflict can also arise between burning practices pursued for weed (e.g. rubber vine) control and conservation of fire-sensitive biodiversity values.

Initiatives that could serve to support improved fire regime management in the SE Gulf coastal zone have been identified by the review of asset condition and consultation with regional stakeholders (Appendix 1), and include:

- Further promotion and distribution of the fire management guidelines that have been developed for the SE Gulf coastal savannahs (CLCAC 2013b);

- Supporting Land and Sea Ranger program capacity to continue and expand controlled burning programs on protected areas and accessible traditional lands and to act as service providers for other land managers wanting to implement controlled burns;
- Including fire regime management objectives in management agreements with pastoralist recipients of material or financial incentives for coastal land weed, total grazing pressure and biodiversity management.

8.2.2.3 TOURISM

The tourism industry within the SE Gulf planning area is discussed elsewhere within the regional NRM plan and in the description of coastal and marine zone assets (see Regional Drivers Chapter, section 5.3). While nature-based tourism is a valued industry within the SE Gulf and provides important employment and economic opportunities for residents, a number of natural resource impacts or threats are attributed to the industry. The significance of the industry as a source of potential threat to assets of the coastal and marine zone relates to the fact that coastal areas particularly those providing recreational fishing opportunities (Section 8.1.3.1), are one of the major drawcards attracting tourists to the region (Greiner *et al.* 2009). NRM issues and threats associated with management of the industry include:

- High levels of seasonally or spatially concentrated and potentially unsustainable recreational fishing effort (discussed under fisheries below);
- Poor understanding of fisheries regulations including for protected species (e.g. freshwater sawfish) and associated take of under-sized fish, excessive bags and protected species;
- Uncontrolled and/or illegal access to culturally or environmentally sensitive areas (e.g. beach foreshores) and associated disturbance of areas by 4WD vehicle traffic, camp site establishment, spreading of weeds or illegal hunting/fishing; and
- Concentrated camping pressure at accessible sites and associated sites disturbance, waste disposal and littering issues.

NRM strategies that could be employed to reduce potential impacts of the tourism industry on coastal fisheries are discussed under fishery threats (below). Other strategies to mitigate potential threats of the tourism industry identified through the assessment of asset status and stakeholder consultation include:

- Facilitating increased controlled access to additional sites within the Gulf coastal zone. The tourism industry within the Gulf coastal zone currently operates via a limited number of more accessible nodes associated with the coastal settlements of Karumba and Burketown. Provision of improved access to additional coastal locations including via the realisation of Traditional Owner aspirations for tourism enterprise development (CLCAC 2014a), could serve to distribute visitor pressure away from sites where impact issues associated with carrying capacity are emerging.
- Establishing Gulf savannah knowledge interpretive center(s). Many tourism operators suggest that inappropriate tourist behavior and associated impacts stem from a general ignorance concerning the Gulf coastal zone and its environmental sensitivities. Greater availability of appropriate interpretive information concerning the coastal Gulf's environment possibly via establishment of dedicated interpretation centres is nominated as a means of addressing this need.
- Expanding the nature-based foundations of the Gulf's tourism industry. Much of the existing tourism to the Gulf is focused around recreational fishing. The extractive nature of this form of tourism can lead to localised resource impacts and concerns for local residents around issues of local fishery depletion. Some Gulf tourism operators have suggested that there are many untapped non-extractive segments of the nature-based tourist market that could be sustainably developed utilising assets of the region e.g. bird watching, cultural tourism, nature appreciation. NRM initiatives that provide support for these segments of the tourism industry could serve to reduce some of the current sources of threat and conflict associated with the industry.
- Engaging or establishing ranger programs for the regulation of tourist camping and access arrangements. The Gulf tourism industry is substantially based around 4WD visitation and 'free bush camping' is an aspiration of many visitors and opportunities to do it are eagerly taken or even illegally made. Currently there is very limited enforcement of local government bylaws pertaining to access rights or camper behavior. Establishment

of camping permit fee for service ranger programs to oversee the management of undeveloped camp sites is a commonly cited need (Appendix 1).

8.2.2.4 Settlements, Port and Industrial Development

While the broader NRM planning region includes a number of larger settlements and other areas of more intensive land use including irrigated agriculture, mining and industrial development (e.g. Mt Isa), intensive land use and industrial development within the SE Gulf coastal zone is limited to a small number of settlements and a zinc concentrate pipeline and associated processing plant and shipping port development at Karumba.

Given the limited extent of more intensive land uses within the Gulf coastal zone, the current threat posed to natural resource assets by intensive land use is also limited, although potentially locally significant. The industrial nature of the main material shipped from the Karumba port (zinc metal concentrate) does expose operational environments to potential metal toxicity risks which could in the case of a catastrophic spillage extend beyond the site scale. Active mineral exploration leases immediately adjoining and within some areas of the coastal zone including for uranium, highlight the potential for intensive land use management issues to become more significant if developable resources are identified (CLCAC 2013a). A multiple use strategic plan for the Southern Gulf of Carpentaria prepared for the Queensland Department of State Development (Environment North 1999) examined a range of regional marine and coastal planning issues that needed to be considered in developing industrial port and shipping operation in the Gulf.

Currently identified threats to coastal and marine assets and NRM issues related to more intensive land uses within the coastal and marine zone include:

- The impacts and sustainability of dredging operations used to maintain the Karumba Port, with the primary concerns related to the potential for accelerating Norman River channel bank erosion and dredge spoil disposal impacts on receiving environments. Conversely, stakeholders also hold concerns that cessation of such operations could lead to a loss of flood protection currently afforded to Karumba by the dredged and deepened Norman River channel (Appendix 1);
- The potential for impacts associated with expansion of shipping activity at Karumba Port or new port establishment elsewhere in the coastal Gulf in association with further development of the port or the hinterland's mineral resources;
- Concerns that heavy metals may or have been released to the environment via zinc concentrate dewatering processes at Karumba or via spills from concentrate ships (with some regional stakeholders referring to anecdotal reports that this has occurred);
- Local government planning and infrastructure development resulting in local scale impacts to threatened biodiversity;
- Potential impacts to coastal features and processes due to proposed engineered structure responses to sea level rise and storm surge risks; and
- Contributions to climate change and associated impact risks via carbon emissions generated by regional settlement dependence on fossil fuel based power generation.

Addressing the planning and management needs associated with the siting and impacts of more intensive land uses is generally beyond the remit and resources of community-based NRM organisations. However, regional NRM bodies can play an important role in identifying community concerns, facilitating representative communication of these concerns to planning and management agencies and via strategic investment in the identification of asset values, impact risks and management needs.

Opportunities for NRM bodies to address the real or perceived threats the community has for coastal and marine assets associated with more intensive land uses include:

- Engagement with industry bodies and port authorities to ensure data collected by impact monitoring programs is available and more actively disseminated to community;

- Contributing to the establishment of independent water quality and marine environment monitoring programs that have publically available reporting outputs;
- Targeted collection and collation of biodiversity value information at a scale relevant to inform local government planning schemes with a particular emphasis on areas subject to more intensive land uses;
- Supporting the establishment of regional technical expertise panels or fora to support local government bodies beyond normal budgetary cycles to: assess sustainable energy options for remote communities; and for examining issues associated with infrastructure needs, potential engineered responses and impacts associated with climate change, sea level rise and increased storm surge intensity.

8.2.2.5 Feral Animals

With few exceptions including exotic fish, some birds and possibly foxes all invasive feral animal species recorded within the broader SE Gulf planning area also occur within the Gulf coastal zone (CLCAC 2014a). Some additional species, e.g. Asian Water Buffalo, are also recorded from the coastal Gulf while others, e.g. feral horses may attain their greatest population densities within it.

The most significant invasive animal species in terms of identified threats to coastal and marine assets include the feral pig (*Sus scrofa*), horse (*Equus cabbalus*), cat (*Felis catus*) and the cane toad (*Rhinella marina*). More information on pest animals can be found in the fauna and pest animals chapter section 6.2.3 and freshwater chapter section 7.3.4. Exotic fish species such as tilapia, guppies and mosquito fish pose a potential threat as perennial freshwater wetland habitats in the coastal Gulf are highly suited to these exotic species if they were to spread to the lower reaches of infested river systems. Further, although no exotic marine species are known to have established in the Gulf, a potential threat has been identified due to the potential risks associated with release of ballast water from foreign ships loading at Port Karumba (PCQ 2002).

8.2.2.6 Weeds

As noted for feral animals (above), weed issues within the Gulf coastal zone represent a subset of those recorded within the broader NRM planning region which are discussed more fully elsewhere within the NRM plan. While weeds impacting the Gulf coastal zone are not unique to it, some of the affected assets are. The more important weeds and weed management issues include:

- Calotrope *Calotropis procera*. This broad leaf species has established dense infestations in coastal areas and is particularly invasive of beach foreshore and beach ridge landforms where it can establish ground cover excluding infestations, limiting the use of fire as a control mechanism. Coastal graziers consider this weed to be one of the more significant in terms of pasture excluding production impacts, although cattle will browse on it. Current control methods are limited in terms of effectiveness. Regional stakeholders have suggested this weed should be considered for nomination as a weed of national significance (WONS) to attract greater resources for control research and program implementation (Appendix 1).
- Rubber vine *Cryptostegia grandiflora*. This vine is well known for its potential to collapse riparian forests, which it does along most of the major river systems entering the Gulf coastal zone. Similarly to calotrope, rubber vine is also extremely invasive of beach foreshore and beach ridge landforms where it establishes ground cover excluding infestations, limiting the use of fire as a control mechanism. Infestations in beach foreshore areas are also reported to interfere with marine turtles being able to access appropriate nesting sites (CLCAC 2014a). Land and sea ranger programs have been actively engaged in pursuing control of rubbervine in coastal areas particularly within the *Nijinda Durlga* IPA which represents the western margin of the rubbervine infestation front moving towards the Northern Territory.
- Aquatic weeds. Currently, exotic aquatic weed infestations within the Gulf coastal zone are limited to the Mitchell River basin (Burrows 2004). Recorded species include water hyacinth, hymenachne, paragrass, salvinia and water lettuce, all of which are recognised as being capable of contributing to aquatic ecosystem collapsing infestations (Perna & Burrows 2005; Tait 2013). Two aquatic weed species that have origins as exotic 'ponded' pastures, are currently used in pasture pondages adjoining the coastal zone in the lower

Leichardt River basin but have not shown any capacity to establish outside of the artificially impounded areas where grazing pressure and habitat seasonality limit infestation potential (Tait 2005).

- Pastoral land woody weeds. A suite of woody weed species in addition to calotrope and rubbervine occur on Gulf coastal plain grasslands used for pastoralism including parkinsonia, chinee apple, mimosa, calotrope and prickly acacia (CLCAC 2014a). Infestation potential is often tied to total grazing pressure with more pressured areas including wetland margins being particularly vulnerable to infestation. These weeds can lead to the collapse or replacement of native wetland riparian vegetation communities, the loss of open habitats adjoining wetland basins and associated nesting, feeding, and roosting habitat resources for waterbirds and other fauna (Tait 2005).

Regional NRM strategies for addressing the threats posed by invasive species are presented elsewhere with the NRM plan. Given the widespread nature of weed and feral animal threats to natural assets, one of the key needs within the broader region and the coastal zone is to develop strategic management approaches that target the limited resources available for management at defined priorities. For the SE Gulf coastal and marine zone the following are nominated:

- Quarantine measures. For invasive species, prevention of infestation is generally recognised to be a much more cost-effective strategy than control. The Gulf coastal zone retains significant areas free of infestation of classes of invasive species that are widespread in other parts of the region or in other regions e.g. exotic fish, aquatic weeds, cane toads, invasive marine organisms. Establishment of NRM strategies that serve to quarantine unaffected areas from the establishment of these invasive species is a prudent and effective investment priority. The role that coastal Gulf management programs can play in quarantining the neighboring Northern Territory from western spreading threats e.g. rubbervine also comes under this strategy rationale.
- Protection of higher values assets. Higher value assets provide an obvious focus for investment in invasive species control programs. In the Gulf coastal zone examples include: marine turtle nesting beaches and DIWA wetlands both threatened by pigs and weeds, protected areas including IPAs generally represent better conditioned assets but are still threatened by weeds and feral species, and threatened fauna species populations (where they occur) threatened by feral cat predation.
- Mapping and monitoring. Understanding the spatial extent of weed infestations is often critical for designing effective control programs, as is knowing the effectiveness of past control efforts. Investment in mapping and monitoring ideally using remote sensing where possible provides the means for achieving this.
- Integrative approaches. Some of the most cost-effective control measures for weeds or feral animals are those that employ and integrate broad acre methods, e.g. the role of grazing and fire regime interactions for controlling woody weeds. Further development and application of such approaches should be progressed where available or possible.
- Targeted research. Further scientific understanding is required to inform some invasive species management issues in the coastal Gulf, e.g. more effective control methods for calotrope, the potential to eradicate toads or to reintroduce affected fauna from coastal islands, the status and recovery mechanisms for predatory fauna populations impacted by cane toads and the interaction between grazing exclusion/spelling, fuel loads and fire regime in the control of coastal weed species.

8.2.3 Fishery and Traditional Hunting Sustainability

As identified in the description of assets (Section *8.1*), the Gulf coastal and marine zone host a range of high value commercial, recreational and traditional fisheries. In terms of generating threats to coastal and marine assets sustainability issues associated with these fisheries have at least three components of potential concern including:

- The level of take or 'fishing pressure' on targeted species;
- Catch impacts on non-targeted species; and
- The potential for environmental impacts to coastal or marine habitats associated with fishery operations or fisher behaviour.

8.2.3.1 FISHING PRESSURE

As identified in the description of fishery assets, assessments of Gulf fisheries have generally produced favourable findings regarding their sustainability in terms of levels of take and stock status although sustainability issues concerning non-targeted species (discussed below) are identified (Zeller & Snape 2006; DAFF 2013; AFMA 2013). An ecological risk assessment of Queensland-managed Gulf fisheries (including recreational fisheries and the non-protected species component of the traditional sector) found only two targeted species in the Gulf net fishery (guitarfish in the N3 fishery and grey mackerel in the N9 fishery) to have a high risk to their sustainability compared to other retained species. Ten other species groups were considered to have a moderate risk to their sustainability including Spanish mackerel, red snappers, barramundi, threadfin salmons, sharks and mud crabs (Zeller & Snape 2006). The commonwealth-managed Northern Prawn Fishery is also cited as an example of a well-managed and sustainable wild fishery (AFMA 2013).

Similarly for traditional hunting: while there is limited available information on the levels of take of targeted species including listed threatened species such as marine turtles and dugong, the general belief is that within the coastal Gulf levels of take are low and sustainable (Smyth & Monaghan 2004; DEWAH 2008).

Despite generally positive assessments of the threat posed to targeted stocks by fishing and hunting pressure in the Gulf coastal and marine area, fishing pressure is still consistently cited as an issue of concern by a range of stakeholder representatives, including traditional owners, recreational fishers, tourism operators and commercial fishers (Appendix 1). These concerns are attributed to a number of factors:

- Existing monitoring of commercial fishery effort is predominantly based on catch log book entries and this data source is not considered by all stakeholders to be accurate or independent of fisher bias;
- There is very limited fishery-independent monitoring of stock status;
- Observed and anecdotal reports of potentially localised overfishing e.g. depletion of barramundi populations due to commercial netting within a particular estuary, traditional take from a particular hunting ground, or recreational fishing pressure on grunter stocks at focal areas, i.e. Karumba, are not captured by existing stock monitoring approaches;
- Perceived competition between fishery sectors (commercial, recreational, traditional) and of historical declines in catch rates or fishery quality;
- Observations of by-catch wastage in commercial fishing operations;
- Observation of exceptionally high seasonal effort and flouting of size and bag limits in the recreational fishery (e.g. at Karumba);
- Poor regulation of input controls (and observed flouting of gear regulations) and absence of output controls (catch quotas) in most Gulf fisheries;
- Comparisons made with the Northern Territory where the number of licensed fishers operating in coastal fisheries in equivalent areas of coastline to the Queensland Gulf is substantially lower.

8.2.3.2 NON-TARGET SPECIES

Bycatch impacts of both commercial and recreational fisheries on non-targeted species are consistently identified as a threat to biodiversity and traditional fishery assets (Sections *8.1.3.2* and 0) of the SE Gulf coastal and marine zone (DSEWPC 2012; CLCAC 2014a). Formal assessments conducted for state-managed commercial fisheries considered no non-target species captured by operating fisheries to be at high risk to their sustainability. Six species groups affected by the net fishery were considered to have a moderate risk to their sustainability including bottlenose dolphins, speartooth sharks and sawfishes, as were several species groups associated with the trawl fishery including sharks, rays and sawfishes (Zeller & Snape 2006).

In addition to the bycatch species assessed by Zeller & Snape (2006) to have a sustainability risk profile, regional stakeholders also hold concerns for dugong and marine turtles, both of which are susceptible to capture in large mesh gill nets and the latter also in prawn trawl nets (CLCAC 2013a; CLCAC 2014a). The numbers of sea snakes captured in the prawn trawl fishery is also identified as a potential species sustainability issue (DSEWPC 2012). Freshwater

sawfish populations are also impacted by the recreational line fishery via take as unintended bycatch on baited lines or due to targeted fishing by those seeking sawfish rostrums as a trophy (DoE 2014).

As per the assessment of fishery sustainability generally, assessment of the significance of bycatch impacts on affected species is limited by two main factors which are:

- The accuracy and comprehensiveness of bycatch reporting by fishers; and
- Limited knowledge on the overall population size and associated vulnerability of affected species.

For some stakeholders the fact that levels of bycatch may be sustainable in terms of population maintenance does not negate concerns regarding perceived unnecessary mortality and wastage of culturally or conservation significant species. Given the late age of reproductive maturity and low reproductive capacity life cycle attributes of many of the affected bycatch species (DSEWPC 2012), a prudent and precautionary management philosophy is to seek continuous improvement in minimising fishery bycatch impacts. In recent decades fishery management initiatives including gear attendance regulations and bycatch reduction devices have significantly reduced levels of bycatch particularly within the northern prawn fishery (Burke *et al.* 2012). Major stakeholder concerns remain regarding the level of bycatch impact associated with gill net fisheries particularly in relation to marine turtles, dugong, dolphins and sawfish (McDonald 2011; DSEWPC 2012; DoE 2014). Spatial and/ or seasonal closures of areas to the gill net fishery have been nominated as a possible management solution, as has increased surveillance and enforcement of net attendance regulations (CLCAC 2014a). Dugong Protection Areas provide an additional management framework for the protection of dugong on the Queensland east coast (Coles *et al.* 2002), this management tool has not yet been utilised in Gulf commercial fisheries.

8.2.3.3 HABITAT IMPACTS

Formal assessments of the sustainability of Queensland-managed Gulf fisheries have found there to be no fishery impacts considered to be high risk factors to the sustainability of the marine ecosystems supporting Gulf fisheries. However some fisher camps were considered to have a moderate risk to the local terrestrial ecosystem (Zeller and Snape 2006). Concerns regarding fisher camp impacts (both commercial and recreational) on riverbank and beach foreshore areas remain current in the Gulf coastal zone (CLCAC 2014). Regional stakeholders also retain concerns regarding the impact of prawn trawling on sea grass beds and benthic habitats. Most shallow sea grass areas are closed to prawn trawling though deeper sea grass meadows remain exposed (Haywood *et al.* 2005). As identified in the discussion of benthic marine habitats (Section 0), impact assessment studies estimate a 12% depletion rate for benthic biota from a single pass of a trawl net and found targeted prawns represent only 20% of the catch by weight of a trawl net (Hill *et al.* 2002). The greatest impacts occur to more sessile biota such as crustaceans, bryozoans and sponges while more mobile taxa such as bivalves are less impacted.

Ultimately it is considered that the long term sustainability of Northern Pawn Fishery (NPF) may depend on the sustainability of the benthic ecosystems that support it (Hill *et al.* 2002; Haywood *et al.* 2005). Satellite tracking data has indicated that only 17% of the NPF area is actively trawled and of that only 14% (2.4% of total) intensively as prawn producing hot spots. 8.5 % of the NPF is protected from trawling permanently or seasonally (Haywood *et al.* 2005).

Considering all identified threats to natural assets of the coastal and marine zone posed by fisheries and traditional hunting, some consistent management requirements across sectors and sources of sustainability concern can be nominated to inform regional NRM planning. These are:

- Improved quantification of fishing pressure on both targeted species and bycatch by more accurate, species-specific and spatially-related reporting methods;
- Improved quantification of fished stock status (including protected species targeted by traditional fisheries) ideally by fishery independent methods, strategically targeting prioritized species and/or areas nominated as being under pressure;
- Increased surveillance of bycatch levels and enforcement of fishery regulations intended to reduce them;

- Continuous development and innovation in bycatch reduction management methods and devices; and
- Further assessment of the role of seasonal or spatial fishery closures, possibly including marine protected areas for the protection of Gulf coastal and marine biodiversity and fishery assets.

8.2.4 Marine Debris

Marine debris - comprised of discarded and lost commercial fishing gear, particularly 'ghost nets' - represents a significant threat to marine biodiversity assets of the SE Gulf and of the broader North Marine Region, where it is assessed to be an ecological pressure *of concern* for the entire Gulf of Carpentaria coastal zone (DSEWPC 2012). The significance of the issue is reaffirmed by consultation with regional stakeholders, particularly sea country traditional owners who regularly witness its lethal impacts on culturally important marine turtles and dugong and have been engaged in ghost net management programs extending back over two decades (Gunn *et al.* 2010; CLCAC 2013a; CLCAC 2014a, Appendix 1). Besides marine turtles which account for 90% of the marine life (other than crabs) recorded from ghost nets (Gunn *et al.* 2010), and dugong, other fauna impacted via entanglement in ghost nets include crabs, sea birds, sea snakes, saw fish, other fish, sharks and rays, crocodiles, dolphins and even terrestrial mammals entangled on beaches (Gunn *et al.* 2010; DSEWPC 2012). Ghost nets can also impact coral reefs and benthic habitats via smothering and destructive drift lines (Gunn *et al.* 2010).

Since the earliest clean-up of ghost nets off beaches of the Gulf of Carpentaria was undertaken in the mid 1990's, and the Ghost Nets Australia Program hosted by Northern Gulf Resource Management Group Ltd and implemented in the last decade, understanding of the problem has developed significantly in terms of its origins, impacts and strategic management options (Gunn *et al.* 2010; Butler *et al.* 2013; Wilcox *et al.* 2012).

Significant factors that need to be understood to inform ongoing efforts to manage the threat of marine debris and ghost nets within the SE Gulf planning area include:

- The effect of the Gulf's clockwise gyre current in the entrainment of marine debris in 'captured' potentially multiple circular movements around the Gulf's coastline (Gunn *et al.* 2010);
- The interaction between current paths and marine fauna density in defining high risk areas for fauna, shore beaching areas for marine debris and strategic interception points for drifting marine debris (Wilcox *et al.* 2012),
- Less than 5% of ghost nets and marine debris recorded from Gulf shorelines has Australian fishing industry origins and the majority originates from Asian fisheries particularly those operating on the Arafura Sea (Butler *et al.* 2013, Wilcox *et al.* 2012);
- There is a range of social, economic and operational factors and motivations leading to the loss or abandonment of fishing gear by Arafura Sea fishery operators (Butler *et al.* 2013); and
- Ghost net cleanup is viewed as a 'looking after country' custodial responsibility and the Ghost Nets Australia Program has been instrumental in building the capacity of indigenous ranger programs and providing benefits to coastal Indigenous communities on a social, economic and environmental basis (Gunn *et al.* 2010).

In addition to the well documented 'ghost net' phenomena, another more localised marine debris issue identified during consultation with regional coastal stakeholders (Appendix 1) is that of abandoned crab pots in the popular recreational fishing areas adjoining Karumba. Local residents have noted that such pots often become 'self-baiting' via entrapped fish and other fauna and can continue to 'ghost fish' for many months until traps become degraded. It has been identified that to address this issue requires consideration of fishery legislation that prohibits disturbance of crab pots not owned by the operator.

From a regional NRM planning perspective, opportunities and priorities for addressing the threat posed by marine debris and ghost nets within the SE Gulf planning areas include:

- Continuation and expansion of the Indigenous Land and Sea Ranger ghost net collection program on shorelines strategically targeted on the basis of higher modeled risk (Wilcox *et al.* 2012) e.g. Karumba north;

- Partner with adjoining Cape York NRM body in the development of a marine debris interception program for sea lanes of the north eastern Gulf identified as the key pathway for marine debris entering the Gulf gyre (Wilcox *et al.* 2012);
- Addressing the other localised marine debris issues of concern identified by coastal stakeholders i.e. crab pots discarded in estuarine areas heavily utilised by recreational fishers in the Karumba area; and
- Supporting further development of marine debris educational and management incentive programs for foreign and Australian commercial fisheries identified as primary sources of marine debris arriving in the Gulf coastal and marine zone.

8.2.5 Climate Change

8.2.5.1 Elevated Temperatures

Elevated temperatures are perhaps one of the most understood and confidently projected changes to climate associated with global warming. Temperature regime is a key physical parameter defining ecosystem composition on the basis of thermal tolerances of constituent species and ecosystem physiology on the basis of temperature driven bio-geochemical processes.

A non-exhaustive listing of potential impacts associated with projected temperature cha**nges** in the Gulf coastal and marine regions include:

- Increased evaporation rates affecting soil moisture, plant survivorship and the availability and/or distribution of perennial aquatic refugia (permanent waterholes) and fire refugia;
- Increased die-back of intertidal sea grass meadows exposed to higher ambient air temperatures during exposure at low tide (Mckenna & Rasheed 2013);
- Elevated sea surface temperatures affecting sea currents and altering foraging behavior and success for marine reptiles and seabirds (Chambers *et al* 2012; Fuentes *et al.* 2012);
- Exposure of ectothermic marine organisms including sea snakes to temperature maxima beyond their thermal tolerances (Fuentes *et al.* 2012);
- Impacts to the survival, growth and abundance of commercial penaeid prawn species and the availability and distribution of their nursery habitat (Hobday *et al.* 2008);
- Alteration of temperature determined sex ratio outcomes for marine turtles and crocodiles (CLCAC 2014a);
- Decreased dissolved oxygen-carrying capacity and increased organic material decomposition rates leading to increased chance of fish kills in dry season stressed waterholes;
- Exposure of a significant proportion of the species comprising native vegetation communities to novel bioclimatic envelopes outside their historical range with a concomitant increase in stress and reduced survivorship (Williams *et al.* 2012); and
- Creation of stressed native ecological communities with less resilience to infestation by invasive species.

8.2.5.2 Altered Rainfall and Extreme Climatic Events

Projecting directional changes in rainfall in the Monsoonal North cluster region is difficult due to the complexity of factors affecting the regions rainfall including monsoon onset and east coast orography (Moise 2014). The most confidently projected changes are increased rainfall variability with either large increases or decreases in annual rainfall relative to 1986-2005 possible, increased intensity of rainfall and increased cumulative time spent in drought. Cyclones are also projected to become less frequent but more intense. These projected changes present a host of potential stressors for the Gulf's coastal and marine ecosystem assets, many of which will be realised by alteration of contributing river basin condition and behaviour. As identified previously (*Section* 0), contributing river basin status including flow regime, vegetation condition, erosion rates and sediment loads is tightly coupled to receiving coastal

ecosystem processes. Climate change projections for rainfall and cyclones in the Monsoonal North cluster region threaten coastal and marine assets via:

- The potential for extended dry seasons to:
    - create stressed and reduced native vegetation cover presenting increased soil exposure to erosive processes;
    - exacerbate total grazing pressure;
    - providing increased infestation opportunities for invasive species;
    - exacerbate 'hot' fire regime impacts to sensitive vegetation communities; and
    - reduce the distribution and availability of freshwater refugia important for the maintenance of obligate freshwater biota in the coastal zone.
- The capacity of more intense rainfall events to generate increased rates of soil erosion and peaked flow pulses capable of transporting increased sediment loads and impacting discharged water quality and receiving coastal ecosystems such as seagrass via turbid and low salinity flood plumes;
- Altered rainfall patterns, and increased evaporation rates contributing to reduced basin runoff and flows impacting:
    - aquatic habitat connectivity, nutrient exports, estuarine salinity regimes, fishery nursery habitat availability and coastal fisheries recruitment and productivity (Hobday *et al.* 2008); and
    - water resource allocation competition between the environment and proposed development consumptive uses (IFED 2013; Petheram 2013a).
- The capacity of cyclones to directly disturb marine and coastal habitats such as seagrass and mangroves with concomitant impacts on dependent fisheries and biota (Hill *et al.* 2002).

8.2.5.3 *Sea Level Rise*

Given the Gulf's low lying, low gradient coastline it is predicted that it is going to experience relatively rapid changes in response to further sea level rise and more extreme storm events. i.e. cyclones and storm surge. These changes will be realised as accelerated retreat and increased disturbance of beach foreshores, salinisation of near coastal freshwater wetlands via greater tidal ingress, inundation of coastal saltpans and impacts to coastal floodplains and floodplain obligate biota over vast spatial scales (Pusey & Kennard 2009; Bustamante *et al.* 2012).

As described in the description of assets, evidence of sea level rise impact is already being observed at a number of coastal sites within the planning area, including beach foreshore retreat emerging at Karumba and Kowanyama, and salinisation of near coastal freshwater wetlands within the Southeast Karumba Plain DIWA wetland aggregations via greater tidal ingress and breaching by storm surge (Per. Obs, Tait 2005; Bell 2009).

As well as coastal land forms, numerous other natural assets within the marine area are also predicted to be impacted by sea level rise. These include:

- Mangrove forests and intertidal and shallow seagrass areas which, dependent upon sedimentation regimes, are expected to retreat landward as sea levels rise or disappear if coastal relief is low and inundation rates rapid (Hobday *et al.* 2008). In many mangrove forests, rates of surface accretion (increase in the elevation of the soil surface) matches or exceeds current rates of sea level rise (Lovelock *et al.* 2012). If rates of sea level rise continue to increase, at some point the surface accretion ability of mangrove forests will be surpassed and mangrove forest will be loss to inundation stress, particularly where their resilience is undermined by extreme events such as cyclones or storm surge (Lovelock *et al.* 2012);
- Both mangroves and shallow sea grass beds are critical fishery habitats with catches of commercial finfish and prawns being shown to be related to their abundance and extent (Hobday *et al* 2008). Sea level rise is expected to considerably reduce both these habitats in the southern Gulf of Carpentaria with concomitant impacts expected for fisheries productivity (Hill *et al.* 2002);
- Where sea level rise impacts on protective coastal wetland vegetation communities their loss will lead to periods of accelerated shore line erosion and migration (AGO 2003);

- Deeper seagrass beds will also be impacted where sea level rise results in too great a limitation in light penetration as may some of the Gulf's deeper platform reefs (Harris 2004; Lovelock *et al*. 2012);
- Distributional shifts in other benthic biota are also expected in response to sea level rise (Poloczanska *et al*. 2012);
- Marine turtle nesting beaches are also recognised to be threatened by increased retreat associated with sea level rise (DSEWPC 2012), and inundation of nest sites by high tides has been observed in adjoining coastal areas in the NT (CLCAC 2014a).
- Inundation of coastal aquatic habitats is also recognised as a potential concern for many other coastal marine fauna including sawfish, dugong and dolphins (DSEWPC 2012).
- Sea level rise is also predicted to place shore bird habitats at risk (Chambers *et al*. 2012), and will impact low-lying and near coastal freshwater wetland habitats of dependent waterbird species although the full implications for water birds species in terms of habitat resource availability are hard to predict;
- For coastal wetlands, floristic changes will include replacement of freshwater *Melaleuca* swamps with mangroves and geomorphic changes will see transition from freshwater wetlands to saline mudflats (Pusey & Kennard 2009); and
- Tidal ingress further inland will result in saltwater intrusion to coastal groundwater systems and upstream movement of tidal influence and freshwater-saline water boundaries within stream channels (Williams *et al*. 2012).

Besides natural assets, built infrastructure is also vulnerable to impacts associated with sea level rise and in turn engineered structures constructed to protect built infrastructure may further impact natural assets by limiting their opportunity for landward retreat (AGO 2003). The limited extent of coastal development within the Gulf coastal zone limits the potential for this type of impact though Karumba have built infrastructure including industrial facilities vulnerable to impacts associated with sea level rise particularly in concert with the risks posed by storm surge (Smith & Harper 2013).

8.2.5.4 Storm Surge

A storm surge (or meteorological tide), is an atmospherically-forced ocean response caused by high surface winds and low surface pressures associated with severe and/or persistent offshore weather systems (Smith & Harper 2013). The most severe storm surges are associated with cyclonic low pressure systems crossing the coast and can result in destructive waves of marine water reaching many kilometres inland. Projections that storm surge impacts have the potential to become more significant in the Gulf coastal zone are tied to predicted increases in the magnitude of cyclones, rising sea levels and the potential degradation of protective coastal wetland vegetation (AGO 2003; Smith & Harper 2013; Moise 2014).

The southern Gulf is considered the most hazardous storm tide region of Australia due to its shallow waters, mild nearshore seabed slopes, low-lying coastal topography and its level of tropical cyclone threat (Smith & Harper 2013). Smith & Harper (2013) examined storm surge risk within the entire Gulf of Carpentaria and found the most extreme risk areas lie within the SE Gulf planning area and to include potential (10,000 year Average Reoccurrence Interval) for storm tide inundation up to as high as 9m AHD (Australian height datum) at the coastline and for inland penetration across the flat featureless coastal margins as much as 30km. Less extreme but very significant threats were found to exist for many Gulf communities at much higher levels of probability, i.e. 100 year ARI, or a 40% chance within 50 years. The communities most exposed in Queensland include Karumba, which is vulnerable with total inundation for events exceeding 1,000 year (5% chance within a given 50 year period). Under projected climate conditions the risk is worsened, with total inundation Karumba for the 500 year return period (Smith & Harper 2013).

As identified through the description of coastal assets, there is current evidence of storm surge impacts on coastal landforms, wetlands and vegetation communities within the planning area. One of the main effects of storm surge events is to speed up the rate of change associated with gradual sea level rise via rapid catastrophic impact. Vulnerable assets include:

- Beach foreshores including marine turtle nesting habitats;
- Beach ridge and freshwater swale swamp complexes;
- Other near coastal freshwater wetlands;
- Mangrove forests, whose resilience to sea level rise may be undermined by storm surge events (Lovelock *et al.* 2012); and
- Built infrastructure, including that which may create additional impacts if inundated by storm surge (e.g. industrial facilities).

8.2.5.5 Elevated Atmospheric Carbon Dioxide Concentrations and Ocean Acidification

While elevated atmospheric carbon dioxide concentrations are commonly cited as the major driver of the greenhouse effect responsible for global warming and associated climate change, its direct ecological impacts are less commonly considered. The most significant of these is its role in ocean acidification which may yet prove globally to be one of the more pervasive and disruptive ecological impacts associated with 'greenhouse gases' (Howard *et al.* 2012). Nearly half the fossil-fuel CO_2 emitted to date has dissolved into the ocean. By the end of this century ocean pH levels are likely to drop 0.2 – 0.3 units below pre-industrial pH. The level of atmospheric CO_2 is now higher than at any time in at least the past 650,000 years, and probably has not been as high as present levels for approximately 4-5 million years. The current rate of increase of CO_2 in the atmosphere is one hundred times greater than the most rapid increases during major climate changes over the last 650,000 years, and the concomitant rate of carbonate chemistry change in the ocean is similarly rapid (Howard *et al.* 2012). This rate of change in atmospheric and ocean chemistry presents an enormous disruption to marine and terrestrial ecosystems globally.

All organisms in the marine environment are expected to directly or indirectly experience, to a greater or lesser degree, changes in ocean chemistry associated with ocean acidification. For many marine organisms, marine carbonate chemistry and pH are known to play important roles in key physiological processes (e.g. calcification in corals and shellfish, acid/base balance, fertilisation etc) that ultimately influence their behaviour, growth, development and/or survival. In Australia, changes in calcification rates have already been demonstrated for plankton and reef building corals (Howard *et al.* 2012).

Continuing ocean acidification is expected to reduce rates of reef accretion below those critical for reef maintenance and ecological function. Models of reef calcification under business-as-usual carbon emission pathways predict that net rates of reef growth may become negative by the middle of the century (Anthony & Marshall 2012). Ocean acidification will impact submerged patch reefs such as those in the Gulf (Harris *et al.* 2004), as well as shallow fringing reefs more vulnerable to a range of other climate change impacts. This is expected to also impact fisheries dependent on reefs (Hobday *et al.* 2008). Acidification will increase physiological stress on many marine fauna and will affect the metabolic efficiency and growth rates of molluscs and the exoskeleton moulting process of crustaceans, including prawns. Freshwater crustacean species are expected to be impacted to a greater degree than estuarine fauna (Hobday *et al.* 2008).

Positive impacts are also attributed to increasing carbon dioxide concentrations, also known as the '*fertilisation effect*' in terms of its proposed role in mitigating some of the potentially negative impacts of climate change toward warmer and drier conditions. Elevated CO_2 concentrations are also expected to increase the growth of mangrove species where humidity or salinity is not limiting suggesting that productivity and expansion of mangroves into fresh and brackish wetlands could occur at an accelerating pace (Lovelock *et al.* 2012).

A common adaptation of plants to elevated CO_2 concentrations is to decrease nitrogen invested in leaves and a concomitant increase in the carbon:nitrogen ratio of plant tissues. Changes in the ratio of carbon and nutrients in plant tissue have been observed to decrease their nutritive value and have flow on effects on consumer organisms and on decomposition processes. Elevated CO_2 concentrations are therefore likely to affect food webs, carbon and nutrient cycling and the quality of material exported from coastal wetlands to near shore waters (Lovelock *et al.* 2012).

8.2.5.6 ADAPTION RESPONSES.

As identified by the climate change projections for the Northern Monsoon cluster (Moise 2014), within the life experience of the current generation of residents of the SE Gulf region significant changes to the natural ecosystems of the coastal and marine zone are going to be experienced. Sea level rise is going to accelerate, coastal erosion and beach foreshore degradation will increase, rainfall will become more variable, including longer and overall more droughts and failed wet seasons generating reduced river flows, but also interspersed with wetter years with intense large wet season flood events, temperatures will rise and there will be extended periods of hotter days and fewer but larger destructive cyclones potentially accompanied by storms surges. Coastal and marine ecosystems are likely to become increasingly stressed. Current projections indicate these changes will be even more exacerbated for the next generation. What adaptive management responses can be pursued to lessen the ecological, economic and social impacts associated with this scenario?

In other regions of coastal Australia, adaptive management responses being considered for coastal assets threatened by sea level rise include engineered structures to protect high value infrastructure or alternatively 'planned retreat' of development and infrastructure from the coastline to facilitate landward migration of coastal ecosystems (Good 2011; Niven & Bardsley 2013). In the SE Gulf coastal region it is unlikely that there would ever be sufficient resources available to implement engineered structural responses to protect natural ecosystem assets although such approaches may be appropriate for the areas of settlement most exposed to sea level rise and storm surge, i.e. Karumba (Smith & Harper 2013), and some higher value natural assets. Ultimately both these settlements and their surrounding natural environment could benefit from implementation of a 'planned retreat' planning strategy that sought to deliver the most ecologically, socially and economically sustainable relocation options for these communities. Such planning considerations are beyond the normal budgetary cycle of local government and may require collaborative support from government agency and community NRM organisations to be initiated.

Whether protective engineering responses could be viable or justified for natural assets of the Gulf coastal zone requires greater resolution of potential asset impacts than currently available. In other regions of tropical Australia e.g. the NT, examples of such approaches include the construction of bund walls on tidal channels within the Mary river basin to limit saltwater intrusion into vulnerable upstream freshwater wetlands. The international value of some natural assets of the Gulf coastal zone, e.g. breeding marine turtle populations and DIWA wetland aggregations, could warrant similar interventionist actions including for example:

- Construction of bunds to protect coastal freshwater lakes and swale swamps important for breeding waterbird populations;
- Terraforming beach foreshores to provide suitable and secure nesting sites for marine turtles.

Non-engineering adaptive responses could include actions such as;

- Monitoring and manipulation of turtle nest sites or clutch relocation for targeted sex ratio or improved survivorship outcomes; and
- Targeted revegetation activities to enhance foreshore stabilisation or recovery following disturbance events.

These examples are currently hypothetical and unrealistic. However, the continued emergence of sea level rise impacts is likely to change such perceptions. Investment in higher resolution risk assessments for natural assets of the Gulf coastal zone that could be used to inform adaptive responses is a prudent regional NRM priority.

The most consistently cited adaptive management recommendation for improving natural ecosystem capacity to cope with the stresses presented by climate change is to build their resilience by addressing the stresses posed by existing non-climate change threats (Kingsford 2011; Williams *et al.* 2012). This is because stressed ecosystems are more susceptible to the impacts posed by climate change and also because many impacts will be realised by exacerbation of existing stresses. The key opportunities for maintaining and improving the resilience of the SE Gulf's coastal and marine ecosystems have largely already been identified and include:

- Addressing the pervasive threats posed by invasive species and altered fire regimes;
- Implementing conservative grazing regimes and reducing the total grazing pressure impact on vulnerable land types and regional ecosystems across the coastal zone;
- Addressing the causes of increased soil erosion rates and elevated sediment loads within contributing river basins;
- Reducing and securing the exposure of sources of mining industry-based contaminant loads within contributing catchments to extreme flood events;
- Reducing the impacts of fisheries on marine ecosystems;
- Avoiding or limiting more intensive development of basin land and vegetation resources; and
- Including increased areas of representative terrestrial and marine ecosystems within protected areas.

8.3 Climate Change Risk Assessment for Coastal and Marine Assets

Key				
Probability	UC- Uncertain	P- Possible	L- Likely	Almost Certain- AC
Consequences	UK- Unknown	L- Low	Mod- Moderate	M- Major
Risk rating	L- Low	Mod- Moderate	H- High	Cr-Critical

Climate Hazard	Coastal Lands	Aquatic and Marine Habitats	Fisheries	Coastal and Marine Biodiversity
8.3.1 Increased incidence of destructive wild fires	• Decreased fertility and resilience of coastal grasslands on self-mulching clays. **PCR –** PModMod • Reduced stability/integrity of fire sensitive beach foreshore and dune vegetation. **PCR -** PModMod • Increased capacity for soil erosion/mobilisation. **PCR -** PModMod • Increased grazing pressure on unburnt pasture refugia. **PCR -** PModMod	• Increased mobilization/elevated sediment loads from basin and coastal land sources and reduced trapping capacity wetland riparian vegetation. **PCR –** PModH • Fire incursions to margins of intertidal mangrove and salt marsh/couch habitats. **PCR -** PModMod • Fire incursions into and degradation of fire sensitive wetland riparian communities. **PCR -** PModH	• Reduced quality nursery habitat associated with intertidal saltmarsh, mangrove fringes. **PCR –** PL(M)L • Reduced viability of aestivation habitat utilised by freshwater long-neck turtles. **PCR –** PLL	• Loss of fire sensitive species from regional ecosystems associated with land zones 1, 2 and 3. **PCR -** PModH • Fire impacts to beach and dune systems resulting in reduced stability and shading and higher sand temperatures with potential impacts on nesting turtles **PCR -** PModH

Climate Hazard	Coastal Lands	Aquatic and Marine Habitats	Fisheries	Coastal and Marine Biodiversity
8.3.2 Increased intensity of high rainfall events (flood and cyclones)	• Increased capacity for soil erosion/mobilisation and scalding and gullying of frontage areas adjoining wetlands and drainage lines. **PCR –** AC(P)MCr • More sustained inundation of coastal grass lands resulting in reduced cover (during recovery period) and impacts to resilience and carrying capacity of grassland communities. **PCR -** ACModMod • Greater water-based dispersal of basin weed infestations to new lower catchment/coastal infestation sites. **PCR -** LModMod	• Greater magnitude (loads/extent/duration) sediment plumes exported from river mouths to turbidity sensitive marine habitats (sea grass, reefs). **PCR –** AC(P)MCr • Increase in sea grass density where nutrient benefits of river discharge experienced independent of turbidity impacts (NGRMG). **PCR -** ACLL • Expansion of mangrove forest area on areas of elevated intertidal sediment deposition. **PCR -** ACLL • Potentially beneficial scouring/flushing of exotic aquatic weed infestations from coastal wetlands providing enhanced control opportunities. **PCR -** LModMod • Greater prospect of contaminant loads within basin retention facilities (i.e. tailings dams), being released via overflow events to aquatic ecosystems **PCR –** LModMod-H	• Subject to event timing, potentially beneficial impacts to fisheries recruitment via nursery habitat inundation, nutrient transfers to coastal and inshore areas and provision of basin habitat connectivity. **PCR –** ACModH • Potentially significant losses of prawn nursery habitat due to cyclonic impacts on sea grass beds and associated reduction in offshore caches. **PCR –** AC(P)ModH	• Reduced abundance sea-grass beds and carrying capacity for dependent fauna e.g. dugongs, turtles with resulting mortality/population reduction **PCR –** AC(P)MCr • Contraction of light dependent / sediment sensitive coral reef communities in marginal areas subject to sediment plume influence. **PCR -** PModH • Conflict between stock and native fauna and flora in limited flood free refugia. **PCR -** PModMod

Climate Hazard	Coastal Lands	Aquatic and Marine Habitats	Fisheries	Coastal and Marine Biodiversity
8.3.3 Increased storm surge and rising sea levels	• Degradation and retreat of beach foreshores and adjoining dune systems. **PCR -** ACMCr • Landward migration of marine plain/salt pan – coastal grassland interface. **PCR -** ACModH • Saltwater intrusion into coastal land drainage networks previously fresh. **PCR –** A(P)CModH	• Elevated sea levels and pulsed turbidity affecting light availability to impact sea grass productivity and density/extent. **PCR –** AC(P)MCr • Potential expansion of mangrove forest area via colonization of inundated coastal areas. **PCR –** AC(P)L(M)L • Breaching of coastal inter-swale swamps by tides/storm surge and alteration from fresh to brackish/saline with loss of associated fringing vegetation communities. **PCR –** AC(P)ModH • Upstream retreat and replacement of freshwater riparian vegetation by marine communities. **PCR –** AC(P)ModH	• Reduction in fisheries productivity reliant on seagrass (and attached algae) either as nursery habitat or for nutrition in adjacent habitats. **PCR –** AC(P)ModH	• Erosion and increased inundation of coastal beaches and salt marshes will impact sea turtle and crocodile habitats, nesting area stability and hatching success **PCR –** AC(L)ModH • Potential loss /reduction in area of low lying island based turtle nesting/basking sites. **PCR –** AC(L)ModH • Reduced productivity / carrying capacity for sea grass dependent fauna e.g. dugong, turtles with resulting mortality/population reduction **PCR –** L(P)ModH • Salinisation of coastal freshwater wetlands and marginal vegetation utilised by breeding aggregations of waterbirds. **PCR –** L(P)ModH • Reduction and fragmentation of breeding habitat for shorebirds and seabirds dependent on low-lying sandy foreshores. **PCR -** PModMod

Climate Hazard	Coastal Lands	Aquatic and Marine Habitats	Fisheries	Coastal and Marine Biodiversity
8.3.4 Longer dry seasons	• Increased grazing pressure on grassland forage resources, resulting in reduced ground cover particularly adjoining perennial – semi-perennial waters. **PCR -** ACModH • Reduced levels in shallow groundwater aquifers and loss of dependent vegetation communities' sites. **PCR -** LModMod • Greater recruitment opportunities for woody and weedy species post-dry season. **PCR -** ACModH	• Loss of refugia and associated obligate freshwater biota in coastal freshwater wetlands. **PCR -** ACModH • Increased pressure from grazing stock and feral animals on frontage and fringing habitats associated with more permanent wetlands. **PCR -** ACMCr • Reduced productivity/extent of coastal seas grass associated with reduced river flows and increased desiccation exposure. **PCR -** ACModMod • Reduced river baseflows to flush wet season run in through system and maintain range of brackish salinities within estuaries. **PCR -** LModH	• Late initiation of nursery habitat inundation, flow based productivity pulses and connective flows leading to late and reduced recruitment. **PCR -** ACModH	• Reduction in resilience/extent of groundwater dependent regional ecosystems i.e. vine thickets on beach swales. **PCR -** LModH • Reduction in extent of functional fire refugia e.g. inter-swale areas, perennial-semi-perennial wetland basins. **PCR -** LModH

Climate Hazard	Coastal Lands	Aquatic and Marine Habitats	Fisheries	Coastal and Marine Biodiversity
8.3.5 Continued warming of temperature, including more hot days	• Promotion of some weed species sites. **PCR - LModMod** • Exceeding thermal thresholds for some coastal vegetation community plant species – leading to loss of species and reduced resilience of native vegetation cover. **PCR - ACModH**	• Decline in abundance or/loss of some species of intertidal sea grass. **PCR – L(P)ModH** • Decreased dissolved oxygen carrying capacity and increased respiration rates (and DO consumption) in shallow freshwater, estuarine and marine waters. **PC(Maj)R - LModH**	• Reduced dissolved oxygen in shallow coastal wetland and upper estuarine nursery habitats decreasing productivity and recruitment levels. **PCR – L(P)Mod(Maj)H** • Reduced sea grass dependent fishery productivity/recruitment. **PCR – L(P)mod(Maj)H** • Reduced availability and altered distribution of prawn nursery habitats, and decreased growth and survival of targeted prawn species. **PCR – L(P)mod(Maj)H**	• Changes to long term sex ratios, hatching size and success of sea turtles and crocodiles **PCR – L(P)Mod(Maj)H** • Changes to the nesting period utilised by turtles / crocodiles with a potentially earlier nesting season utilised under elevated temperatures. **PCR – PL(Mod)Mod** • Higher sea surface temperatures are likely to impact on the foraging and subsequent breeding success of migratory sea birds. **PCR – L(P)ModH**

Climate Hazard	Coastal Lands	Aquatic and Marine Habitats	Fisheries	Coastal and Marine Biodiversity
8.3.6 Increasing atmospheric CO_2 concentration and ocean acidification	• Woody vegetation growth promoted relative to grassy vegetation promoting woodland thickening. **PCR -** PModMod	• Corals, coralline algae and benthic molluscs will continue to experience reduced calcification/ increased dissolution rates. **PCR –** ACMH • Growth of mangroves and seagrasses, being of terrestrial origin, may be stimulated by additional CO2 levels in the atmosphere and ocean respectively. **PCR -** PModMod	• Increased mortality of fish larvae and juveniles may result from acidification effects on sensory systems and behavior, leading to decline in recruitment to adult populations. **PCR -** PModH • Reduced aerobic capacity in some fish due to acidification could exacerbate other climate change impacts (e.g. reduced dissolved DO). **PCR -** PModH	• Plant foliage will become more sclerophyllous and nutritive value of plant material consumed by herbivorous animals including arboreal mammals will reduce relative to energy required to digest it. **PCR -** PLMod

APPENDIX 1: SUMMARY OF FINDINGS FROM STAKEHOLDER CONSULTATIONS

TRADITIONAL OWNER GROUPS

- CLCAC wishes to disengage from current regional Community NRM providers (SGC, NGRMG) and become sole provider for coastal Gulf community NRM
- GRAC still supportive engagement with SGC – see delivery via support for Ranger program (including funding coordinator) and Local Govt initiatives / projects
- Ranger program has fallen over and is in hiatus awaiting funding and administrative issue resolution
- Keen for projects that bring in additional resources / technical expertise to add to core funding available to ranger programs (4 years committed associated with IPA management) – looking to fee for service arrangements with Govt agencies operating in Wellesley Is e.g. AQIS

Identified NRM concerns /Project Opportunities (Mornington)

- Fishery sustainability primary concern – amount of take (gill net, line fishery, trawlers) and impact to non-target species & fisher interactions i.e. accessing culturally sensitive sites / islands
- Red bank creek management / rectification – concern re: pollution of marine environment
- Health of marine fauna i.e. turtles, dugong related to potential industrial pollutants (e.g. cited concentrate spill from transporting barge, and contribution from river basin run off) and degradation of sea grass grounds
- Ghost net program still seen as important priority
- Weed management focus on islands – Bellyache bush identified as priority – issue re: expiry of chemicals
- Marine Parks proposal – seen to have benefits to community incl protection of culturally important Mundarlbi Reef – had concerns re: establishment of scallop fishery due to potential impacts to benthic communities
- Sea grass survey needs updating – concerns previously mapped sea grass beds have been lost to recent flood events – linked to increased sediment rates from catchments
- Quarantine arrangements to prevent introduction of toads to Mornington Island - Loss of goanna and other fauna associated with toad invasion of Bentick Island NB: Mornington Island still toad free – examine options to eradicate toads from smaller islands plus re-introduction of key fauna e.g. Goannas
- Native tree nursery establishment – to operate in conjunction with local Govt works program (road works, gravel/ sand pit revegetation needs) and to support outstation projects – bush tucker plantings – good community engager if get locals to provide seed collection

COASTAL PASTORALISTS

- Weeds remain key issue of concern
- Want access to competitive provision of NRM services / support re: weed management
- Distinction between corporate and family owner operations
- Open to projects involving coastal country wetland management i.e. fencing off of coastal frontages / wetlands /waters and stocking/grazing conservatively, allowing fuel load build up for weed control via fire. Reduce rubbervine (too costly to spray) reduce pig habitat –reduce their impact on beach nesting turtles, birds, digging up swamp habitat etc. require aerial shooting as well. Saline flats and lakes secondary fencing priority to ridgelines for Wenadinga. Spelling in growing season would provide additional late season fodder and burning options. (Escott also supportive subject to >50% costs funded and control over contractors and concerns re: cultural clearance imposts). Question nature of coastal country support/agreements – nature refuge

commitments? complete exclusion some wetlands (Wernadinga wants discussion sooner than later). Magowra could also be interested subject to further information)

- Armrayald nominated Iluka waterhole adjacent Burketown – as potential site for fencing off wetland plus provision of turkey nest water for cattle
- Escott – don't actively burn that much – only occasionally rank growth – everyone else initiates burns for them
- NB: Utilisation of Ranger programs supported for fire management and fencing wetland projects. For weed management seek continued access to competitive provision of contractor services.
- Case for reducing stock/herd size – less pressure on country, less overheads, greater per beast weight gains (Armraynald reduced herd X 4000 head). Conservative stocking density / management case studies?
- Weed management priority related to 'production burden' – e.g. rubber vine / acacia control don't see production benefits as readily, callotrope – more significant impact on carrying capacity – needs greater investment and recognition as WONS and investigation of better control options. Prickly acacia mainly issue around 'flogged country' i.e. waters can be controlled with allowed buildup of fuel and fire. – Finucane Island National Park – needs chemical spraying follow up after controlled burning which has been coducted
- NB: Initial fencing costs seen to be less significant than ongoing maintenance costs – would pay for fencing if maintenance especially weed management was covered for next 15 years
- River basin management – 'sump of the Gulf' lower basin coastal Gulf receives upstream weeds, tailings dam overflows etc. – later issue potentially to get worse under climate change (extreme events etc) – role for community NRM – independent monitoring – letting people know what's going on.
  Concerns regarding viability of proposed river basin water resource development economics – nees case studies re; access to proximal markets/ transport costs etc.

Recreational Fishers

- Socioeconomic benefits / costs to community of rec only areas (seen as employment generator). Existing examples NSW, NT several existing in Gulf e.g Norman and Albert Rivers.
- Commercial effort effectiveness seen to have increased with improved gear in recent decades e.g. GPS, drum nets etc.
- Recreational fishing license seen as way to increase management resources available to sector.
- Still examples of commercial operators running nets across tops of systems.
- Existing Boating and Fisheries Officer enforcement levels seen to be too low, concerns re: Land and Sea Rangers having enforcement capacity due to conflict potential.
- Bitumen road access has increased recreational fishing pressure places like Karumba ~105 boats on water at a time.
- Offset $ could be used to buy back commercial effort in Gulf and help establish recreational only areas with potential greater economic benefits to broader community – e.g. of NT example where number of licenses vastly reduced – leading to highly viable commercial and recreational fishing sectors.
- Restocking efforts for Barra and key recreational species (particularly in impoundments) supported as means of generating additional economic development / community amenity (life be in it).
- Impacts of water resource development could potentially be offset by buy back of commercial fishing pressure especially gill net effort which is considered too high.
- Elevated erosion rates cattle grazing in catchment – Giffith Uni radar data study supports greater efforts in riparian frontage / erosion prone area fencing and stock grazing pressure management.
- Perennial flowing multi-braided channel Gregory system considered especially sensitive to water outtake.
- Gregory example of poorly managed 'Wild River' system. Managed demonstration reach –zoned public access, controlled grazing/exclusion fencing, weed management, ranger overseen camping permit system would be good goal.
- Wildallion Creek – example of flow allocation key restoration need.

- Fire key to management or riparian weeds (?) – compliance notices for weeds not being issued by Local Govt lands protection officers.
- Fish passage still an issue for targeted species – observed reduction in Cherabin numbers in Gregory – Nicholson system may be related to barriers. Flinders system also affected (Walkers Bend), sawfish affected (observed reductions last 40 years).
- Bag and size limits need tightening for Grunter in Gulf waters (NB > 80+ boats fishing breeding aggregations in one day) – heavy fishing of spawning aggregations seen to be sure fail for stock sustainability.
- Need greater research reproductive biology – size and timing of breeding (check status of knowledge) – while commercial fishers don't take as much as recs (100's versus 1000's tonnes) need assessment of brood stock.
- Commercial fishers have fishery access State Wide – crab and gill netters, need regional entry controls.
- Possession limits seen to be too high for recs by other industry (tourism, commercial fishing) and other rec fishing stakeholders.
- Stock assessment studies for grunter critically important.
- Studies of Griener *et al* questionable re key findings. Anecdotal information of stock reduction e.g. having to travel further to find aggregations and banks that previously produced fish no longer doing so.
- Fishery independent stock assessment – grunter, crabs – much debate about stock status and overfishing levels but very limited availability of fishery independent stock status data.
- Buy back of effort only one way to reduce pressure, exclusion areas seen to have role also.
- "Ghost' crab pots becoming significant issue in Norman estuary close to Karumba, can continue to fish for six months including by rebaiting via feral cats at low tide – potential role for sea rangers / community program to remove.
- R & D needs – post stocking monitoring surveys =- growth rates, populations (used to be done by DAFF), Commercial fishery take levels, Gulf Saratoga, Extension needs.

Commercial Fishers

- Key issues is with sustainability – most fishers have concerns re: levels of take are not likely to be maintained, analogous to grazing pressure 'there is only so many head than can be run in the bottom paddock' – investment warning have been in place for fishery since later 90's e.g commercial crab licenses NT – 49 – Qld – 440
- Some believe status of Gulf fishery generally healthy especially relative to east coast –e.g. well managed Prawn fishery, barra fishery
- Catch quota and reduced license numbers seen as means by which to better underpin economic and ecological sustainability of fishery.
- Range of not mutually exclusive clichés in industry (1) lifestyle fishers some of which form part of 'latent' effort often utilise leased fishing licenses, can depend on 'unregulated effort' and not so open to output controls i.e. catch quotas (2) Increased management supportive 'Professional' full time fishers often well capitalized and seeking reduction in effort and open to input / output controls as way of ensuring continued profitability and viability and (3) Increased management adverse "commercial fishers' who are opposed to additional controls on fishery i.e. increased input / output controls as see this as reducing their flexibility and potential 'take' especially by currently poorly regulated / enforced input controls becoming regulated (i.e. number of pots, number of net sheets etc.)
- Commercial fisher representation need seen for representation of wild catch component of industry e.g. Gulf Fishers Association as opposed to aquaculture / seafood industry.
- Grey Nomad 'fishery' interacting with commercial fishery via provision of gear / payment for catch by licensed fishers - > bag limits so there is no surplus for trading and/or catch quotas for commercial operators could help control this black-market.
- Regional management preferred to 'co-management' being proposed as part of current fisheries review – seen to be key role for regional NRMs to participate / facilitate.

- Much attention being focused on reducing commercial effort without knowing real pressure drivers of fishery decline.
- Monitoring systems e.g. boat tracking devices have potential role to play in management of fishery.
- Monitoring of fishery take affected by log book record inaccuracies no real validation of logbook data and a range of motivations for falsification (keeping licenses, selling operations etc.).
- Fishery independent stock assessment key need and more credible validation of catch required to assess stock status before new management regimes entered into.
- Need perceptions of industry impacts managed to avoid undue controls e.g. impacts of boat strike, turtle and dugong by-catch levels – boat go slows would lead to non-profitable crabbing industry.y Public perceptions important and can lead to commercial $ impacts.
- Some feel recreational sector needs better management of take e.g. tagged catch and reduced bag limits.
- Rec only closures near population centers affect viability of commercial operators based in such centres by increasing travelling distances /times.
- Need more independent science to identify reality re: water quality issues and other potential catchment based impacts on fisheries (Role for NRMs to facilitate).
- Introduction of licenses for rec fishers would pay for increased management options.
- Gulf fishery should aim for world's best practice complete with input and output controls to help ensure sustainability.

Tourism Industry

- Free camping on commons big cost to community – access to USL – Burketown doing deal with CLCAC to deliver management of USL areas – green zone belt around town. Aspirational goal for Traditional Owner/ Ranger programs – manage camping ground development via dedicated facilities and permit system.
- Environmental tourism – new class of 'red wine and cheese' tourists don't all want to kill stuff.
- Hunting and fishing tourism good sideline for Cape Properties cf. Gulf properties where pastoral viability reduces need for tourism sideline.
- Gregory River need to get an outcome away from stream bed based camping – currently no legal right to exclude and don't want to dissuade tourists too much. Can shut down road access – river reach access and permit system could manage better. Offset investment $ could be used to survey and set up managed reach access possible via alienation of land from pastoral lease - need to cover cultural survey costs etc.
- Fisheries sustainability ultimately comes back to education, long term caravan park stayers want to take fish home, need brochure available re: fisheries sustainability issues when people book into caravan parks.
- Tougher enforcement of fishery resource exploiters would only affect small percentage of tourist population.
- Require access to information regarding Gulf environment that can build a profile for sustainable management of businesses operating in the Gulf – use to engage business community as a template for sustainable management – how to care for environment and WHY! E.g. of recreational fishery sustainability needs to be engendered within community and businesses. Compare with NT example of 'Desert Knowledge' NRM program established in central Australia in vicinity of Alice Springs.
- Potential role for Fishcare (or general environmental awareness) volunteers program could embed using long term staying residents of caravan parks (or like) – use as conduit for providing visitors information on appropriate behavior, why Gulf is a sensitive marine - environment and fishing regulations.
- Boat ramps in coastal Gulf currently lack species identification and fishing regulations information key material (boat ramp signage and brochures) required to improve sustainability of recreational fishery.
- Much more environmental interpretation information generally required. Brochures and signage – mooted role for 'Monsoon Centre' (to be established in conjunction with Muttonhole Wetlands interpretation centre?) – also place that can act as focal point for bringing in collaborative field research for Gulf savanna environment into one collective place. Access to Muttonhole wetlands provides improved understanding that helps underpin improved NRM management.

- Opportunity seen for much greater engagement of Aboriginal community in managing / interacting with tourists and tourism industry. Training of Savanna Guides and Rangers.
- Currently observed how weather drives fishery productivity and associated business activity – 'drought on the land = drought in the water' key issue for consideration of water resource development options in Gulf catchments.
- Loss of MMG from Karumba will have impacts on community – how to maintain dredging and associated flood relief, viability of commercial wharf?
- Tourism industry such as Karumba's based on exploitation of fishery resources and natural environment condition considered delicate.
- Alternative focus for Coastal Gulf tourism could be developed on Bird watching – education / promotion of such would expand tourist market and help realise environmental values of region and underpin need for improved NRM.
- Local environmental values not recognised by local government e.g. example at Karumba of star finch habitat being cleared to make way for dump.

Local Government

- Remote and small sized councils don't have access to resources /agencies / expertise available to coastal councils, need to be lead to an extent in terms of responding to longer term ~20 yr budgetary cycle issues e.g. sea level rise / storm surge / climate change – scenario generation for Gulf coastal communities could be useful – how Gulf will look, implications for settlement /infrastructure, implications re: engineered specifications of roads, bridges etc. against event reoccurrence frequency.
- Mining development delivers lots of infrastructure for community roads etc. Minerals province of Gulf has lots of outstanding development potential. Century infrastructure being moth balled rather than closed.
- Climate change abatement options relevant to remote area local governments re: power supply options – Burke Shire examining small hydro option for Gregory – could do with further technical support / regional examination of alternative power options for remote communities – solar plant mooted for Normanton (but people have been burnt by industry), wind resources of Karumba potentially significant.
- Burke Shire enjoys good working relationship with CLCAC Ranger program – have Indigenous land Use agreement Rangers take lead in Landcare issues.
- Woods Lake – example of saltwater intrusion issue.
- Tourism development potential still not realised – recreational fishers and tourist development can help replace some of the economic inputs being lost with cessation of Mining projects.
- Councils need to act as key articulate voice in water resource development issues.
- Local environmental values not recognised by local government e.g. example at Karumba of star finch habitat being cleared to make way for dump.
- Karumba interests suggest funding directed at their area needs to come through local chamber of commerce if intending to specifically serve Karumba projects.

Conservation Interests

- Local environmental values not recognised by local government e.g. example at Karumba of star finch habitat being cleared to make way for dump.
- Feral cat population out of control in coastal Gulf e.g. Karumba outskirts puts pressure on bird populations.
- Appropriate burning practices positive for environment but still under utilised.
- While wading shore bird habitat values of coastal Gulf well recognised many other species that have greater rarity occur in coastal Gulf habitats including mangrove, wetland and woodland associated species e.g. Rails, Star finches, Zitting Cisticolas, White Breasted Whistlers, Red Headed Honey eaters

- Need greater access to environmental interpretive information to explain for visitors the specialness and sensitivity of coastal Gulf environments use KISS principle – brochures and signage and survey to identify appropriate places to locate promote.

PORT OPERATIONS

- Local government examining options for taking over running of Port – currently don't see generated $ coming back to community – opportunities to re-invest $ in port development to serve fishing industry – 100's K spent on examining viability of marina for Karumba cf. port redevelopment option to commercial wharf and lift out facility
- Dredging operations have benefits re: reduced flood risks but also generating erosion problems with river bank and sea wall

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