

CHAPTER 1.1  
CORAL REEF  
STATE OF REGION REPORT 2013

MARINE



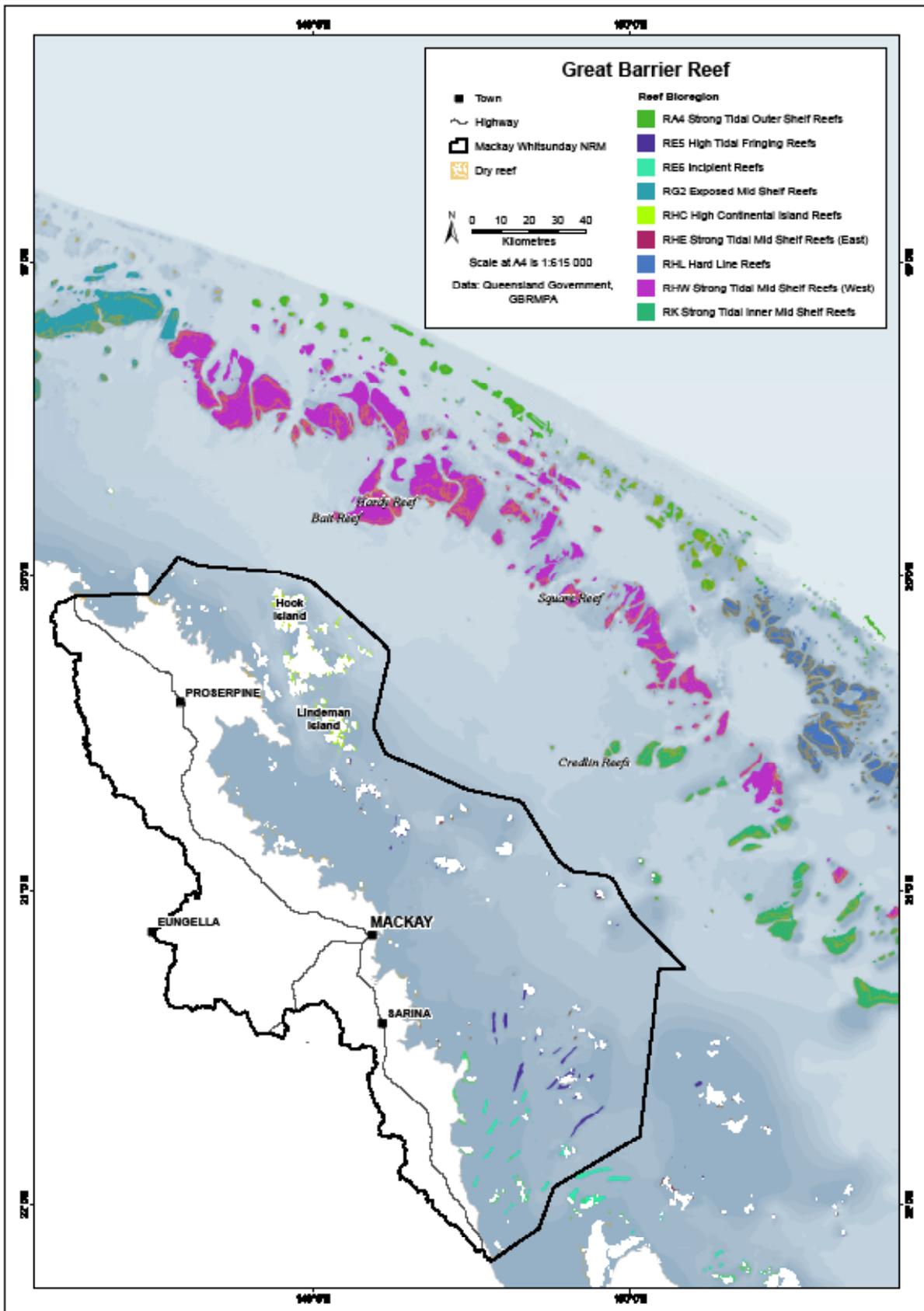


Figure 1: Coral reefs of the Mackay, Whitsunday and Isaac Region and immediate surrounds

## SUMMARY

The Great Barrier Reef (GBR) stretches more than 2,300 km from the south-east Gulf of Papua to just north of Bundaberg. The GBR consists of over 2,500 individual reefs, over 900 islands and covers more than 348,000 square kilometres. The larger part of this area was gazetted as a World Heritage area in 1981. It is the only living organism that can be seen from space, is considered by some to provide the most spectacular marine scenery on the planet, is one of the richest and most complex natural ecosystems on earth and has globally significant marine faunal groups (DSEWPAC, 2012).

The regions fringing reefs vary considerably from species-poor muddy reefs close to the discharge of the Proserpine River, through to fragile hard and soft coral communities in inlets and embayments. Significant cross shelf and north to south gradient of reef type exists, so the reef changes gradually from a particular state inshore to mid-shelf and outer reefs, and in a similar manner from north to south.

In the Shoalwater Bay area incipient reefs are common. Here corals can grow but sediment is high and the water deep, meaning the conditions for forming reefs are poor. Conditions improve around southern Mackay islands with clear and shallower water. The northern Mackay and Whitsunday Islands provide the best conditions for coral growth in the north south gradient with shallow, warm water and high island density.

The cross shelf (or in the case of the GBR west to east) gradient is influenced by distance from the coast. Inshore and fringing reefs are exposed to higher levels of sedimentation and lower wave energy, which generally grades across the mid-shelf (lower sediment, higher energy) to the outer reef that has the least sedimentation and highest exposure. However, broad generalisations do not account for all factors, or combinations of factors that result in the differences in individual reefs.

Strong tidal mid-shelf reefs (e.g. Bait and Hardy Reefs) are typified by high-energy environments and contain distinct fish communities. Similarly, strong tidal outer shelf reefs (e.g. those associated with the outer area of Hydrographer's Passage) have high-energy environments, strong tidal influences and distinct biological communities. Hard line reefs (e.g. Cockatoo Reef) form an extensive outer barrier to this section of the GBR. Hard line reefs contain steep walled channels and sheltered leeward reef communities.

Strong tidal mid-shelf reefs (e.g. Credlin Reef) are high in diversity and are characterised by non coral dominated communities in leeward areas. Strong tidal inner mid-shelf reefs (e.g. those around Mackay islands such as Flat Top and Round Top Islands) form in moderate to high turbidity (very hazy) with varying exposure to wave action and other factors that influence their biological diversity and health. High tidal fringing reefs (e.g. Keswick and St Bees Islands) generally have high turbidity, which advantages non-hermatypic corals, octo-corals and gorgonian communities. Incipient Reefs are high in macro-algae coverage and poor in coral diversity.

REEF BIOREGION	EXAMPLE
RG2: Exposed mid shelf reefs	Stanley Reef
RHC: High continental islands (fringing reefs)	Whitsunday Islands fringing reefs
RHW: Strong tidal mid shelf reefs (west)	Hardy and Bait reefs
RA4: Strong tidal outer shelf reefs	Hydrographer's Passage reefs
RHL: Hard line reefs	Cockatoo Reef
RE4: Strong tidal inner mid shelf reefs	Flat Top and Round Top Islands
RK: Strong tidal mid shelf reefs	Credlin Reef
RE5: High tidal fringing reefs	Keswick and St Bees Islands fringing reefs
RE6: Incipient reefs	Cape Palmerston fringing reef

Table 1 Regional Reef Bioregions

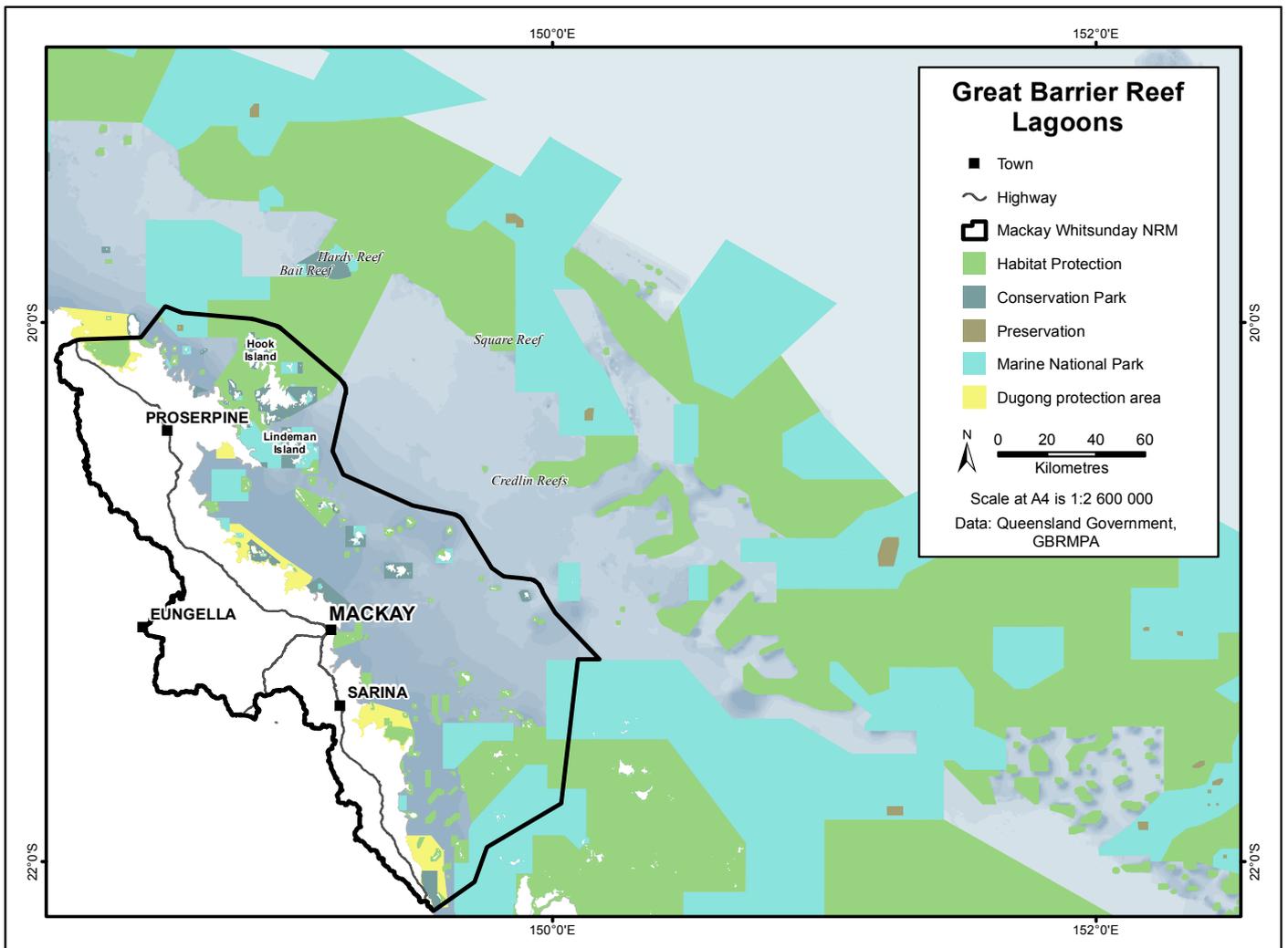


Figure 2 Protection areas within the GBR lagoon in the region

## VALUES AND SERVICES

### International Environmental Value

Inscribed on the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage List in 1981, the GBR was the first ever marine site listed for all four of the natural criteria and considered to have Outstanding Universal Value (OUV) as the largest assemblage of coral reefs in the world (McGrath, 2012). The OUV criteria were of sites that represent:

- Major stages of earth's evolutionary history
- Superlative natural phenomena or exceptional natural beauty
- Significant ongoing geological processes, biological evolution and man's interaction with his natural environment
- Habitats where populations of rare or endangered species still survive.

### Ecological Value

Ecologically the GBR is unique amongst reef systems in the world. It provides habitat for a number of key species and assemblages that are international migrants. These include marine turtles, shorebirds and humpback whales. These natural assets are shared amongst international communities and Australia's duty of care for these whilst in Australian territories, is embedded within international treaties, such as the China-Australia Migratory Bird Agreement and Japan-Australia Migratory Bird Agreement.

The following provides a breakdown of the extent of the GBR's ecological values:

- The world's most extensive stretch of reef and an area of outstanding aesthetic value, providing what some consider the most spectacular marine scenery on earth.
- The Whitsunday Islands are an important calving area for humpback whales (GBRMPA, 2008), and an important feeding ground for turtles.
- Has globally significant marine fauna groups, providing habitat for:
  - o 1,500 species of fish
  - o 30 species of cetacean
  - o 6 species of turtle (out of a total of seven world-wide)
  - o 400 species of coral (including almost 1/3 of the world's species of soft coral)
  - o 800 species of echinoderms (e.g. sea stars) constituting 13% of the world's total species
  - o 4,000 species of mollusc
  - o 240 species of birds
  - o An array of other species such as dugong, sponges, anemones marine worms and crustaceans. (DSEWPAC, 2012).

## Economy, Trade and Shipping

A variety of commercial and recreational activities are supported by the GBR and many Australians rely on these regional economies for their livelihoods. In 2005 the GBR was considered to be worth over \$5 billion per annum to the Australian economy (Access Economics, 2008) and accounted for some \$17 billion of Australia's export trade.

At present 12 ports operate within the GBR World Heritage Area and two are within the Marine Park. One of the largest, Hay Point, is located within the catchment and Abbot Point is less than 30 km to the north. The port of Mackay and Dalrymple Bay are also found within the catchment.

These ports service a population of around 1 million in northern regional Queensland - nearly 27% of Queensland's population (Access Economics, 2008). The GBR is an internationally recognised safe shipping route, and as a marine nation the ports are valuable trade access points for Australian goods.

## Visitor Services

According to the Great Barrier Reef Marine Park Authority (GBRMPA) (2011a) approximately 1.92 million visitor days are recorded on the Great Barrier Reef each year with 800,000 and 120,000 of those visiting the Townsville/Whitsunday and Mackay/Capricorn areas respectively during 2011/2012.

Recreational use of coral reefs including fishing is very high within the region. The Queensland direct economic value of this activity is estimated at \$300 million (Anon, 2005) of which at least 10% would be spent within the Mackay Whitsunday region.

Access Economics (2008) provide figures for tourism expenditure within the region in 2004/05 and 2005/06. \$1,202 million was spent within the Mackay Whitsunday Region in 2005/06, a 30% increase from 2004/05 (Table 2). Across Reef Catchment areas, tourism industries are responsible for employing at least 30,000 people directly (Anon, 2005). Based on the assumption that employment level is proportional to expenditure it is estimated that approximately 6,600 people are directly employed by tourism industries in the region. It is important to note that neither expenditure nor employment figures take into consideration indirect benefits to the economy from tourism, and that these are substantial.

Tourism Region	2004-05				2005-06				2005-06	
	day	domestic overnight	intl	total	day	domestic overnight	intl	total	overnight share (%)	intl share (%)
Tropical North Qld	141	1,377	1,039	2,557	178	1,346	1,111	2,635	39%	82%
Northern	67	477	74	618	121	460	64	645	13%	5%
Whitsundays	19	440	110	569	32	676	121	829	20%	9%
Mackay	56	284	13	353	79	280	14	373	3%	1%
Fitzroy	179	435	30	644	182	502	32	716	14%	2%
Bundaberg	50	195	15	260	85	200	11	296	5%	1%
<b>Total GBRCA</b>	<b>512</b>	<b>3,208</b>	<b>1,281</b>	<b>5,001</b>	<b>677</b>	<b>3,464</b>	<b>1,353</b>	<b>5,494</b>	<b>100%</b>	<b>100%</b>
Australia	11,614	39,380	12,544	63,538	12,611	40,691	13,402	66,704		
GBRCA/Aust	4.4%	8.1%	10.2%	7.9%	5.4%	8.5%	10.1%	8.2%		

Table 2 Tourism expenditure in Great Barrier Reef Catchment Areas \$ Million.

### Other Values

Due to the relatively new nature of biotechnology industries, the potential contribution of coral reefs to development of resources such as novel pharmaceuticals is difficult to gauge. However, due to their inherent biodiversity the value of coral reefs is likely to be high to very high. At present, biotechnology industries in Queensland are generating in excess of \$150 million per annum and employ over 1000 persons (Anon, 2005).

## PRESSURES AND THREATS

“Almost all the biodiversity of the Great Barrier Reef will be affected by climate change, with coral reef habitats the most vulnerable. Coral bleaching resulting from increasing sea temperature and lower rates of calcification in skeleton-building organisms, such as corals, because of ocean acidification, are the effects of most concern and are already evident.”

Great Barrier Reef Outlook Report (GBRMPA, 2009; i)

### Climate Change

Coral reefs have always been impacted by tropical cyclones and are adapted to recover. However under climate change scenarios the intensity of cyclones is expected to increase (IPCC, 2007), therefore a threat exists in the cumulative impacts of cyclone damage particularly when combined with anthropogenic impacts. Cyclones are expected to track further southwards with some studies suggesting by as much as 130 km (Hardy et al., 2004 in Low, 2011), meaning the reefs within the catchment could experience more cyclone damage than in previous centuries (DERM, 2010). Reef damage from cyclonic activity includes damage to the physical structure of coral as well as the impacts of flood plumes including increased sedimentation, nutrient levels and an increase in turbidity.

The combined impacts of climate change, such as increased temperatures and reduced water quality, has potential to result in a reduced ability of a reef to recover from future cyclone impacts (GBRMPA, 2012). A rapid health assessment survey was conducted following category five cyclone Yasi which crossed the coast in February 2011 and was one of the most powerful cyclones to affect the Queensland coast since records began. Surveys confirmed that more severe damage occurred to reefs in areas exposed to greater wind speeds, and reefs south of the cyclone were more damaged than those to the north. It is expected that signs of reef recovery will occur within 5 years in areas of low to moderate damage providing no further cyclones or other impacts such as Crown of Thorns Starfish (COTS) outbreaks occur. In more severely impacted areas this can be expected to increase to about 15 years, however damage will still be seen for decades on the reef proper.

### Ocean Acidification and Coral Bleaching

Ocean acidification is the name given to the process of the world's oceans absorbing excess carbon dioxide from the atmosphere. A chemical reaction between water and the carbon dioxide results in a net increase in the acidity of the oceans. Further chemical reactions mean that there are a reduced number of carbonate ions available for reef builders such as corals to form their calcium carbonate (limestone) skeletons and make them more prone to dissolving. Calcium carbonate is also the main component of the shells of marine organisms.

This process, which is projected to increase in projected climate change scenarios, has obvious impacts on the ability of coral reefs to grow and repair following damage (e.g. after a cyclone) or bleaching event and make them more prone to breakage thus resulting in greater initial impact and possibly slower recovery time.

### Water Quality

Coral ecosystems depend on the quality of water that surrounds them. Sediment, nutrients and contaminants such as pesticides all impact coral colonies. It has recently been shown that pollution and sedimentation combined dramatically increase coral death, and that this can occur rapidly when exposed to sediment containing even small amounts of organic matter (Weber et. al, 2012).

Coastal corals are naturally resilient to low levels of organic matter within the water, however when corals are coated with a thin layer of sediment such as occurs following flood plumes and through regular run off, just 1% organic matter within this sediment removes oxygen (through increased microbial activity) and raises acidity levels resulting in small areas of the coral dying (Weber et al., 2012). Continued microbial activity creates hydrogen sulfide that is highly toxic to coral and in the rest of the colony covered in sediment results in death in as little as 24 hours.

Earlier studies outline other problems with poor water quality for example Fabricius (2005) found that high sediment loads reduced the ability of coral polyps to settle and form new colonies and resulted in their death. Fabricius and De'ath (2004) found reduced recruitment, reduced diversity and subsequently a reduced species richness in highly turbid environments. Weber et al in 2012 found that marine snow (microscopic algae bound with sediment) has resulted in a major loss of coral cover and sea grass decline on the GBR by smothering young corals. They found that sediments enriched with organic nutrients reduced oxygen and increased acidity and caused coral death and were most common in areas of coastal development exposed to water enriched by flood plumes or during re-suspension events (e.g. dredging). Combine this information with the findings of Andutta et. al (2013), discussed below, and Brodie et. al (2012) that sediment, nutrients and other pollutants are thought to remain longer in the GBR lagoon than the freshwater they are suspended in, and a picture of the importance of water quality to coral colonies and their survival becomes evident, particularly close to areas of coastal development.

### Coastal Development

*"It is clear that the scale of coastal development currently being proposed and consented presents a significant risk to the conservation of the OUV (outstanding universal value) and integrity of the property, and that the scale and pace of development proposals appear beyond the capacity for independent, quality and transparent decision making"*

(Douvere and Badman, 2012; 255)

### *Coal Port Expansion*

The pressures placed on the GBR by the expansion of coal ports within and adjacent to the catchment (Hay and Abbot Points), is considered significant and compounded by current governance arrangements including regulatory, administrative and operational, which can inhibit effective management of port and shipping impacts (Grech et. al, in review).

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A report commissioned by the Abbot Point Working Group with direction from BHP Billiton and North Queensland bulk ports states that as a direct consequence of the coal port expansion shipping traffic is expected to increase more than 9 times out of Abbot Point and nearly three times out of Hay Point in the next 20 years (Polglaze, 2012).

Increased coal shipping traffic increases the risk of oil and coal spills, groundings and vessel strikes impacting species such as migrating humpback whales. Other impacts include underwater acoustic (noise) pollution, coal dust, the impacts of dredging spoil on reef water quality, and the aesthetic values of the region. Increased shipping traffic also increases the risk of invasive species being introduced and contaminants such as toxic antifoul, sewage and galley scraps impacting marine ecosystems.

#### *Dredging, Marinas and Marine Material Placement*

The GBRMPA consider that the major impacts from dredging activity within the GBR come from the operation of coal ports (GBRMPA, 2011b). However, new and existing coastal developments such as marinas and other land reclamation activities have short-term (construction phase) and longer-term impacts on coral reefs that should also be considered when discussing the impact of dredging and marine material placement at the local scale.

New marinas such as the development at Port of Airlie (Muddy Bay) and the proposed marina development at Shute Harbour place increasing pressure on coral communities especially within inshore areas, as well as having detrimental impacts to other marine life such as seagrass communities. With a rapidly growing regional population, such pressures are forecast to increase.

Recent studies have shown that within the central GBR the time taken for fresh water from outside the reef to flush waters inside the reef under real wind conditions was 67 days. However, under calm weather conditions and with little external reef current inflow the flushing time could be as long as 9 months. In addition, up to half of the water leaving the GBR returns to the GBR through the movement of oceanic currents (Andutta et al, 2013). This means that marine material dredged from the ocean floor stays within the GBR for an extended period and may return once it has left.

#### *Pests*

Increased shipping and other vessel traffic increases the risk of species such as the Asian green mussel being transported to the catchment. The Asian green mussel can be carried on vessel hulls, in ballast water and in internal seawater systems (e.g. fire hoses) and may have serious economic, ecological and human health implications.

COTS (*Acanthaster planci*) are a species of starfish native to the Indo-Pacific region that consume hard corals and in high numbers can dramatically reduce living coral cover. These outbreaks cause considerable public and industry concern particularly amongst marine tourism operators as they reduce the aesthetic value of the reef at the outbreak site. When combined with pressures such as declining water quality and climate change, COTS outbreaks reduce the reefs capacity to recover from such disturbances.

It is now well understood that COTS numbers increase as nutrient levels increase (Brodie et al. 2005). Phytoplankton are the primary food source of larval-stage COTS and increase in numbers due to elevated nutrient levels. COTS populations are thus able to increase dramatically as their primary food source also increases.

Outbreaks occur when the COTS summer breeding season coincides with a dramatic increase in nutrient levels in the water such as has occurred from the recent La Niña cycle. Increased nutrient levels allow many more of the larval COTS to survive, causing localised outbreaks on the GBR.

The GBRMPA is in the process (at April 2013) of formulating a control strategy for COTS to assist the tourism industry to protect coral at high value visitor sites. This short-term strategy is backed by longer term plans to improve water quality entering the GBR lagoon, such as the Reef Rescue Initiative and the Reef Water Quality Protection Plan (Reef Plan).

### *Coral Disease*

Like COTS coral diseases are a natural occurrence in coral ecosystems and to date have not caused significant outbreaks on the GBR possibly due to its overall condition. Osbourne et. al (2011) state that only 6.5% of coral mortality between 1995 and 2009 was attributed to coral diseases and managing overall reef health will likely maintain this low incidence.

However world-wide infectious disease in corals has increased since the 1970's. Multiple factors are at play, however it has been established that increased ocean temperatures, increased carrier and host densities and the intensity of coral bleaching have a significant relationship with coral disease prevalence. Nearly all of the other negative anthropogenic coral reef impacts (e.g. ocean acidification, overfishing and marine pollution) have been suggested contributors in some way to coral disease (The Nature Conservancy, 2012).

### *Commercial Marine Tourism*

According to Harriott (2002) the pressures of commercial marine tourism on the GBR can be summarised into 6 main types; coastal tourism development, island and marine based tourism infrastructure, boat-induced damage, water-based activities and wildlife interactions.

Commercial marine tourism is managed by GBRMPA and the Queensland Parks and Wildlife Service (QPWS) through a permit system. Anchor damage is managed through the installation of mooring and 'no-anchor zones' in heavily used areas. 85% of tourism on the GBR is centred around Cairns and the Whitsundays collectively meaning visitor numbers are high over an area covering only 7% of the GBR. This impacts coral reefs in particular through fin damage, collecting, in-water pollutants (such as sunscreens and oils) and impacts on the behavioural characteristics of marine creatures.

### *Fishing*

Commercial and recreational fishing have a direct impact on the GBR through the removal of herbivorous fish, damage to the seabed and other habitats and removal of non-target species (by-catch). For example the removal or reduction in the number of herbivorous fish present within a coral colony can allow excessive growth of resilient and aggressive algae and seaweed. If fish stocks are consistently depleted algae and seaweed may dominate in the coral colony, and in some cases completely destroy it.

No take zones and other commercial fishing restrictions have a significant positive impact on the protection of the GBR and its coral colonies (McCook et. al, 2010). Various other functional groups of herbivorous marine creatures (such as bioeroders or coral grazers) play important roles in the health of coral communities so maintaining the variety and abundance of the various functional groups and species will have the highest ecological impact.

## CONDITIONS AND TRENDS

“While most of the stressors that are responsible for the decline of coral reefs worldwide are present on the GBR, damage to date has been localised rather than system wide”

Sweatman, 2011; 1

The condition of Australia's marine environment, when compared to the rest of the world is considered good (Australian Government, 2011). The eastern region including the GBR as defined by the SoE (2011) is also considered to be in good overall condition. However, herbicides in significant levels have been found within all sampling sites within the GBR and Kennedy, et. al (2010) consider these levels to have significant impacts on coral and other marine life. According to Reef Plan (2012), inshore reefs are in moderate condition and coral cover is poor but macroalgae results are very good (low cover). The number of juvenile corals is good but has declined in recent years.

The primary information sources on coral reef condition within the region are: Sweatman et al. (2011) - Long-term Reef Monitoring Project (LTRM) (Australian Institute of Marine Science (AIMS), 2012, which has occurred since 1985; and Sweatman et al, 2012) (AIMS); individual reports on local reefs available online; the first report card of the Reef Water Quality Protection Plan (Queensland Government, 2013); and the Great Barrier Reef Outlook Report 2009 (GBRMPA, 2009). It should be noted that The Outlook Report and Reef Plan report do not incorporate more recent information that includes recent storm and subsequent flooding events that will have impacted water quality.

“The major conclusion from the Long-Term Monitoring Program is that coral cover has undergone a wide range of changes, including dramatic increases and decreases on different reefs, and that there is no strong, consistent overall trend across the Great Barrier Reef... This is a reflection of the vast size of the ecosystem, the number and diversity of reef types, and the circumstances and events that affect them”  
Outlook Report (2013; 14)

Although long-term data (i.e. greater than 20 years) are not available, there is some agreement from authors that there has been a general decline in coral cover (Bellwood et. al, 2004, Death et al, 2012) some by as much as 50%. However, other reports state that coral cover is stable (Osbourne et al, 2011), although a criticism of this study remarks that due to the depth at which the study was undertaken (6-9m) effects of flood plumes and coral bleaching may not be adequately considered as they tend to occur in shallower regions of the reef (Brodie, 2012). Indeed Brodie (2012) provide a comprehensive overview of the assessment of coral condition and the difficulty faced in coming to an absolute measure of coral health of the GBR.

In 1999, Van Woesik et al. found that inshore reefs close to river discharge had limited 'reef building' capacity and that this capacity had only recently been lost. They proposed that inshore reefs such as those at the mouth of the Proserpine River (e.g. Repulse Island fringing reefs) have 'switched off' as a result of increased nutrient and sediment load.

Cheal et al. (2001) also propose that patterns in reef development within the Northumberland Island are correlated with distance away from river discharge. Further, these authors recommend that reefs at South Percy, Pine and

Prudhoe Island are most suitable for monitoring studies because they are reef building, but lie on the limits of incipient reefs e.g. they may be more sensitive to disturbance.

The below tables represent a range of sites across the catchment and include inshore, mid shelf and outer shelf sites. These sites were selected to give an overview of the catchment trends (further information including data on all reefs from the AIMS LTMP can be found at <http://www.data.aims.gov.au>).

Fixed sites on NE flank	Current 10 year GBR		
	Year	Range	Mean
Hard Coral Cover in 2011	31%	28%	23%
Number of Fish Species	46	45	64

Table 3 Border Island Fringing Reef (surveyed for 16 years, last survey April 2013)

Fixed sites on NE flank	Current 10 year GBR		
	Year	Range	Mean
Hard Coral Cover in 2011	28%	33%	23%
Number of Fish Species	71	69	64

Table 4 Reef 19-138 mid-shelf lagoonal reef (surveyed for 23 years, last survey April 2013)

Fixed sites on NE flank	Current 10 year GBR		
	Year	Range	Mean
Hard Coral Cover in 2011	3%	15%	23%
Number of Fish Species	69	68	64

Table 5 Rebe Reef outer shelf planar reef (surveyed for 17 years, last survey April 2013)

There are active COTS outbreaks on 3 reefs adjacent to the catchment at present and an incipient outbreak on 1, while 19 have no outbreaks and 5 are recovering. On each of the reefs with current outbreaks hard coral cover is still in good condition and as they are mid-shelf reefs located well away from river mouths their ability to recover should be high.

Cyclone Hamish, a category 5 tropical cyclone that passed to the east of the region in March 2009, significantly damaged the outer shelf of the reef in the northern part of the catchment. According to Miller (2011) large areas of coral at Rebe Reef weighing tonnes were 'thrown onto the reef crest like so much gravel' demonstrating the damage caused by cyclonic activity.

Long term monitoring data describing reef fish communities is only available for some of the Whitsunday sector of the region. Generally populations of key indicator species have remained stable over 13 years of monitoring. On some reefs e.g. Border Island numbers of heavily targeted species such as coral trout (*Plectropomus leopardus*) and sweetlip/snapper (*Lutjanidae*) have decreased noticeably, although on some other reefs coral trout numbers have increased. A key tool in managing reef fish populations is through dedication of No Take Areas (NTA's). Within the region, the percentage of area of each reef bioregion within NTA's is relatively high but not always the 30% required for each bioregion (Bellwood, 2004). No take areas have been proven effective in recovering fish numbers (McCook et. al 2010).

REEF BIOREGION	% WITHIN NO TAKE AREAS (NTA'S)
RG2: Exposed mid shelf reefs	20.3
RHC: High continental islands (fringing reefs)	21.0
RHW: Strong tidal mid shelf reefs (west)	27.0
RA4: Strong tidal outer shelf reefs	31.8
RHL: Hard line reefs	21.4
RE4: Strong tidal inner mid shelf reefs	21.2
RK: Strong tidal mid shelf reefs	21.0
RE5: High tidal fringing reefs	30.2
RE6: Incipient reefs	40.0

*Table 6 Percentage of No Take Areas (NTA's) over each reef bioregion.*

Within the Whitsunday Islands sector of the region the level of damage from anchoring and swimmer/diver activity formed the impetus for a major investment in public mooring and fringing reef marker infrastructure. However, little such investment has been made within other areas of the region, and significant damage has been recorded from fringing reefs around the islands off Mackay (CREW, 2001). Nevertheless, the magnitude and distribution of current damage remains unclear.

## Location of public moorings and reef protection markers

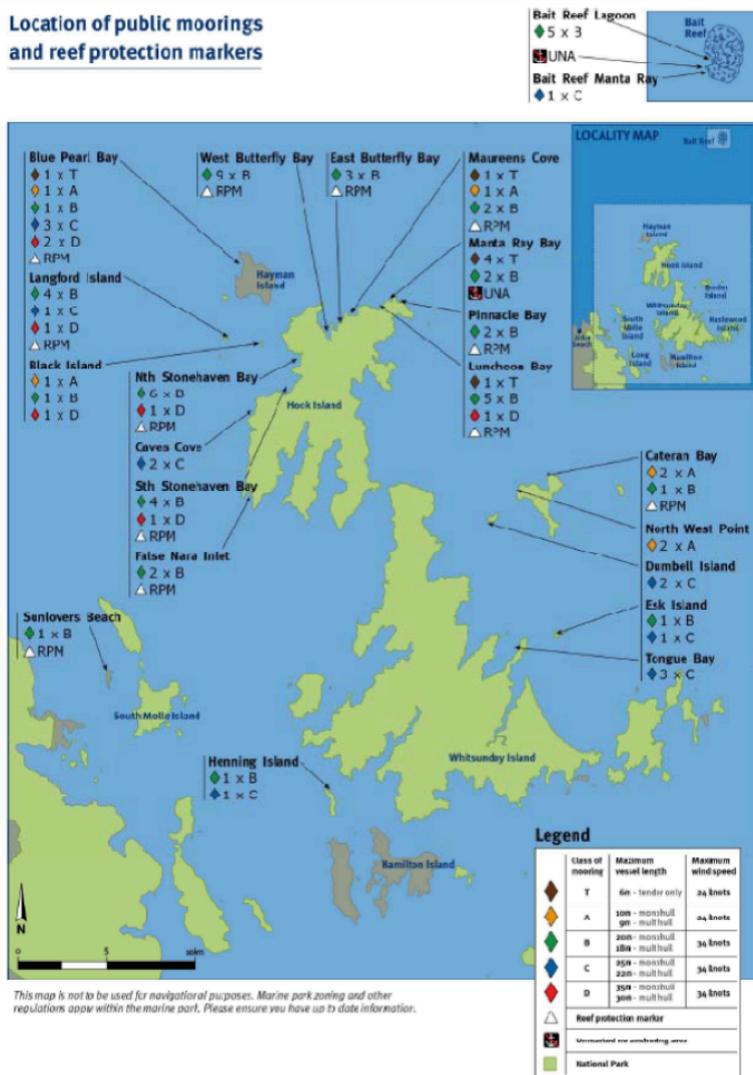


Figure 3 Reef protection infrastructure within the Whitsunday sector of the region

World Heritage Committee (WHC) and the International Union for the Conservation of Nature (IUCN) conducted a reactive monitoring mission in early 2012 that culminated in a report to the WHC (Douvere & Badman, 2012) co-authored by UNESCO and the International Union for the Conservation of Nature (IUCN). The conclusions of the report were that significant and positive steps towards effective management of the GBR had been undertaken by the state and federal governments to date including increasing no-take zones to 33% and the implementation of programs such as Reef Rescue to improve water quality. However, should the current impacts and proposed future development of coastal areas (in particular, coal ports and coal seam gas infrastructure) and greater measures not be taken to increase resilience of the reef to climate change continue, the GBR was on track to be included in the List of World Heritage in Danger under the World Heritage Convention.

In summary coral reef condition varies with time and coral cover is dynamic and driven by various factors. There is a great deal of information available on reef condition, much of it conflicting, but there is general agreement that coral cover reef wide has declined at least in the last 20 years particularly in inshore areas. Local reef specific data is available but is not an adequate reflection of the trend of coral generally within the region as the sites selected have not been monitored for long enough to show a reasonable trend (e.g. Penrith Island fringing reef has only been established for 3 years, Pompey 1 Reef for 4 years), or are poorly selected to adequately reflect the effects of changes in water quality within the catchment (e.g. inshore sites are located in the northern Whitsunday Islands aggregation and not adjacent to river mouths).

## GOVERNANCE

Most of the GBR within the region lies within the Great Barrier Reef Marine Park (GBRMP) and is managed under the auspices of the Great Barrier Reef Marine Park Act 1975 and Regulations. The latest review of the Zoning Plan for this area was completed and gazetted in 2004. GBRMPA has management responsibility for the area in partnership with the Queensland Parks and Wildlife Service as set out in the Great Barrier Reef Intergovernmental Agreement. The agreement outlines the obligation of each party in managing the reef through the Field Management Program. The sections of the GBR which fall within Queensland State waters lies within the Great Barrier Reef Coast Marine Park (GBRCMP) which was formed, and is managed through the Queensland Marine Parks Act 2004 and Regulations. Rezoning of the GBRMP was mirrored within the GBRCMP in 2004. These marine parks combined form the Great Barrier Reef World Heritage Area for which Australia has international management obligations.

There are four Port areas within the region that are not part of either Marine Park; Abbot Point, Port of Bowen, Port of Mackay, and Hay Point/ Dalrymple Bay. Coral reefs occur within the jurisdiction of the latter three areas.

Commercial and recreational fishing throughout the GBR is managed by the Queensland Department of Primary Industries and Fisheries under the Fisheries Act 1994. Management instruments notably include reef zoning, quotas, size and bag limits and seasonal closures. Compliance is undertaken by the Boating and Fisheries Patrol (DPIF), Marine Parks (QPWS) and the Queensland Water Police.

## INDICATORS

Reef water quality is improved in line with the thresholds, indicators and mechanisms identified by the Mackay Whitsunday Isaac Water Quality Improvement Plan and the Water Quality Management Plan (in press) due for release in June 2014. The condition and resilience of offshore reefs will continue to be measured by the long term monitoring study (AIMS, 2013) using key indicators including coral cover and type, reef fish assemblages, presence of COTS, disease and bleaching.

Measurement of the condition and resilience of inshore reefs should be improved through the establishment of a monitoring project that assesses coral cover, coral diversity, (using growth form) and selected species of herbivorous fish (e.g. coral trout, sweet lip and other selected species that are considered good indicators of overall health of coral colonies). This approach is desired as the current LTRM project does not have adequate coverage for the local area with monitoring sites locally in the northern Whitsunday Islands, well away from river mouths. Suggested sites for monitoring include those most influenced by outflows of the Pioneer River, the largest within the catchment, and could include, Flat Top, Keswick and Penrith Islands Derek Ball, Pers. Comm (2013).

COTS and/or other pressures continue to be monitored at key marine tourism settings using robust coral reef assessment techniques (AIMS, 2013).

Representative inshore reefs are assessed for condition using robust coral reef assessment techniques including assessment of anchor damage. Resilience of these reefs is increased by improved water quality, and reduction in unnecessary impacts such as anchor damage.

“Fisheries catch data continue to demonstrate general sustainability of reef based fisheries with only one, the snapper (*Pagrus auratus*) considered overfished, however for many species the level to which they are fished sustainability is uncertain or not assessed”

DEEDI, 2010; 5

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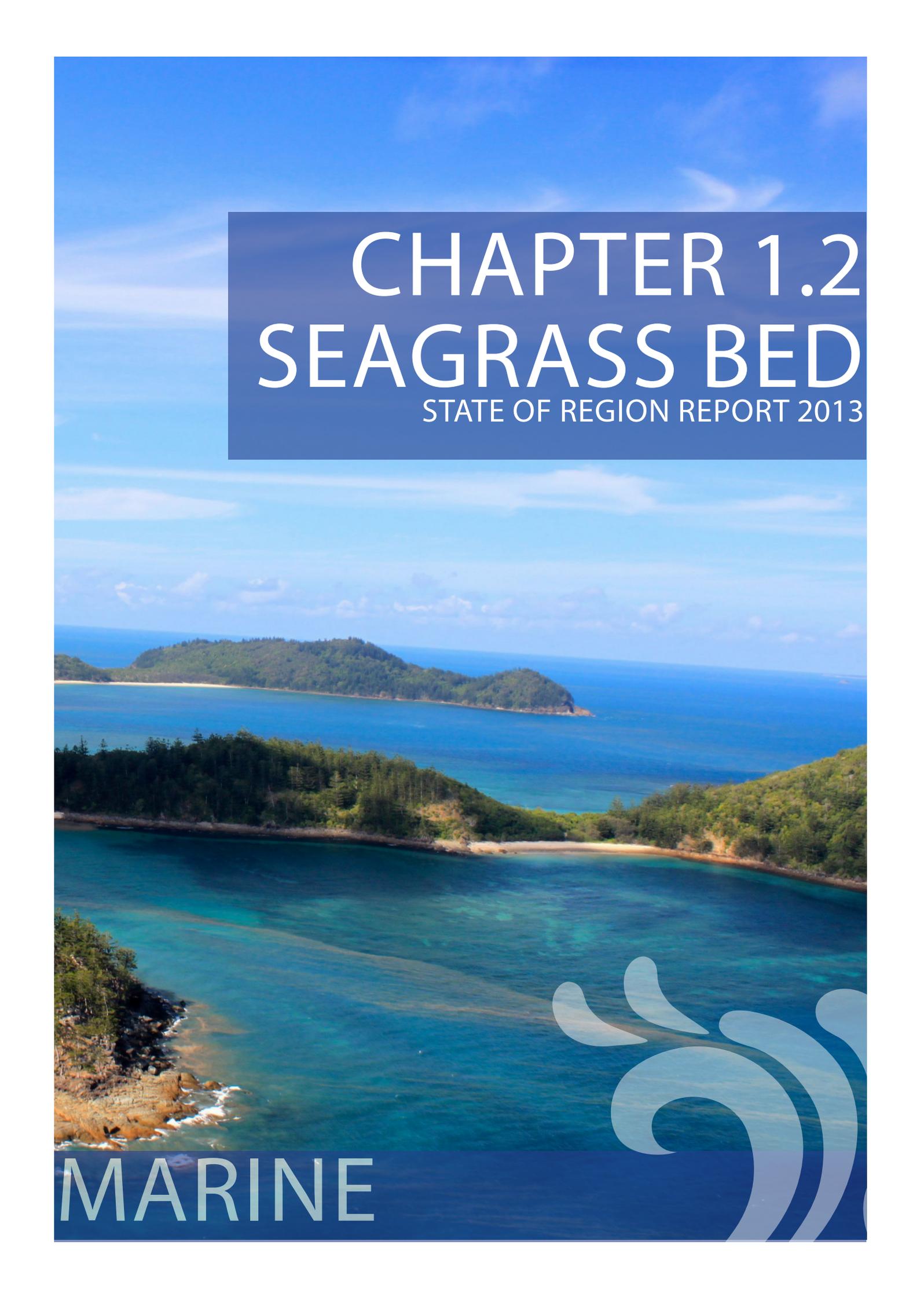
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An aerial photograph of a coastal bay. In the foreground, a rocky shoreline with sparse vegetation meets the water. The water is a vibrant turquoise color, transitioning to a deeper blue as it extends into the distance. A large, forested island is visible in the middle ground, surrounded by a sandy beach. The sky is a clear, bright blue with a few wispy clouds. A dark blue semi-transparent box is overlaid on the top right of the image, containing white text.

# CHAPTER 1.2 SEAGRASS BED

STATE OF REGION REPORT 2013

MARINE

A stylized graphic of three overlapping, curved shapes in shades of light blue and white, resembling waves or a stylized 'S' shape, located in the bottom right corner of the page.

## SUMMARY

“Since the time of the dinosaurs, three groups of flowering plants (angiosperms) colonised the oceans. Known as ‘seagrasses’, they are the only flowering plants that can live underwater. More closely related to terrestrial lilies and gingers than to true grasses, they grow in sediment on the sea floor with erect, elongate leaves and a buried root-like structure (rhizome)”

Seagrass Watch (2013; n.d.)

Shallow seagrass beds cover approximately 13% or 6000 km<sup>2</sup> of the Great Barrier Reef World Heritage Area (Coles et al, 2003) and on an international scale, are at their most extensive and diverse in Australian waters (Connolly, 2012). Shallow sub tidal or intertidal seagrass beds occur along the entire length of the Mackay Whitsunday region (Map 2.1) with 14 species of seagrass recorded in this area (Coles et. al, 2007). Deep water habitats mainly occur in the northern part of the region in clear water lagoon areas associated with exposed mid shelf reefs and cover a further 40,000 square kilometres (Coles et al. 2003), though considerably less is known about these areas.

Seagrass beds change over time both in terms of cover and species composition. In intertidal areas between Bowen and Yeppoon, seagrass beds are dominated by *Halodule* spp. and *Zostera* spp. (GBRMPA, 2012) with a cover of between 10 and 50 % (GBRMPA, 2005). During surveys between 1984 and 1988, the Mackay Whitsunday Region was recorded as having 15,386 ha of seagrass beds, largely dominated by *Halodule uninervis*. Cover ranged widely but was generally high in Upstart Bay and around the Whitsunday Islands (Coles et al. 1987, 2001).

Dodds (2004) provides a synopsis of seagrass communities within the region. Within the Bowen area the most extensive seagrass beds are associated with Upstart Bay, while in Whitsunday 5,553 +/-1,182 ha of seagrass was found among 177 individual areas. Seagrass was found in water from 0.05m to 15m below mean sea level. The deeper sites (11-15m) were associated with clearer waters around the offshore islands, for example off Whitehaven Beach on the eastern side of Whitsunday Island. In more inshore areas habitat was limited to 11m in depth. The lowest diversity and abundance of seagrass was found in Repulse Bay, an area influenced by agricultural runoff. The first surveys conducted within the Mackay area identified 7,400 ha of seagrass of which 4,900 ha had a low cover and 2,500 ha a medium cover. Detailed surveys were conducted within the Newry Islands Dugong Protection Area in 1999 and these found 2,450 +/- 360 ha in winter and 2,451 +/- 345 ha in spring.

Interestingly, no seagrass was found in the Sand Bay Dugong Protection Area. Small seagrass beds were found associated with both Flat Top and Round Top Islands and also in deeper water (17.7 to 21.7m deep) offshore. Ince Bay supports extensive seagrass beds ranging from 1203.6 +/- 133.8ha in winter to 1572.8 +/- 187ha in spring). A total of 1880ha of seagrass was mapped in the Clairview area. Survey results clearly demonstrate the highly variable nature of seagrass beds.

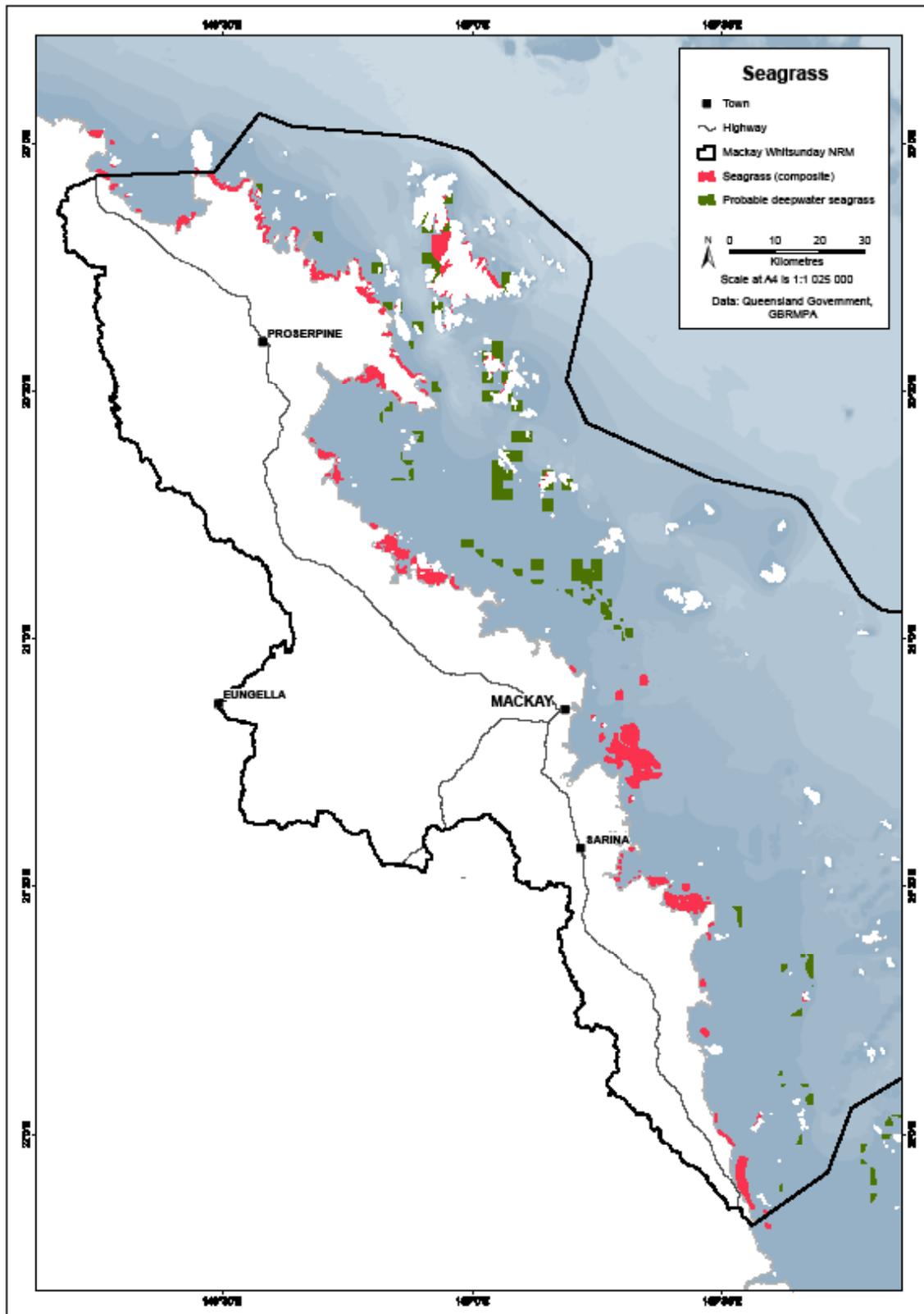


Figure 1 Extent of seagrass beds within the region compiled from all sources from 1984-2005

Biomass	Community	Mean Area		May/ Oct 1999	
		May/ Oct 1999	May/ Oct 1999	% of study area	
Low	<i>Halophila ovalis</i>	8.8	0.3	<	< 1
Low	<i>Halophila decipiens</i> dominated	0.0	4.5	0	< 1
High	<i>Halophila spinulosa</i> dominated	2.9	4.4	< 1	< 1
Low	<i>Halophila tricosta</i> dominated	0.0	471.2	0	9
Low	<i>Halophila ovalis</i> and <i>Halodule uninervis</i>	6.41	122.74	< 1	2
Low	<i>Halophila</i> and <i>Halodule</i>	1694.3	1266.5	34	23
Low	<i>Halodule uninervis</i> (narrow)	1300.37	1440.6	26	27
Low	<i>Halodule uninervis</i> (wide)	14.2	25.01	< 1	< 1
Low	<i>Halodule uninervis</i> and <i>Halophila ovalis</i>	405	448.7	8	8
Low	<i>Halodule/ Halophila/ Cymodocera</i> mixed	650	0.0	13	0
Low	<i>Halodule/ Halophila/ Zostera</i> mixed	48.5	106.6	1	2
High	<i>Zostera capricorni</i> dominated	0.9	204.6	< 1	4
Low	<i>Zostera capricorni</i> dominated	424.64	671.72	8	12
Low	<i>Zostera capricorni</i> and <i>Halodule uninervis</i> (narrow)	0.0	12.21	0	< 1
Low	<i>Zostera capricorni</i> and <i>Halodule ovalis</i>	0.0	17.3	0	< 1
Low	<i>Zostera/ Halophila/ Halodule/ Cymodocera</i> mixed	466.4	0.0	9	0
High	<i>Zostera/ Halophila/ Halodule/ Cymodocera</i> mixed	16.1	598.6	< 1	11
High	<i>Zostera/ Halophila/ Halodule</i> mixed	0.0	1.7	0	< 1
		5038.5	5396.7		

Table 1 Area and percentage area of 18 seagrass communities within the Region's Dugong Protection Zones.

During more detailed surveys, conducted within smaller areas of the region (Dugong Protection Areas) (Coles et al. 2001) seagrass beds were grouped into 18 communities (Table 2.1). There was considerable variation in distribution, extent, cover (biomass) and community composition (diversity) between winter and spring. The dominant seagrass community was *Halodule uninervis* and *Halophila*/*Halodule* mixes. Comprehensive surveys such as these provide important baseline information on condition of key seagrass beds within the region, including expected seasonal change.

## VALUES AND SERVICES

“Seagrasses have been ranked as one of the most ecologically and economically valuable biological systems on earth. They are widely referred to as “ecological engineers” because of their significant influence on their physical chemical and biological surroundings. They play an important role in:

- Regulating oxygen in the water column and sediments
- Regulating nutrient cycles
- Stabilising sediments
- Protecting shorelines through the restriction of water movements
- Providing an important food source for finfish, shellfish and mega-herbivores including green sea turtles and dugong.
- Providing habitat for microbes, invertebrates and vertebrates including commercially and recreationally important species, as well as crucial habitat for endangered species.”

Marine Climate Change in Australia: Impacts and Adaptation Responses 2012 Report Card – Seagrass (extract) (Connolly, 2012; 178).

### Habitat

Shallow seagrass beds cover approximately 13% or 6000 km<sup>2</sup> of the Great Barrier Reef World Heritage Area (Coles et al, 2003) and on an international scale, are at their most extensive and diverse in Australian waters (Connolly, 2012). Shallow sub tidal or intertidal seagrass beds occur along the entire length of the Mackay Whitsunday region (Map 2.1) with 14 species of seagrass recorded in this area (Coles et. al, 2007). Deep water habitats mainly occur in the northern part of the region in clear water lagoon areas associated with exposed mid shelf reefs and cover a further 40,000 square kilometres (Coles et al. 2003), though considerably less is known about these areas.

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Both dugong and green turtles have highly significant cultural value to Indigenous Australians.

Seagrass beds are important fish nursery habitat, particularly for penaeid prawns and fish (Coles, 1992; Watson et al., 1993, Coles et al, 2004, Zeller et. al, 2012) that support the fishing industry. They also form the basis of an important detritus based food chain, which is in turn, the basis of a number of commercial and recreational fisheries (Dodds, 2004).

The availability of seagrass habitat could also affect giant mud crab (*Scylla serrate*, *S. olivacea*) numbers. Juvenile giant mud crabs are known to prefer to settle on sea grass rather than other benthic substrates and as such a reduction in seagrass habitat availability could reduce the population Grubert et. al (2012).

### Ecosystem Services

Seagrass beds assist in maintaining coastal water quality by assimilating nutrients and stabilising sediments (Dodds, 2004, Coles et al, 2004). Tropical seagrasses are important in their interactions with mangroves and coral reefs. All these systems exert a stabilizing effect on the environment, resulting in important physical and biological support for the other communities. Seagrasses also trap sediment and slow water movement, causing suspended sediment to fall out, benefiting the coral by reducing sediment loads in the water.

The role of seagrass in mitigating climate change impacts is an emerging area of study. Seagrass, along with mangroves and salt marshes, are well known as highly efficient carbon sinks (Chmura et al. 2003; Duarte et al. 2005; Bouillon et al. 2008; Lo lacono et al. 2008; Duarte et al. 2010; Kennedy et al. 2010) and are collectively referred to as 'Blue Carbon' (McLeod et al, 2011).

In a study of published reports Unsworth et. al (2012) suggest that seagrass may play a role in maintaining reef calcifiers (including corals and shellfish) that act as a carbon sink. Local variations in bathymetry and water residence time mean that the study implications are more relevant at a local scale and where seagrass meadows occur upstream of reef calcifiers.

Globally it has been estimated that seagrass may sequester as much as 15% of the oceans' carbon. The rate of long-term carbon storage in some seagrass species exceeds many terrestrial ecosystems, commensurate with wetlands (Kennedy & Bjork, 2009), and is made possible by the fact that seagrass communities do not become saturated with carbon (as do terrestrial ecosystems) as they accumulate sediment over time (McLeod et al, 2011, Bos et al, 2007).

### Economic Value

The economic value of seagrass beds is difficult to estimate because the links between particular species within the fisheries, and their use of seagrass resources, has not been completely clarified (Watson et al., 1993; FRDC, 2000). However, there are clear ecological links between seagrass and commercial prawn species. Dodds (2004) reports that during 2000, the prawn harvest within the region was over 400 tonnes, and produced revenue in excess of 7 million dollars.

In 2009-2010 Queensland caught 12,268 tonnes of prawns, nearly double all other states combined and over 45% of the total Australian catch. In total, the value of this catch was \$31 million in 2009-10 – nearly a four fold increase on it's average value between 1989 and 2000. (ABS, 2012).

The commercial value of the crab catch for Queensland in 2009-10 was 28.5 million dollars, more than half the total Australian value (ABS, 2012).

## PRESSURES AND THREATS

“There are many threatening human activities to seagrasses including direct threats such as land reclamation and chemical spills as well as diffuse threats such as water quality and the influence of climate variability. In the Indo-Pacific conservation activity is focused on coral reefs, with little conservation and emphasis and placed on interconnectivity with other marine environments such as seagrasses.” Coles, et al (2011; 225)

The GBRMPA (2012) define the major pressures affecting seagrass communities in the GBR as:

- Poor water quality from catchment runoff (agricultural and urban/industrial).
- Habitat loss and modification from increasing coastal development
- Expansion in ports and shipping
- Increased intensity of storms, floods and cyclones
- Sea surface temperature and sea level rise.

In extreme conditions such as those that occur during flood events, seagrasses can be smothered by sediment, impacted by high nutrients and chemical loads or killed by a lack of light available in the turbid water. The value of seagrass in relation to other marine ecosystems in maintaining coastal water quality is a role that depends on the ability of seagrass to adapt to impacts, in particular climate change.

“Dugongs are also under threat from diminishing food sources. Seagrass meadows are being detrimentally affected by pollution (pollutants can include herbicide runoff, sewage, detergents, heavy metals, hypersaline water from desalination plants, and other waste products), algal blooms, high boat traffic and turbid waters. Today, dugongs need to rely on smaller seagrass meadows for food and habitat. When the seagrass habitat becomes unsuitable for foraging, dugong populations are displaced and placed under greater threat” DEHP, 2013a; web page.

In addition to the information provided by GBRMPA above, specific pollutants such as heavy metals, herbicides, and polycyclic aromatic hydrocarbons (residue from burning fuels) are also considered an issue (Schaffelke, 2001). These are derived primarily from urban and river runoff. Sewerage and aquaculture effluent discharges contribute a relatively minor amount of nutrients. However, they can have significant localised impacts (GBRMPA, 2012). This is particularly the case when discharges are made into estuaries during low, or no flow periods. Cyclonic flood plumes can significantly reduce water salinity in coastal areas, and can deposit large amounts of fine sediments over seagrass beds (Schaffelke, 2001).

Physical damage can be done to seagrass beds by trawling, although this is typically avoided by fishermen as it is counter-productive to fishing efforts when nets become clogged and inoperable (GBRMPA, 2005). In addition, the great majority of seagrass beds are now closed to trawling under zoning arrangements.

When seagrasses are subjected to temperatures outside of their tolerance, they can undergo 'burning' with subsequent degradation of the beds (Campbell et al., 2006). In this respect, warming of coastal waters as a result of climate change is now a significant concern.

Locally, Abbot Point (as well as Mourilyan near Innisfail) differs from other Queensland regions defined as the states most at risk seagrass locations due to its high distance from a major urban centre. The other locations include Gladstone, Townsville/Cleveland Bay, and Cairns/Trinity Inlet caused by cumulative impacts. The GBRMPA however acknowledge that local scale non-cumulative impacts may be significant in some areas (GBRMPA, 2012).

"At the scale of the Great Barrier Reef, the most significant response to improve the resilience for seagrass meadows is to improve water quality. Therefore the most important action is to continue to implement the joint Australian and Queensland Government's Reef Water Quality Protection Plan to reduce pollutants released to receiving waters from diffuse sources. Actions to improve waterway stability, riparian and wetland condition and the maintenance of environmental flows are critical" GBRMPA, 2012; 3

## CONDITION AND TRENDS

Condition of seagrass beds can be assessed and described by their distribution, extent, cover and species diversity. However, the nature of these communities is that they are highly variable in all these respects and as such, determining condition requires an understanding of their long-term dynamics. This view was supported by the Great Barrier Reef Outlook Report, released in 2009 that stated that although seagrass communities were affected by runoff from catchments, they mainly appeared to fluctuate due to natural cycles of decline and recovery. However since 2009, severe flooding and cyclonic activity have had a significant impact on seagrass communities.

The Great Barrier Reef 2011 Report Card (Queensland and Australian Governments, 2013) reports on the condition of seagrass meadows within the region in its summary for the Mackay Whitsunday area comparable to the 2009 baseline. In the baseline report the reproductive capacity of seagrass was considered very poor and the nutrient status and abundance poor. Results to the current year (2013) are unavailable. The level of abundance of seagrass was moderate and in decline in some areas (Queensland Government, 2009).

"Inshore seagrass meadows along the developed Great Barrier Reef coast (i.e. south of Cooktown) have declined over the past three to five years and are in poor condition." Brodie et. al, 2013;3

The 2011 report card reflects the effects of the severe weather events during the period 2009–2011. These impacts fall on seagrass ecosystems that are already stressed following extended periods of cloud cover, limiting available periods of growth, as well as major freshwater inflow from flooding on a massive scale (GBRMMPA, 2012). The reduction in reproductive capacity raises concerns about the regions seagrasses resilience to disturbance (Queensland Government, 2011) given they are sensitive to increased temperatures and extreme weather events (GBRMMPA, 2009), which are forecast to increase in climate change scenarios (IPCC, 2007).

“Inshore seagrass meadows remained in poor condition, having progressively declined since 2005-2006. This reflects long-term declines in abundance and reproductive effort, which is a concern in terms of capacity of local seagrass meadows to recover from disturbances. The nutrient status of seagrass tissue was rated as poor and reflected local water quality, particularly high concentrations of nitrogen” Queensland Government, 2013; 1

Increased levels of nitrogen have been observed in seagrass leaf tissue since 2005, which has resulted in an increase in epiphytes (suspended plants) growing on the leaves, reducing the light available to the seagrass to photosynthesise. This may be due to increased nutrient supply in the water.

The risk to seagrass communities and corals from different pollutants was reviewed through a risk assessment conducted as part of the Reef Plan 2013. The risk assessment investigated the relative risk of nitrogen, sediments and pesticides to catchment regions including the Mackay Whitsundays. The results of the assessment (Fig X) can be seen below.

Region	Overall relative risk	Priority pollutants for management		
		Nitrogen	Pesticides	Sediment
Cape York	LOW			
Wet Tropics	VERY HIGH			
Burdekin	HIGH	*		
Mackay Whitsunday	MODERATE			
Fitzroy	HIGH			
Burnett Mary	UNCERTAIN**			

\* Lower Burdekin and Haughton focus

\*\* Most reefs and seagrass meadows in this region were not included formally in the analysis and therefore the validity of the result has high uncertainty.

Table 2 Risk Assessment for Priority Pollutants for Management (Queensland Government, 2013)

As at 2013, the Mackay Whitsunday region is considered a ‘Moderate’ overall risk, however improvements in water quality from other pollutants and continued improvement against general water quality targets will still be required to assist seagrass communities within the local area to recover from recent flood and storm activity and remain resistant to climate change. A priority for the region will be reducing the risk of, in particular, pesticides (very high risk) and nitrogen (high risk) to seagrass and the marine environment in general.

However, the effects of land based pollution are not the only threat to seagrass communities. There are four port areas within the region; Abbot Point, Port of Bowen, Port of Mackay, and Hay Point/Dalrymple Bay. Seagrass is found both within and around port areas. Current and future expansion of these ports has and will continue to affect seagrass communities both within the ports jurisdiction and in the surrounding Marine Park through dredging, both within the construction phase and through on-going channel clearing. The effects of dredging (smothering from sediments and other decreases in water quality) compound the effects of poor water quality of terrestrial origin, increased urban expansion and climate change.

Despite the challenges faced by seagrass communities within the local area, on a reef-wide scale the Mackay Whitsunday region is under only moderate relative risk overall from priority pollutants. This level of risk is second only to the remote Cape York region.

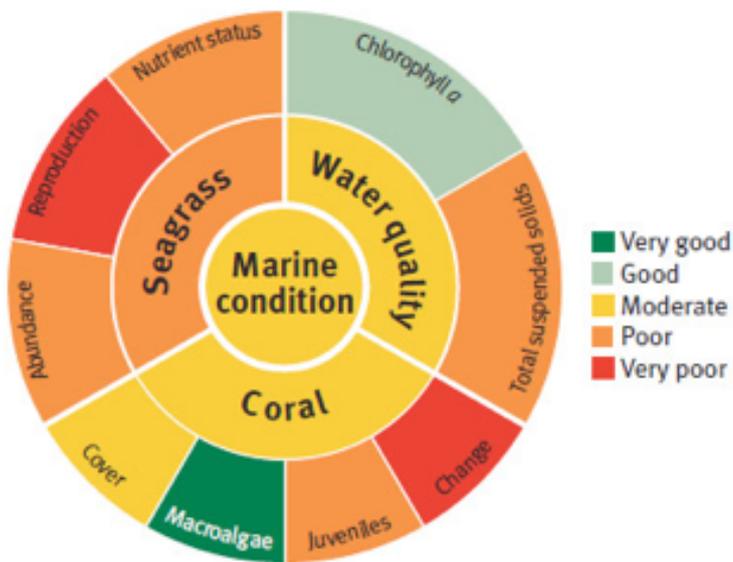


Figure 2 According to the second Reef Report Card (2010), overall condition of seagrass remains poor

Seagrass communities are known to fluctuate with natural cycles. Providing continued improvement in the management of pollutants, particularly pesticides, and continued uptake of Reef Plan activities the seagrasses of the region should be in a relatively good position to recover from their recent decline.

Long-term however climate change will continue to impact seagrass communities, primarily through rising seawater temperatures, changes in the East Australian Current and cyclone and storm activity moving further south and becoming more intense. The effects of climate change at a local scale are more poorly known.

“Improving water quality will also build resilience in inshore coastal and seagrass areas which support significant biodiversity such as turtles and dugongs, and drive fisheries productivity.” Reef Water Quality Protection Plan, 2013. Queensland Government (2013;7)

## GOVERNANCE

By area the great majority of seagrass beds within the region lie within the Great Barrier Reef Marine Park or the Great Barrier Reef Coast Marine Park. These areas lie under the jurisdiction of the Great Barrier Reef Marine Park Authority and/ or the Queensland Parks and Wildlife Service. The Queensland Department of Agriculture, Fisheries and Forestry (DAFF) enforce statutory provisions related to protection of marine plants, net fishing within Dugong Protection Areas, and the use of turtle excluding devices within the East Coast Otter Trawl Fishery. That organisation also administers the shark control program adjacent to some swimming beaches in the region.

Recently, research activities related to seagrass have been transferred from DAFF to James Cook University's Tropical Water and Aquatic Ecosystem Research (TropWATER) facility in Townsville.

The four port areas within the region that are not part of either Marine Park. These come under the jurisdiction of the various port authorities. Seagrass beds occur within the jurisdiction of these Ports although the geographical size of these is very small relative to areas within marine parks, however as discussed earlier their impact can be felt more broadly.

## INDICATORS

Seagrass beds are distributed over very large areas, often in turbid coastal waters. Sometimes it is possible to accurately map these areas by aerial surveys using helicopters. However, other surveys rely on estimating actual distribution by sampling smaller areas (usually by divers) and then making broader assumptions based on these results. As this technique can only estimate the true distribution, ecologists use statistical analysis to 'estimate' the accuracy of the survey results. Thus the results of these figures are often given as the estimate +/- the likely error; e.g. 1234 +/- 234ha.

Suitable methods for surveying and monitoring of seagrass are available. The important indicators are distribution, extent, cover and diversity. Depth range of seagrass beds is also useful as this allows development of a relationship between condition and water turbidity. The latter is related to water quality, particularly near river mouths and smaller point sources of sediments and nutrients.

Aerial survey techniques have been developed and refined and can be used to gain reliable estimates of dugong numbers. However, such survey methods are less robust in areas of smaller population numbers.

Water quality targets for the next five years align with or exceed those in the Reef Catchments Water Quality Improvement Plan (in prep.) and contribute to the Reef-wide goal of Reef Plan by ensuring that by 2020 the quality of water entering the Great Barrier Reef has no detrimental effect on its health and resilience.

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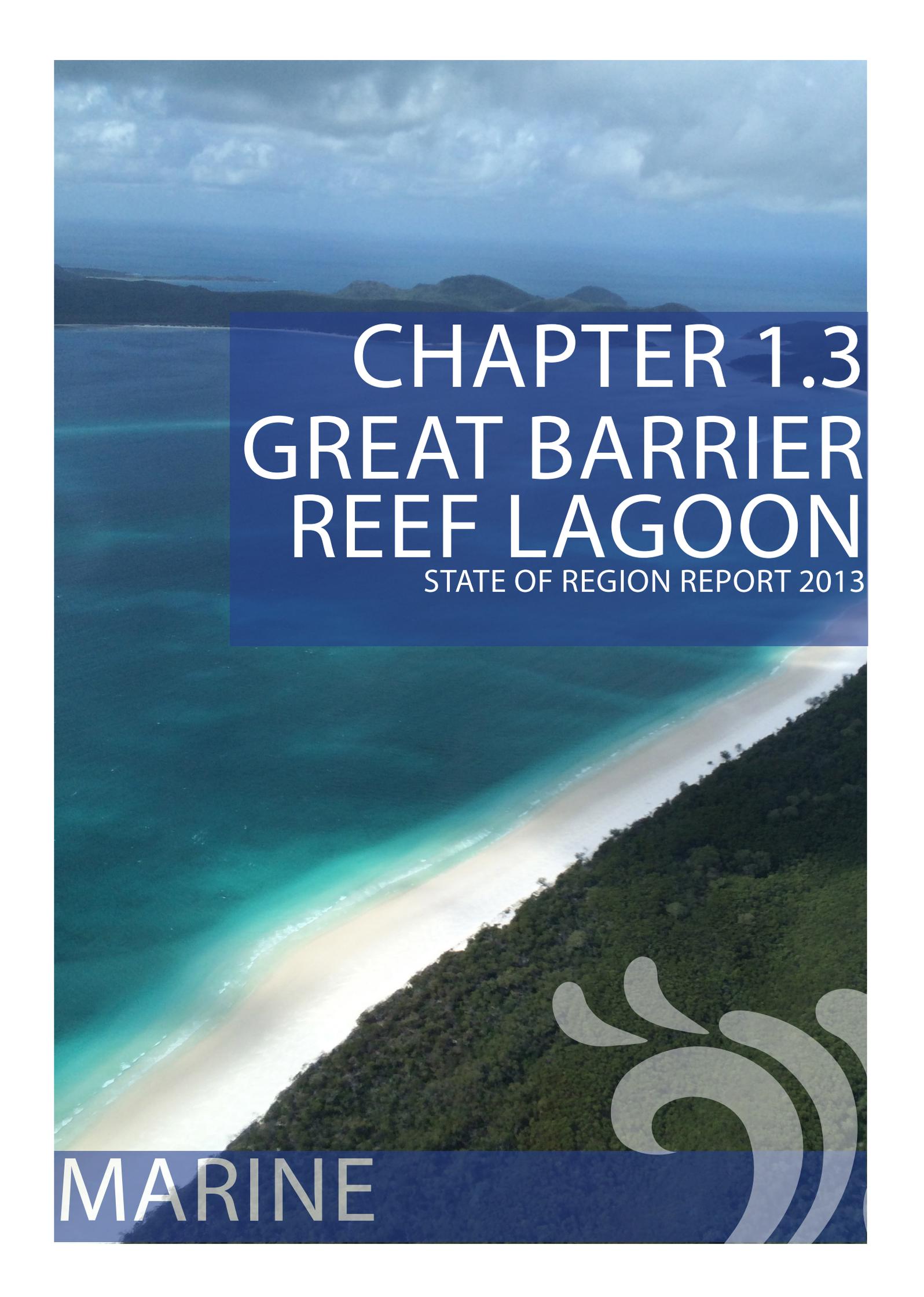
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# CHAPTER 1.3 GREAT BARRIER REEF LAGOON

STATE OF REGION REPORT 2013

MARINE



## SUMMARY

The Great Barrier Reef lagoon consists of shallow coastal sea between the mainland and outer reefs, and the area separating individual reefs. Within the region there are extensive areas of shallow lagoon (< 20m deep) and a broad, deeper, offshore shelf. On the seaward edge of the GBR the continental shelf ends and the deeper waters of the Coral Sea begin. Within the Mackay Whitsunday Region, extensive reef development forms a barrier along the edge of the continental shelf (approximately 90% by area). This situation restricts water exchange between the lagoon and the Coral Sea to a few narrow passages (Furnas, 2003). Water circulation patterns within the lagoon are influenced by sub-surface circulation patterns, tides and wind. The East Australian Current broadly flows south at up to 48km per day within open waters of the central GBR (Furnas, 2003).

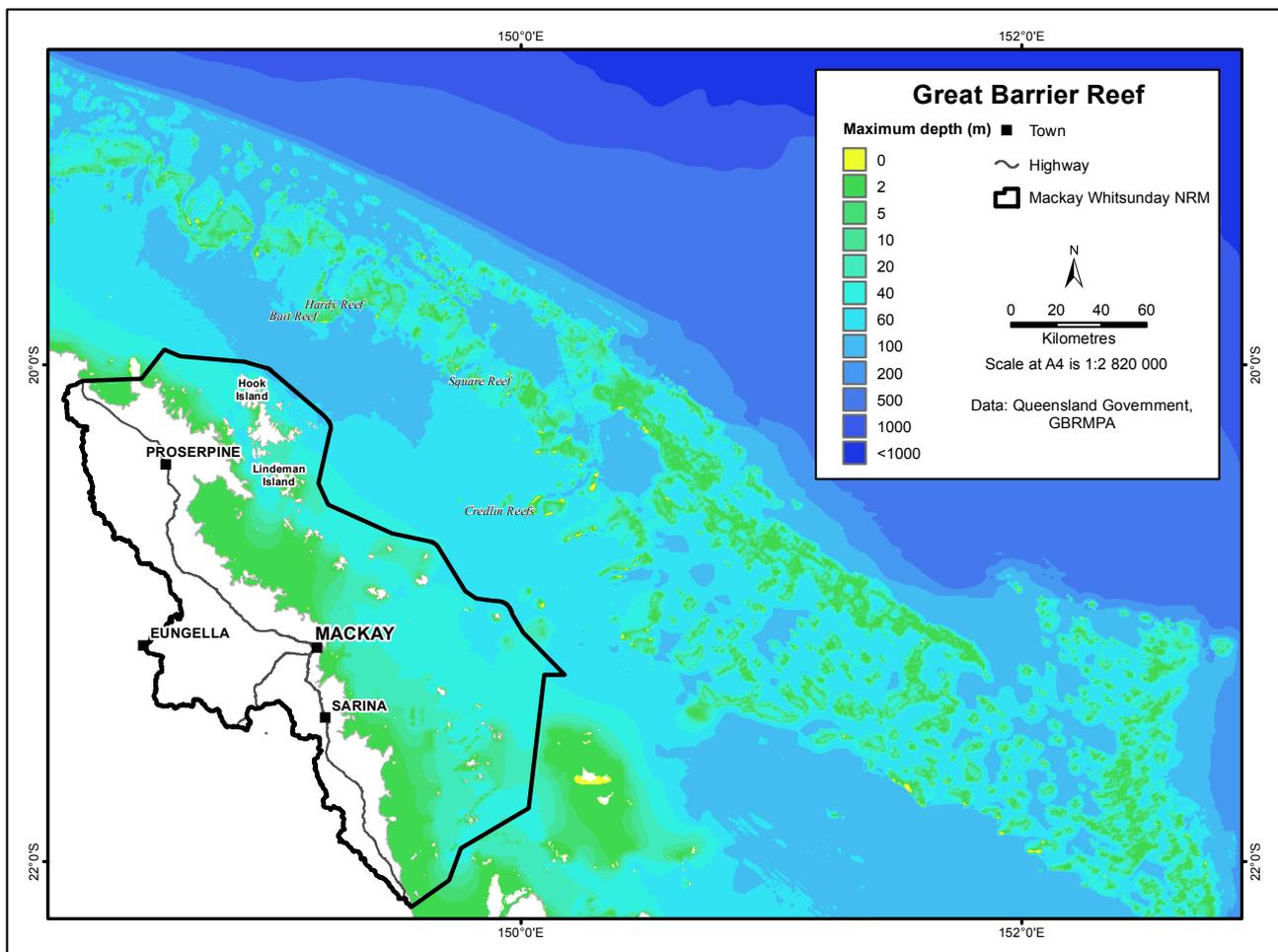


Figure 1 Great Barrier Reef Lagoon bathymetry

The region experiences some of the largest tidal ranges along the Queensland coast from about +/- 4m in the north to +/- 7m towards Broadsound. Generally, flooding (e.g. rising) tides produce southward flowing current, and ebb tides produce a northerly current. In addition, some cross shelf effects are evident. Superimposed on these diurnal tidal currents are surface and shallow currents produced by prevailing winds, typically from the south-east trade winds. Surface currents produced by these winds are an important consideration as they largely dictate transport of river discharges along the coast. In addition, they are responsible for long-shore transport of sediments along the coast (assisted by re-suspension of sediments by wave action). Long-shore transport is responsible for movement of in excess of 35,000 m<sup>3</sup> of sediment per annum along the coast with consequences for beach erosion and/or accretion (EPA, 2004).

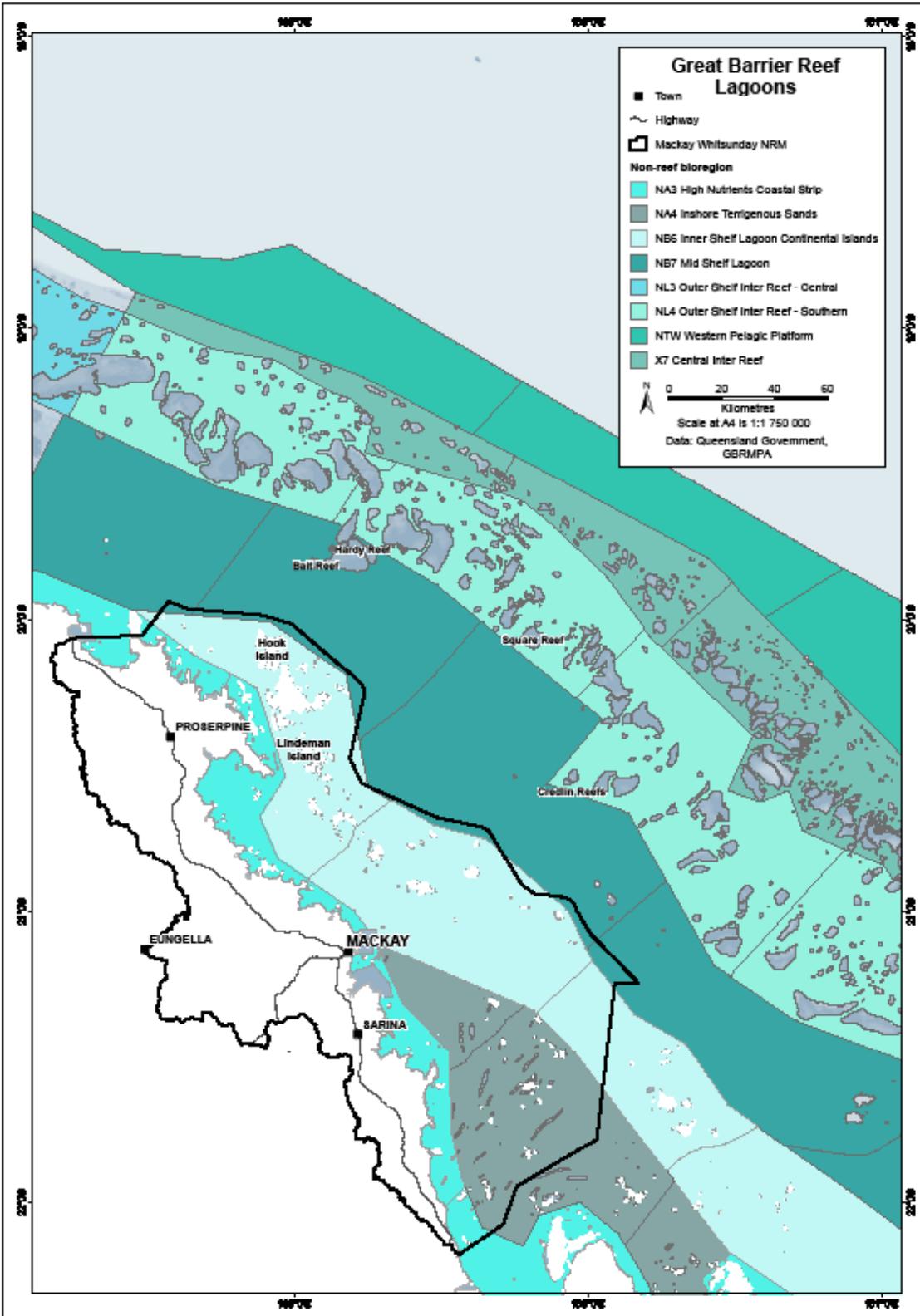


Figure 2 Non Reef Bioregions of the MWI GBR Lagoon area

Ecologically, the lagoon area within the Mackay Whitsunday Region is biodiverse, containing 7 (18%) of the 40 non-reef Bioregions found within the broader GBR region (Figure 2 and Table 1).

NON-REEF BIOREGION	BRIEF DESCRIPTION
NA3: High Nutrient Coastal Strip	The bioregion lies along the Queensland coast, varying in width. Water depth is generally < 20m and the region is highly influenced by nutrient outfall from the coast. Sheltered areas supports seagrass beds which in turn form habitat for marine turtles and dugong.
NA4: Inshore Terrigenous sands	A broad fan commencing in Broadsound and extending north to about the Pioneer River and east across Shoalwater Bay. Sediments on the seafloor are largely composed of terrestrially derived sands which are very mobile and tend not to support seagrass or algae.
NB6: Inner shelf lagoon Continental Islands	This bioregion lies directly to the east of the above near-shore regions, from Gloucester Island, through to the Whitsunday, Northumberland and Percy Islands. Some areas support hydroids and gorgonians.
NB7: Mid shelf lagoon	The mid-shelf lagoon lies between the island groups and the beginning of outer reef development. The bioregion is largely devoid of reef development. Sediments (sands) are influenced by the East Australian Current.
NL4: Outer shelf inter reef platform	The Outer Shelf includes lagoon areas interspersed among the major development of outer reefs along most of the offshore edge of the continental shelf.
X7: Central Inner Reef	This bioregion includes lagoon areas outside of the major development of the outer reef but includes lagoon areas around and interspersed among the Hardline Roofs.
NTW: Western pelagic platform	The Western Pelagic Platform overlies the transition zone between Continental Shelf and Slope waters and the Coral Sea.

*Table 1 Non-reef bioregions represented within the Mackay Whitsunday Region.*

## VALUES AND SERVICES

### Ecosystem Services

Collectively the oceans surrounding Australia are invaluable in the ecosystem services they provide. A report by the Centre for Policy Development (2011) concluded that Australia's oceans contribute around \$25 billion per year to the economy through ecosystems services alone, in addition to the economic data, and calls to raise the profile of the marine sector in policy and investment decisions. This is considered critical in capturing the wealth from our oceans.

CPD (2011) also outlined that Australia's oceans provide, 'free of charge':

- o \$15.8 billion in carbon storage
- o \$6.2 billion a year in fish nursery services and pest and disease control – essential to sustain the commercial and recreational fishing industries and
- o \$1.85 billion a year in fish and recreation services.

## Habitat

The sheltered waters of the GBR lagoon are an important calving area for humpback whales (*Megaptera novaeangliae*). The whales that utilize this area are from a distinct southern population known as Group V (Vang, 2002). Due to commercial whaling, the size of this population declined dramatically and remained very low until approximately 1985, when some recovery began (Figure 3.3). Although numbers remain low compared to the original population size, steady increases are apparent (Vang, 2002). The Whitsunday area represents the southern limit of the main calving grounds (Chaloupka and Osmond, 1999) and it appears that only mother - calf pairs remain in the area for any length of time during this period.

“Humpback whales come from Antarctic waters to the Great Barrier Reef World Heritage Area from May to September to calve and to build up strength over the winter before they return to the Antarctic in summer. Because of their status, and the fact that Great Barrier Reef World Heritage Area waters are nursery areas, the Great Barrier Reef Marine Park Authority (GBRMPA) is committed to ensuring that all whales are able to use the Great Barrier Reef waters without being pressured by human interference.”

Whales and Dolphins, GBRMPA (n.d.)

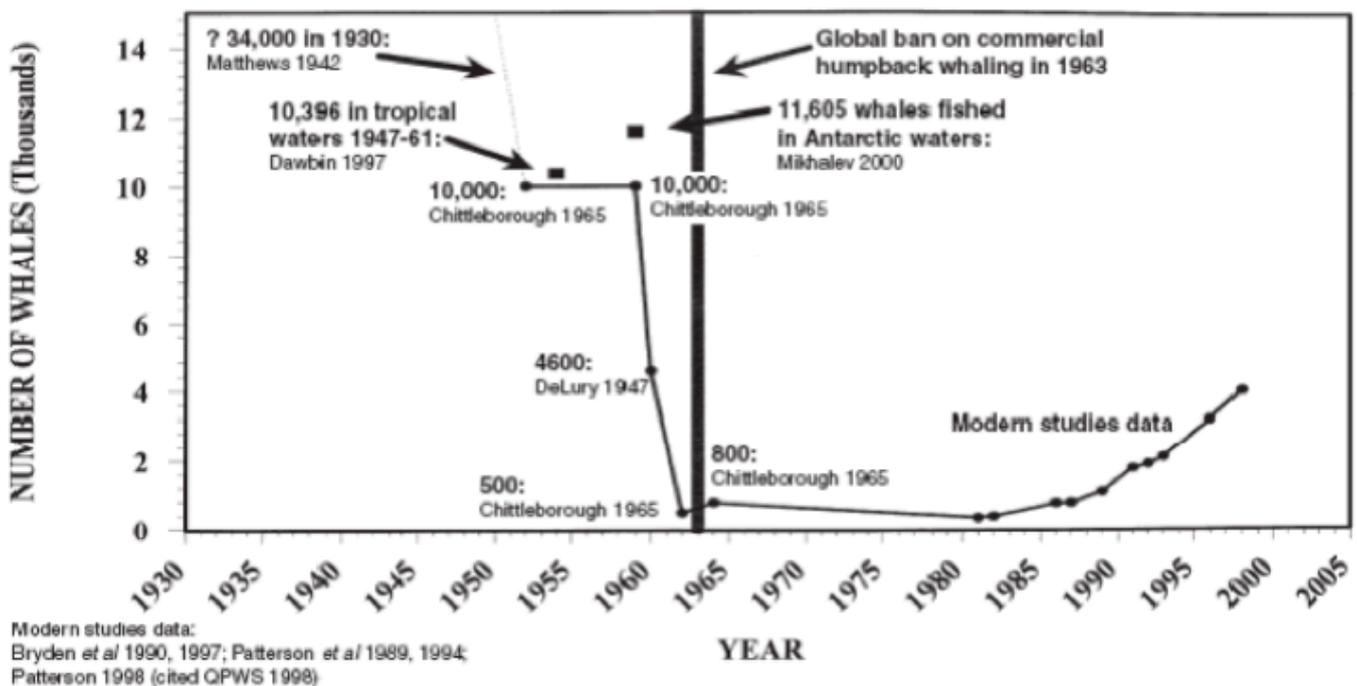


Figure 3 Summary of estimated population size of Group 5 humpback whales (reproduced from Vang, 2002).

Within the Townsville-Whitsunday and Mackay-Capricorn sections of the GBRMP, 21 commercial whale watching permits have been issued (GBRMPA, 2007). However, numerous other marine tourism operators opportunistically use the presence of humpback whales as an attraction. The two primary whale watching centres within the GBR (Cairns and the Whitsunday) provide for more than 40,000 whale watchers per annum creating a direct revenue of \$3.25 million and a total contribution to the economy which is in the order of \$12.9 million (Schaffar & Garrigue 2003).

Both Indo-Pacific humpback dolphins (*Sousa chinensis*) and the Australian snub-fin dolphin (*Orcaella heinsohni*) are present within the region. The latter species has only recently been discovered (Beasley, et al. 2005) and is considered threatened. Although these species are typically inhabitants of inshore areas, little is known of their population sizes, structure or distribution within the region.

## Recreation

Recreational boating and fishing are popular pastimes with 19,303 vessels registered in the combined Mackay and Whitsunday local government areas in March 2013, or more than 20% of the vessels registered for the whole GBR (GBRMPA, 2011).

While the Mackay region has the lowest number of registered vessel in Queensland, anecdotal evidence suggests that the population increase will in turn enhance the recreational fishery of the local area, particularly the southern half of the catchment around Mackay region (Ball and Adams, 2010) and in the far north in line with the 'opening-up' of the Bowen Basin. As the resource sector has a large number of shift workers, the pressure placed on fisheries is spread throughout the week rather than confined to the traditional weekend (Ball and Adams, 2010). This has a two-pronged impact: there are more people fishing and the opportunity to take advantage of good weather windows may increase this activity in certain locations.

## Economy

The AIMS Index of the Marine Industry (2012) highlights the important role Australia oceans play in livelihoods, the economy and environment. In 2009-10 Marine Based Industries contributed more than \$42 billion to the Australian Economy, more than the agricultural sector.

The Australian economy obtains great benefit from the commercial fishing and recreational use of the GBR. According to GBRMPA (2010) commercial fishing reaped 139 million in 2006/2007 and recreational use (including recreational fishing,) 153 million.

As a proportion of the state total the GBR also supports:

- 95% of Queensland's reef line fishery,
- 60% of the trawl fishery,
- 40% of the net fishery and
- 40% of recreational fish.

Key commercial fisheries within the lagoon include pelagic fish (mackerel and shark), scallops and bugs. In 2000 catch from these fisheries attracted revenue of about \$2 million (Dodds, 2004). However recreational fisheries which target pelagic fish, particularly prized species such as Spanish mackerel, are likely to be worth considerably more. For example the fishing charter industry alone, within the Mackay and Airlie Beach centres, have been estimated as attracting approximately \$5 million per annum (Fenton and Marshall, 2001).

The region supports Australia's largest group of charter boat operators, with an annual turnover in excess of \$100 million (Anon, 2006).

There are two major ports within the region, Hay Point and Mackay, with Abbot Point lying just outside of the northern catchment boundary, in addition to Bowen Harbour which hosts a major commercial fishing fleet. Hay Point which consists of Dalrymple Bay Coal Terminal and Hay Point Coal Terminal and is the largest coal export port in the world with a output of nearly 90 million tonnes exported via 900 bulk carriers in 2012.

## PRESSURES

### Pests

Similar to terrestrial and freshwater areas, exotic pests invade marine ecosystems. Several such invasions have resulted in significant environmental and economic costs in Australia, such as the Northern Pacific seastar (*Asterias amurensis*) in Tasmania and Port Philip Bay; and the Black striped mussel (*Mytilopsis sallei*) in Darwin Harbour (NIMPIS, 2007). Introduction of exotic pests can occur through ship fouling and by release of ballast waters (Sliwa et al. 2006). However, species may also modify their range due to changing environmental conditions including temperature gradients or through changing current climate regimes (CSIRO, 2007).

“The economic cost of aquatic exotic species is significant. Pimental et al. (2000) estimated conservative economic costs attributable to exotic fishes in the United States at US\$1 billion annually. 1993 estimates put damage caused by and control of zebra mussel (*Dreissena polymorpha*), Asiatic clam (*Corbicula fluminea*) and the European green crab (*Carcinus maenas*) at US\$4.4 billion annually, while purple loosestrife cost US\$45 million annually and aquatic weed control cost US\$110 million annually”

(Hall and Mills 2000)“ McEnnulty et al (2005)

### Water Quality

Decline in the quality of water runoff into the GBR lagoon is documented as a major threatening process for marine ecosystems both as a direct impact and as one which lowers the resilience of ecosystems to climate change.

The Scientific Consensus Statement (Brodie et al. 2013) was developed to support the Reef Water Quality Protection Plan 2013 (Reef Plan), which aims to review and synthesise the significant advances in scientific knowledge of water quality issues in the Great Barrier Reef and to reach consensus on the current understanding of the system. According to this, from a combined assessment of relative risk of water quality variables in the Great Barrier Reef (using the total area of habitat affected in the areas identified to be of highest relative risk) and end-of-catchment anthropogenic loads of nutrients, sediments and photosystem II inhibiting herbicides, the regional ranking of water quality risk to coral reefs is (from highest risk to lowest): Wet Tropics; Fitzroy; Mackay Whitsunday; Burdekin; Cape York; Burnett Mary.

Priority areas for managing degraded water quality in the Great Barrier Reef are Wet Tropics for nitrogen management; Mackay Whitsunday and the lower Burdekin for photosystem II inhibiting herbicide management; and Burdekin and Fitzroy for suspended sediment management.

Of equal importance is the risk to seagrass from suspended sediments discharged from rivers in excess of natural erosion rates, especially the fine fractions (clays). Whether carried in flood plumes, or re-suspended by waves, suspended solids create a turbid water column that reduces the light available to seagrass and corals. High turbidity affects approximately 200 inshore reefs and most seagrass areas. Seagrass loss severely impacts green turtle and dugong populations (Brodie et al. 2013).

At smaller scales, particularly in coastal seagrass habitats and freshwater and estuarine wetlands, pesticides can pose a high risk. Concentrations of a range of pesticides exceed water quality guidelines in many fresh and estuarine water bodies downstream of cropping lands. Based on a risk assessment of the six commonly used photosystem II inhibiting herbicides, the Mackay Whitsunday and Burdekin regions are considered to be at highest risk, followed by the Wet Tropics, Fitzroy and Burnett Mary regions. Importantly in the Mackay Whitsunday region, 40 per cent of the seagrass area is in the highest relative risk class compared to less than 10 per cent for all other regions (Brodie et al. 2013).

“The overarching consensus is that key Great Barrier Reef ecosystems are showing declining trends in condition due to continuing poor water quality, cumulative impacts of climate change and increasing intensity of extreme events. The evidence base is synthesised in a series of five supporting chapters and the following conclusions are based on those detailed reviews:

1. The decline of marine water quality associated with terrestrial runoff from the adjacent catchments is a major cause of the current poor state of many of the key marine ecosystems of the Great Barrier Reef.
2. The greatest water quality risks to the Great Barrier Reef are from nitrogen discharge, associated with crown-of-thorns starfish outbreaks and their destructive effects on coral reefs, and fine sediment discharge which reduces the light available to seagrass ecosystems and inshore coral reefs. Pesticides pose a risk to freshwater and some inshore and coastal habitats.
3. Recent extreme weather—heavy rainfall, floods and tropical cyclones—have severely impacted marine water quality and Great Barrier Reef ecosystems. Climate change is predicted to increase the intensity of extreme weather events.
4. The main source of excess nutrients, fine sediments and pesticides from Great Barrier Reef catchments is diffuse source pollution from agriculture.
5. Improved land and agricultural management practices are proven to reduce the runoff of suspended sediment, nutrients and pesticides at the paddock scale.” Scientific Consensus Statement, Brodie et al. (2013; 1)

Pollutants can directly affect dugong in a number of ways. Hormonal impacts can be caused by a range of contaminants known to act as endocrine disruptors, in particular organochlorines. Reproductive disorders such as reduced reproductive rate and success are especially caused by PCBs and DDT. Tumour development (both benign

## Coastal Development

An emerging pressure of international significance is the expansion of port and shipping activities in the GBR World Heritage area, driven by the global demand for coal and minerals. Coal contributes to almost half of Australia's total exports by value, and significant coal reserves exist in areas adjacent to Mackay, Whitsunday and Isaac. Port capacity in the GBR region is expected to triple by 2020 to support the predicted growth in Queensland's annual coal production (BREE 2012). Major expansions are underway and proposed for the Ports of Hay Point near Mackay (the world's largest coal export port), Abbot Point, Townsville and Gladstone.

The failure to inform the World Heritage Committee of several proposed liquefied natural gas plants at the Port of Gladstone, together with reported declines in biodiversity, prompted a United Nations Educational, Scientific and Cultural Organization-International Union for Conservation of Nature (UNESCO-IUCN) reactive monitoring mission in 2012 (Brodie 2012; McGrath 2012). The mission highlighted the possibility of adding the GBR to the List of World Heritage in Danger because the number and extent of port developments presents 'a significant risk to the conservation of the Outstanding Universal Value and integrity of the region' (Douvere and Badman 2012).

According to a report by Grech et al (2013), the key issue stems from weaknesses in the governance arrangements surrounding port developments within the GBR region due to a lack of transparency and rigour in the decision processes that is not being addressed by the Australian or Queensland Governments. The paper calls for "better alignment of purpose and approach of Governments" to "reduce tension between managing authorities, necessitating substantial changes to the current governance arrangements", however warns that "changing the current governance arrangements, however, would not necessarily lead to positive biodiversity outcomes if the alignment of purpose was pro-development" (2013; 10). Instead, Grech et al suggest a mandatory, independent peer-review process for Environmental Impact Assessments, and greater stakeholder involvement to ensure greater impartiality and transparency in decision making, while increasing public confidence.

"Ports and shipping exert a variety of pressures across multiple temporal and spatial scales with diverse impacts on biodiversity in the GBR region. Port infrastructure, port-related boat traffic, and dredging are localised to designated port areas and disposal sites, within and adjacent to the GBR World Heritage Area. Shipping lanes extend along the entire length of the region, exposing a wider area to shipping-related pressures. Pressures exerted by ports occur within the construction phase (e.g. reclamation) and during operation (e.g. introduction of contaminants from storage facilities and maintenance dredging of channels). Capital (initial) dredging during construction establishes shipping lanes, swing basins and berth pockets that require maintenance dredging during the operational life of the port. Capital and maintenance dredging exert similar pressures (although over different spatial and temporal scales), including the removal of benthic biota, smothering in spoil dumping areas, and elevated turbidity around dredging and dumping sites. Pressures from shipping and port-related boat traffic include noise, abrasion from grounding, scarring from anchoring and propeller turbulence, introduction of non-native (pest) species, and leaching of toxic anti-foulants into coastal waters. Pressures related to ports and shipping range from acute (e.g. ship grounding) to chronic (e.g. port illumination)"

(Foster et al. 2010)", Guiding Principles for the Improved Governance of Port and Shipping Impacts in the GBR, Grech et al. (2013; 7).

### Other Impacts

A significant potential impact on dugong and green turtles is drowning after becoming tangled in set fishing nets or shark control program nets. This threat has been largely countered by establishment of Dugong Protection Zones, which regulate set net fishing to significantly reduce dugong deaths (Map 2.2). However, this does not negate the threat from the shark control program.

Also, since 1999 turtle excluding devices have been mandatory in the east coast otter trawl fishery. Incidental capture and mortality has now decreased substantially (Anon, 2005). Another impact on green turtles and dugong is boat strike by fast moving vessels, particularly over shallow seagrass beds.

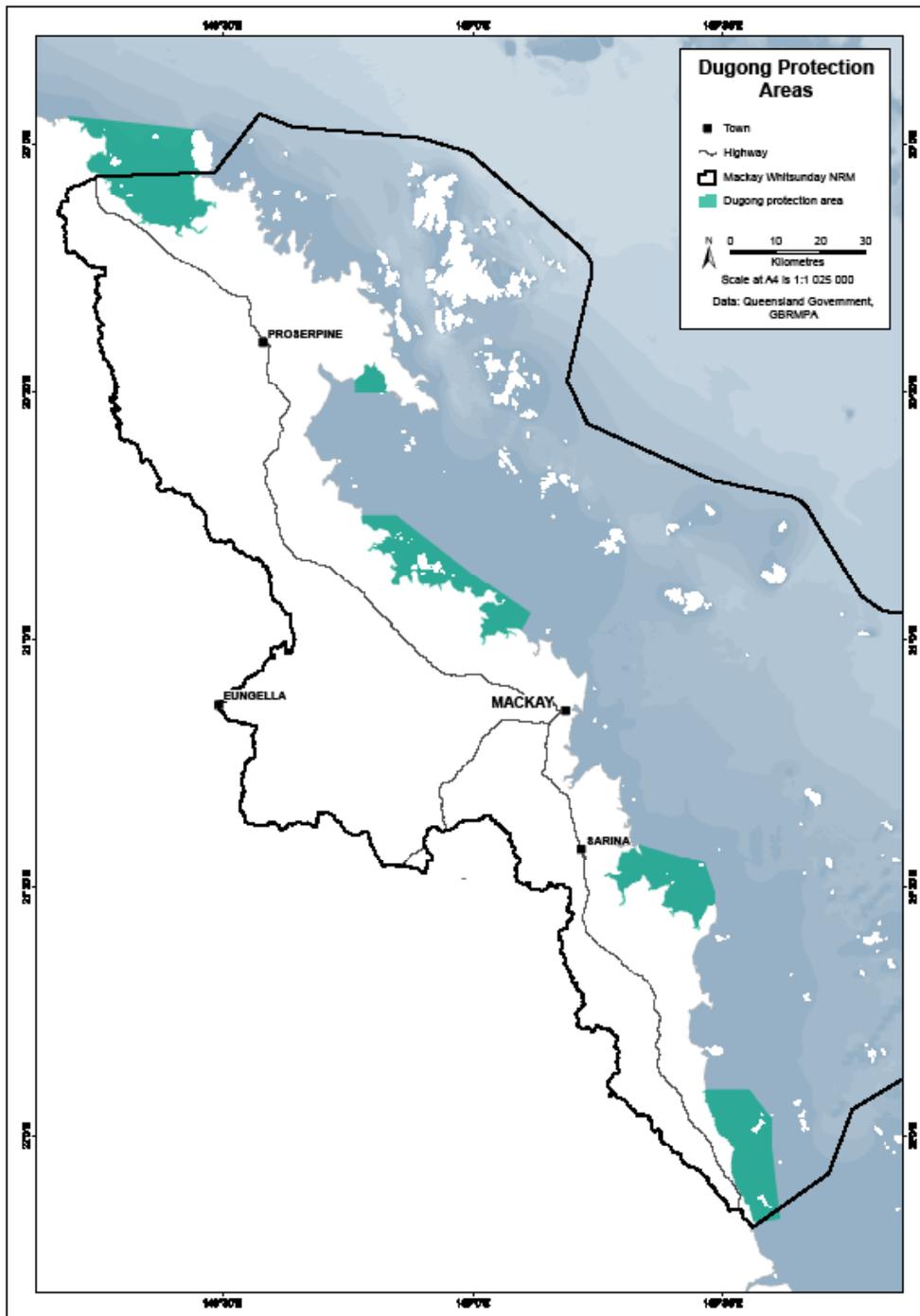


Figure 4 Dugong protection areas in MWI region

“A more serious threat posed by an increased frequency in cyclones and associated rain and flooding is an increase in the transport of pathogens and agricultural and urban-sourced pollutants into coastal waters of the GBR. As top-level predators, dolphins concentrate contaminants through bioaccumulation. High concentrations of heavy metals and persistent organic compounds containing halogens have damaging effects on marine mammals. Recent studies have shown that pathogen pollution may have considerable negative effects on populations of coastal marine mammals. The carcasses of three humpback dolphins recovered in the Townsville region between 2000 and 2001 were infected with *Toxoplasma gondii*, a terrestrial parasite that can be fatal or have deleterious effects to the health of marine mammals (e.g. infection with *T. gondii* is one of the leading causes of mortality of southern sea otters along the California coast). The introduction of this parasite to the coastal ecosystem appears to be linked to runoff of contaminated water with cat faeces or litter carrying oocysts of *T. Gondii*.”

Extract from Lawler et al. 2004. Great Barrier Reef Marine Park Authority



*Figure 5 Long-shore drift replenishes beaches with sediments supplied by coastal rivers from higher up in the catchment. Extensive sand deposits associated with Bakers Creek pictured.*

## CONDITIONS AND TRENDS

Despite the prevailing pressures and threats, the decline of loggerhead turtles and dugongs is believed to have halted and some species, such as the humpback whale, are increasing in numbers in the GBR (GBRMPA, 2009).

Comprehensive surveys of Abbot Point, Hay Point and the Mackay Port have detected introduced marine animals and plants and cryptogenic species (i.e. species whose natural range is not yet known) (CRIMP, 1998; Hoedt et al. 1999). However, none of these species are on the Australian Ballast Water Management Advisory Council list of targeted species (e.g. those with potentially significant environmental impacts).

Seven areas within the region are designated as Fish Habitat Areas (Dodds, 2004) (Table 3.2). These are designed to protect fisheries habitats from direct physical disturbance and coastal development.

DECLARED FISH HABITAT AREA	SIZE (HA)
Repulse Bay	6,162
Midge Point	798
Sand Bay	2,640
Bassett Basin	371
Cape Palmerston	895
Rocky Dam	1,549
Marion	493

Table 2 Regional Fish Habitat Areas

Available data (summarised by Dodds, 2004) illustrates stability in the Spanish mackerel fishery for the period 1989 to 2000 (Figure 3.5). However, trawl fisheries such as bugs and scallops show considerably more variability over that period (Figure 3.6). Interpretation of these data should be done with caution as catch effort is not constant among years.

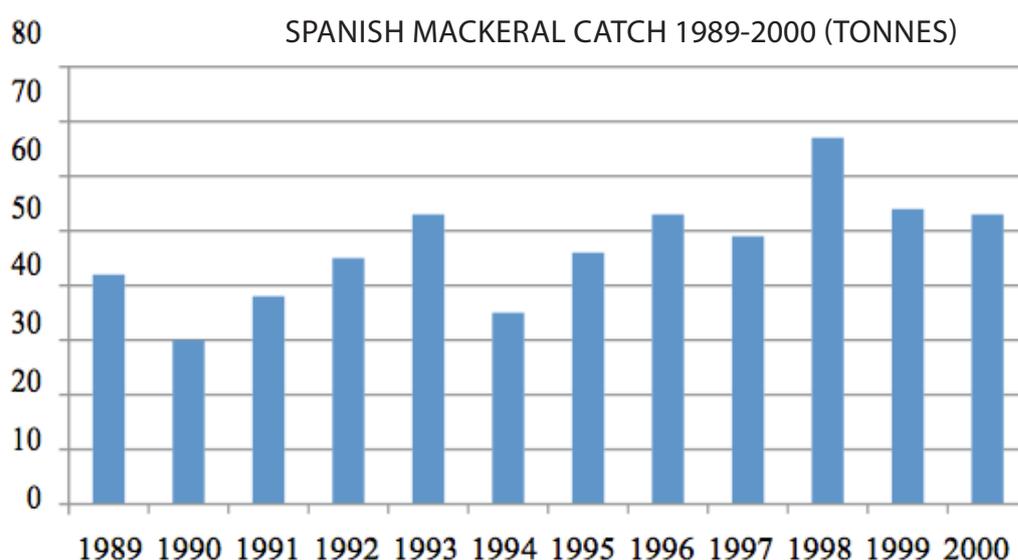


Figure 6 Spanish mackerel regional catch 1989-2000

BUG AND SCALLOP CATCH (TONNES)

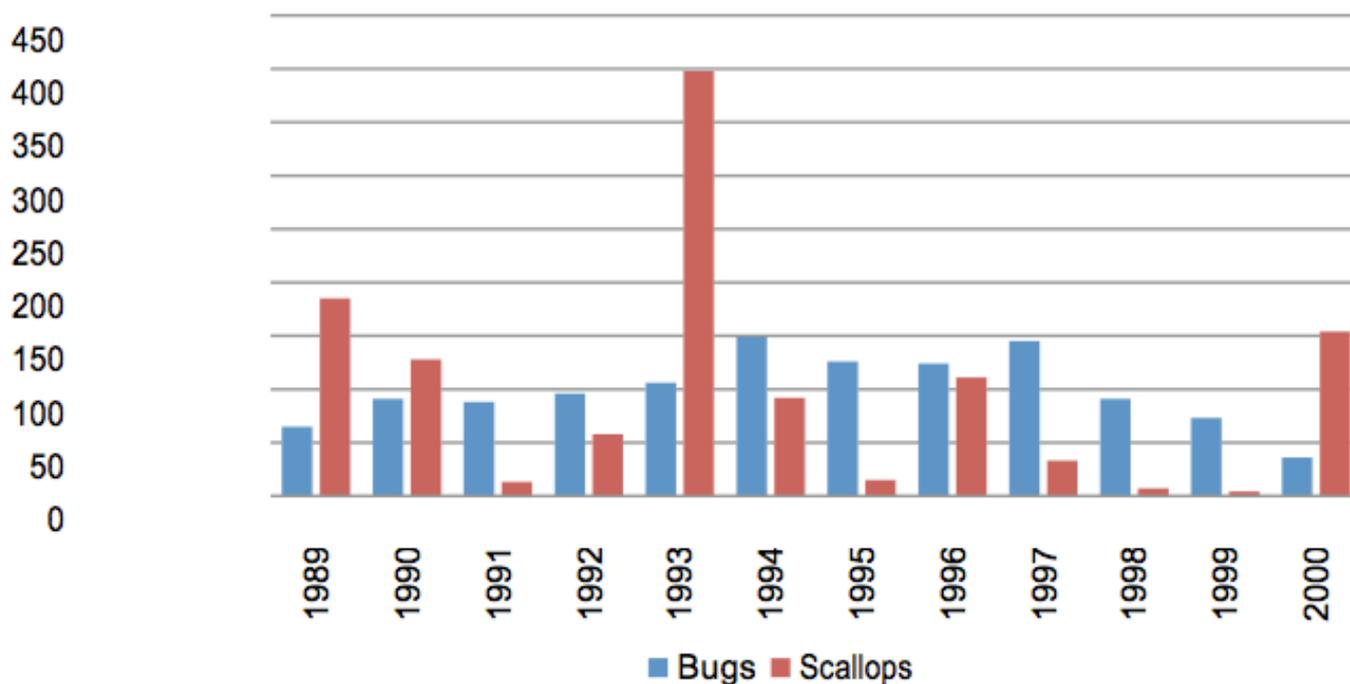


Figure 7 Bug and scallop (meat) regional catch 1989-2000

The region's catchments (Don, Proserpine, O'Connell and Pioneer Rivers and Plane Creek) historically contributed about 1161 tonnes of nitrogen (dissolved inorganic fraction) to the GBR lagoon annually, about 9% of the total outfall from the reef catchments (Furnas, 2003). Phosphorous (dissolved inorganic fraction) outfall was approximately 130 tonnes per annum or 13% of the total from all reef catchments (Furnas, 2003). Herbicide residues are present within all major waterways of the region but little is known in relation to presence of pathogens.

The Reef Water Quality Protection Plan (Reef Plan) was first endorsed by Queensland and Commonwealth governments in 2003, updated in 2009 and recently updated in July 2013. Reef Plan represents a coordinated and cooperative approach to improve the water quality in the GBR from agricultural activities. It focuses on achieving clear goals and specific targets regarding pollutant levels, groundcover, wetland extent and adoption of better management practices. A monitoring and evaluation program, Paddock to Reef, assesses the success of Reef Plan actions. Paddock to Reef issues a baseline report in 2009, and subsequently report cards measure progress yearly.

To this date, report cards tracking progress for the periods 2009-2010 and 2010-2011 have been published. Report cards for 2011-12 and 2012-13 will expectedly be published in 2014. So far the report cards indicate that management changes and water quality improvements are on a positive trajectory and progress toward Reef Plan targets (Figure 8). Albeit not at the rate needed to achieve the 2013 targets set in Reef Plan 2009, progress is encouraging, particularly the on-ground management practice changes which are the key to reducing pollutant loads entering the reef.

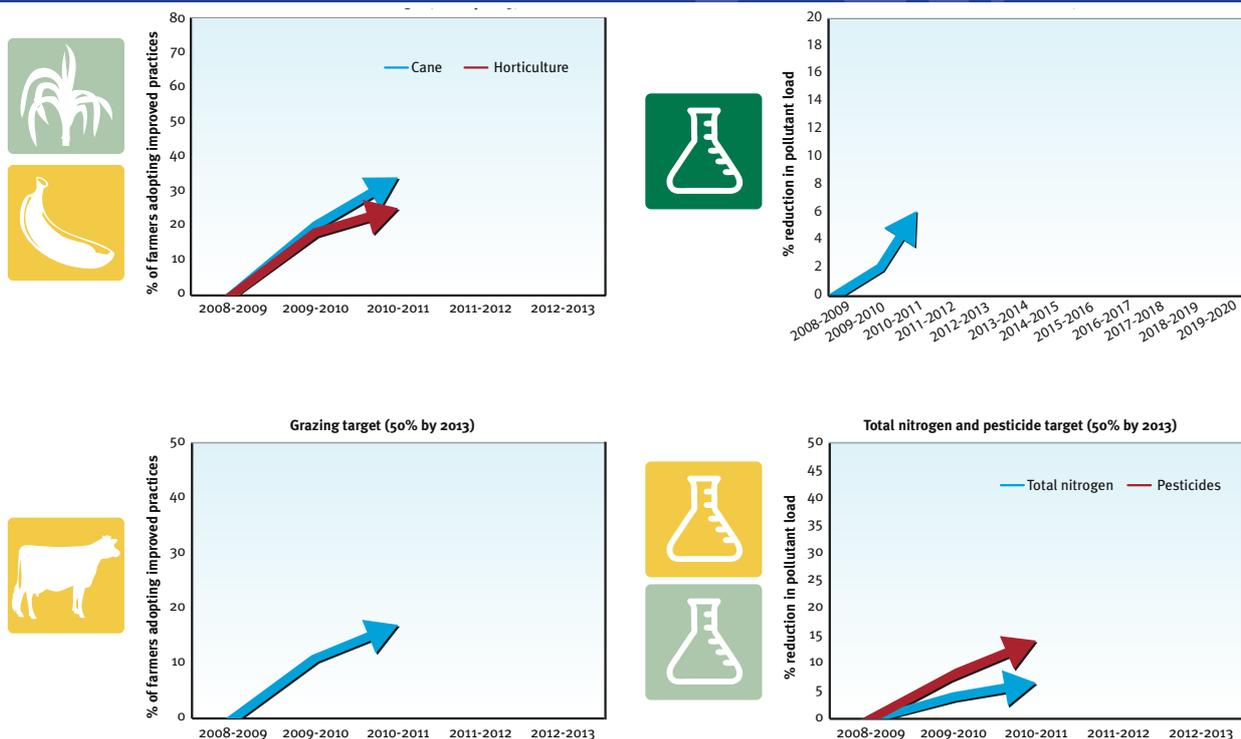


Figure 8: Trends in the adoption of best management practices for sugarcane, horticulture and grazing (the two graphs on the left), and in the concentration of pollutants (the two graphs on the right) (Report Card, Reef Plan Secretariat 2013b)

Due to lag effects, it will take time to see the results of improved land management practices translated in improved marine condition. In addition, extreme weather events in recent years have led to the discharge of higher than average loads of sediment, nutrients and pesticides, negatively impacting the reef and obscuring the benefit of improved practices. High rainfall in 2010-2011 caused higher than average discharge especially the Fitzroy and Proserpine Rivers. Also in 2011, tropical Cyclone Yasi caused significant damage to seagrass meadows and reefs from Cooktown to Mackay. These extreme weather events significantly impacted the overall condition of the marine environment. As a result, in 2010-2011, The Mackay Whitsunday's marine condition declined from moderate to poor. Inshore water quality also declined from moderate to poor, inshore seagrass meadows declined from poor to very poor and coral reefs remained in moderate condition.

Reef Catchments enables the implementation of Reef Plan in the Mackay Whitsunday region by managing the Reef Rescue water quality grants and contributing to promoting improved sugarcane and grazing practices. In addition, Reef Catchments since 2009 has contributed directly to the Paddock to Reef program by managing key monitoring sites and collecting data on practice adoption. Since 2008, Reef Catchments has facilitated the investment in the Mackay Whitsunday region of \$27.5 million into improved agricultural practices achieving: 918 projects in 3 industries, \$29.5 million co-investment by farmers, 93,000ha of improved soil management, 59,000ha of improved nutrient management and 95,000ha of improved pesticide management.

Thirty four per cent of sugarcane growers, 17 per cent of graziers and 25 per cent of horticulture producers adopted improved management practices by June 2011. The highest regional level of adoption in the grazing and horticulture industries was in the Mackay Whitsunday region and the highest level of adoption in the sugarcane industry was in the Burnett Mary region. The estimated annual average sediment load reduced by six per cent with good to very good progress across all regions. The total nitrogen load reduced by seven per cent; however dissolved nitrogen, the key pollutant of concern, reduced by 13 per cent. The pesticide load reduced by 15 per cent, with a 31 per cent reduction in the Mackay Whitsunday region.

## GOVERNANCE

Most of the GBR lagoon within the region lies within the Great Barrier Reef Marine Park (GBRMP) and is managed under the auspices of the Great Barrier Reef Marine Park Act 1975 and Regulations. The latest review of the Zoning Plan for this area was completed and gazetted in 2003. The Great Barrier Reef Marine Park Authority has management responsibility for the area in partnership with the Queensland Parks and Wildlife Service under the Day to Day Management Program. The sections of the GBR which fall within Queensland State waters lies within the Great Barrier Reef Coast Marine Park (GBRCMP) which was formed and is managed through the Queensland Marine Parks Act 2004 and Regulations. Rezoning of the GBRMP was mirrored within the GBRCMP in 2004. These marine parks combined form the Great Barrier Reef World Heritage Area for which Australia has international management obligations.

Jurisdictions include local governments, State (Queensland) lands and waters, the Commonwealth (Australian) Great Barrier Reef Marine Park (GBR Marine Park), and the Great Barrier Reef World Heritage Area (GBR World Heritage Area).

The GBR Marine Park Authority, Australian Maritime Safety Authority, and Maritime Safety Queensland jointly manage shipping under domestic laws and regulations as well as international treaty law, such as the United Nations Convention of the Laws of the Sea and MARPOL. The GBR region is listed as a Particularly Sensitive Sea Area by the International Maritime Organization. All large vessels are monitored by a vessel traffic system (REEFVTS) and ships are only permitted to transit through Designated Shipping Areas (Figure 9). Much of the region requires the compulsory pilotage of large vessels.

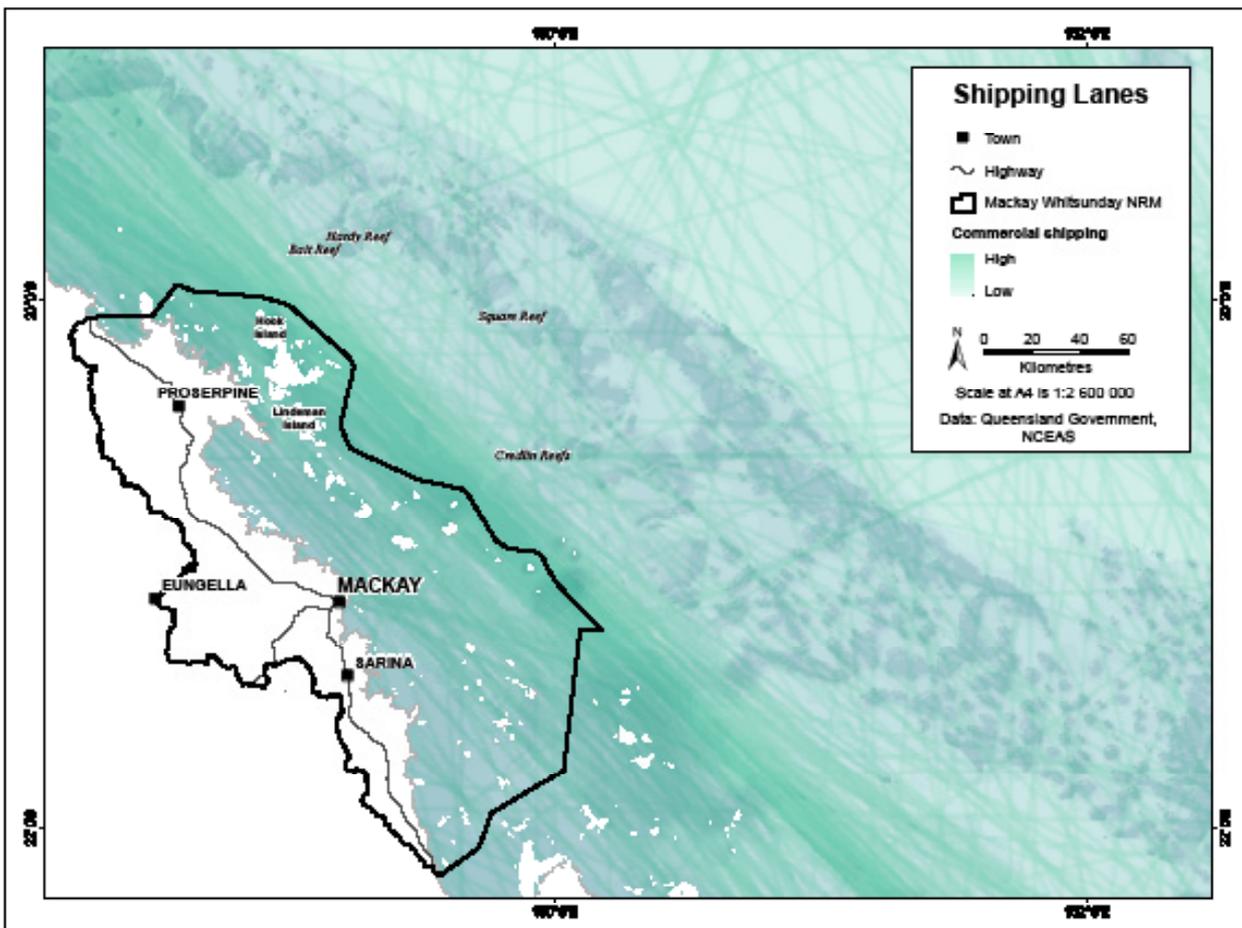


Image 9 Designated Shipping areas in MWI region

There are four Port areas within and adjacent to the region that are not part of either Marine Park; Abbot Point, Port of Bowen, Port of Mackay, and Hay Point/ Dalyrymple Bay.

Commercial and recreational fishing throughout the GBR is managed by the Queensland Department of Primary Industries and Fisheries under the Fisheries Act 1994. Management instruments notably include reef zoning, quotas, size and bag limits and seasonal closures. Compliance is undertaken by the Boating and Fisheries Patrol (DPIF), Marine Parks (QPWS) and the Queensland Water Police.

“There are more than 30 pieces of legislation at both the State (Queensland) and Commonwealth (Australia) levels that administer and regulate the assessment and decision processes of port developments in the GBR region. Management and environmental plans by Local Government and Port Authorities can also influence the approvals process. The spatial overlap between jurisdictions is complex. For example, 10 of the 12 GBR ports are excluded from the GBR Marine Park but some of these remain within the World Heritage boundary, and all are within State (Queensland) waters.

This complexity of legal constraints is characterized by divergence of purpose and approach within the decision processes for major projects by State and Commonwealth Governments, especially in the administration of Environmental Impact Assessments (EIAs). EIAs for significant port developments in the GBR region are directed by the Queensland Coordinator General in the Department of State Development Infrastructure and Planning. This department is also broadly responsible for facilitating economic development and ensuring the management, delivery and facilitation of high priority commercial projects. The GBR Marine Park Authority’s goal is the long-term protection and ecologically sustainable use of the GBR Marine Park, whilst the Commonwealth Government is focused on legal process and administering the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). These differences in expectations and needs create tension between managing authorities”

Guiding Principles for the Improved Governance of Port and Shipping Impacts in the GBR, Grech et al. (2013; 9).

## INDICATORS

The quality of water flowing into the GBR lagoon has been improved since 2008 in line with the thresholds, indicators and mechanisms identified by the Mackay Whitsunday Water Quality Improvement Plan (Drewry et al., 2008).

A key part of the Water Quality Improvement Plan implementation strategy has been ABCD Management Frameworks. These provide a way of classifying different suites of agricultural and urban practices on the basis of water quality benefits. They are valuable tools in communicating to policy makers, investors and farmers and the framework has been adopted across all the Great Barrier Reef catchment regions. The Water Quality Improvement Plan set scientifically robust targets that were supported by practical on ground solutions.

Fisheries catch data continue to demonstrate sustainability of lagoon based fisheries. Cetacean populations are monitored by a combination of incidental sightings records and dedicated aerial surveys.

Areas with a high potential for marine bio-invasion are monitored using the methodology designed by the CSIRO Marine Research Centre for Research on Introduced Marine Pests. No further net loss of foreshore vegetation to beach erosion.

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