Centre for Tropical Water and Aquatic Ecosystem Research

Status of Coastal and Marine Assets in the Burnett Mary Region

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Report No. 14/36

2014

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A Report for the Burnett Mary Regional Group

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Information should be cited as:

Coppo, C., Brodie, J., Butler, I., Mellors, J. and S. Sobtzick, 2014. Status of Coastal and Marine Assets in the Burnett Mary Region Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication, James Cook University, Townsville, Report No. 14/36, 89 pp.

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This publication has been compiled by the Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University.

Acknowledgments:

The authors of this report would like to thank the Burnett Mary Regional Group for the project funding.

EXECUTIVE SUMMARY

Information in this report will assist development of the Water Quality Improvement Plan in the Burnett Mary region. It will assist delivery of the plan by documenting the status of coastal and marine assets in the region. The key components of the **coastal assets** in the Burnett Mary region are:

Estuaries

- Seventeen estuaries are identified in the region and the majority are considered near pristine (35.3%) or largely unmodified (47.1%);
- The Kolan River estuary is considered modified (5.9%) and the Burnett and Mary River estuaries are considered extensively modified (11.8%);
- Thirteen declared Fish Habitat Areas include most of the estuaries; and
- Diverse habitats are represented in these estuaries including flood and ebb tidal deltas, intertidal flats, mangroves, saltflats and tidal sand banks.

Coastal Wetlands and Mangroves

- Includes Great Sandy Strait (93,160 hectares), a RAMSAR listed wetland of international significance.
- At least 3,914 freshwater lacustrine and palustrine wetlands as well as artificial, estuarine, and riverine wetlands which collectively cover an area of 1,630 km^2;
- The most modified catchments are the Burnett, Kolan and Mary River catchments with 54.4%, 60% and 61.4% of the pre-clearing vegetation remaining in 2001 respectively;
- The least modified catchments are Fraser Island, Baffle and Burrum River catchments with 99.5%, 89.5% and 88.7% of the pre-clearing vegetation remaining in 2001 respectively;
- Wetlands in the Kolan River catchment are ~40% riverine and ~46% artificial; and
- Includes at least six coastal wetlands of National Significance.

Coastal Islands

- Fraser Island is a World Heritage Area and the largest sand island in the world (1,840 km^2); and
- Other coastal islands are limited to Hummock Hill Island in Rodds Bay, in the north, and those in the Great Sandy Strait region in the south.

The key components of the **marine assets** in the Burnett Mary region are:

Inshore Coral Reefs

- Have been present for up to 6500 years;
- Are the current known southern limit for consolidated reef formation along the mainland of eastern Australia and are an unusual example of marginal, subtropical coral reefs;
- Have 102 coral taxa identified of which 78 are hermatypic hard corals, 6 ahermatypic hard corals and 18 soft corals, including gorgonians;
- Are located in either the Great Barrier Reef Marine Park (GBRMP) or in the Great Sandy Marine Park (GSMP), with the exception of a stretch of water roughly bounded by 24^{o} 30’ and 24^{o} 40’that lies unprotected in between the GBRMP and the GSMP;
- Are relatively healthy but have experienced a 60% decrease in coral abundance in reefs surveyed from Woongarra to Great Sandy Strait from 2010 to 2013, with up to 89% decrease at Point Vernon East; and
- Their most significant threat is considered to be sediment derived from the adjacent catchments, particularly the Mary River catchment which will be exacerbated by climate change effects.

Offshore Coral Reefs

- Were originally formed in the early Pleistocene, approximately two million years ago. Current reef morphology has evolved during the Holocene period, <10,000 years to the present;
- Have 244 hard coral species recorded, an unknown number of soft coral genera and 920 species of fish;
- Are within the GBRMP and zoned either Scientific Research Zone, Marine National Park Zone or Habitat Protection Zone;
- Have experienced significant temporal changes in hard coral cover (between 0-100%) during recent surveys with significant associated changes in fish communities; and
- The most significant threat to their viability is considered to be climate change.

Seagrass Meadows

- Are a key ecosystem within the Burnett Mary region supporting populations of dugong, turtle, fisheries of commercial and recreational importance and seabirds;
- Seven species of seagrass were recorded in 1973; presently only five species are regularly recorded;
- There is a recorded history of loss and recovery of seagrasses within this region from 1992;
- There is no documented knowledge of reef seagrass habitat;
- Due to topography of the region very few coastal seagrass meadows persist;
- Deepwater seagrass meadows are well represented in this region but their current status is unknown due to a lack of monitoring;
- Estuarine seagrass meadows are well represented in this region and the regional status of seagrass condition is based on two intertidal estuarine seagrass meadows at Rodds Bay and Urangan where:
  - Seagrasses have been declining since 2005/2006;
  - Plant tissue nutrients are indicative of poor water quality;
  - Reproductive effort across the region is in a poor state; and
  - Overall condition of seagrass habitat is very poor.
- Status of seagrasses in the Great Sandy Strait is reliant on opportunistic community monitoring and there is insufficient data to rate the condition of seagrass in this area; and
- Deteriorating water quality associated with flood plumes has been strongly linked to seagrass decline in the region and is considered to be the most significant threat to their viability.

The most **significant species of conservation concern** in the Burnett Mary region are dugong, cetaceans, turtles and seabirds and the key points from these are:

Dugong

- Burnett Mary region includes Hervey Bay Dugong Protection Area (A) 1,703 km^2 and the southern part of Rodd's Bay Dugong Protection Area (B);
- After Torres Strait, the Hervey Bay region, as well as the northern Great Barrier Reef region are the areas with the highest relative dugong density along the Queensland coast;
- High mortality rates due to extreme weather events (cyclones and floods) and associated seagrass pasture disturbances; and
- Aerial surveys of dugongs in Hervey Bay estimated to be approximately 2,100 dugong in 2011.

Cetaceans

- There are approximately 30 species of whales and dolphins found in the Great Barrier Reef World Heritage Area (GBRWHA) that are considered likely to occur in the Burnett Mary region. High priority species (GBRMPA) in the region are:
    - humpback whale (vulnerable);
    - dwarf minke whale (No Category Assigned (NCA) - insufficient information);
    - Australian snubfin dolphin (NCA - insufficient information); and
    - Indo-Pacific humpback dolphin (NCA - insufficient information) and Great Sandy Strait is considered a key locality for this species with two communities present.
- Australian snubfin dolphin and Indo-Pacific humpback dolphin are coastal species that are particularly vulnerable to water quality decline;
- The Southern right whale is not recorded from the GBRMP but, along with humpback whales, are the most commonly sighted whales in the Burnett Mary region; and
- Risso's Dolphin - Fraser Island has the only known 'resident' population in Australia.

Turtles

- Six of the world's seven sea turtle species have been recorded in the Burnett Mary region;
- Includes the most significant loggerhead turtle (Endangered) nesting population in the South Pacific Ocean region and successful breeding here is critical for species survival. Approximately 300 females nest at Mon Repos, Bundaberg every year;
- The southern stock of Green turtle (Vulnerable) nests primarily in the Capricorn/Bunker group with an average annual nesting population estimated at 8,000 females;
- Low density nesting of Flatback turtles (Vulnerable) occurs on the Bundaberg coast; and
- The olive ridley turtle (Endangered) and hawksbill turtle (Vulnerable) have also been recorded in the region and the leatherback turtle (Endangered) has been recorded as nesting in the region (rare).

Seabirds

- Internationally and nationally important wetlands habitat for shorebirds, waterbirds, waders and seabirds particularly in the Great Sandy Strait;
- Approximately 400 species of birds in Great Sandy Strait. Counts between 30 000 and up to 40 000 shorebirds were recorded in 1990 including in excess of 20 000 migratory shorebirds;
- Of these seabirds 22 are considered nationally threatened species and approximately 50 are considered Migratory Marine, Terrestrial or Wetland species; and
- At least 30 species are listed under each international JAMBA, CAMBA and ROKAMBA agreement.

The major pressures and threats to coastal and marine assets in the Burnett Mary region include terrestrial pollutants (sediment, nutrients and pesticides), coastal development, shipping (and boating) and climate change. Climate change, coastal development and increases in terrestrial pollutants are all considered serious threats to each coastal and marine asset, to varying degrees. The cumulative effect of all of these threats will be significant. Addressing increases in terrestrial pollutants as part of the Water Quality Improvement Plan is likely to result in healthier inshore coral reefs and seagrass meadows which will be more resilient to the likely impacts of climate change.

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INTRODUCTION

The Burnett Mary region covers an area of 55,768 km^2 (excluding the marine area) and includes the major coastal towns of Bundaberg, Hervey Bay and Maryborough (WetlandInfo, 2014). The marine area is at least 40,000 km^2, stretching out past the continental shelf into the South Pacific Ocean. The marine boundary of the region includes the Capricorn Bunker group of islands at the southern end of the Great Barrier Reef Marine Park (GBRMP) and Great Sandy Marine Park (GSMP) which includes Great Sandy Strait (Figure 1). There is a stretch of water roughly bounded by 24^{o} 30' and 24^{o} 40'that lies unprotected in between GBRMP and GSMP (GBRMPA, 2011b, 2011c, 2011d).

Figure 1. The marine boundary of the Burnett Mary region.

Source: BMRG

The adjacent coastal area, from north to south, include the Baffle, Kolan, Burnett, Burrum and Mary River catchments and the northern part of the Noosa River catchment (Figure 2). The predominant land use in these catchments is grazing and forestry is the second most common land use (Figure 3). Other land uses include sugarcane, intensive animal production, other cropping, horticulture, urban and other intensive uses. The Burnett, Kolan and Mary River catchments are the most modified with 54.4%, 60% and 61.4% respectively of the pre-clearing vegetation remaining in 2001. The least modified catchments are Fraser Island and the Baffle and Burrum River catchments with 99.5%, 89.5% and 88.7% respectively of the pre-clearing vegetation remaining in 2001.

Figure 2. River catchments of the Burnett Mary region.

Source: (WetlandInfo, 2014).

Figure 3. Land Use in the Burnett Mary region.

Source: (Australian Government, 2009).

The Burnett Mary region encompasses significant coastal and marine assets many of which are acknowledged for their uniqueness at a state, national and international scale. The coastal assets considered in this report are estuaries, coastal wetlands and mangroves and coastal islands. The marine assets considered in this report are inshore and offshore coral reefs, seagrass meadows and species of conservation concern; dugong, cetaceans, turtles and seabirds.

There are various threats and potential threats affecting these coastal and marine assets which are broadly grouped to include terrestrial water quality pollutants (sediment, nutrients and pesticides), coastal development, shipping and climate change. The impact of these threats on each of the coastal and marine assets is considered to highlight the role improved water quality will have on the state of each asset.

STATUS AND TRENDS OF COASTAL ASSETS

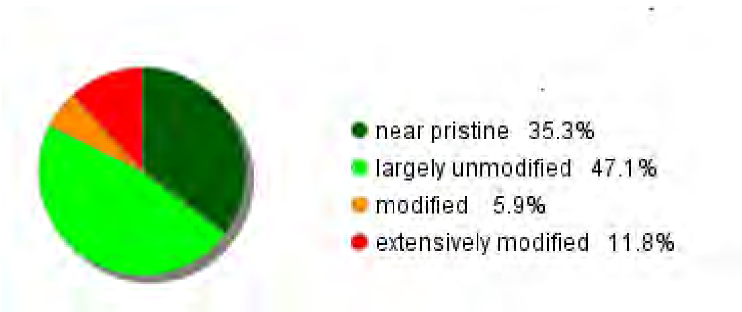
ESTUARIES

Status and Trends of Estuaries in the Burnett Mary region:

- Seventeen estuaries are identified and the majority are considered near pristine (35.3%) or largely unmodified (47.1%)
- The Kolan River estuary is considered modified (5.9%) and the Burnett and Mary River estuaries are considered extensively modified (11.8%).
- Thirteen declared Fish Habitat Areas include most of the estuaries.
- Diverse habitats are represented in these estuaries including flood and ebb tidal deltas, intertidal flats, mangroves, saltflats and tidal sand banks.

The estuaries of rivers in the Burnett Mary region vary significantly in their condition and characteristics (Table 1). The condition of these estuaries has been assessed as near pristine (35.3%), largely unmodified (47.1%), modified (5.9%) and extensively modified (11.8%) (Figure 4). The Burnett and Mary River estuaries are most extensively modified and the Kolan River is considered modified. The other estuaries are near pristine or largely modified and many of these are included in National Parks or Conservation Parks. The five rivers in the north of the region, Rodd's Bay (Harbour), Pancake Creek/Jenny Lind Creek, Eurimbula Creek, Round Hill Creek, Blackwater/Mitchell Creek and Baffle Creek are all considered near pristine and many of these areas are included in Eurimbula National Park and Joseph Banks Conservation Park (Figure 5 and Figure 6). There is also the Mouth of Kolan River Conservation Park and the Burrum Coast National Park which includes Coonar and Theodolite (Lagoon) Creeks and the Burrum River. Parts of Hervey Bay and the Mary River and the Great Sandy Strait are included in the Great Sandy Marine Park. Sections, or all of, many of these waterways are also declared Fish Habitat Areas (Table 1).

Figure 4. Estuarine condition status in the Burnett Mary region.

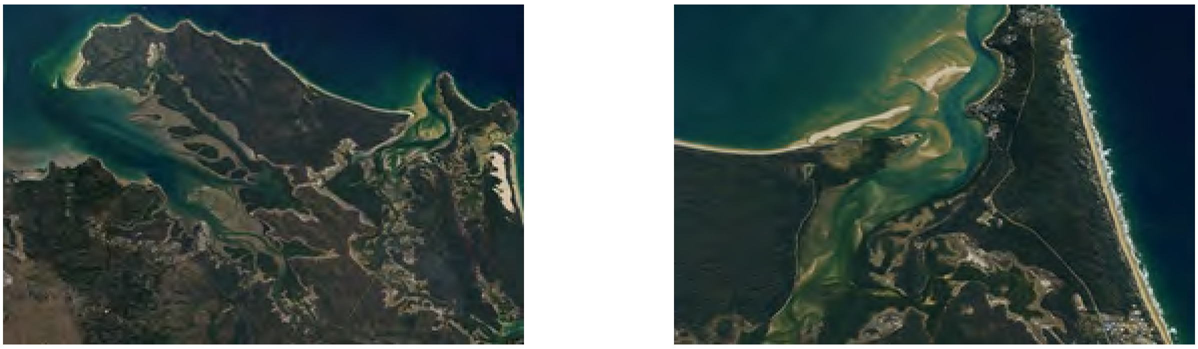


Source: (Australian Government, 2013).

Figure 5. The headland, Joseph Banks Conservation Park.

Source: (Queensland Government, 2014a).

Figure 6. Rodds Harbour and b. Seventeen Seventy - Round Hill declared Fish Habitat Areas.



Source: (Queensland Government, 2014a).

Many habitat types are represented in these estuarine areas including barrier/back barrier (2.1 km^2), flood and ebb tidal delta (72.2 km^2), intertidal flats (143.2 km^2), mangroves (158.2 km^2), saltmarsh/saltflat (82.3 km^2) and tidal sand banks (343.5 km^2) (Australian Government, 2013).

Table 1. Estuaries in the Burnett Mary region.

Estuary	Condition	Description	FHA	Area (km^2)						
				Total	**Barrier/ back Barrier**	**Flood and ebb tidal delta**	**Intertidal flats**	**Mangroves**	**Saltmarsh /Saltflat**	**Tidal sand banks**
Rodd's Harbour (Bay)	near pristine	Check for data	✓							
Pancake Creek/Jenny Lind Creek	near pristine	Check for data	✓							
Eurimbula Creek	near pristine	Check for data	✓							
Round Hill Creek	near pristine	Check for data								
Blackwater/Mitchell Creek	near pristine	Check for data								
Baffle Creek	near pristine	Check for data	✓							
Littabella Creek	largely unmodified	Wave-dominated delta		4.0	0.9	0.4	1.8			0.9
Kolan River	modified	Wave-dominated delta	✓	14.0		1.7	2.0	7.1	0.2	2.7
Burnett River	extensively modified	Tide-dominated delta		13.3			1.1	8.7	0.3	3.3
Elliot River	largely unmodified	Tidal flat/tidal creek	✓	7.3		0.2	1.9	2.1	1.9	1.2
Coonar Creek	largely unmodified	Strand plain	✓	1.2		0.3	0.2	0.3	0.3	
Theodolite/Lagoon Creek	largely unmodified	Tidal flat/tidal creek	✓	6.2		1.5	0.1	1.3	2.4	0.9
Burrum River	largely unmodified	Tide-dominated delta	✓	52.3		36.6	1.6	6.7	1.7	5.8
Beelbi Creek	largely unmodified	Tidal flat/tidal creek	✓	13.8		8.4	0.1	1.1	3.8	0.3
Hervey Bay	largely unmodified			323.7	1.2	47.4*	35.7	24.0	15.4	200.0
Mary River	extensively modified	Tide-dominated estuary	✓**	77.9			5.4	30.8	9.3	32.4
Great Sandy Strait	largely unmodified		✓**	335.5		23.1	93.3	76.1	47.0	96.0

Source: (Australian Government, 2013).

A tidal flat/tidal creek – this estuary would have low sediment trapping efficiency; naturally high turbidity, well mixed circulation and there is low risk of sedimentation.

A tide-dominated delta - this estuary would have low sediment trapping efficiency; naturally high turbidity, well mixed circulation and there is a low risk of habitat loss due to sedimentation.

A wave-dominated delta - this estuary would have low sediment trapping efficiency; naturally low turbidity, salt wedge/ partially mixed circulation and there is a low risk of habitat loss due to sedimentation.

A strand plain – this estuary would have low sediment trapping efficiency; naturally low turbidity, negative/ salt wedge/ partially mixed circulation and there is low risk of habitat loss due to sedimentation.

*Fluvial bay head delta ** includes Maroom, Susan, Kauri Creeks and Tin Can Inlet and parts of Fraser Fish Habitat Areas.

COASTAL WETLANDS AND MANGROVES

Status and Trends of Coastal Wetlands and Mangroves in the Burnett Mary region:

- Includes Great Sandy Strait (93,160 hectares), a RAMSAR listed wetland of international significance;
- At least 3,914 freshwater lacustrine and palustrine wetlands as well as artificial, estuarine, and riverine wetlands which collectively cover an area of 1,630 km^2;
- The most modified catchments are the Burnett, Kolan and Mary River catchments with 54.4%, 60% and 61.4% of the pre-clearing vegetation remaining in 2001 respectively;
- The least modified catchments are Fraser Island, Baffle and Burrum River catchments with 99.5%, 89.5% and 88.7% of the pre-clearing vegetation remaining in 2001 respectively;
- Wetlands in the Kolan River catchment are ~40% riverine and ~46% artificial; and
- Includes at least six coastal wetlands of National Significance.

The Burnett Mary region includes Great Sandy Strait which covers an area of 837.4 km^2 between the mainland and Fraser Island (Queensland Government, 2014c). It is a RAMSAR listed wetland of international significance and part of the Great Sandy Marine Park. It is 'a double-ended sand passage estuary that is flat nearshore with large tidal movement, and has the only known subtropical, southern hemisphere example of patterned fens, an elaborate network of pools surrounded by vegetated peat ridges' (Queensland Government, 2014c). It includes a diverse range of habitats such as intertidal sand and mud flats, seagrass meadows, mangrove forests, salt flats and freshwater *Melaleuca* wetlands and coastal wallum swamps which support numerous shorebirds, waterfowl and seabirds, marine fish, crustaceans, oysters, dugong, sea turtles and dolphins (Queensland Government, 1999).

The Great Sandy Strait includes a large area of subtropical mangrove communities near their northern limit and represents a transition between essentially temperate and tropical flora (Dowling and McDonald, 1982). Nine species of mangrove occur in Tin Can Bay/Great Sandy Strait including cedar mangrove (*Xylocarpus granatum*), milky mangrove (*Excoecaria agallocha*), river mangrove (*Aegiceras corniculatum*), myrtle mangrove (*Osbornia octodonta*), club mangrove (*Aegialitis annulata*) large-fruited orange mangrove (*Bruguiera gymnorhiza*) and spotted mangrove (*Rhizophora stylosa*) (Queensland Government, 2014c). In the Great Sandy Strait the swamp she-oak (*Casuarina glauca)* uncharacteristically grows below high water mark and it is also the southernmost limit of the club mangrove (Aegialitis annulata) and cedar mangrove (Xylocarpus granatum) (Queensland Government, 1999).

The Great Sandy Strait holds significant cultural heritage values for local indigenous groups where evidence of occupation dates back 5,500 years and middens are frequently found in the site (Ford, 1995). The tidal wetlands are extremely important as a source of food, as well as for the protection of, various species of juvenile and adult fish, prawns and other crustaceans which are also highly valued for local commercial and recreational fishing such as an offshore prawn fishery dependent on the migration of prawn stocks out of the Strait (Queensland Government, 1999).

Figure 7. The Great Sandy Strait.

Source: (Commonwealth of Australia, 2011).

The Burnett Mary region has 12 Nationally Important Wetlands, six of which are considered coastal; Great Sandy Strait, Burrum Coast, Bustard Bay Wetlands, Colosseum Inlet - Rodds Bay, Deepwater Creek and Wide Bay Military Training Area C (Table 2) (Australian Government, n.d.). These wetlands are distributed along the region's coastline, encompassing a diversity of ecological features and are included in National Parks or Conservation Parks (see Estuaries section above).

The region includes wetlands of various types; artificial (dams and weirs), estuarine (including mud and sand flats, mangroves) lacustrine and palustrine freshwater wetlands and riverine wetlands which cover an area of 1,630 km^2 (Table 3). There are at least 3,914 lacustrine and palustrine located in drainage basins throughout the region. The Burnett, Kolan and Mary River catchments are the most modified with 54.4%, 60% and 61.4% respectively of the pre-clearing vegetation remaining in 2001 (Table 3). The least modified catchments are Fraser Island and Baffle and Burrum River catchments with 99.5%, 89.5% and 88.7% respectively of the pre-clearing vegetation remaining in 2001. The Kolan River catchment is a short catchment that includes Lake Monduran and Fred Haigh Dam which was constructed in 1974 resulting in 46% of the Kolan Creek wetlands being artificial. The Burnett Mary is a much longer catchment that contains several dams (Wuruma, Boondooma and Paradise Dams) and numerous weirs and consequently 25.4% of the wetlands are artificial.

The biggest threat to estuaries, coastal wetlands and mangroves in the Burnett Mary region is coastal development (Threat Table 1) as indicated by the loss of wetlands since pre-clearing of the catchments (Table 3). Terrestrial pollutants, particularly sediment and pesticides, are also considered a threat as are the effects of climate change.

Threat Table 1. Estuaries, Coastal Wetlands and Mangroves in the Burnett Mary region.

Threat	Level of Impact*	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
• Sediment	M	15
• Nutrients	L	10
• Pesticides	H	25
Coastal Development	H	30
Shipping	L	5
Climate Change	M	15
Other:		
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

Table 2. Wetlands of International and National Importance.

Internationally and Nationally Important Wetlands	
Great Sandy Strait - approximately 93 160 Hectares which includes wider channels and open water.	
Description	Ramsar site including Great Sandy Strait, Tin Can Bay, Tin Can Bay Inlet, parts of Fraser Island and the mainland. It is a sand passage estuary between the mainland and Fraser Island. Fraser Island has formed sufficiently close to the mainland to block the flow of a substantial river system, creating a double-ended estuary with a shifting (though relatively stable) pattern of mangroves, sand banks and mud islands.
Ecological Features	Great Sandy Strait is a large area of tidal swamps consisting of intertidal sand and mud flats, extended seagrass meadows, mangrove forests, salt flats and saltmarshes, and often contiguous with freshwater Paperbark wetlands and Coastal Wallum swamps. Internationally significant for migratory birds and also significant for turtles, dugong and cetaceans and commercial fishing, recreational fishing, boating and tourism related activities.
Nationally Important Wetlands	
Burrum Coast *– 15,140 Hectares*	
Description	Made up of extensive intertidal flats associated with the mouth of the Burrum River and adjacent coastline; mangrove and saltflat systems along estuaries and coastline; freshwater wetlands dominated by wallum heaths, and lesser areas of sedgeland and swamp forests.
Ecological Features	Major habitat types include seagrass beds, mangrove low closed forest to open shrubland, saltmarsh, bare claypan, and extensive bare sandflats (exposed at low tide); sedgelands, open forest/woodland and closed heath occur in swampy areas of the beach ridge systems; fringing woodlands and open forests, dominated variously by *Casuarina*, *Melaleuca* and *Eucalyptus spp*., occur adjacent to the beaches and wetland communities.
Bustard Bay Wetlands *– 21,854 Hectares*	
Description	The site includes the embayment and estuaries between Rodds Peninsula and Round Hill. It is comprised of three interconnected, mangrove dominated, estuarine wetlands on and around Middle Island (Pancake, Middle and Jenny Lind creeks), plus two similar small estuaries at the southern end of Bustard Bay (Eurimbula and Round Hill creeks); an extensive non tidal, seasonal, freshwater wetland exists between the two southern estuaries in Eurimbula National Park.
Ecological Features	The dominant plant community in the site is mangrove forest and shrubland, with relatively small areas of saltflats behind; mangroves exhibit distinct banding from seaward to land.
Colosseum Inlet - Rodds Bay *– 24,314 Hectares*	
Description	The site is comprised of the area of the Curtis Coast between Wild Cattle Island and Rodds Peninsula. It contains three large estuaries/embayments with extensive mangroves and lesser areas of coastal saltflat and seagrass beds, supporting fauna of state and national significance.
Ecological Features	Extensive mangrove forests and shrublands; restricted seagrass beds; coastal saltflats (claypan and saltmarsh) and a small coral reef. Mangroves exhibit distinct banding from seaward to land.
Deepwater Creek *– 6,573 Hectares*	
Description	The Deepwater landscape is characterised by a gently sloping alluvial plain that is closed by a coastal dunefield in the north and east.
Ecological Features	Catchment and lowlands are a large and relatively intact wetland system at the northern limit of the coastal lowland 'wallum' ecosystem of SE Queensland. The area is one of the least disturbed mainland representatives for coastal acid freshwater wetlands in Queensland and is part of the Macpherson-Macleay zone of biogeographical transition, an area with enhanced species diversity.
Wide Bay Military Training Area C *– 19,617 Hectares*	
Description	The training area lies within the Fraser Island and Great Sandy Region World Heritage Nomination. Much of the wetland value is in the Littoral Fringe Landform. Three estuary areas constitute much of the wetland value.
Ecological Features	The training area covers almost the entire catchment of the three main creeks Kauri, Teebar and Snapper Creek. Their estuaries contain mangrove forest, clay pans and salt flats. Extensive seagrass meadows, of *Halophila spinulosa* and *H. ovalis*, are located just offshore particularly around the mouths of Kauri and Teebar Creeks. Also, a monospecific stand of the seagrass, *Cymodocea serrulata*, occurs on either side of the Kauri Creek mouth. Other wetland features in the area include Melaleuca swamps, mostly along drainages, and treeless heathland mixed through all terrain types and often intergrades with most of the forest and woodland habitats.

* Coalstoun Lakes, Conondale Range Aggregation, Granite Creek and Obi Obi Creek are Nationally Important Wetlands in the Burnett Mary region but are not considered coastal; Fraser Island is outside the scope of this report; Great Barrier Reef Marine Park not discussed here.
Source: (Australian Government, n.d.).

Table 3. The extent change of wetland systems in river catchments in the Burnett Mary region.

Drainage Basin	System	Number of wetlands	Area	Wetland Area	Total Area	2009 Area	Change in Extent 2005-2009	Change in Extent 2001-2005	2001/Pre-clearing
			km^2	%	%	km^2	km^2	km^2	%
Baffle	**Total**		**320.1**	**100**	**7.8**	**320.1**	**-0.9**	**-0.1**	**89.5**
	Artificial	630	7.7	2.4	0.2	7.7	0.0	0.5	n/a
	Estuarine		134.5	42.0	3.3	134.5	0.0	0.0	99.4
	Lacustrine		1.8	0.6	0.0	1.8	0.0	0.1	100.0
	Palustrine		106.8	33.4	2.6	106.8	-0.7	-0.4	81.7
	Riverine		69.2	21.6	1.7	69.2	-0.3	-0.3	88.4
Kolan	**Total**		**147.1**	**100.0**	**5.1**	**147.1**	**-0.1**	**0.1**	**60.0**
	Artificial	194	68.0	46.2	2.3	68.0	0.1	0.2	n/a
	Estuarine		15.1	10.3	0.5	15.1	0.0	0.0	83.8
	Palustrine		5.4	3.7	0.2	5.4	-0.1	-0.1	17.0
	Riverine		58.5	39.8	2.0	58.5	-0.1	0.0	67.7
Burnett	**Total**		**432.4**	**100.0**	**1.3**	**432.4**	**0.4**	**9.5**	**54.4**
	Artificial	1,022	110.0	25.4	0.3	110.0	0.8	19.3	n/a
	Estuarine		11.6	2.7	0.0	11.6	0.0	-0.2	82.4
	Lacustrine		0.3	0.1	0.0	0.3	0.0	0.2	n/a
	Palustrine		16.8	3.9	0.1	16.8	0.0	0.0	37.8
	Riverine		293.7	67.9	0.9	293.7	-0.4	-9.8	54.5
Burrum	**Total**		**258.3**	**100.0**	**7.7**	**258.3**	**0.5**	**-0.1**	**88.7**
	Artificial	712	27.7	10.7	0.8	27.7	1.3	0.8	n/a
	Estuarine		27.1	10.5	0.8	27.1	0.0	0.0	96.7
	Lacustrine		1.6	0.6	0.0	1.6	0.0	0.0	n/a
	Palustrine		93.7	36.3	2.8	93.7	-0.4	-0.7	83.6
	Riverine		108.2	41.9	3.2	108.2	-0.4	-0.2	92.2
Mary	**Total**		**276.5**	**100.0**	**2.9**	**276.5**	**0.2**	**-0.4**	**61.4**
	Artificial	890	29.7	10.7	0.3	29.7	0.4	0.5	n/a
	Estuarine		43.2	15.6	0.5	43.2	0.0	0.0	96.9
	Lacustrine		0.0	0.0	0.0	0.0	0.0	0.0	n/a
	Palustrine		57.6	20.8	0.6	57.6	-0.1	-0.6	45.2
	Riverine		146.0	52.8	1.5	146.0	-0.2	-0.3	65.5
Fraser Island	**Total**		**196.3**	**100.0**	11.8	196.3	0.0	0.0	99.5
	Estuarine	466	34.0	17.3	2.0	34.0	0.0	0.0	100.2
	Lacustrine		11.2	5.7	0.7	11.2	0.0	0.0	100.0
	Palustrine		151.1	77.0	9.1	151.1	0.0	0.0	99.3
TOTAL		**3,914**	**1,630.7**						

Areas do not include marine or estuarine waters but do include estuarine wetland vegetation (e.g. mangroves and tidal flats).

Modified from: (Queensland Government, 2014c).

COASTAL ISLANDS

Status and Trends of Coastal Islands in the Burnett Mary region:

- Fraser Island is a World Heritage Area and the largest sand island in the world (1,840 km^2)
- Other coastal islands are limited to Hummock Hill Island in Rodds Bay, in the north, and those in the Great Sandy Strait region in the south.

There are only a few coastal islands located in the Burnett Mary region with one, Hummock Hill Island in Rodds Bay to the north and several, of varying sizes, in the Great Sandy Strait. From north to south in the region the largest islands are:

Hummock Hill Island is a large low-lying island located in Rodds Bay. Historically it had a pastoral lease. Currently it is proposed that this area be redeveloped into a residential project to accommodate approximately 1200 permanent residents and 2800 tourists when the development is at full capacity in 15 to 20 years and the island will be linked to the mainland by a causeway (The Coordinator-General, 2011).

Fraser Island is the largest sand island in the world, with an area of 1840 km^2, and is a World Heritage Area with outstanding cultural and natural values (Queensland Government, 2014b). As it was deemed to have no adverse impact on water quality in the Burnett Mary region it is not being considered in this report however its assets are potentially under threat from terrestrial water quality pollutants (sediment, nutrients and pesticides) derived from the adjacent coast as well as climate change.

Islands in Great Sandy Strait include Woody Island and Little Woody Island at the northern end of Great Sandy Strait and Turkey Stewart and, Dream in the middle and southern end of Great Sandy Strait. These islands have open forests and fringing mangroves which provide habitat for a variety of birds (Queensland Government, 2014b).

STATUS AND TRENDS OF MARINE ASSETS

CORAL REEFS

The Burnett Mary region has two geographically distinct areas of coral reef. Firstly the inshore coral reefs along the coastline and in Hervey Bay and the offshore coral reefs of the Capricorn-Bunker Group and Lady Elliot Island. These are discussed below.

Inshore Coral Reefs

Prepared by Ian Butler

Status and Trends of Inshore Coral Reefs in the Burnett Mary region:

- have been present for up to 6500 years;
- are the current known southern limit for consolidated reef formation along the mainland of eastern Australia and are an unusual example of marginal, subtropical coral reefs;
- have 102 coral taxa identified of which 78 are hermatypic hard corals, 6 ahermatypic hard corals and 18 soft corals, including gorgonians;
- are located in either the GBRMP or in GSMP, with the exception of a stretch of water roughly bounded by 24^{o} 30' and 24^{o} 40'that lies unprotected in between GBRMP and GSMP;
- are relatively healthy but have experienced a 60% decrease in coral abundance in reefs surveyed from Woongarra to Great Sandy Strait from 2010 to 2013, with up to 89% decrease at Point Vernon East; and
- their most significant threat is considered to be sediment derived from the adjacent catchments, particularly the Mary River catchment which will be exacerbated by climate change effects.

The inshore coral reefs of the Burnett-Mary region (BMR) in south-eastern Queensland Australia are a relatively healthy and unusual example of marginal, subtropical coral reefs. They represent an important transitional area between the more tropical reefs of the north, including the Great Barrier Reef Marine Park, and the sub-tropical reefs to the south. These coral communities are subject to and survive through a wide range of conditions annually. At around 25 -26^{o} S, the reefs of the BMR are subtropical and experience reduce temperatures and reduced light conditions. The reefs of the BMR near Great Sandy Strait are the current known southern limit for consolidated reef formation along the mainland of eastern Australia (DeVantier, 2010). Hervey Bay, which includes a large portion of the reefs, is considered an inverse estuary and experiences high salinity levels for much of the year (Grawe *et al.*, 2009). The whole region is also subject to large freshwater, sediment and nutrient input through flooding (Butler *et al.*, 2013). As a result of the often turbid waters and reduced light, the presence of coral can be limited in depth, with the coral presence in the more southern sections of BMR are often limited to depths of less than five metres (Alquezar *et al.*, 2011; Butler *et al.*, 2013). Despite these marginal conditions, and the occasional setbacks from flooding mortality, coral reefs appear to thrive in the region. Preliminary results of palaeoecological studies indicate that coral reefs have been present for up to 6500 years (Butler *et al.*, 2014). These palaeoecological studies also indicate that while most of the inshore coral communities are fringing and based on rocky substrate, there are also more offshore shore reefs that have developed on other substrates such as Pleistocene mud and old river bed (Butler *et al.*, 2014).

The most recent inshore coral abundance measurements for the BMR show hard and soft cover ranging from 0 – 80% within reef areas (Figure 8), though most of these data are from single measurements made prior to 2010 (Table 4). Soft corals often dominate the coral communities in the BMR, though there appears to be higher proportions and increased dominance of hard coral towards the southern end of the region (Figure 8). There are few data with repeated measurements at a particular location with which to measure longer term trends in abundance for the whole BMR (Figure 9). Recent work by Butler et al.(Butler *et al.*, 2013; Butler *et al.*, 2014), however, which repeatedly survey a series of reef areas from Woongarra to Great Sandy Strait from 2010 to 2013, indicate that coral abundance has decreased by 60% over all of the coral reef communities that were surveyed (Figure 9), with up to 89% decrease at Point Vernon East (Butler *et al.*, 2013; Butler *et al.*, 2014). It was also found that the coral communities changed over this time, with increased relative abundance of the stress tolerant coral *Turbinaria*, (especially *T mesenterina*). These decreases in abundance coincide with and are attributed to moderate flooding in 2011 and more severe flooding in 2013 from the highly modified Burnett and Mary Rivers. Areas near the mouth of the Mary River (e.g. Little Woody Island areas, Duck Island) currently show zero abundance, but are known to have a historical presence of coral. If conditions are favourable in the future and there is an extended reprieve from flooding, then it would be expected that the future trend would be of generally increased coral abundance as the reefs recover, which they have done from flooding in 1974, 1992 and 1999.

<u>*Management zones*</u>

All of the identified reefs in the BMR are located in either the GBRMP or in GSMP (Table 4), with the exception of a stretch of water roughly bounded by 24° 30' and 24° 40'that lies unprotected in between GBRMP and GSMP (GBRMPA, 2011b, 2011c; QPWS, 2009). Although the majority of identified reef areas are protected by Habitat Protection Zones and Conservation Park Zones these areas tend to only restrict commercial use while still allow intensive non-commercial use of the zoned area. It is expected that many more reef areas will be identified, most likely in deeper water, and these will likely be in General Use Zones. While 20% of GBRMPA zoning is of high protection (Marine National Park or greater) as a part of the "representative areas" approach, only 4% of GSMP is of high protection (Schwarzrock, 2014). As a result of recent flooding mortality, less than 1% of living coral communities south of Woongarra are currently in MNP.

<u>*Ecological Values*</u>

<u>Diversity</u> - The inshore coral reef areas of the Burnett Mary region occur in a diverse range of conditions, many of them considered quite marginal for coral reef presence. Marginal areas, or areas on the edge of tolerance, such as the BMR, often represent a hotspot for "evolutionary innovation" (Budd and Pandolfi, 2010). Coral colonies can be found in scattered coral communities or on consolidated reef structures and in conditions that range from exposed rocky coasts to very sheltered locations in small embayments, and even inside coastal creeks. The reefs areas of the BMR are not well researched and the true diversity of the biota of the region is only starting to be realized. In terms of coral taxa compiled from available studies, 102 coral taxa have been identified of which 78 are hermatypic hard corals, 6 ahermatypic hard corals and 18 soft corals, including gorgonians (Table 5). Many of the identified taxa are to genus, so the true number of taxa will increase as the coral taxa are identified in greater detail. The numbers of taxa are comparable to the more well researched areas to the south such as the Sunshine Coast (94 hard coral taxa) and Moreton Bay (60 hard coral taxa) (DeVantier, 2010) but lower than the offshore Keppel Islands (176 hard coral taxa) to the north (Jones *et al.*, 2011).

<u>Distinctiveness</u> - Fringing reefs are not common along the mainland of eastern Australia and for the reefs of the BMR to be found in marginal conditions within metres of urban centres makes them very unique (DeVantier, 2010; Zann, 2012). A number of the species of coral found in the BMR are uncommon or rare in GBR waters, for example: *Acanthastrea lordhowensis* and *A. hillae*, *Acropora bushyensis, Turbinaria radicalis*, *T bifrons* and *T. conspicua* (DeVantier, 2010). The composition of the

Figure 8: Abundance of hard and soft coral on inshore reefs of the Burnett-Mary region.

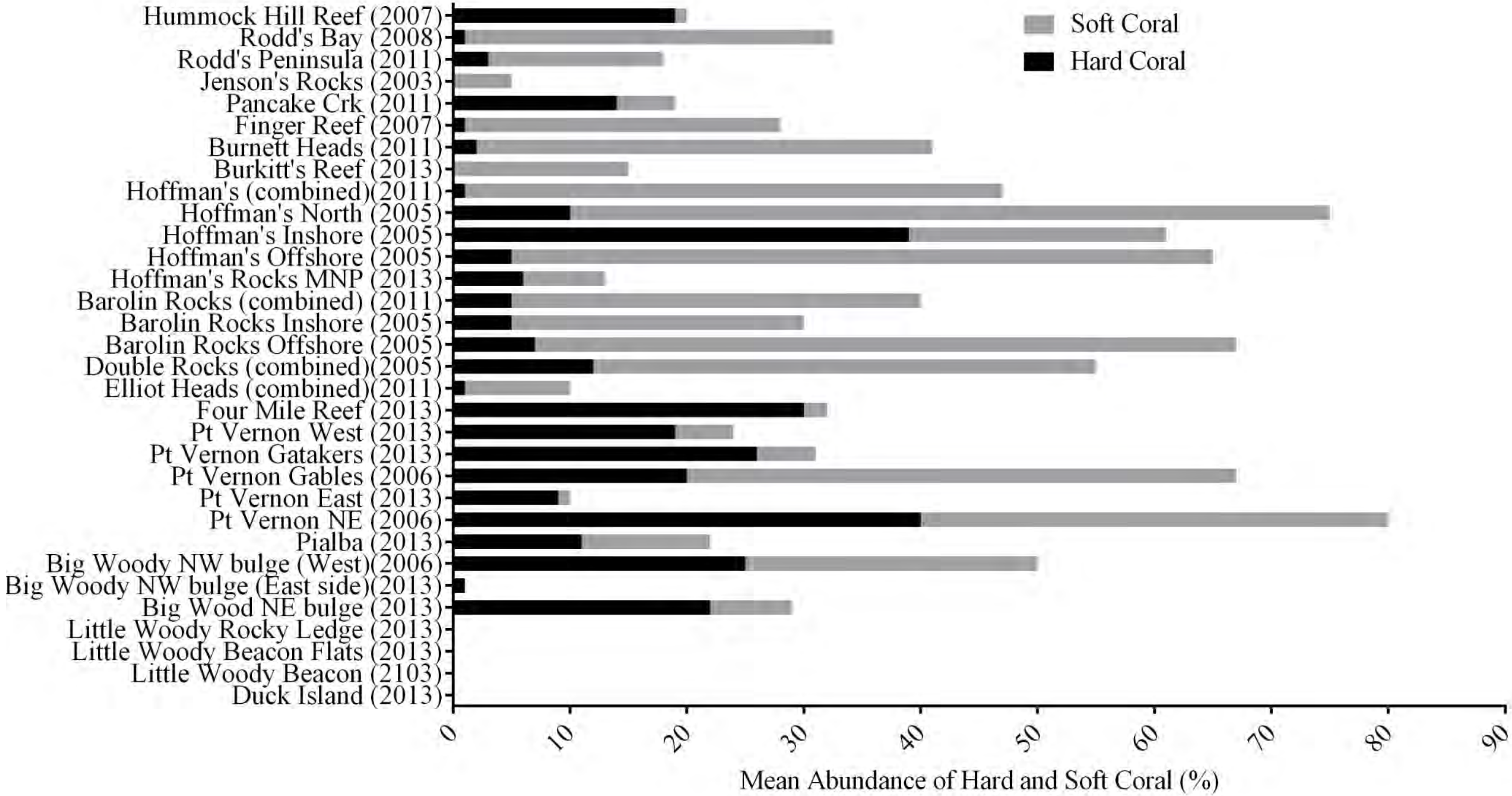
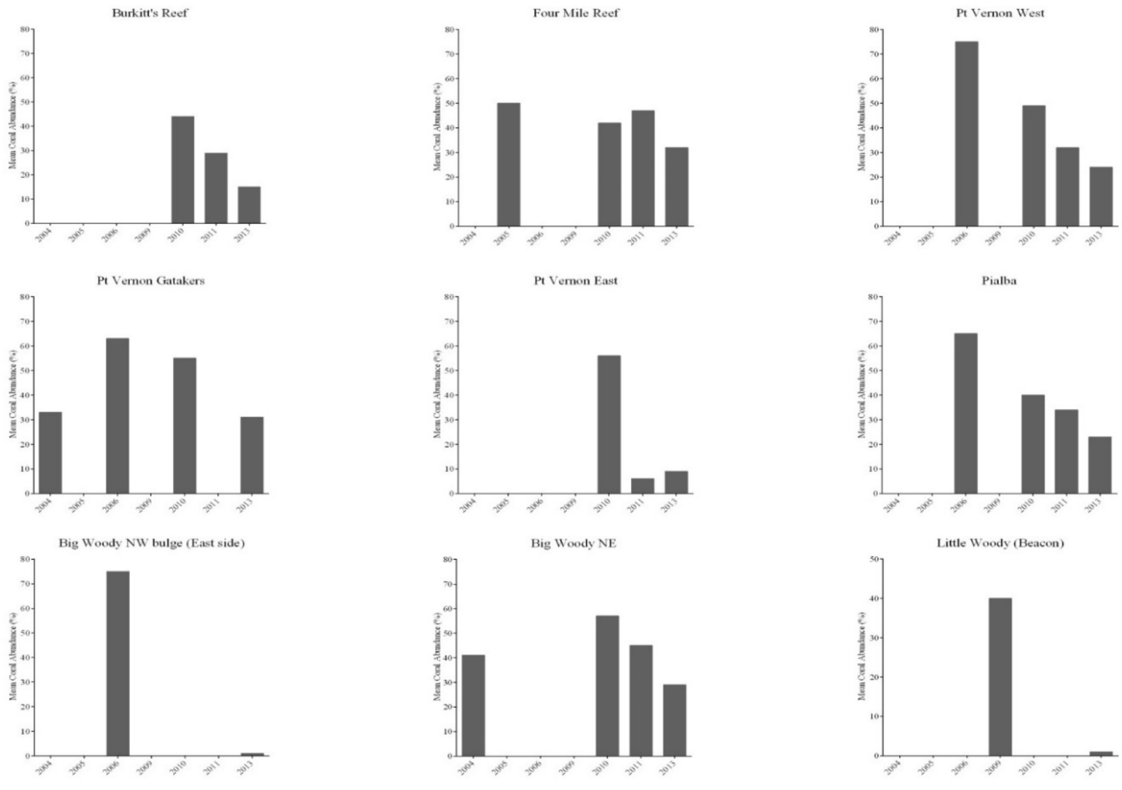


Table 4: Location of inshore reefs in the Burnett Mary region and available data.

Coral Reef Area	Location	Available Coral Datasources	Coral Abundance (Year + Value)	Number coral taxa	Zoning (BR GSS)
Seal Rocks	23° 57.406'S, 151° 29.193'E	NA	NA	NA	HPZ
Hummock Hill Reef	23° 59.400'S, 151° 28.800'E	1	2007, ~20% (H 19, SC<1)	14	Gen
Rodd's Bay	24° 0.602'S, 151° 30.905'E	2,3	2008, ~32% (H <1, SC 31.5)	NA	Gen, HPZ
Rodd's Peninsula	23° 58.776'S, 151° 39.838'E	4	2011, ~18 (H 3, SC 15)	22	CPZ, MNP
Jenson’s Rocks	24° 0.211'S, 151° 43.314'E	4	2003, GIS estimate 0% H, 5% SC	NA	HPZ
Pancake Crk	24° 1.278'S, 151° 44.373'E	4	2011, ~19% (H 14%, SC 5%)	14	HPZ
Finger Reef (Stringer's)	24° 29.138'S, 152° 2.711'E	1	2007, 27% (H <1, SC 27%)	8	Gen
Burnett Heads	24° 45.811'S, 152° 25.042'E	4	2011, 41% (H 2, SC 39)	10	HPZ
Burkitts Reef	24° 48.595'S, 152° 28.294'E	4,5,6	(5) 2010 44% (H5, SC 39), 2011 29% (H10, SC19), (4) 2011 32% (6) 2013 15% (H<1, SC 15)	(5) 15, (4)12	MNP
Hoffman’s Rocks (Kelly's Beac + Rocks MNP)	Kellys 24° 49.857'S, 152° 28.247'E Rocks 24° 50.473'S, 152° 28.805'E	4	2011 47% (H 1, SC 46)	9	CPZ, MNP
Hoffman's North	24° 50.045'S, 152° 28.412'E	7	2005 75% (H 10, SC 65)	13	MNP
Hoffman's Inshore	24° 50.283'S, 152° 28.638'E	7	2005 61% (H 39, SC 22)	8	MNP
Hoffman’s Offshore	24° 50.311'S, 152° 28.712'E	7	2005 65% (H 5, SC 60)	12	MNP
Hoffman's Rocks (MNP)	24° 50.473'S, 152° 28.805'E	6	2013 ~13% (H 6, SC 7)	NA	MNP
Barolin Rocks (North, MNP, South combined)	North 24° 51.796'S, 152° 29.037'E MNP 24° 53.013'S, 152° 29.410'E South 24° 53.861'S, 152° 29.452'E	4	2011 ~40% (H 5, SC 35)	12	CPZ, MNP
Barolin Rocks Inshore	24° 52.897'S, 152° 29.338'E	7	2005 ~30% (H 5, SC 25)	11	MNP
Barolin Rocks Offshore	24° 52.885'S, 152° 29.362'E	7	2005 ~67% (H 7, SC 60)	13	MNP
Double Rock (Three sites)	24° 53.907'S, 152° 29.495'E	7	2005 ~55% (H 12, SC 43)	16	MNP
Elliot Heads (North, Heads, Dr Mays)	North 24° 54.478'S, 152° 29.566'E Heads 24° 55.127'S, 152° 29.658'E Dr Mays 24° 55.884'S, 152° 29.786'E	4	2011, ~10% (H <1, SC 9)	8	CPZ
Four Mile Reef	24° 59.474'S, 152° 33.218'E	5,6,7	(7) 2005 50% (H 40, SC 10), (5) 2010 42% 2011 47%, (6) 2013 32% (H30, SC 2)	(5)7 (7) 10	Gen
Pt. Vernon West	25° 14.813'S, 152° 47.931'E	5, 6, 12	(12) 2006 75% (H42, SC 33) (5) 2010 49%, 2011 32%, (6)2013 24% (H19, SC5)	(5) 20	CPZ
Pt.Vernon (Gatakers)	25° 14.670'S, 152° 48.402'E	6, 8, 9, 12	(8)2004 ~33% (H 10, SC 23), (12) 2006 63% (H35, SC28), (9) 2010 55% (H40, SC15), (6) 2013 31% (H 26, SC 5)	NA	CPZ
Pt. Vernon (Gables)	25° 14.715'S, 152° 49.509'E	8, 12	(8) 2004 ~30% (H17, SC 13) (12) 2006 67%	NA	CPZ
Pt. Vernon (NE)	25° 14.847'S, 152° 49.832'E	12	2006 80% (H40, SC40)	NA	CPZ
Pt. Vernon East	25° 15.607'S, 152° 49.734'E	5, 6	(5) 2010 56%, 2011 6% (6) 2013 9% (H9, SC	(5) 16	CPZ
Pialba	25° 16.373'S, 152° 50.742'E	5, 6, 12	(12) 2006 65% (H40, SC 25), (5) 2010 40%, 2011 34%, (6) 2013 23%	(5) 16	CPZ
Scarness	25° 16.825'S, 152° 51.388'E	8, 12	(8) 2004 ~ 58% (H 40, SC 18), (12) 2006 67% (H41, SC26)	NA	CPZ
Torquay	25° 16.835'S, 152° 51.847'E	8, 12	(8) 2004 ~60% (H 48, SC 12), (12) 2006 62% (H50, SC12)	NA	CPZ
Round Island	25° 17.113'S, 152° 55.454'E	6	2013 9% (H 8, SC 1)	NA	CPZ
Big Woody NW bulge (East side)	25° 16.059'S, 152° 55.824'E	6, 12	(12) 2006 75% (H55, SC 20), (6)2013 1% (H 1, SC 0)	NA	MNP
Big Woody NW bulge (West side)	25° 16.344'S, 152° 55.635'E	12	2006 50% (H25, SC25)	NA	MNP
Big Woody NE bulge	25° 15.841'S, 152° 56.180'E	5, 6, 8	(8) 2004 41% (H 18, SC 23) (5) 2010 57% 2011 45% (6) 2013 29% (H 22, SC 7)	(5) 18 (9) 31	CPZ
Little Woody (Rocky ledge)	25° 19.174'S, 153° 1.164'E	6, 10	(10) 2006 presence low , (6) currrently 0%	NA	MNP
Little Woody (Beacon flats)	25° 20.075'S, 153° 1.755'E	6, 10	(10) 2006 presence low , (6) currrently 0%	NA	CPZ
Little Woody (Sth beacon)	25° 20.128'S, 153° 1.688'E	9	(9) 2009 40%(H10, SC 30), last visual 2013 0%	NA	MNP
Duck Island	25° 21.302'S, 153° 0.374'E	6, 10	Historical presence low 2006 (10), (Thorium dates 2002-09), (6)currrently 0%	NA	CPZ
	Reference				
1	Alquezar, R. and W. Boyd (2007)				
2	DHI (2013)				
3	Bunce, A. et al. (2008)				
4	Alquezar, R. et al. (2011)				
5	Butler, I. R. et al. (2013)				
6	Butler, I.R. et al 2014 Unpublished data.				
7	Bushell, H. L. (2008)				
8	Bennett, C. (2004)				
9	DeVantier, L. (2010)				
10	Zann, M. (2012)				
11	Alquezar, R. et al. (2007)				
12	FRC (2007)				

Figure 9: Mean coral abundance trends at inshore reefs of the Burnett-Mary region.



coral communities in the BMR are quite unique. Unlike other adjacent subtropical coral communities, *Goniopora* and *Turbinaria* are abundant in the BMR, with nine of eleven known indo-pacific species of *Turbinaria* present (DeVantier, 2010). Also, unlike many other areas, the *Goniopora* and *Acropora* coral colonies in the BMR can often be found in unusually large mono-specific stands of hundreds of square meters (DeVantier, 2010). *Turbinaria* colonies commonly take on a large morphology and form extensive semi-consolidated reef structures through lateral growth (Zann, 2012). The large colonies of Faviids, Turbinaria, Goniopora and Acropora that are found scattered throughout the region are likely to be at least a century old (DeVantier, 2010). The coral reef areas of BMR are unique in many aspects and similar examples of these reefs are not found anywhere else along the Australian coast.

Naturalness - Many of the coral reef areas of the BMR, especially those near Hervey Bay were little known to the public before recent decades. This, combined with turbid water and difficult direct access by foot, has probably reduced direct physical damage to the coral reefs by reef walkers, snorkelers and divers and preserved the more natural aspects of the reef areas. Still, fishing pressure is intense and anchor damage is apparent at most reef areas (Butler *et al.*, 2014).

Palaeoecological studies are currently taking place to establish the historical ecology of the reefs in the Woongarra to Great Sandy Strait areas of BMR with a view to providing an historical baseline. Preliminary results indicate that substantial community changes from *Acropora* to *Pocillopora*/*Turbinaria/Goniopora/*Faviid communities have taken place at various reef locations, but further work is required to establish whether these are a result of anthropogenic activity (Butler *et al.*, 2014). Current coral communities in Hervey Bay appear to be increasingly similar to those in Moreton Bay, where modifications to the Brisbane River catchment and the resulting runoff has been identified as the major cause of change from *Acropora* to Faviid coral communities (Lybolt *et al.*, 2011).

Table 5: Hard and soft coral and gorgonian taxa recorded at inshore reefs of the Burnett Mary region.

Reef-building hard coral taxa	Ref	Reef-building hard coral taxa	Ref
*Acanthastrea hillae (*Wells, 1955)	9	*Goniastrea favulus* (Dana, 1846)	9
*Acanthastrea lordhowensis (*Veron & Pichon, 1982)	9	*Goniopora cf. cellulosa* (Veron, 1990)	9
Acropora aspera (Dana, 1846)	9	*Goniopora columna* (Dana, 1846)	9
Acropora austera (Dana, 1846)	12	*Goniopora djiboutiensis* (Vaughan, 1907)	9
Acropora bushyensis (Veron and Wallace, 1984)	9	*Goniopora lobata* (Milne Edwards and Haime, 1860)	9
Acropora cerealis (Dana, 1846)	11	*Goniopora minor* (Crossland, 1952)	9
Acropora digitifera (Dana, 1846)	9	*Goniopora stokesi (*Milne Edwards and Haime, 1851)	9
Acropora formosa (Dana, 1846)	4	*Goniopora stutchburyi* (Wells, 1955)	9
Acropora glauca (Brook, 1893)	5	*Goniopora tenuidens* (Quelch, 1886)	12
Acropora hyacinthus (Dana, 1846)	1	*Hydnophora sp*	11
Acropora latistella (Brook, 1891)	11	*Leptoria phrygia* (Ellis and Solander, 1786)	1
Acropora millepora (Erhenberg, 1834)	11	*Lobophyllia corymbosa* (Forskål, 1775)	12
Acropora nobilis (intermedia) (Dana 1846)	11	*Montastrea curta* (Dana, 1846)	9
Acropora nasuta (Dana, 1846)	11	*Montipora capricornis (*Veron 1985)	1
Acropora pulchra (Brook, 1891)	9	*Montipora cf. mollis (*Bernard, 1897)	9
Acropora samoensis (Brook, 1891)	11	*Montipora spongodes* (Bernard, 1897)	5
Acropora sarmentosa (Brook, 1892)	9	*Montipora turtlensis* (Veron and Wallace, 1984)	5
Acropora tenuis (Dana, 1846)	11	*Montipora verrucosa* (Lamarck, 1816)	9
Acropora valida (Dana, 1846)	11	*Pavona cactus* (Forskal, 1775)	4
Acropora yongei (Veron and Wallace, 1984)	11	*Platygyra acuta* (Veron, 2002)	9
Coeloseris mayeri (Vaughan, 1918)	1	*Platygyra daedalea* (Ellis and Solander, 1786)	12
*Cycloseris cyclolites (*Lamarck, 1801)	9	*Plesiastrea versipora* (Lamarck, 1816)	9
Cyphastrea chalcidium (Forskål, 1775)	9	*Pocillopora damicornis* (Linnaeus, 1758)	9
Cyphastrea microphthalma (Lamarck, 1816)	9	*Pocillopora verrucosa* (Ellis and Solander, 1786)	4
Cyphastrea serailia (Forskål, 1775)	9	*Porites sp.* Massive growth-form	1
Favia danae (Verrill, 1872)	9	*Porites lutea (*Milne Edwards & Haime, 1851)	12
Favia favus (Forskål, 1775)	9	*Psammocora albopicta (*Benzoni 2006)	9
Favia maritima (Nemenzo, 1971)	9	*Psammocora nierstraszi (*Horst, 1921)	9
Favia speciosa Dana, 1846	9	*Psammocora superficialis (*Gardiner, 1898)	9
Favia stelligera (Dana, 1846)	12	*Seriatopora sp*	4
*Favia veroni (*Moll and Borel-Best, 1984)	5	*Turbinaria bifrons* (Brüggemann, 1877)	9
Favites chinensis (Verrill, 1866)	9	*Turbinaria conspicua* (Bernard, 1896)	9
Favites complanata (Ehrenberg, 1834)	9	*Turbinaria frondens* (Dana, 1846)	9
Favites flexuosa (Dana, 1846)	9	*Turbinaria mesenterina* (Lamarck, 1816)	9
Favites halicora (Ehrenberg, 1834)	12	*Turbinaria patula* (Dana, 1846)	9
*Favites cf. paraflexuosa (*Veron, 2002)	9	*Turbinaria peltata* (Esper, 1794)	9
Favites pentagona (Esper, 1794)	1	*Turbinaria radicalis* (Bernard, 1896)	9
*Goniastrea aspera (*Verrill, 1905)	9	*Turbinaria reniformis (*Bernard, 1896)	9
Goniastrea australensis (Milne Edwards and Haime, 1857)	9	*Turbinaria stellulata* (Lamarck, 1816)	9
Total reef building hard corals	**78**		
Non reef building hard coral taxa	**Ref**	**Non reef building hard coral taxa**	**Ref**
Tubastrea sp (or Dendrophyllia sp)	9	*Heterocyanthus aequicostatus* (Milne, Edwards and	12
Millepora sp	11	*Heterosammia cochlea* (Spengler, 1781)	12
Tubipora sp	11	*Flabellidae*	12
Total non-reef building hard corals	**6**		
Soft coral and gorgonian taxa	**Ref**	**Soft coral and gorgonian taxa**	**Ref**
Lobophytum sp	1	*Briaerium sp*	11
Sinularia sp	1	*Anthogorgia sp*	11
Sarcophyton sp	1	*Dendronephthya sp*	11
Cladiella sp	5	*Hicksonella sp*	11
Capnella sp	11	*Isis sp*	11
Xenia sp	5	*Menella sp*	11
Klyxum sp	11	*Anthoplexaura sp*	12
Alcyonium	12	*Echinogorgia sp*	12
Caspitularia sp	12	*Melithea sp*	12
Total soft corals and gorgonians	**18**		

Source: 1. (Alquezar *et al.*, 2007) 2. (DHI, 2013) 3. (Bunce *et al.*, 2008) 4. (Alquezar *et al.*, 2011) 5. (Butler *et al.*, 2013) 6. (Butler *et al.*, 2014) 7. (Bushell, 2008) 8. (Bennett, 2004) 9. (DeVantier, 2010) 10. (Zann, 2012) 11. (Alquezar *et al.*, 2007) 12. (FRC, 2007).

Threats

The most significant threat to inshore coral reefs in the Burnett Mary region is considered to be sediment derived from the adjacent catchments, particularly the Mary River (Threat Table 2). Other threats include coastal development, increased nutrients and pesticides, shipping/boating and climate change.

One of the primary threats to the persistence of inshore coral reefs such as those in the BMR is poor catchment management with resulting increased freshwater, sediment and nutrient runoff. Although runoff and flooding are a natural occurrence and coral reefs can recover from these disturbances, the capacity for a coral reef to recover can be detrimentally affected where the runoff and flooding are exacerbated by anthropogenic modifications to the catchment (Hughes *et al.*, 2010; Pandolfi *et al.*, 2003). Flooding from the highly modified Mary and Burnett rivers in 2011 and 2013 resulted in a cumulative 60% loss of coral abundance from reefs in Hervey Bay (Butler *et al.*, 2013; Butler *et al.*, 2014). The water quality of Hervey Bay in both years was altered for months with high turbidity, low salinity and high nutrients (Butler *et al.*, 2013; Butler *et al.*, 2014). It is predicted that severe storms and flooding will be become more frequent in the future (Queensland Government, 2009) and recovery of coral communities from recent and future events is not certain.

The coral reefs of the region are known to show bleaching when under stress from heat and poor water quality (Butler *et al.*, 2014; FRC, 2007). Heat related bleaching has only been reported in the summer of 2005-2006 (FRC, 2007). Anecdotal evidence suggests that scattered bleaching in the Point Vernon areas has been fairly continuous since the 2011 floods up until early 2014, though this has not been quantified (Butler *et al.*, 2014).

Other threats to inshore coral reefs include; anchor damage as boating and fishing pressure is great in the region and anchor damage is evident at most reef areas from Woongarra to Great Sandy Strait (Butler *et al.*, 2014); intense fishing pressure on local reefs; coral collection is allowed by permit within GSMP conservation zones and the collection of aquarium fish, the Scribbled Angelfish, is allowed by permit within GSMP conservation zones.

Climate change is considered a significant threat to inshore coral reefs in the Burnett Mary region because increased frequency and severity of storms will result in secondary impacts of increased terrestrial runoff and sediment resuspension (Hoegh-Guldberg *et al.*, 2007). Also inshore coral reefs of the Hervey Bay region, located at low latitudes, are more sensitive to seasonal variability in light intensity and quality as well as experience large tidal fluxes which collectively can have substantial effects on photosynthesis and the ability of coral reefs to survive in this area (Hoegh-Guldberg *et al.*, 2007).

Threat Table 2: Inshore Coral Reefs in the Burnett Mary region.

Threat	Level of Impact*	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
Sediment	VH	40
Nutrients	M	10
Pesticides	L	5
Coastal Development	H	20
Shipping/Boating	L	5
Climate Change	H	20
Other:		
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

Recommended Monitoring required to support WQIP

Coral reef abundance monitoring - Monitoring of hard and soft coral abundance should take place on a regular basis throughout the BMR to monitor recovery from recent flooding and to measure impacts of future large floods. Underwater photo/video transects should be used comparable to the methods used by Butler et al. (2013) though preferably with the use of fixed transects. The impacts of flooding can be patchy and the use of the latest high resolution satellite/aerial imagery for monitoring coral reef abundance, similar but higher resolution to that used by Zann (2012), would also be beneficial for assessing coral abundance and impacts over wider areas. They would also potentially enable the direct comparison of flood plume and/or water quality imagery with same location coral health and abundance measurements.

Long term turbidity monitoring - Turbidity, the transport of sediments and resuspension have been identified as a likely major cause of negative impacts to coral communities in the region (Bennett, 2004; Butler *et al.*, 2013; DeVantier, 2010; FRC, 2007; Gräwe *et al.*, 2010; McKenzie *et al.*, 2003; Zann, 2012). Though the dynamics of sediment movement and turbidity are speculated on, and certainly during floods the turbidity remains elevated for extended periods, there are few data with which to understand the day to day behaviour of turbidity and to potentially link high turbidity with long term impacts to the marine habitat. Turbidity should be monitored at a number of inshore and offshore locations (e.g. coral reef, seagrass areas) on a constant basis and into the foreseeable future to better understand background levels of turbidity and changes of turbidity through tidal and seasonal cycles. This should also be part of a wide ranging water quality testing program to monitor changes of water quality into the future as the WQIP takes effect.

Water quality monitoring - High nutrient levels have also been identified as a likely major cause of negative impacts to coral communities in the region (Bennett, 2004; Butler *et al.*, 2013; DeVantier, 2010; FRC, 2007; Gräwe *et al.*, 2010; McKenzie *et al.*, 2003; Zann, 2012). Although the Department of Science, Information Technology, Innovation and the Arts (DSITIA) undertakes monthly water quality testing in GSMP, for example, the testing takes place in deeper, more offshore areas and is not capable of assessing short term changes in water quality through daily tidal cycles nor is it capable of detecting acute events such as flood plumes or storms. Water quality is generally very different at inshore locations and it can vary widely over the course of a day (e.g. wind resuspension, tidal effects, submarine ground water). High frequency water quality monitoring should take place at a variety of depths at offshore and inshore locations, including coral reef areas, to better understand background changes of water quality parameters through tidal and seasonal cycles. Once the variability in background levels are better understood, it will then be possible to assess the true changes in water quality associated with not only acute events, but over the long term as changes occur to catchments.

Flood plume water quality and post flood coral abundance monitoring - Flood plumes are a known cause of acute, significant coral mortality in the region (Butler *et al.*, 2013). Flood plumes are also believed to be the primary avenue of transport of sediment and nutrients to coral reef areas in the BMR. In conjunction with water quality monitoring, extra effort should be made during flooding events to measure the water quality in coral reef areas, the duration of the altered conditions that result from the flooding, the duration of coral stress (e.g. bleaching) and the post-flood change in coral abundance. There is also evidence of a major output of submarine groundwater several months after a flooding event (Butler, pers com) and this should be factored into the long term monitoring as the water may travel from very long distances in the catchment.

Offshore Coral Reefs

Status and Trends of Offshore Coral Reefs in the Burnett Mary region:

- were originally formed in the early Pleistocene, approximately two million years ago. Current reef morphology has evolved during the Holocene period, <10,000 years to the present.
- have 244 hard coral species recorded, an unknown number of soft coral genera and 920 species of fish;
- are within the GBRMP and zoned either Scientific Research Zone, Marine National Park Zone or Habitat Protection Zone;
- have experienced significant temporal changes in hard coral cover (between 0-100%) during recent surveys with significant associated changes in fish communities;
- The most significant threat to their viability is considered to be climate change.

The marine boundary of the Burnett Mary Regional Group extends up to approximately 260km offshore of the coastline (Figure 1). It includes the southern extent of the Great Barrier Reef Marine Park (GBRMP) as well as marine areas to the south of this; including shoals and inshore reefs in the Great Sandy Marine Park.

The Burnett Mary regional boundary crosses the Capricorn Group of islands and only partially includes Heron Island (reef only) and a small section of Wistari Reef and wholly includes Sykes Reef, One Tree Island and Lamont, Fitroy and Llewellyn Reefs. South of the Capricorn Group is the Bunker Group of islands comprising Boult Reef, Hoskyn Islands, Fairfax Islands and Lady Musgrave Island. The Capricorn and Bunker Groups are collectively referred to as the Capricorn Bunker Group. Within the GBRMP the southernmost island is Lady Elliot Island, an isolated outer shelf lagoonal reef with a well-developed sand cay and to the south of this, at the northern most tip of Fraser Island the deep reef areas called Heralds Patches (No. 1, 2 and 3) are located.

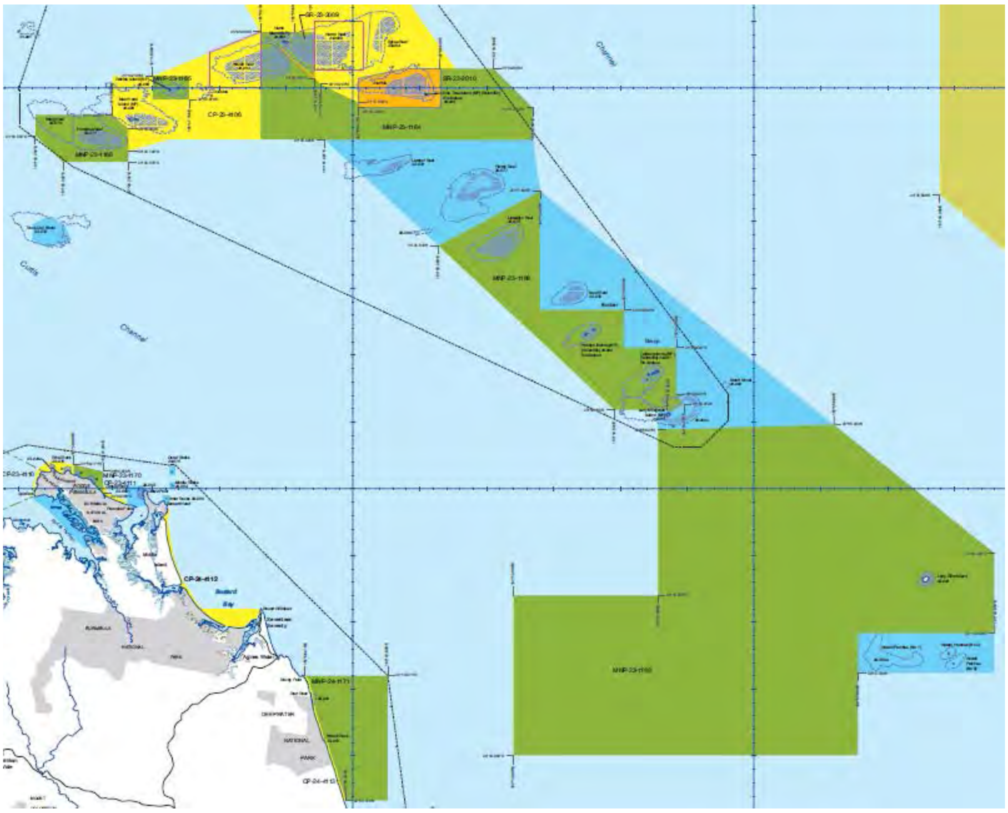
Historically phosphate mining occurred on Fairfax Islands and this area was also used for military bombing practice (Jell and Flood, 1978). Today some of the islands have 'low key' tourism and research facilities and the marine areas are zoned either Scientific Research Zone, Marine National Park Zone or Habitat Protection Zone (Figure 10).

Geology

The reefs of the Capricorn Bunker region were first formed h in the early Pleistocene, approximately two million years ago, and over time have been exposed to subaerial weathering and subsequent sea level rise (Jell and Flood, 1978). Their geological history has resulted in pre-existing reefal bodies being recolonised and, in some locations, a karst topography is found underlying the reef formations of today (Jell and Flood, 1978).

The reefs in the Capricorn Bunker group are located approximately 10km west of, and parallel to, the edge of the continental shelf in a zone of pure carbonate sediment (Jell and Flood, 1978).The reefs of this region develop in a north-westerly direction which may reflect the rate of reef productivity (Jell and Flood, 1978). All of these reefs have similar hydrological, bathymetric, geological and tectonic settings and have common morphological features however are all very different in their size, shape and reef, lagoon and cay formation. The sediment in the area also varies, reflecting the changing nature of the top of the reef top, and varies according to the percentage contribution of four dominant skeletal types of organisms in the area; coral, corraline algae, *Halimeda* and foraminiferans (Jell and Flood, 1978).

Figure 10. Offshore coral reefs in the Burnett Mary region.



Source: (GBRMPA, 2011c).

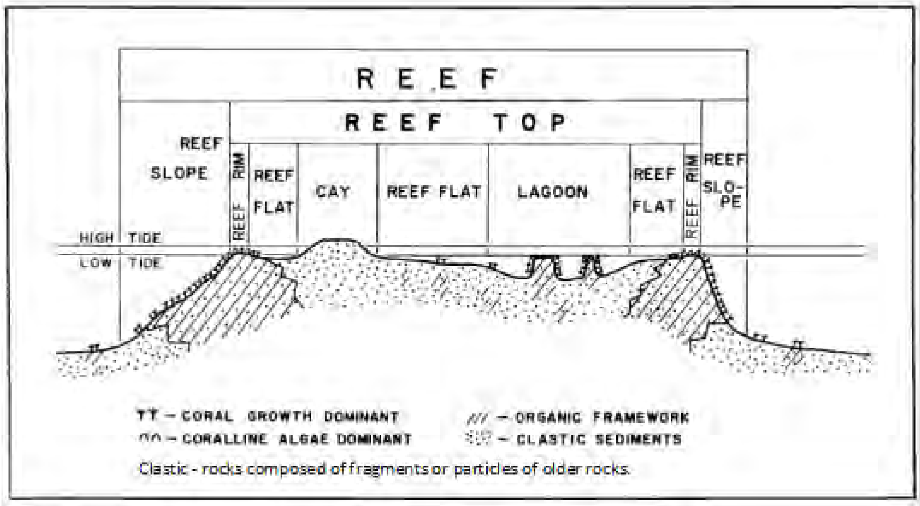
<u>*Reef structures*</u>

The reefs of the Capricorn Bunker group have a similar cross-sectional structure which is represented in Figure 11. The reef rim is characterised by crustose corraline algae, a robust, hard form of algae that grows close to the reef substratum and found in high energy areas of the reef (Jell and Flood, 1978). The reef top is a lower wave energy area that includes the reef flat and it is here that cays and/or islands form. The reef flat consists mainly of *Acropora spp*. which cover less of the reef top as you move from the reef rim as well as branching and massive corals in the lagoon which may form patch reefs (Jell and Flood, 1978).

The windward reef slope is steeply inclined (10º - 40º), from the reef rim to the relatively flat continental shelf and spur-and-groove structures are found above a flat terrace at 4-6 metres (with respect to low water level) (Jell and Flood, 1978). The upper surface of the spurs are exposed at low tide and were recorded to support 'luxuriant low-profile growths of *Acropora spp*.' whereas the 'growing edges and the terrace support the branching (staghorn) varieties' below 10m coral cover decreases and 'the reef is a coral veneered cemented limestone mass' (Jell and Flood, 1978, pg.8). The leeward reef slope has a gently inclined slope with a sandy substratum and coral species can be found here up to a depth of about 10metres for example massive corals such as *Porites spp.* are common (Jell and Flood, 1978).

Many of the inter-reefal shoals in the Capricorn Bunker region 'appear to be pre-existing reef masses on which coral growth was not able to keep pace with the rising sea level during the Holocene transgression' (Jell and Flood, 1978, p.15). At the southern extreme of the Great Barrier Reef the Capricorn Bunkers are a high energy 'front' of living coral that has kept pace with changes in sea level for approximately two million years (Jell and Flood, 1978).

Figure 11: Generalised cross-section view of a lagoonal platform reef.



Source: Maiklem 1968 in Jell and Flood, 1978.

Weather

In the Capricorn Bunker region the Southern Trade Wind blows at an average speed of 20-40km/hr for approximately 70% of the year whereas in the summer it is either calm or experiencing north-northwesterly winds or the occasional cyclone (Jell and Flood, 1978). The tidal range is 0.8 – 2.3 metres with ocean swells from 1-3m, predominantly from the east-southeast, and these waves ‘refract around the reef resulting in transport of sedimentary particles to leeward and, where the waves converge, may accumulate to produce sand cays and eventually vegetated islands’ (Jell and Flood, 1978, p.8).

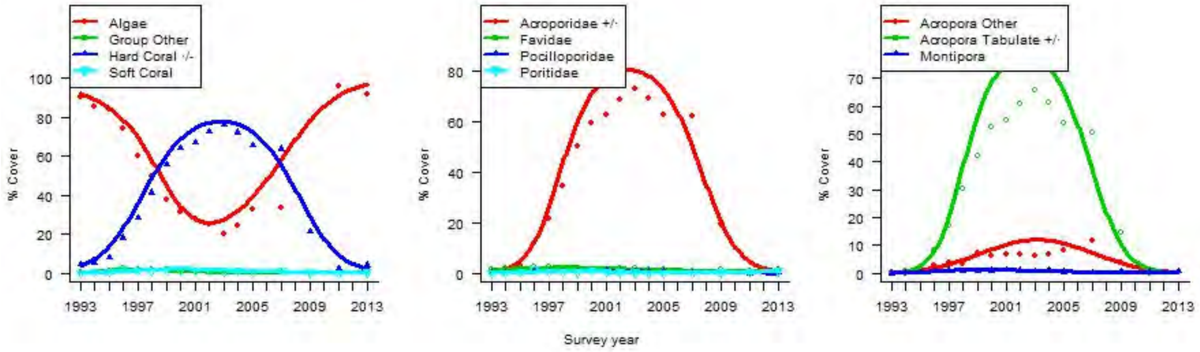
Reef communities

There are 244 hard coral species recorded in the Capricorn-Bunker group, fewer than in the northern and central GBR, and an unknown number of soft coral genera but again fewer than the approximately 60 genera of soft corals present on the GBR (Chin, 2004). Of the 920 species of fish recorded in the Capricornia section of the GBRMP 8.5% are trawl-fishes, 90% are coral reef fish and 1.5% are oceanic-pelagic species (Lowe and Russell, 1990).

The AIMS Long Term Monitoring Program has regularly surveyed the benthic organisms and fish at reefs in the Capricorn Bunker group including One Tree Island, Boult Reef, Hoskyn Islands Reef, Fairfax Islands Reef and Lady Musgrave Island Reef (AIMS, 2014). A summary of the survey findings for each of these reefs is provided below.

One Tree Island Reef is an outer shelf lagoonal reef with an area of 18.09 km^2. This reef has been surveyed by manta tow for 22 years, (since 1986), and fish and benthic organisms since 1993 (AIMS, 2014). The cumulative results of the benthic surveys during this period are presented in Figure 12. When surveying commenced in 1993 the reefs had been denuded of hard coral by a severe storm event. The reef then recovered, being colonised predominantly by tabulate *Acropora spp*., to coral cover as high as 75% in 2002. In 2009 coral cover had declined to a moderate level (21-30%) again, considered to be due to storm events in 2008 as storm damage (overturned corals and rubble banks) was observed (AIMS, 2014). Further decline was evident in 2011 when live coral cover had declined further to a low level (6-10%) which was attributed to Cyclone Hamish which passed approximately 100km to the east of One Tree Island Reef in March 2009 (AIMS, 2014). Surveys in 2013 show the early signs of recovery in coral cover that has increased to a moderate (10-20%) level.

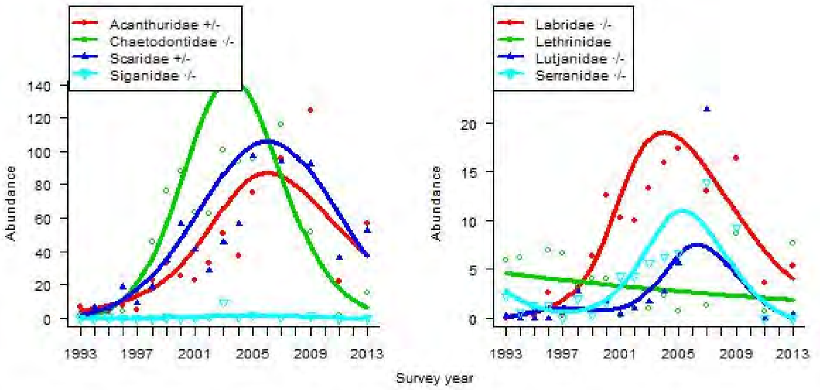
Figure 12. Trends in cover of benthic organisms at One Tree Island, 1993 – 2013.



Source: (AIMS, 2014).

Changes in the benthic organism composition; coral, algae and other organisms alter the habitat complexity and food sources available to other organisms such as fish. The fish community has significantly changed in abundance and diversity throughout the survey period in response to the benthic changes (Figure 13). Butterflyfish (Chaetodontidae) are corallivorous fish and their abundance reflects the abundance of hard coral (Figure 12). Even though surgeonfish (Acanthuridae), parrotfishes (Scaridae) and rabbitfish (Siganidae) are herbivorous increases in their abundance is perhaps in response to a more complex substratum being provided by the live coral as well as different species of algae being available as compared to when the reef was predominantly covered in algae (1993-97 and 2007-13). The abundance of carnivorous fishes such as wrasses (Labridae), emperors (Lethrinidae), snapper (Lutjanidae) and sea bass and groupers (Serranidae) also reflects the dependence of these on a healthy coral reef (AIMS, 2014).

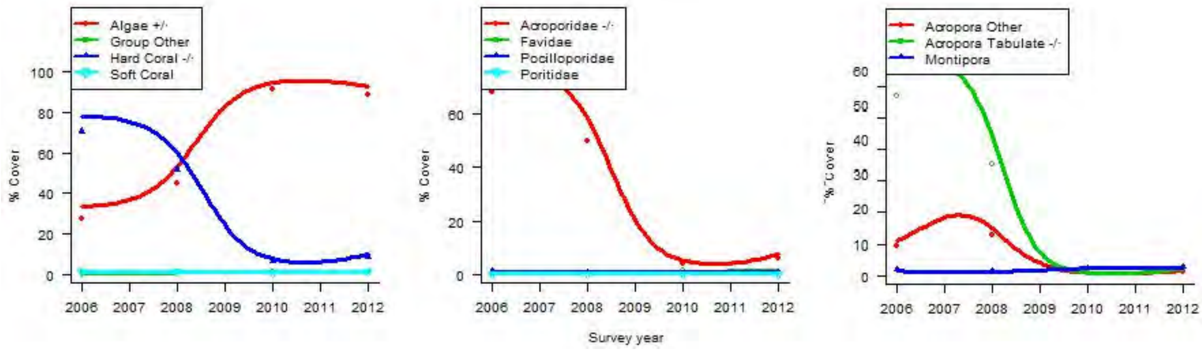
Figure 13. Trends in fish abundance at One Tree Island, 1993 – 2013.



Source: (AIMS, 2014).

Boult Reef is an outer shelf lagoonal reef with an area of 6.3 km^2 at which long term monitoring sites were established in 2006. The changes in benthic cover are illustrated in Figure 14. Hard coral cover was at a very high level in 2006 (71%) with most of the hard coral cover attributed to tabulate *Acropora spp* (Figure 14). By 2008 hard coral cover had declined to a moderate level (21-30%) and then to a low level (0-10%) by 2010 which was most likely due to a combination of disease and storm damage (AIMS, 2014) particularly by Cyclone Hamish in March 2009. In 2012 there was a slight increase in hard coral cover to a moderate level (10-20%), most likely due to coral recruits (Figure 15) indicating recovery of the coral reef system (AIMS, 2014). Percentage cover of turf and coralline algae increased in response to decreases in hard coral cover and was approximately 90% during the 2010 and 2012 surveys (Figure 14).

Figure 14. Trends in cover of benthic organisms at Boult Reef, 2006 – 2012.



Source: AIMS, 2014.

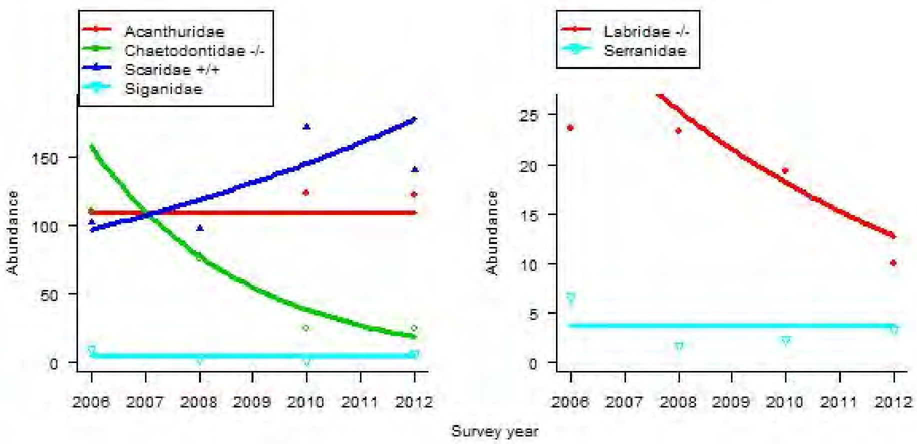
Figure 15. a. High level coral cover at Boult Reef. b. Young coral recruits, mainly tabulate *Acropora spp*.

Source: AIMS, 2014.

As illustrated for One Tree Island Reef the dramatic changes in benthic cover had a significant impact on the fish communities of Boult Reef (Figure 16) however changes at this reef were different.

Corallivorous butterflyfish (Chaetodontidae) and carnivorous wrass (Labridae), populations declined significantly whereas herbiverous surgeonfish (Acanthuridae) and rabbitfish (Siganidae) and carnivorous sea bass and groupers (Serranidae) showed no change in abundance over the survey period. Conversely herbivorous parrotfishes (Scaridae) increased in abundance over the survey period.

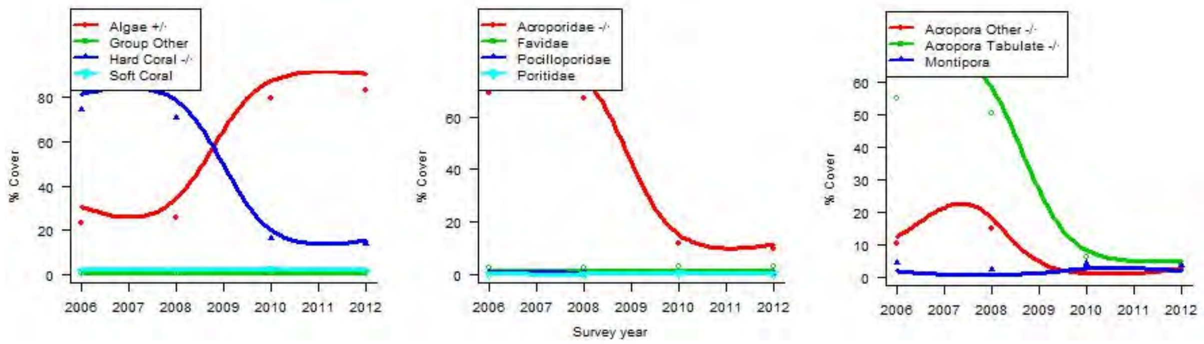
Figure 16. Trends in fish abundance at Boult Reef, 2006 – 2012.



Source: AIMS, 2014.

Hoskyn Islands Reef is an outer shelf planar reef with an area of 3.8 km^2 which was initially surveyed by manta tow in 1986 when hard coral cover was recorded as extremely high (76-100%) (AIMS, 2014). Subsequent manta tow surveys recorded moderate levels (11-30%) of coral cover in 1990 and high levels (31-50%) in 1992 (AIMS, 2014). Intensive survey sites, established in 2006, recorded hard coral cover of 74%, predominantly tabulate *Acropora spp.* (Figure 17); by 2012, following severe storms in the area hard coral cover had decreased to 14% (AIMS, 2014).

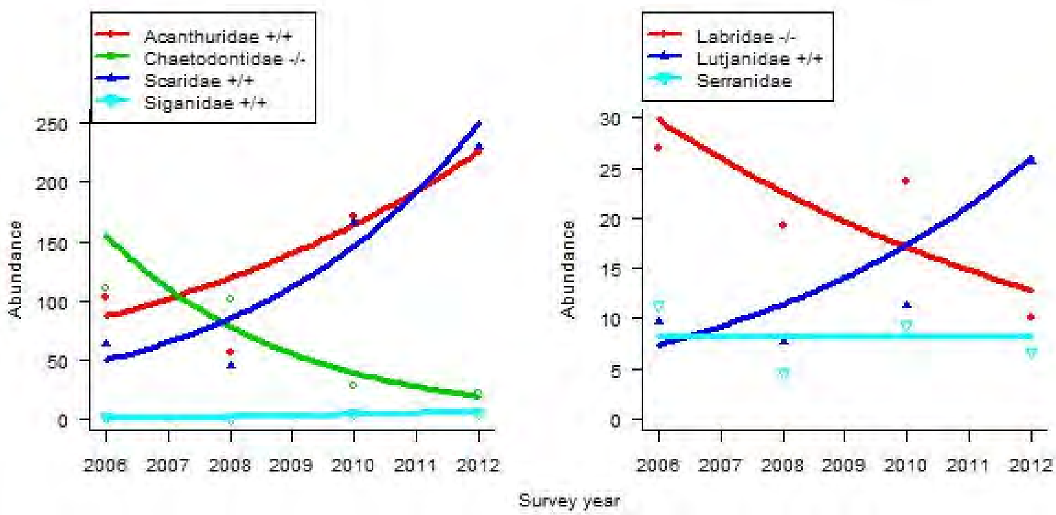
Figure 17. Trends in cover of benthic organisms at Hoskyn Islands Reef, 2006 – 2012.



Source: AIMS, 2014.

Again the fish communities reflected the changes in benthic organisms over the sampling period (Figure 18). The abundance of herbivorous parrotfishes (Scaridae) and surgeonfish (Acanthuridae) and carniverous snapper (Lutjanidae) increased significantly over the survey period. Wheras corallivorous butterflyfish (Chaetodontidae) and carnivorous wrass (Labridae), populations declined significantly. The populations of rabbitfish (Siganidae) and carnivorous sea bass and groupers (Serranidae) showed no change in abundance over the survey period.

Figure 18. Trends in fish abundance at Hoskyn Islands Reef, 2006 – 2012.

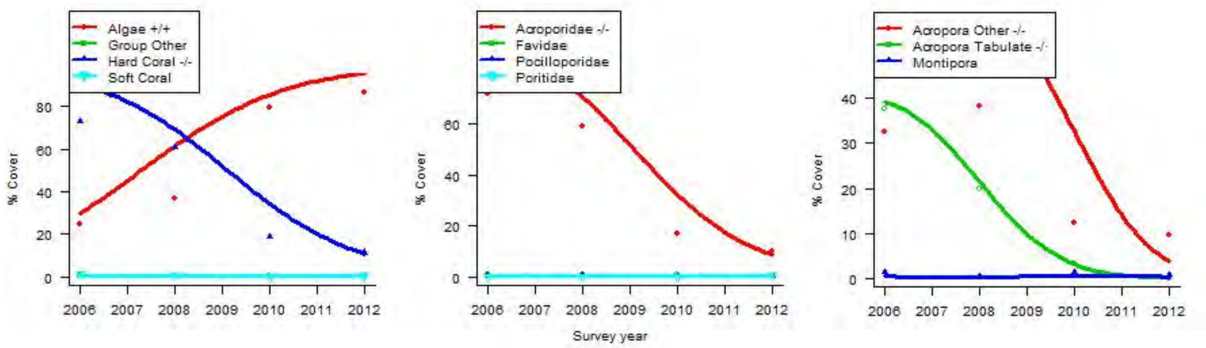


Source: AIMS, 2014.

Fairfax Islands Reef is an outer shelf planar reef with an area of 3.8 km^2 was surveyed by manta tow in 1991 and live coral cover was high (31-50%) for the whole reef (AIMS, 2014). Fairfax Islands Reef was re-zoned from an 'open to fishing' to a 'closed to fishing' reef in 2006 and intensive survey sites, established at this time recorded very high hard coral cover levels (51-63%) (AIMS, 2014). By 2008 hard coral cover had declined to 31-40% and then by 2010 it had further declined to low levels (0-

10%) (Figure 19) most likely because of severe storms and cyclones (Cyclone Hamish) as well as an 'Incipient Outbreak' of crown-of-thorns starfish (COTS) on part of the reef (AIMS, 2014). In 2012 coral cover remained low and an Active Outbreak of COTS was recorded for the first time in the Capricorn Bunker sector of the Great Barrier Reef (AIMS, 2014).

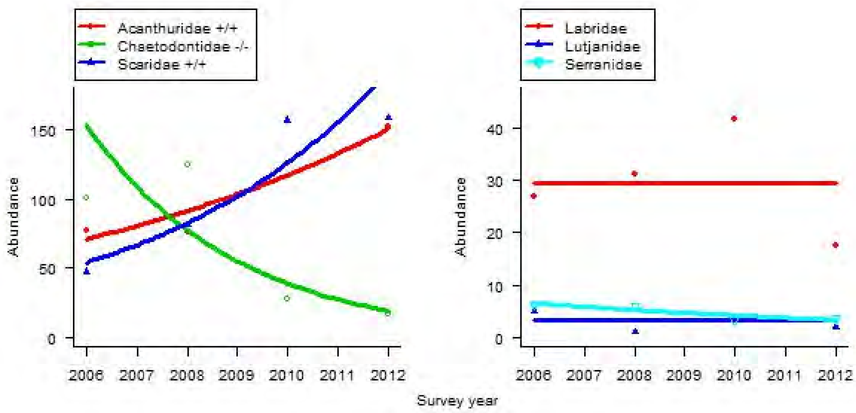
Figure 19. Trends in cover of benthic organisms at Fairfax Islands Reef, 2006 – 2012.



Source: AIMS, 2014.

The changes in benthic organisms affected the fish community of Fairfax Island Reef (Figure 20) in a similar manner to other Capricorn Bunker group Reefs. Herbiverous surgeonfish (Acanthuridae) and parrotfish (Scaridae) increased whereas corallivorous Butterflyfish (Chaetodontidae) decreased in abundance between 2006 and 2012 (AIMS, 2014). The abundance of carnivorous fishes such as wrasses (Labridae), snapper (Lutjanidae) and sea bass and groupers (Serranidae) were considered to remain stable over the same sampling period.

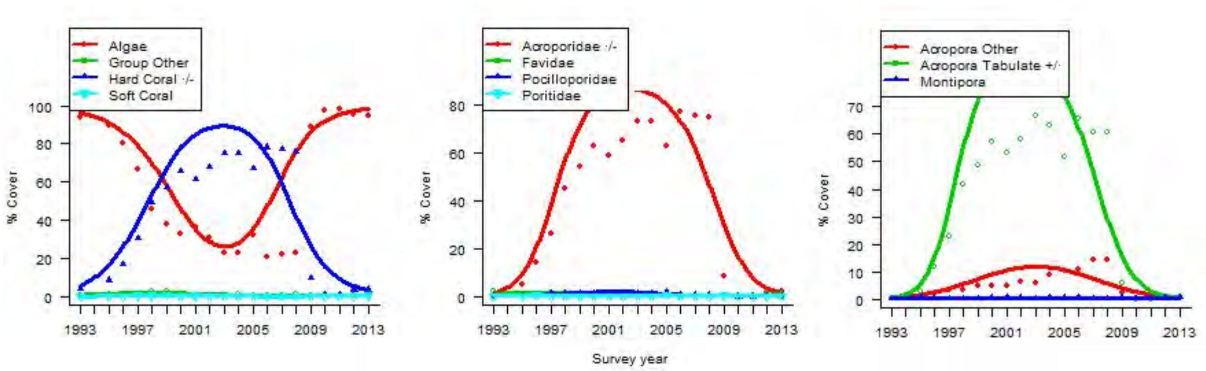
Figure 20. Trends in fish abundance at Fairfax Islands Reef, 2006 – 2012.



Source: AIMS, 2014.

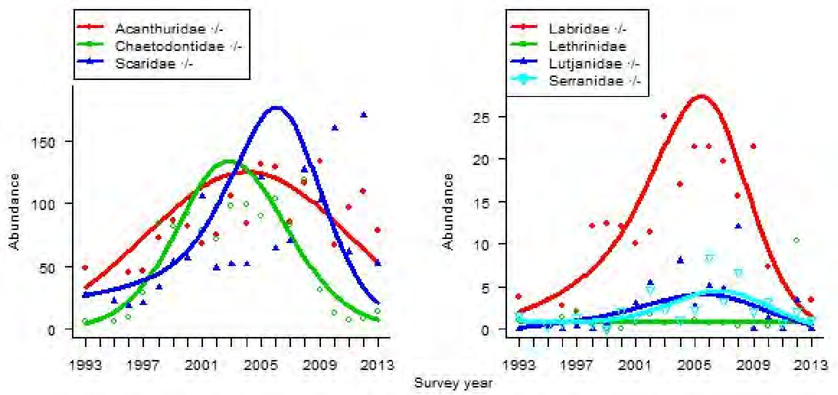
Lady Musgrave Island Reef is an outer shelf lagoonal reef with an area of 12.5 km^2 which has been surveyed regularly by the AIMS Long Term Monitoring Program since 1986 (AIMS, 2014). In 1986 broadscale surveys recorded very high median reef-wide live coral cover (51-75%) and extremely high levels (76-100%) in 1987 and 1988 however by 1990 reef-wide live coral cover had fallen to a moderate level (11-30%) due to storm damage (AIMS, 2014). Intensive survey sites were established in 1993 and since that time coral cover increased to a very high level (51-75%) in 2002 before again declining possibly due to *white syndrome disease* which had been present or common at Lady Musgrave Island Reef from 2001 (AIMS, 2014) (Figure 21). By 2007 reef-wide live coral cover again increased to very high levels (51-75%) but by 2009 declined to 31-40% and by 2010 to due to (0-10%), most likely due to storm activity and cyclones (Cyclone Hamish) (AIMS, 2014). Intensive surveys in 2013 recorded low coral cover (5-10%) with few signs of coral recovery (AIMS, 2014). COTS have been recorded at Lady Musgrave Island Reef and an Incipient Outbreak was declared in 2013 (AIMS, 2014).

Figure 21. Trends in cover of benthic organisms at Lady Musgrave Island Reef, 1993 – 2013.



Source: AIMS, 2014.

Figure 22. Trends in fish abundance at Lady Musgrave Island Reef, 1993 – 2013.



Source: AIMS, 2014.

Again changes in the benthic community resulted in significant changes in the fish community of Lady Musgrave Island Reef (Figure 22). The abundance of most families correlated with the percentage cover of hard coral cover including surgeonfish (Acanthuridae), butterflyfish (Chaetodontidae), parrotfishes (Scaridae) and wrasses (Labridae), and to a lesser extent, snapper (Lutjanidae) and sea bass and groupers (Serranidae). Such declines reflect the magnitude of loss of habitat complexity and concomitant loss of available shelter available (AIMS, 2014).

Lady Elliot Island Reef is not included in The AIMS Long Term Monitoring Program but is monitored as part of a community monitoring program 'CoralWatch', facilitated by the University of Queensland and conducted by tourism operators on Lady Elliot Island ((2014)). Lady Elliot Island is the southernmost reef and island complex in the GBRMP and has a diverse coral community found on bommies and platform reefs (GBRMPA, 2011e). The reef crest and much of the steep slope has good coral cover whereas coral cover significantly reduces with distance from the reef front (GBRMPA, 2011e). No temporal quantitative data has been sourced for Lady Elliot Island Reef.

Threats

The most significant threat to offshore coral reefs in the Burnett Mary region is climate change (Threat Table 3) the effects of which includes increased water temperature, increased light and ultraviolet radiation, ocean acidification, sea level changes and increased frequency and severity of tropical storms and flooding events (Hoegh-Guldberg *et al.*, 2007).

Increases in water temperature are already pushing corals beyond their thermal tolerance, which is highly variable between species and is one reason coral bleaching occurs and corals under thermal stress are also more highly sensitive to light and ultraviolet radiation levels (Hoegh-Guldberg *et al.*, 2007). The early life stages or corals, including oocytes, sperm, larvae and recruits and also critical transitions (fertilisation and larval settlement), may also be just as susceptible to thermal stress which will determine the ability of coral communities to recover from climate change effects (Hoegh-Guldberg *et al.*, 2007).

Ocean acidification significantly reduces the skeleton forming capacity of corals and consequently their ability to maintain their reef's underlying structure (Hoegh-Guldberg *et al.*, 2007). Sea level changes are predicted to be slower than the rate of coral growth however this depends of healthy coral growth and in some instances the reef matrix will not be able to keep up with sea level rise which, historically has already occurred in the Capricorn Bunker region with many inter-reefal shoals being 'pre-existing reef masses on which coral growth was not able to keep pace with the rising sea level during the Holocene transgression' (Jell and Flood, 1978, p.15).

The number of severe cyclones has nearly doubled over the past three decades and cyclone destructiveness has also increased dramatically since 1970 (Hoegh-Guldberg *et al.*, 2007). Increased frequency and severity of destructive storms reduces the opportunity for reef communities to recover, the possibility of which is indicated by the Long Term Reef Monitoring Program data (AIMS, 2014). With increased frequency and severity of storms communities are less likely to recover, reef resilience will decline and reef communities will shift to alternative, less desirable states (Hoegh-Guldberg *et al.*, 2007). The ability of coral reef communities to recover from such events will be further limited by the other effects of climate change including sea level rise, continued ocean warming and ocean acidification (Hoegh-Guldberg *et al.*, 2007).

On a number of reefs in the Capricorn-Bunker sector crown-of-thorns starfish (COTS) numbers remain elevated with an Active Outbreak on Fairfax Reef since 2012 and an Incipient Outbreak on Lady Musgrave Island Reef (AIMS, 2014), however, these are not considered significant threats to offshore coral reefs in the Burnett Mary region.

The waters surrounding the Capricorn Bunker Group are a Designated Shipping Area (DSA) and part of The Great Barrier Reef and Torres Strait Vessel Traffic Service (REEFVTS) which was established by the Australian and Queensland Governments to improve safety and efficiency of vessel traffic and to protect the environment in the GBR and Torres Strait (AMSA, n.d.). The threat of shipping as well as damage from boating (due to the distance from the coast for recreational boating) in the Capricorn Bunker group is not considered significant.

Threat Table 3. Offshore Coral Reefs in the Burnett Mary region.

Threat	Level of Impact*	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
Sediment	VL	5
Nutrients	L	10
Pesticides	VL	5
Coastal Development	VL	5
Shipping	VL	5
Climate Change	H	70
Other:		
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

SEAGRASS MEADOWS

Prepared by – Dr Jane Mellors

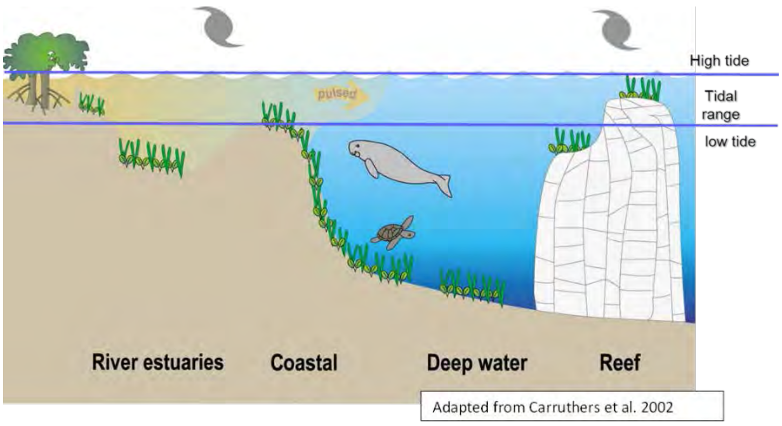
Status and Trends of Seagrass Meadows in the Burnett Mary region:

- are a key ecosystem within the Burnett Mary region supporting populations of dugong, turtle, fisheries of commercial and recreational importance and seabirds;
- Seven species of seagrass were recorded in 1973; presently only five species are regularly recorded.
- There is a recorded history of loss and recovery of seagrasses within this region from 1992.
- There is no documented knowledge of reef seagrass habitat.
- Due to topography of the region very few coastal seagrass meadows persist.
- Deepwater seagrass meadows are well represented in this region but their current status is unknown due to a lack of monitoring.
- Estuarine seagrass meadows are well represented in this region and the status of seagrass condition in this region is based on two intertidal estuarine seagrass meadows at Rodds Bay and Urangan.
    - Seagrasses have been declining since 2005/2006.
    - Plant tissue nutrients are indicative of poor water quality.
    - Reproductive effort across the region is in a poor state.
    - Overall condition of seagrass habitat is very poor.
- Status of seagrasses in the Great Sandy Strait is reliant on opportunistic community monitoring and there is insufficient data to rate the condition of seagrass in this area.
- Deteriorating water quality associated with flood plumes has been strongly linked to seagrass decline in the region and is considered to be the most significant threat to their viability.

Seagrasses are flowering plants (angiosperms) that have adapted fully to life in the marine environment. The term 'seagrass' is used as a functional grouping of plants and is not a taxonomic word. Despite their evolutionary independent origins, seagrasses have developed a set of common/convergent morphological and physiological characteristics (Walker *et al.*, 1999). All species are rhizomatous, clonal plants with leaves and roots produced via rhizome extension. They have evolved mechanisms to reproduce in the marine environment (den Hartog, 1970; Les *et al.*, 1997; Waycott and Les, 1996). Key elements for seagrass survival include suitable; light, sediment, salinity and temperature ranges; an appropriate level of nutrients and minimal disturbance whether it be natural or anthropogenic. Whilst this list is indicative of survival, tolerance to differing levels of these elements is species-specific in relation to reproduction, colonisation, survival, and growth (Coles *et al.*, 2007; Waycott *et al.*, 2004). It follows then, that these species-specific differences are paramount to the level of disturbance and recovery that a meadow can sustain.

Seagrasses are viewed as a habitat type – a seagrass meadow. Seagrass meadows are attributed with a number of ecosystem services: trophic, nursery, sediment and nutrient filters and carbon sequestering (Coles *et al.*, 2007; Duarte, 1999; McRoy and Helfferich, 1977; Walker *et al.*, 1999). Globally they are viewed indisputably as a critical ecological habitat (Orth *et al.*, 2006), however, meadows vary in size, location, species mix and distribution. Physical factors, such as tidal variation and wave exposure, are the overarching factors influencing seagrass distribution (Grech and Coles, 2010) and the habitats that they occupy. Along the coast of Queensland seagrass meadows can be split into four major habitat types: estuary/inlet, coastal, deepwater and reef (Carruthers *et al.*, 2002) (Figure 23).

Figure 23: Generalised habitat types of the Queensland coastline.



Source: Adapted from (Carruthers et al., 2002).

All four habitats are influenced to some degree by severe weather events, wind and waves, and macro grazers (fish, dugongs and turtles). With the exception of outer reef habitats the other three habitat types are significantly influenced by seasonal and episodic pulses of sediment-laden, nutrient-rich river flows, resulting from high volume summer rainfall. Consequently, community structure (colonization depth, species mix and abundance) can vary spatially and temporally across water quality gradients (Abal and Dennison, 1996; Collier, 2013; Fourqurean *et al.*, 2001). As seagrasses are sessile and integrate water quality attributes they are ideal as bio-indicators. Measuring changes in meadow distribution, community structure, abundance and condition can provide insight into deteriorating ecological conditions caused by poor water quality.

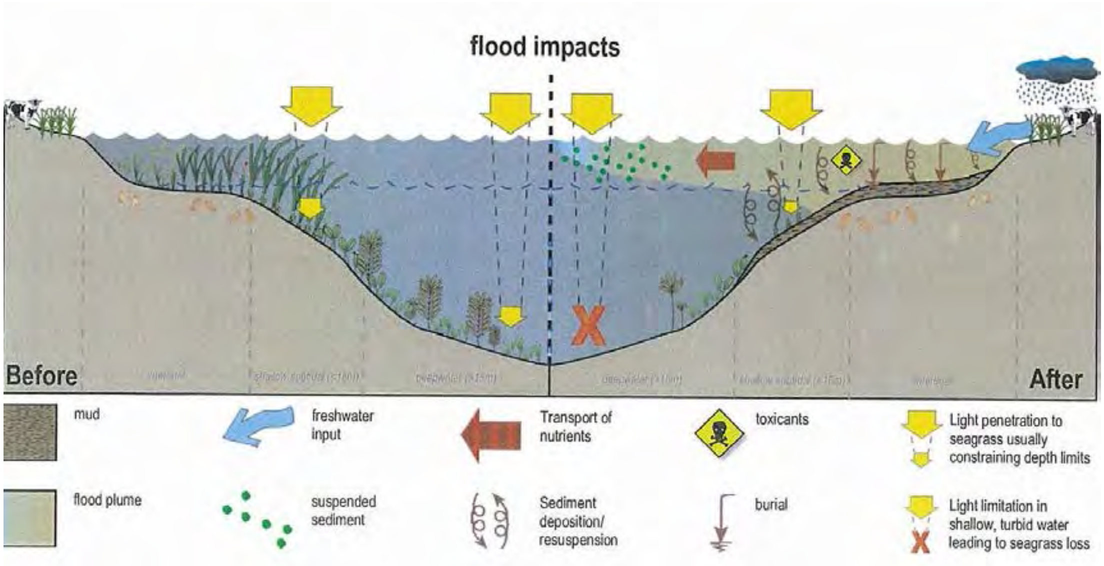
Seagrasses face a number of threats both natural and anthropogenic ranging from: increasing severe weather events, sea surface temperature and sea level rise, increased coastal developments, ports and shipping expansion to poor water quality from catchment runoff (agricultural and urban/industrial). A recent risk assessment, showed flood plumes and their associated agricultural and urban runoff were rated as the greatest risk to seagrass meadow health in the GBR (Grech *et al.*, 2011a). River flood plumes are the conduit for transporting fresh water, sediment, nutrients, other pollutants (insecticides, fertilisers, herbicides, heavy metals) and debris from the mainland to the coastal zone. By virtue of seagrass predominance in nearshore areas, seagrass meadows, experience the greatest exposure to flood plumes (Collier, 2013; Devlin *et al.*, 2012). However it is the water quality and duration of the plume that influences seagrass condition. This is clearly illustrated by comparing the condition of meadows in the vicinity of altered catchments with those catchments in near pristine condition (Northern Cape York: (McKenzie *et al.*, 2010b), Shoalwater Bay: Mellors 2012, unpublished data).

Seagrass meadows that occur within the spatial extent of either sediment deposition or the water lens of a flood plume, are likely to be impacted (Figure 24). Impacts will vary according to the duration (from days to weeks) and the extent of the plume (kilometres to several hundreds of kilometres), and may include:

- hypo- saline waters;
- high light attenuation (sediment in water column;
- algal blooms of phytoplankton and epiphyte from excess nutrients in water column);
- toxicant stress (excess nutrients, pesticides, herbicides, heavy metals);
- burial by sediment flocculation; and
- physical damage (localized scouring of sediments, and gross pollutants)

Source: (Devlin et al., 2012).

Figure 24. Conceptual diagram depicting expected impacts on seagrasses from flood plumes.



Source: (McKenzie and Unsworth, 2011).

As the flood plume progresses a water quality gradient is created and the severity of impact on seagrass meadows will correlate with this gradient. The gravity of the impact will depend on the seagrass community (species composition); where they are located (habitat), and the duration of the impact. Recovery from disturbance will also differ between species and habitat (Birch and Birch, 1984; Gordon *et al.*, 1994; Longstaff and Dennison, 1999; Schaffelke *et al.*, 2005).

Seagrass species that are structurally smaller, rapidly growing and set seed banks (eg Halophila and Halodule) are typically adapted to higher disturbance regimes. These species have a lower tolerance to impacts (Longstaff and Dennison, 1999), but are quicker to recover. In contrast, species that are structurally larger and slower growing, react more slowly to disturbance as they are able to resist the impact for longer (greater carbon reserves). The downside to this is they take longer to recover, (Birch and Birch, 1984; Gordon *et al.*, 1994; West *et al.*, 1989).

Recovery rates for meadows are also dependent on the duration of the event; the primary impact of the event and the persistence of the secondary effects. For example: an intertidal estuarine meadow in Hervey Bay, where the primary impact was sedimentation/burial, showed signs of recovering 14-18 months after the event, with full recovery after to 2-3 years (Campbell and McKenzie, 2004). In contrast, a shallow subtidal, estuarine, meadow took longer to recover (3-5 years) due to the persistence of a secondary effect: wind/tidal driven resuspension of sediment that was continually settling on the plants and seafloor (McKenzie and Unsworth, 2011). For a seagrass meadow to be resilient, with a chance of full recovery, a number of factors are required. Resilience factors are complex and include:

- species mix;
- genome types;
- availability of viable seed banks/ fragments for recolonisation;
- reproductive ability;
- nutrient availability;
- sediment type;
- variety of location specific factors; and
- previous history (disturbance/recovery) of the meadow – as a meadow that has repeatedly been disturbed with partial recovery has little chance of persisting (GBRMPA, 2012).

The different responses by meadows and species to local and seasonal influences/changes in biophysical factors, requires monitoring of the changes/status/trends in any NRM over extended time periods and using fine and meadow scale assessment. What is known is that deteriorating water quality, influenced by terrestrial run-off, exacerbated by extreme weather events are a threat to all seagrass habitat.

Seagrasses of the Burnett Mary Region

Seven species of seagrass have been recorded across all surveys from intertidal, shallow subtidal and deepwater locations, since the first survey of seagrasses within this region was undertaken in 1973 (Dredge *et al.*, 1977; Lee Long *et al.*, 1992; McKenzie, 2000; McKenzie and Campbell, 2003) (Figure 25). Seagrass meadows in the Burnett Mary region constitute a major component of the marine areas identified as internationally (RAMSAR sites and GBRWHA) and nationally significant (Dugong Protection Areas (DPAs), Fish Habitat Area's (FHA'a)) that are discussed elsewhere in this report.

Halodule uninervis, Zostera muelleri (capricorni), Halophila ovalis, Halophila spinulosa and *Halophila decipiens* are commonly mentioned in all surveys/monitoring of this region (1973- present). *Zostera muelleri (capricorni),* is often the most dominate or co-dominant species with *Halodule uninervis* within intertidal and shallow subtidal meadows. These species have not been found below 9m (Lee Long *et al.*, 1992; McKenzie and Yoshida, 2008). *Halophila spinulosa* is the dominant species of the subtidal, deepwater meadows in the Hervey Bay region. This species co-occurs with *Halophila decipiens* and *Halophila ovalis* at depths greater than 15m (Lee Long *et al.*, 1992; Preen *et al.*, 1995). *Cymodocea serrulata* was first recorded in 1973 in the vicinity of Kauri Creek (Dredge *et al.*, 1977). It was described as a meadow on a sand bank that extended from the intertidal to subtidal areas. A 1992 survey also described this meadow, however by 1994 it was described as being sparse subtidally and replaced intertidally by *Zostera capricorni* [*sic muelleri*], The 1998 dive survey of the Great Sandy Straits also recorded this subtidal *Cymodocea* meadow in the Kauri creek area however by April 1999 the meadow had disappeared**.** It was during the 1998 survey that *Syringodium isoetofolium* was also recorded (McKenzie, 2000) and mapped in 2002 as part of a mixed meadow in the Poona area (McKenzie and Campbell, 2003). Since then this species has not been cited in any literature. Changes in species composition of a meadow can be a consequence of chronic declines in water quality (Fourqurean *et al.*, 2001).

Seagrass Distribution of the Burnett Mary Region

Surveys of this region reflect the funding priority at the time a survey was conducted. Each survey had its own set of aims, objectives and methodologies, making direct comparison between locations and years difficult, as seagrass meadows are known to vary spatially and temporally. Regardless, a baseline map of the distribution of meadows in this region (accurate to 2007) has been produced (Figure 26).

Meadow distribution, within Burnett Mary area is disparate. Meadows have been mapped north of Rodds Peninsula, through to Tin Can Bay. Along the open coastline between Bustard Head and Elliot Heads no meadows were encountered with the exception of some small meadows at deep sites out from Baffle Creek and Littabella Creek (Lee Long et al., 1992). The location of these meadows may have been coincidental due to the annual nature of the species present and the timing of the survey (Oct/Nov). No reef top seagrass habitat has been mapped for this region (lack of surveys), though undoubtedly seagrass meadows exist on the reef tops of Lady Musgrave and Lady Elliot islands. The other three seagrass habitat types: coastal, deepwater and estuarine (Figure 26), have been definitively surveyed.

Coastal meadows were restricted to the area north of Rodds Peninsula, where they are protected from strong south-easterly winds (Figure 26). These meadows occurred on intertidal to shallow sub-tidal sand banks and were dominated by *Halodule uninervis* and *Halophila ovalis* (Coles *et al.*, 2007). Distribution, depth range and species composition of these meadows are constrained by disturbance, exposure (desiccation) at their upper edge and turbidity (light attenuation) at their lower boundary. In this region turbidity affecting this habitat type is driven by wind and waves.

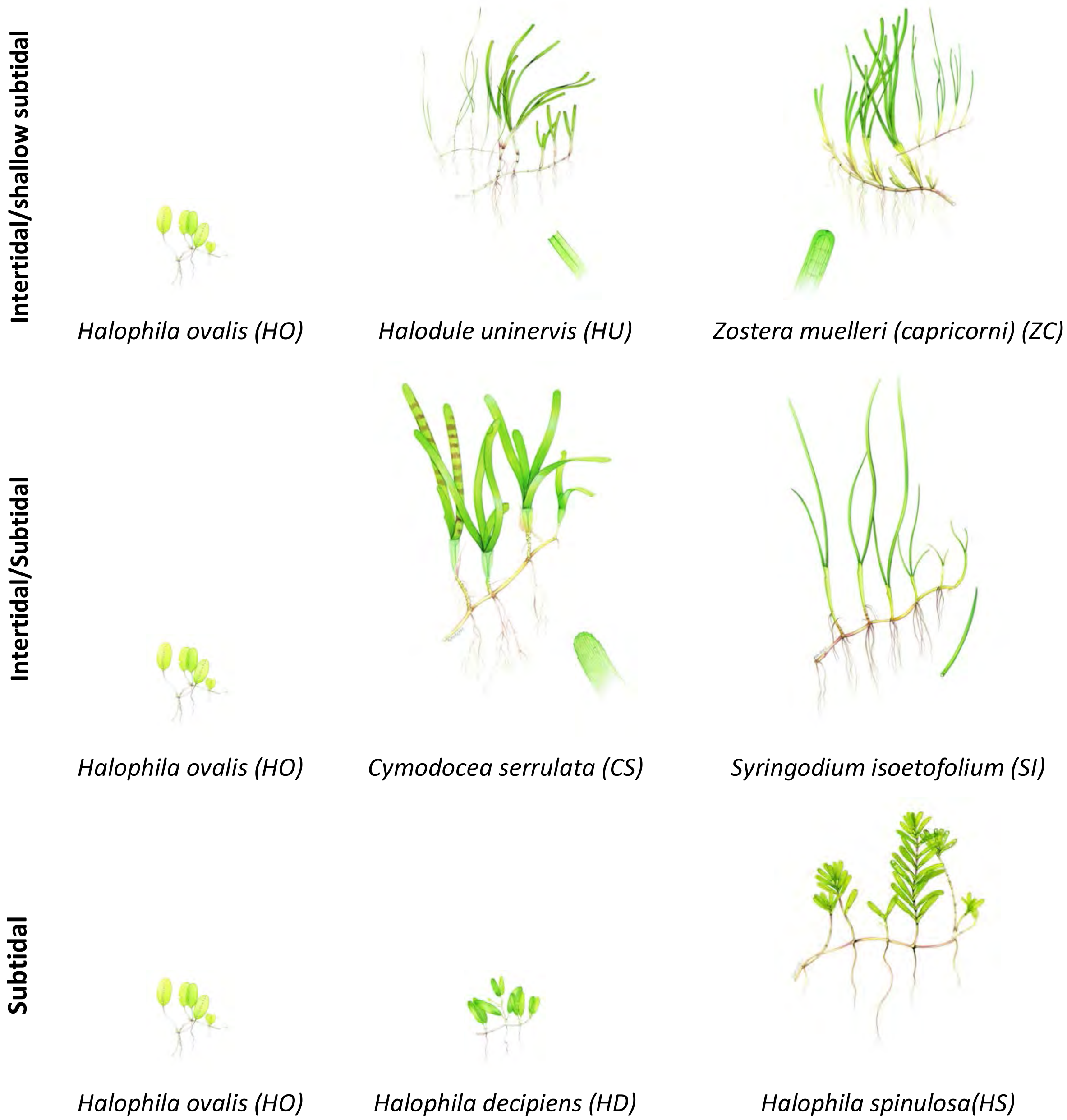
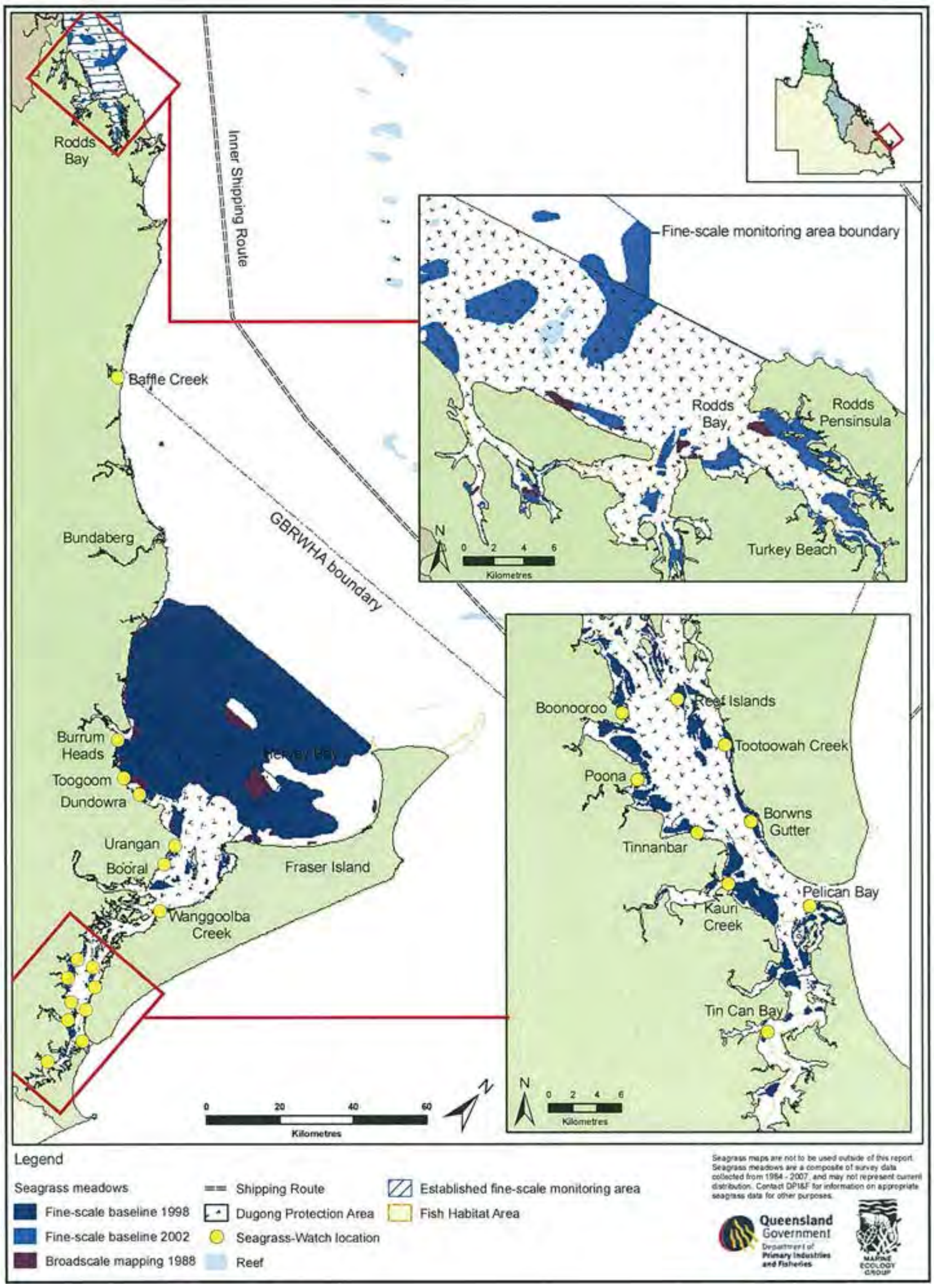


Figure 25. Seagrass species recorded within the Burnett Mary region.

Deepwater meadows occurred to the north of Rodds Peninsula in the lee of the peninsula. To the south of Rodds Peninsula no permanent deepwater meadows have been identified until the sheltered waters of Hervey Bay (Figure 26). The Hervey Bay deepwater meadow stretches from Elliot Heads to north of Vernon Point out into the bay nearly to Fraser Island and it is a key feature of the bay (Coles *et al.*, 2007). This meadow first mapped in 1988 was, at the time, the largest single area of seagrass in Queensland waters (Lee Long *et al.*, 1992). Deepwater meadows tend to be dominated *by Halophila spinulosa, Halophila ovalis and Halophila decipiens.* The distribution, formation and species composition of these meadows is driven by light availability at depth. Lack of suitable light will restrict the lower limits of these meadows, which in Hervey Bay was around 30m (Preen *et al.*, 1995).

Estuarine meadows, which can be either intertidal or subtidal, are the predominant seagrass habitat type in this region and have been mapped in Rodds Bay, Hervey Bay and the Great Sandy Strait

Figure 26. Seagrass distribution and monitoring locations in the Burnett Mary region.



Note: This map was compiled from surveys undertaken by the Marine Ecology Group (ex QFS) between 1984 and 2007 and may not represent current seagrass distribution, as the extent of these surveys reflect funding priorities at the time.

Source: (Coles et al., 2007).

(Figure 26). The location of these meadows is controlled by the level of protection they have from south-easterly winds and consequent wave action and their ability to tolerate environmental changes due to their proximity to rivers. This scenario is prevalent in this region due to the presence of Fraser Island and a number of rivers that empty into the marine environment of this region.

The depth range of these meadows is determined by exposure (desiccation) at its intertidal limit and by light attenuation at its deep edge. The species that inhabit these meadows must also survive pulsed/seasonal events of terrestrial run-off: turbidity, burial (sediment incursion) and drops in salinity (freshwater influx) (Coles *et al.*, 2007). These meadows often have high shoot densities but low species diversity (Lee Long *et al.*, 1992). Differences in life history strategies and resilience to habitat variability and the physical characteristics of the inlet control the species assemblages in different river and inlet systems Species composition of these meadows tends to be *Halodule uninervis, Zostera muelleri (capricorni)* and *Halophila ovalis.*

Meadow Variability within the Burnett Mary Region

The 1973 survey of Great Sandy Straits (Dredge *et al.*, 1977) recorded meadows south of the co-tidal line (Moonboom Islands (25°20’ S) while north of this line no seagrass meadows (including Urangan) were located. A 1988 survey mapped estuarine and deepwater meadows within Rodds Bay and Hervey Bay. In 1992 (October/November) an aerial photographic survey noted seagrass meadows present between River Heads to Urangan absent from the 1973 survey (McKenzie and Campbell, 2003). A 1994 survey of the same area reported a further increase of these meadows since the 1992 survey of the Great Sandy Straits. In June of that year, long-term monitoring transects were established throughout the Great Sandy Strait, to determine any changes in seagrass presence and depth profiles. Monitoring of these transects was conducted in March 1995, November 1996, February 1998, September 1998 and February 1999. Results from these surveys recorded large decreases in seagrass distribution in 1996, with subsequent recovery till monitoring concluded in 1999. Recovery levels however were lower than levels recorded prior to 1996 (McKenzie, 2000).

Seagrasses in Hervey Bay however did not fare as well. Massive losses of seagrass occurred throughout Hervey Bay inclusive of all habitat types following the 1992 flood events (ex-cyclone Fran, March 1999; (Preen *et al.*, 1995). This catastrophic decline of seagrass meadows triggered a mass migration of dugongs from Hervey Bay as well as mortality of a large number of dugong because of starvation (Preen and Marsh, 1995). Signs of subtidal meadow recovery began in 1994, but recovery of intertidal seagrass was much slower (4-5 years, (McKenzie and Yoshida, 2008). By 1998 a detailed dive and camera survey revealed partial to full recovery of previously mapped meadows in Hervey Bay (McKenzie and Campbell, 2003).

Flooding of the Mary River in February 1999 once again adversely affected the seagrass meadows in Hervey Bay (McKenzie, 2000). By December 1999 a complete loss of seagrass from the intertidal and shallow subtidal meadows was recorded. By May 2000 initial recolonisation of the intertidal meadows was recorded with complete recovery to pre-flood levels occurring by August 2001 (Campbell and McKenzie, 2004). Deepwater meadows were also impacted. These meadows declined in abundance, but did not disappear and had recovered to pre-flood levels by February 2002 (McKenzie and Campbell, 2003). Following the same flood event of the Mary River in 1999, seagrass meadows were completely lost from the northern Great Sandy Straits with some losses recorded from the central and southern Sandy Strait region (McKenzie, 2000). Recovery to pre-flood abundances for these meadows had occurred by February 2002 (Campbell and McKenzie, 2004).

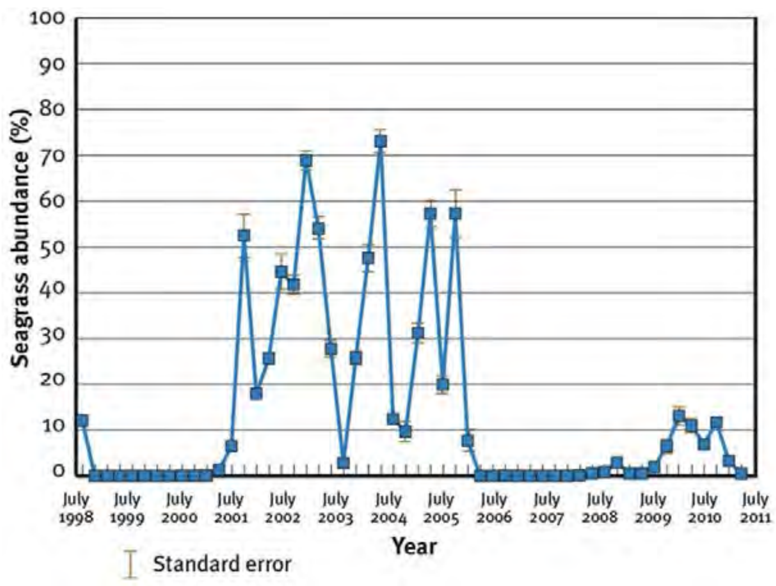
With such large scale fluctuations in seagrass abundance and the flow on effects to dugong populations, a citizen science monitoring program, Seagrass Watch (Anon, 2013) was initiated within this region. To date 38 sites have been established at different times within the Burnett Mary Region; two in Rodds Bay, 13 in Hervey Bay and 23 in the Great Sandy Straits all of which are monitored at varying levels of regularity (Appendix 1).

With the advent of the Marine Monitoring Program in 2005 ((McKenzie *et al.*, 2010a) sites at Urangan were integrated into the program and sites at Rodds Bay were established in 2007. The Rodds Bay sites were selected because 1) they are within the boundary of the GBRWHA) and 2) are thought to generally experience a lower level of anthropogenic threat, in contrast to the Urangan sites (Coles et al 2007). In addition to the regular data collected using Seagrass-Watch methodology, information on tissue nutrients, sediment nutrients and occasionally levels of sediment herbicide is collected. These sites are considered typical of seagrass meadows within this NRM region; however they only represent intertidal estuarine habitat. No shallow subtidal, reef or deepwater seagrasses are monitored within the Burnett Mary region.

Since regular monitoring commenced at these sites, seasonal and annual fluctuations in seagrass abundance have been recorded. These smaller scale patterns occur within larger cycles of seagrass loss and recovery due to extreme weather events, well-illustrated at Urangan (Figure 27) where the effects of flooding in 1999, 2006, and 2011 are evident. Recovery rates in 2010 were minimal compared to abundance measures in 2004 (Figure 27).

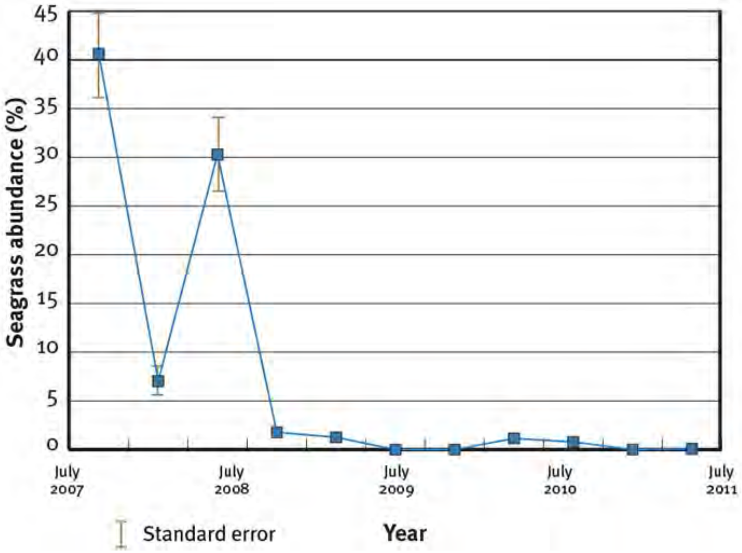
Prior to the Rodds Bay sites becoming part of the MMP program, regular meadow scale monitoring in partnership with the Central Queensland Ports Authority has been occurring since 2004, after a baseline study in 2002 (Taylor and Rasheed, 2011). This monitoring showed the intertidal meadow, encompassing the MMP site, maintained a relatively constant area from 2002 but experienced a sharp decline in biomass during 2004, before recovering in 2005 and 2006 (Coles *et al.*, 2007, p.90). Ongoing monitoring of the Rodds Bays' meadows showed that while there were still seagrass present, dramatic declines in cover had occurred (Figure 28), and following the floods of February 2011 the areas of seagrass had decreased to its lowest recorded level since monitoring commenced in 2002 (GBRMPA, 2012). MMP monitoring, post 2012 monsoon, observed the onset of recovery, with the presence of early colonising species, however the meadow had been reduced to isolated patches (McKenzie *et al.*, 2012).

Figure 27. Trends in mean seagrass abundance at Urangan, an intertidal estuarine habitat.



Source: MMP

Figure 28. Trends in mean seagrass abundance at Rodds Bay, an intertidal estuarine habitat.

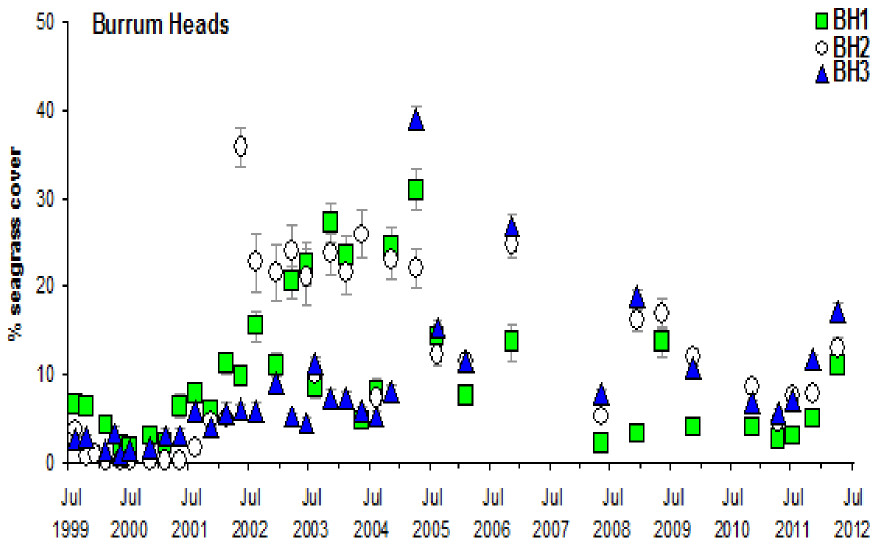


Source: MMP

Based on the evidence of these sites, seagrasses in the Burnett Mary region have been declining since 2005/2006, with their overall condition deteriorating from poor to very poor (GBRMPA, 2012; McKenzie *et al.*, 2012). It should be noted, however, that this rating is based on a limited number of sites, representative of one habitat type within two areas of the Burnett Mary region (southern section GBRWHA and Hervey Bay section of the Marine Park).

In contrast, Seagrass-Watch sites at Burrum Heads, Hervey Bay (also an intertidal estuarine meadow) recorded percent covers in early 2012, comparable to baseline percent cover (1999) after declines in 2007 (Figure 29). The Burrum Heads sites are predominantly inhabited by *Halodule uninervis* (*cf* MMP sites - *Zostera*), that put down seed banks which can lay dormant for extended periods of time. *Zostera muelleri* seeds do not have this capacity. Monitoring at the MMP sites have described their seed banks and reproductive effort as being in in a poor state (GBRMPA, 2012). The lack of a large and viable seed bank can impede recovery following disturbance (Inglis, 2000).

Figure 29. Percent seagrass cover at Burrum Heads, Seagrass-Watch sites.



Source: Seagrass-Watch 2013.

Citizen science aided monitoring is the only monitoring occurring in the Great Sandy Straits (Anon, 2013), however, monitoring appears to be opportunistic. The last known compilation of information received from this monitoring indicated that there was insufficient data to rate the condition of the intertidal estuarine habitats of the Great Sandy Strait (Anon, 2013). Current condition of deepwater seagrass habitat within this region is unknown as no monitoring occurs for this habitat.

Causes of seagrass decline and recovery within the Burnett Mary

Declining marine water quality, influenced by terrestrial runoff, is recognised as one of the most significant threats to the long-term health of key ecosystems within the GBR (Brodie *et al.*, 2013; Grech *et al.*, 2011b). In the Burnett Mary region, seagrass loss has been linked to river plumes produced by flooding in corresponding catchments (Campbell and McKenzie, 2004; McKenzie, 2000; McKenzie and Campbell, 2003; Preen *et al.*, 1995).

Land clearing and subsequent increases in erosion and sediment transport into Hervey Bay were implicated as the causes of massive losses of seagrass meadows from this area following a flood event (ex-cyclone Fran) in 1992 (Preen *et al.*, 1995). Sediment loads and sediment resuspension increasing and prolonging (light deprivation) within the flood plume were identified as the causative element for the decline in the deepwater meadows. Meadow recovery was attributed to a viable seed bank, and enough remaining propagules to form the foundation of a new population/meadow. Loss of shallow subtidal and intertidal seagrass meadows during this event was attributed to physical disturbance.ie seagrass plants were uprooted by the strong winds caused by ex-cyclone Fran. Recovery for these meadows took longer than that of the deepwater meadow. This was attributed to sediment disturbance associated with the cyclonic winds. As this type of disturbance may have interfered with the seed bank causing death of the seeds; either by deep burial or abrasion (Preen *et al.*, 1995).

Sediment deposition associated with the 1999 flood was the attribute linked to the major loss of intertidal seagrass in the region (McKenzie, 2000). Signs of meadow recovery were not apparent until 14-18 months after the impact. Again it was thought that sediment disturbance and its concomitant effects were the agent affecting seed germination (Campbell and McKenzie, 2004). In this instance the subtidal meadows took longer to recover and this was attributed to the persistence of wind driven resuspension of fine sediments continually settling on the seagrass.

Herbicides, as part of the deteriorating water quality associated with river plume and resuspension events, were also implicated in seagrass die off and slow recovery. Experimentally, it has been shown that after water column exposure of herbicides in concentrations as low as 0.1 μgl^{-1} photosynthesis is rapidly inhibited (Haynes *et al.*, 2000; Macinnis-Ng and Ralph, 2003). These same controlled experiments showed seagrasses to recover once the seagrasses were no longer directly exposed to the herbicide. The Australian low risk trigger value (water column) for diuron is 0.2µg L-1, for protection of 95% of species in a slight to moderately disturbed aquatic environment (ANZECC, 2000). This limit was not exceeded in the Mary River or Hervey Bay (GBRMPA, 2012). Whilst levels were slightly higher in sediments seagrass stress was not detected (McMahon *et al.*, 2003). There is no information, however, about the effects of chronic exposure of seagrasses to low herbicide levels**.** Chronic levels of exposure may eventually reduce growth and reproductive effort within a meadow; important processes in meadow recovery after disturbance.

Even though changes in salinity have not been implicated in seagrass loss in this region, it may be worthwhile considering its effect. It is acknowledged that estuarine/coastal species are tolerant of pulsed reductions in salinity. Recent research has even quantified that estuarine seagrasses can survive salinity extremes (Collier, 2013). This experiments however used seagrass acclimated to the salinity of standard seawater. A Hervey Bay hydrological survey found salinity increased through the bay not only laterally but also throughout the water column (Ribbe, 2006). The highest salinities were found to be in the southwest area of the bay in range of any freshwater plumes brought about by flooding. Seagrass meadows that are adapted to hypersaline conditions may well be experience hyposaline stress, when salinity due to freshwater incursion.

Threats

Water quality is the greatest concern for the long-term health and resilience of seagrasses in the GBR (Brodie *et al.*, 2013). This is even truer for seagrasses in the semi-enclosed areas of Hervey Bay and the Great Sandy Straits, where water exchange can take up to 65 days (Grawe *et al.*, 2009). Ongoing water quality issues reduce the resilience of seagrass meadows. With the predicted increase, due to climate change, in the intensity and periodicity of severe weather events water quality impacts will be exacerbated. If this occurs in time frames that do not allow seagrasses to adapt or acclimatize, then there is a very real possibility of this key ecosystem disappearing. Seagrasses are the foundation for healthy populations of turtles, dugongs and commercially and recreationally important fisheries, a loss of seagrass will lead to a loss of these attributes and ecosystem services.

Location as in the geographical and environmental history of an area may be the most important influence on the presence, distribution, abundance and recovery of seagrass meadows (Mellors, 2003). The geographic setting of a location dictates its sediment regime, while the frequency of disturbance dictates the structure and composition of the meadow. Tolerances to environmental and anthropogenic perturbations are different for different species and populations (Waycott, 1998), possibly leading to a loss of genetic diversity due to anthropogenic impacts (Alberte *et al.*, 1994). This will have serious implication for the management of different populations (Waycott, 1998). Consequently, species- and location-specific information, through regular monitoring, is required for the effective management of water pollution impacts on seagrass meadows.

Recent research has determined thresholds/tolerance limits for some environmental factors for some species. These experiments out of necessity focused on the impacts of single factors. Examination of the interaction between these factors (eg light and salinity) is critical for enhancing our understanding of water quality effects on seagrass decline and recovery. Recovery processes are key to the long-term health and resilience of seagrass meadows, yet the features that confer resilience are not well documented or understood. Increased frequency of major flooding caused by extreme weather events, means seagrass meadows are unable to recover fully, thereby lowering their resilience to change. Being able to gauge the level of recovery after impact requires monitoring.

Monitoring must:

- Quantify the level of change in abundance, distribution, species composition and reproductive health within a meadow
- Examine and assess the acceptable ranges of change for the particular site;
- Measure the level of impact from environmental events and
- Assist in separating natural from anthropogenic causes of seagrass change.

The decline in seagrass abundance and health of the region is documented (GBRMPA, 2012; McKenzie *et al.*, 2012) and is in response to successive years of flooding and surviving conditions under flood plumes. Seagrass meadow recovery will be given it’s best chance by continuing to work with stakeholders within the catchments to reduce the pollutant loads entering the rivers.

Threat Table 4. Seagrass habitat in the Burnett Mary region.

Threat	Level of Impact*	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
Sediment	H	30
Nutrients	M	20
Pesticides	M	20
Coastal Development	L	10
Shipping	L	10
Climate Change	L	10
Other:		
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

Knowledge gaps and recommendations

- *What is the current distribution of seagrass meadows of all habitat types within the Burnett Mary region?*
  - A complete re-survey of the region, in particular that of Hervey Bay and the Great Sandy Strait.
- *There is little/ no current information on deepwater meadows of Hervey Bay.*
  - Establish routine monitoring of deepwater seagrass habitat – annually/biannually.
- *What is the status of intertidal seagrass habitat in the Great Sandy Straits?*
  - Formally/financially support citizen based monitoring within this area.
  - Establish complementary sites which are monitored through the MMP process within the Great Sandy Straits.
- *What is the meadow response to resuspension events outside of extreme weather events?*
  - Support experiment- based studies and establish turbidity/light monitoring stations throughout the region.
- *Has bioaccumulation of herbicides in seagrass meadows been occurring in this region?*
  - Include routine monitoring of herbicides in the water column and sediment to assess against baseline information.
- *How does seagrass loss affect dependent faunal populations particularly fisheries related populations?*
  - Multidisciplinary studies that examine flood plume/water quality gradients their effect seagrass meadows and the congruent effects on associated green turtle, dugong populations and fisheries status be supported.

SPECIES OF CONSERVATION CONCERN

The species of conservation concern in the Burnett Mary region are dugong, cetaceans, turtles and seabirds. The conservation status of these is discussed below.

DUGONG

Prepared by Dr Susan Sobtzick

Status and Trends of Dugong in the Burnett Mary region:

- Burnett Mary region includes Hervey Bay Dugong Protection Area (A) 1,703,km^2 and Rodd's Bay Dugong Protection Area (B);
- After Torres Strait, the Hervey Bay region, as well as the northern Great Barrier Reef region are the areas with the highest relative dugong density along the Queensland coast;
- High mortality rates due to extreme weather events (cyclones and floods) and associated seagrass pasture disturbances;
- Population dependent on condition of seagrass meadows in the region; and
- Aerial surveys of dugongs in Hervey Bay estimate a population of be approximately 2,100 dugong in 2011.

Conservation Status

In Australia, dugongs (*Dugong dugon*) are protected as a migratory species and *Matter of National Environmental Significance (MNES)* under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (Australian Government, 1999)*. The *EPBC Act* provides the legal framework to protect and manage *MNES* and presents a streamlined national assessment and approval process for activities that are likely to significantly impact on them. Further protection in Queensland includes listing dugongs as a vulnerable species in the Nature Conservation (Wildlife) Regulation 2006 under the Nature Conservation Act 1992 (Queensland Government, 1992). The international significance of Australia's dugong populations was made explicit in 1981 when the Great Barrier Reef was declared a World Heritage Area, by recognizing that one of the World Heritage values of the Great Barrier Reef is that it "provides major feeding grounds for large populations of the endangered species *Dugong dugon*" (Anon, 1981, p.7). Nonetheless, a recent informal assessment of the dugong's status by Marsh *et al.* (2011) concluded that the dugong population on the urban coast of Queensland (south of Cooktown) met the IUCN criteria for Critically Endangered.Most of the dugongs and their habitats on the urban coast of Queensland occur in marine parks: the Great Barrier Reef Marine Park and the associated Queensland Marine Parks in the Great Barrier Reef region, the Hervey Bay Marine Park and the Moreton Bay Marine Park.

In August 1997, the *Great Barrier Reef Ministerial Council* recognised the importance of several areas along the Queensland coast to support significant dugong populations by establishing a two-tiered system of Dugong Protection Areas (DPAs) in the southern Great Barrier Reef. Seven DPAs A and eight DPAs B (which differ in restrictions on fishing practices) cover a total of 4,650 km^2 along the southern Great Barrier Reef coastline (Figure 30). An additional Zone A DPA of 1,703 km^2 was established in Hervey Bay and forms part of the Burnett Mary marine area. Rodd's Bay, a DPA B, is located just to the north of the Burnett Mary area. The benefits of DPAs were significantly enhanced under the Great Barrier Reef Marine Park Zoning Plan 2003, which increased the proportion of strictly protected zones in the Park from less than five percent to over 33 percent (GBRMPA, 2009).

Dugong distribution and relative abundance

Aerial surveys for dugongs, as developed by Marsh and Sinclair (1989a) and later refined by Pollock *et al.* (2006), were designed to investigate spatial patterns of abundance and temporal trends in an index of population size at regional scales (i.e. tens of thousands of square km). These surveys are not appropriate to investigate local spatial scales, such as in the Burnett Mary marine area, since local population size estimates are confounded by large scale animal movements. Satellite tracking studies indicate that individual dugongs can move hundreds of kilometres in a few days (Sheppard *et al.*, 2006), and habitat-driven changes in dugong distribution and regional abundance have been shown for several regions (for Shark Bay and Exmouth Gulf, WA, (Gales *et al.*, 2004; Preen and Marsh, 1995); for the southern GBR region (Sobtzick *et al.*, 2012)). Although this report presents relative abundance estimates for smaller spatial scales, these results must be understood in a wider context, considering animal movements in and out of the study areas.

Although abundance estimations attempt to correct for known biases, such as availability bias (animals are in the survey area but not available for detection, e.g. too deep to be spotted from the air) and perception bias (animals are available for detection but missed by the observers), it is generally accepted that such surveys underestimate true population size and provide standardized minimum estimates only (Marsh *et al.*, 2002; Marsh *et al.*, 2004; Marsh *et al.*, 2011; Marsh and Sinclair, 1989a, 1989b). As opposed to the Marsh and Sinclair (1989a) method, the Pollock *et al.* (2006) method accounts for spatial heterogeneity in sighting conditions and is therefore considered to be the superior approach to estimate animal abundance.

Aerial surveys for dugong and other marine megafauna (e.g. dolphins, whales, and turtles) along the urban coast of Queensland have been conducted by Helene Marsh and her group at James Cook University (JCU) since 1986. An overview of survey dates and references for the Hervey Bay and Southern/Central section of the Great Barrier Reef Marine Park (GBRMP) is presented in Table 6.

Figure 30. Locations of Dugong Protection Areas (DPAs) along Queensland's east coast.

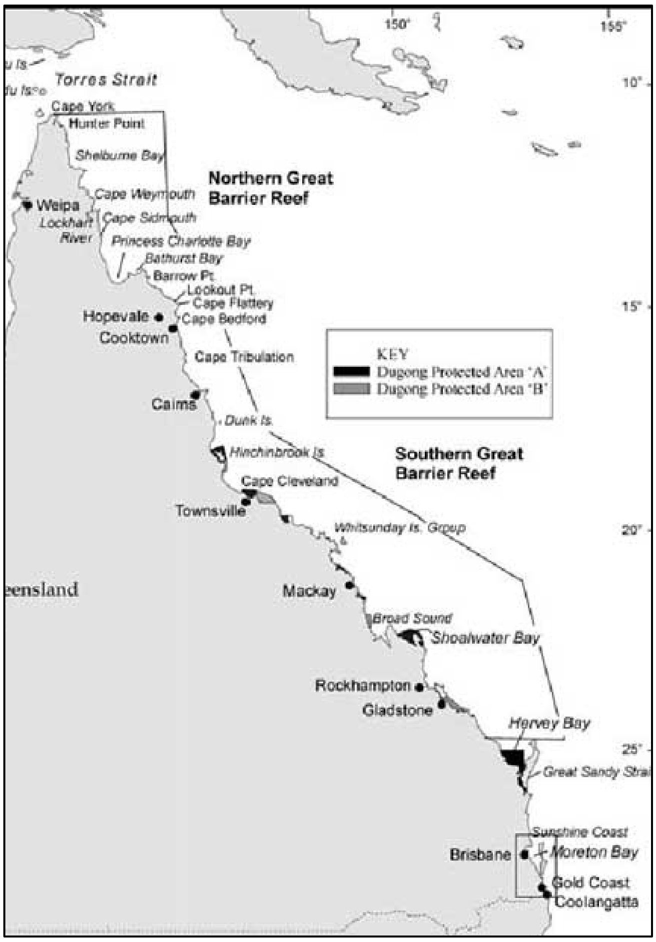


Table 6. Details of aerial surveys for dugongs conducted by James Cook University since 1986.

Date of survey	Reference	Date of survey	Reference
Hervey Bay		**Southern and Central Section of the GBRMP**	
August 1988	Marsh & Saalfeld, 1990 a and b, unpublished;	November 1986	Marsh & Saalfeld, 1990 a and b
November 1992	Preen & Marsh, 1995	November 1987	
November 1993		November 1992	Marsh *et al.*, 1994, unpublished
November 1994	Marsh *et al.*, 1996	November 1994	Marsh *et al.*, 1996
November 1999	Marsh & Lawler, 2001	November 1999	Marsh & Lawler, 2001
April & November 2001	Lawler, 2002, unpublished	November 2005	Marsh & Lawler, 2007
November 2005	Marsh & Lawler, 2007		
November 2011	Sobtzick *et al.*, 2012		

Source: Adapted from Sobtzick et al., 2012.

Abundance estimates resulting from aerial surveys of Hervey Bay indicate that in 1988, the Hervey Bay Region supported a large population of dugongs (estimated at 2,175 ± 419; (Marsh and Saalfeld, 1990a, 1990b); Table 7). When the survey was repeated in 1992, it indicated a large decrease in dugong numbers in the Region. Relative abundance estimates for dugongs more than halved from 1988 to 1992 (1,088 ± 382 in 1992). This decrease in dugong relative abundance coincided with the loss of 1000km^2 of seagrass habitat in the Region (Preen and Marsh, 1995) and an unprecedented number of dugong strandings along the coast of Hervey Bay and the Great Sandy Strait. As many as 99 dugong carcasses were recovered with most of the animals having died of starvation (Preen and Marsh, 1995). By December 1993, the dugong population of the Hervey Bay Region halved again and was estimated to be 524 (± 124) animals. A survey in the following year (November 1994) indicated that the population in the Region was still low (695 ± 140 dugongs; (Marsh *et al.*, 1996). When this survey was repeated again in November 1999, dugong numbers had increased and were estimated to be 1,653 (± 248) (Marsh and Lawler, 2001). This increase between 1994 and 1999 was too great to be attributed simply to natural increase in the absence of migration and satellite tracking of individual dugongs provides evidence of such migrations (Marsh and Lawler, 2001). The survey conducted in 2005 resulted in the highest abundance estimates for Hervey Bay to date (2,547 ± 410 for the Marsh and Sinclair method and 2,077 ± 543 for the Pollock *et al*. method; (Marsh and Lawler, 2007)). The final survey in the time series was conducted in November 2011. Abundance estimates were somewhat lower than population estimates obtained during the 2005 survey (Table 7); however the difference was not statistically significant (Sobtzick *et al.*, 2012).

Due to the very low numbers of dugongs sighted during aerial surveys, abundance estimates for the southern GBR region from Rodd's Peninsula to Hervey Bay could only be obtained for one of the six surveys conducted between 1986 and 2011. In 1992, the population in this area was estimated at 122 ± 71 animals (Table 7).

Table 7. Dugong number estimates (+ s.e.) for the Hervey Bay Region from surveys in 1988 – 2011.

	Marsh and Sinclair (1989a)							**Pollock *et al.* (2006)**	
Hervey Bay									
Year	**1988**	**1992**	**1993**	**1994**	**1999**	**2005**	**2011**	**2005**	**2011**
Abundance estimate	2175	1088	524	695	1653	2547	2116	2077	2029
(± s.e.)	(419)	(382)	(124)	(140)	(248)	(410)	(108)	(543)	(576)
Southern Great Barrier Reef Region from Rodd's Peninsula to Hervey Bay									
Year	**1986**	**1992**		**1994**	**1999**	**2005**	**2011**	**2005**	**2011**
Abundance estimate	tfe	122		0	0	zzt	tfe	zzt	tfe
(± s.e.)		(71)							

tfe = too few to estimate (<5 dugongs sighted);
zzt = zig zag transect (transect was flown in zig zag pattern across the depth gradient)

Source: *Using methodologies by Marsh and Sinclair (1989a) and Pollock et al. (2006). Historical data from Marsh and Saalfeld (1990a and b); Marsh et al, (1996) and (2004); Marsh and Lawler (2000) and (2007), and Sobtzick et al. (2012).*

Grech *et al.* (2011b), based on work by Grech and Marsh (2007), incorporated data from the JCU aerial surveys in the southern GBR spanning 20 years (1986, 1987, 1992, 1994, 1999, and 2005) to create a spatially-explicit model of dugong relative density (Figure 31). By using such a long-term dataset, the model accounts for temporal changes in habitat use including large scale movements of dugongs due to changes in seagrass distribution (Gales *et al.*, 2004; Holley *et al.*, 2006; Marsh *et al.*, 2005; Marsh *et al.*, 2002; Marsh *et al.*, 2004; Preen and Marsh, 1995). Grech *et al.* (2011a) estimated dugong distribution and relative density at a scale of 2 km * 2 km planning units. This scale: (1) corresponds with the scale of the aerial survey data allowing the model to account for: (a) slight changes in altitude of the aircraft (which affects transect width at the surface); and, (b) the blind area under the aircraft; and, (2) is recommended under Criterion B of the International Union for Conservation of Nature and Natural Resources Red List (IUCN, 2001). Each grid cell in the completed model was regarded as a dugong planning unit.

The modelled abundance and distribution layers show the relative density of dugongs (areas where there are more or less dugongs) and not the absolute dugong density. Corrections for perception bias and availability bias can only be applied at the spatial scale of entire surveys (thousands of square kilometres), making them inappropriate for the spatial scale for this dataset. Nonetheless, the relative densities among regions should be approximately comparable.

Dugong planning units were classified into four categories: low, medium, high and very high dugong relative density. Low density areas equate to: 0 dugongs / km^2; medium density areas 0.0015 - 0.25 dugongs / km^2; high density areas 0.25 - 0.5 dugongs / km^2; very high density areas > 0.5 dugongs / km^2. Grech *et al.* (2011b) included planning units with 0 dugongs per square km to ensure that the spatial layers extended across the entire survey region and because dugongs are likely to move across units where they were not detected during the surveys. The Grech *et al.* (2011b) classification approach makes the assumption that dugong relative density is a robust index of dugong habitat utilization. This assumption is justified because specialised areas for dugong reproduction and migratory corridors have not been identified and density estimates are regarded as a suitable surrogate measurement of habitat utilization (Hooker and Gerber, 2004). However, this approach does not account for the changes in availability bias due to spatial heterogeneity of sighting conditions (Pollock *et al.*, 2006) or water depth (Hagihara *et al.*, 2014) so is likely to underestimated the importance of deeper and more turbid areas.

The spatially-explicit model of dugong relative density along the Queensland coast (Figure 31) shows that the areas with the highest relative dugong density along the Queensland coast are (1) Torres Strait, followed by (2) the northern Great Barrier Reef Region (around Princess Charlotte Bay) and Hervey Bay; (3) Moreton Bay; and (4) large, northward facing bays along the urban coast which are sheltered from the prevailing southeast winds (such as Hinchinbrook Island area, Cleveland Bay and Shoalwater Bay).

In comparison with the southern GBR Region, the Hervey Bay Region consists of larger areas of higher relative dugong density. Hervey Bay is thus the most important dugong habitat on the urban coast of Queensland.

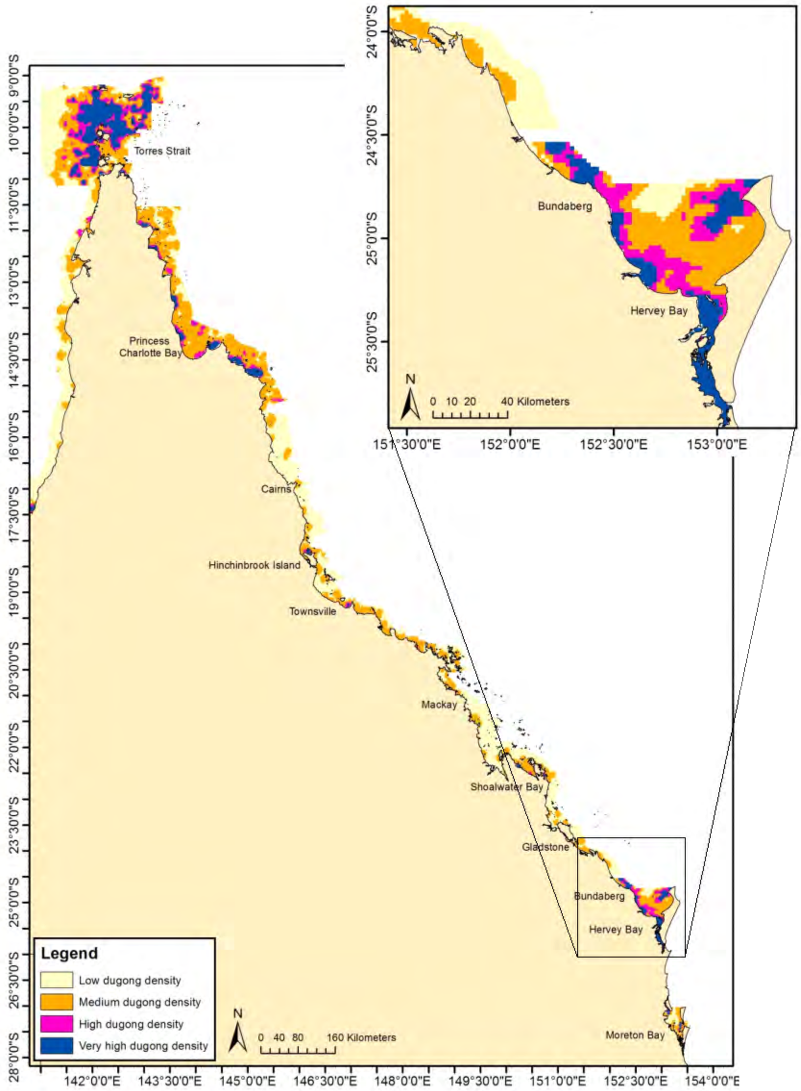
Recorded dugong mortality

Dugong stranding from 1996 – 2012 documented in StrandNet annual reports are summarised in Figure 32 (total number of reported strandings with dugong taken during indigenous hunting activities excluded). Strandings recorded from the Burnett Mary region and adjacent areas (23˚-25˚ latitude) were highlighted in red.

The data show a clear increase in number of reported strandings after extreme weather events (such as floods and cyclones) or outbreaks of the toxic blue green algae (*Lyngbya majuscula*) which all cause damage to seagrass habitats. Record level flooding of the Mary River in February 1999 (the highest since January 1898), as well as flooding of the Barron River (the highest since January 1979) and the Johnstone River (the highest since February 1986, (Australian Government, 2010)) triggered a chain of ecological events associated with an increased number of carcasses recorded in 1999.

The elevated mortality of dugong for years 2009-2010 was primarily attributed to the elevated rainfalls in 2009 which impacted seagrass meadows (Biddle *et al.*, 2011). Mortalities of dugongs in 2011 were the highest ever recorded in Queensland and were likely to be attributed to the effects of extreme weather events of the summer 2010-11 (cyclones and floods) and associated seagrass pasture disturbances (Meager and Limpus, 2012).

Figure 31. Relative dugong density along the Queensland coast from Torres Strait to Moreton Bay.



Source. After Grech et al. (2011). Modeled distribution of relative animal density covers the spatial extend of aerial surveys conducted by James Cook University 1986-2005.

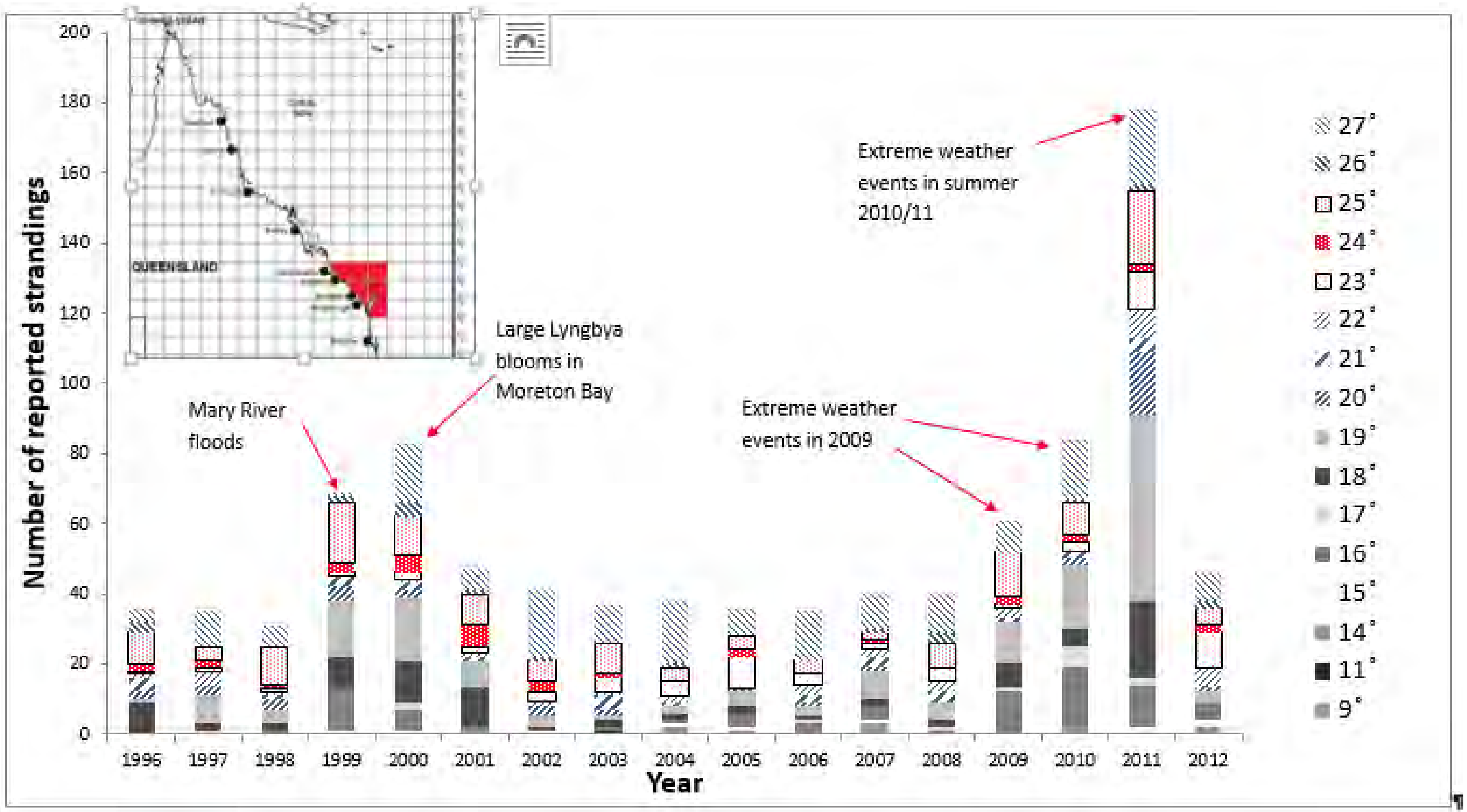
The Burnett Mary region and adjacent areas (23̊-25̊ latitude, in red) recorded around a quarter of all strandings recorded in Queensland per year, varying from 12.5% in 2007 to 41.9% in 1998.

Dugong population status

Historical estimates of dugong abundance along the Queensland coast prior to the dedicated aerial surveys are largely based on temporal changes in bycatch data from the Shark Control Program (Marsh *et al.*, 2005). This study showed that historical dugong population sizes exceeded current estimates. Overall, the available evidence suggests that dugong population size and relative density in Hervey Bay exceeds estimates for the southern GBR. The Hervey Bay population shows short-term fluctuations caused by local impacts such as seagrass die-offs and animal movements.

Although relative dugong density in the Rodd's Bay region is lower than in Hervey Bay, observations of dugong feeding trails during seagrass surveys showed that dugongs use the Rodd's Bay seagrass meadows for feeding (data provided by M. Rasheed summarised in Sobtzick *et al.* (2013). The

Figure 32. Annual reported dugong strandings in Queensland by latitudinal increments.



Note: For locations refer to insert. Dugong taken during indigenous hunting activities have been excluded. Strandings reported from 23˚-25˚ latitude (Burnett Mary region and adjacent areas) are highlighted in red and bordered in black. No strandings have been reported for 10˚, 12˚, 13˚, and 28˚ latitude.

Source: Data from Meager and Limpus (2012).

seagrass meadows in Rodd's Bay stand halfway between the important dugong habitats in Shoalwater Bay and Hervey Bay. As those areas are approximately 400 km apart, the Rodd's Bay region is important in maintaining the interchange of dugongs between central and south-east Queensland. A recent study by Blair (2012), based on mitochondrial sequences and microsatellites, suggested that dugongs between Shoalwater Bay and Moreton Bay are genetically connected while there is a distinct break in the dugong population structure between about Shoalwater Bay and Townsville. Tagging studies have shown movements of individual dugongs between Shoalwater Bay and Hervey Bay (Sheppard *et al.*, 2006), further suggesting population connectivity between these locations.

The establishment of DPAs in response to the decline of dugong populations along the Queensland coast and the establishment of green zones have been key strategies to protect dugongs from direct impacts such as netting and boat strikes. However, protected areas in the Great Barrier Reef World Heritage Area are under threat from landbased activities in the adjacent Great Barrier Reef catchment that affect water quality, particularly in coastal areas (Schaffelke *et al.*, 2002). Deterioration in water quality can have direct effects on the health of the animals, or indirect effects through adverse impacts on the quantity and quality of seagrass, the animals' main food source. To manage protected areas effectively, water quality-related problems need to be addressed (Schaffelke *et al.*, 2002).

Threat Table 5. Dugong in the Burnett Mary region.

Threat	Level of Impact*	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
Sediment	H	30
Nutrients	M	15
Pesticides	M	15
Coastal Development	L	5
Shipping/Boating	M	15
Climate Change	L	5
Other: Netting – SCP and commercial	M	15
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

CETACEANS

Status and Trends of Cetaceans in the Burnett Mary region:

- There are approximately 30 species of whales and dolphins found in the GBRWHA that are considered likely to occur in the Burnett Mary region. High priority species (GBRMPA) in the region are;
  - humpback whale (vulnerable)
  - dwarf minke whale (No Category Assigned-insufficient info)
  - Australian snubfin dolphin (NCA-insufficient info)
  - Indo-Pacific humpback dolphin (NCA-insufficient info) Great Sandy Strait is considered a key locality for this species with two communities present
- The later two are coastal species with increased vulnerability to water quality decline
- The Southern right whale is not recorded from the GBRMP but, along with humpback whales, are the most commonly sighted whales in the Burnett Mary region.
- Risso's Dolphin - Fraser Island has the only known 'resident' population in Australia

There are approximately 30 species of whales and dolphins found in the Great Barrier Reef World Heritage Area which are also considered likely to occur in the Burnett Mary region. In addition the Southern right whale (*Eubalaena australis*) has also been recorded in Hervey Bay but this is considered a rare occurrence (Australian Government, 2014). The species of cetaceans likely to occur in the Hervey Bay region are listed in Table 8. Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Great Barrier Reef Marine Park Regulations 1983* all cetaceans (whales, dolphins and porpoises) are protected in Australian waters (GBRMPA, 2007).

The GBRMPA currently considers four species to be a high priority for management; the humpback whale (*Megaptera novaeangliae*), dwarf minke whale (*Balaenoptera acutorostrata* subspecies), Australian snubfin dolphin (*Orcaella heinsohni*) and Indo-Pacific humpback dolphin (*Sousa chinensis*) (GBRMPA, 2007). In the case of humpback and dwarf minke whales they are considered a high priority due to commercial tourism. In the case of the coastal dolphin species, Australian snubfin dolphin and Indo-Pacific humpback dolphin, they are considered a high priority due to evidence of decline in population numbers which may be due to anthropogenic activities including boating, netting and declining water quality (GBRMPA, 2007).

In Queensland marine stranding and mortality data for cetaceans from 2008 to 2011 indicated 72 to 91% of records occurred in southern Queensland, between Hervey Bay and the Gold Coast (Meager *et al.*, 2012).

Priority Species for the Great Barrier Reef Marine Park

Humpback whales (*Megaptera novaeangliae)* have been protected in the southern hemisphere since 1963 when their population was as low as 500 animals (GBRMPA, 2011a). Since the early 1980's the east coast population has rapidly increased in size and the population estimate for 2011 is 14,600 whales, based on a long-term average rate of increase of 10.9% per annum (Smith *et al.*, 2011). They are still considered a vulnerable species (Table 8) with their population in 2008 estimated to be more than 10,000 animals which is half of the estimated pre-whaling population size (GBRMPA, 2011a).

Humpback whales migrate from feeding grounds in southern waters to the Great Barrier Reef region to breed from June to October. Once the calves are born they travel south again with their mothers (July to November). On this annual southern migration they usually stop and rest or play in Hervey Bay for several days as it is sheltered by Fraser Island. Many humpback whales frequent Hervey Bay over multiple years (Rock *et al.*, 2006) and it is one of the ten top whale watching locations in Australia (Australian Geographic, 2014).

The humpback is protected in the waters of the Great Barrier Reef World Heritage Area and is listed as vulnerable under both the *Environment Protection and Biodiversity Conservation Act 1999* and *Queensland's Nature Conservation (Wildlife) Regulation 2006* (GBRMPA, 2011a).

Table 8. Conservation Status of cetacean species likely to occur in the Burnett Mary region.

Common Name	Scientific Name	Conservation Status [*1]
Dolphins: ***Family Delphinidae***		
Australian snubfin dolphin	*Orcaella heinsohni*	Insufficiently known
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	NCA (a)
Bottlenose dolphin	*Tursiops truncatus*	NCA (a)
False Killer whales	*Pseudorca crassidens*	NCA (a)
Fraser's dolphin	*Lagenodelphis hosei*	NCA (a)
Indo-Pacific humpback dolphin	*Sousa chinensis*	Insufficiently known
Killer whale	*Orcinus orca*	NCA (c)
Long beaked common dolphin	*Delphinus delphis*	NCA (b)
Long-finned pilot whale	*Globicephala melas*	NCA (b)
Melon headed whale	*Peponocephala electra*	NCA (b)
Pantropical spotted dolphin	*Stenella attenuata*	NCA (a)
Pygmy killer whale	*Feresa attenuata*	NCA (a)
Risso's dolphin	*Grampus griseus*	NCA (a)
Rough-toothed dolphin	*Steno bredanensis*	NCA (a)
Short beaked common dolphin	*Delphinus delphis*	NCA (b)
Short-finned pilot whales	*Globicephala macrorhynchus*	NCA (c)
Spinner Dolphin	*Stenella longirostris*	Insufficiently known
Striped dolphin	Stenella coeruleoalba	NCA (a)
Whales: ***Family Physeteridae***		
Sperm Whales	*Physeter macrocephalus*	Insufficiently known
Family Kogidae		
Dwarf sperm whale	Kogia simus	NCA (a)
Pygmy sperm whale	Kogia breviceps	NCA (a)
Family Ziphidae		
Blainville's beaked whale	*Mesoplodon densirostris*	NCA (a))
Cuvier's beaked whale	*Ziphius cavirostris*	NCA (b)
Longman's beaked whale	*Mesoplodon pacificus*	NCA (a)
Strap-toothed (Layard's) beaked whale	*Mesoplodon layardii*	NCA (b)
Family Balaenopteridae		
Dwarf minke whale	*Balaenoptera acutorostrata* subsp.	NCA (a)
Fin whale	*Balaenoptera physalus*	Vulnerable
Humpback whale	*Megaptera novaeangliae*	Vulnerable
Sei whale	*Balaenoptera borealis*	Vulnerable
Blue whale	*Balaenoptera musculus musculus*	Endangered
Pygmy blue whale	*Balaenoptera musculus brevicauda*	NCA (a)
Bryde's whale	*Balaenoptera edeni*	NCA (a)
Antarctic minke whale	*Balaenoptera bonaerensis*	
Family Balaenidae		
Southern right whale*3	*Eubalaena australis*	Vulnerable

Source : (Australian Government, 2014; Bannister *et al.*, 1996; Lawler *et al.*, 2007)
Vulnerable: As defined by IUCN.
Insufficiently known: As defined by IUCN, and involving a *suspicion* that the species or subspecies may belong to any of the above.
No Category Assigned (NCA)
Where there is no firm basis on which to infer a significant threat, past or present.
(a) because of insufficient information It thus differs from the IUCN category insufficiently known.
(b) but possibly secure but there are general indications of wide distribution and abundance.
(c) but probably secure but reasonably objective assessment exists of numbers in the wild.

In 2008 65,000 tourists were recorded by ten commercial operators on whale watching trips in Hervey Bay with a direct ticket revenue of $5.9 million (O'Connor *et al.*, 2009) and an estimated indirect expenditure of $7.0 million (Knowles and Campbell, 2011).

Dwarf minke whales *(Balaenoptera acutorostrata subspecies)* is an undescribed subspecies of *Balaenoptera acutorostrata*, the northern hemisphere minke whale, (Arnold *et al.*, 1987) to which it is more closely related than the Antarctic minke whale, *Balaenoptera bonaerensis,* also present on the east coast of Australia. Minke whales usually migrate between cold water feeding grounds and breeding grounds in warmer water (Bannister *et al.*, 1996) and dwarf minke whales have been recorded from Victoria to northern Queensland during May to December (Arnold *et al.*, 1987).

Australian snubfin dolphin (*Orcaella heinsohni*)**,** formally known as the Irrawaddy River Dolphin, (*Orcaella brevirostris*) is a coastal, estuarine and riverine species in tropical and subtropical areas which, in shallow areas, may occur several kilometres from shore. There is anecdotal evidence that Australian snubfin dolphins are less common in the GBR region today, however, this is difficult to confirm without long term monitoring studies (GBRMPA 2007).This species has been recorded north of Gladstone (23°50'S) however may not occur in the Burnett Mary region (Bannister *et al.*, 1996).

The Indo-Pacific humpback dolphin (*Sousa chinensis*) form small, localised populations in coastal, estuarine and sometimes riverine habitats and are not known to be highly migratory (GBRMPA, 2007). Aerial surveys of the GBR region recorded a decline in sightings of these dolphins between 1987 and 1995 (GBRMPA, 2007). They are not known to be a migratory species and the Great Sandy Strait is considered a key locality for this species as they are regularly seen there (Bannister *et al.*, 1996). Two communities of Indo-Pacific humpback dolphin have been identified in the Great Sandy Strait, a northern community and a southern community (Cagnazzi *et al.*, 2011).

Also Recorded from the Great Barrier Reef Marine Park

Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*) and **Bottlenose Dolphin** (*Tursiops truncatus*) are both found in this area and were considered two subspecies of *Tursiops truncatus* (Bannister *et al.*, 1996). *T. aduncus* is generally considered a warm water, inshore species whereas *T. truncatus* is usually found in colder and deeper waters. They are coastal, estuarine, pelagic and oceanic and usually in tropical to temperate areas (Bannister *et al.*, 1996). Where *T. aduncus* occurs in the same geographical area as *Sousa chinensis* it occurs slightly further offshore but often in water of <10 m depth, and may range to approximately 10 km offshore in oceanic waters. Live capture of this species is currently permitted in Queensland, for up to 12 individuals per year.

No accurate population estimates of bottlenose dolphins, with confidence intervals, are available anywhere in Australia however a mimimum estimate of a local population of 334 in Moreton Bay (south of Hervey Bay) has been calculated from photo-identification studies (Bannister *et al.*, 1996).

False killer whale (*Pseudorca crassidens*) prefer tropical to temperate oceanic waters, approaching close to land only where the continental shelf is narrow, possibly attracted to zones of enhanced prey abundance along the continental slope. There are no population assessments available for southern hemisphere populations.

Killer whale (*Orcinus orca*) are oceanic, pelagic and neritic, in warm and cold waters and are not known to be migratory however seasonal movements may occur, possibly related to food supply.

Melon-headed whale (*Peponocephala electra)* is primarily a tropical and subtropical species that is pelagic and oceanic and generally found in upwelling areas. It may be more common in Australian waters than records suggest. In August 1976 there was a mass stranding of 53 melon-headed whales at Moreton Island, south of Hervey Bay (Bannister *et al.*, 1996).

Pan-tropical spotted dolphin (*Stenella attenuata*) is a pelagic and oceanic species of which little is known. In other areas they are known to seasonally migrate, north/south off Japan and inshore/offshore in the eastern tropical Pacific (Bannister *et al.*, 1996). In a past offshore gill-net fishery off northern Australia the incidental catch of dolphins suggests that there are fewer pan-tropical spotted dolphins than bottlenose and spinner dolphins (Bannister *et al.*, 1996). Studies conducted in the eastern tropical Pacific indicate that this species has declined most likely as a result of by-catch in purse-seine netting operations (Bannister *et al.*, 1996).

Pygmy killer whale (*Feresa attenuata)* is a little known species of tropical and subtropical waters which is possibly pelagic and generally found in areas where water temperatures are 18°C or greater (Bannister *et al.*, 1996).

Risso's Dolphin (*Grampus griseus)* is generally considered a pelagic and oceanic species in tropical, subtropical, temperate and subantarctic waters but seasonal migrations are considered likely (Bannister *et al.*, 1996). There are no estimates of abundance available however they are considered to be reasonably abundant throughout the main part of their range. Fraser Island has the only known 'resident' population of Risso's Dolphin in Australia (Bannister *et al.*, 1996).

Common dolphin *(Delphinus delphis)* is a short-beaked form which is found in Queensland, both nearshore and offshore. A second long-beaked form, which is likely to be a separate species, *D. capensis, is* usually found nearshore, however, there is unconfirmed evidence of its presence in Queensland waters (Bannister *et al.*, 1996). Very few records from tropical regions around Australia may not truly reflect distribution as this species has common occurrence in tropical habitats elsewhere (Bannister *et al.*, 1996).

Short-finned pilot whale (*Globicephala macrorhynchus*) are widespread and apparently common however there is no information on numbers or trends in southern hemisphere populations. At other locations studied groups exhibit seasonal inshore–offshore movements, apparently in response to abundance and spawning of prey and this is considered likely in Australia. They have been recorded during cetacean aerial surveys off Fraser Island (Bannister *et al.*, 1996).

Spinner dolphin (*Stenella longirostris)* is a very acrobatic and playful species which can leap and spin in the air and often ride the bow waves of boats. There are generally considered common and are not known to be migratory. They are often seen with tuna, pan-tropical spotted dolphin and sea birds and the stomach contents of animals studied in northern Australia have contained reef-living and benthic organisms (Bannister *et al.*, 1996).

Blainville's beaked whale (*Mesoplodon densirostris)* apparently prefers tropical (ca 22–32°C) to temperate (ca 10–20°C) oceanic regions; sighted in waters 700–1000 m deep, adjacent to much deeper waters of 5000 m (Bannister *et al.*, 1996).

Additional species in the Burnett Mary region

Southern right whale (*Eubalaena australis*) is generally found in southern areas approximately between 30^o – 60^{o}S where it feeds in summer and, like the humpback whale, migrates to lower latitudes to breed in winter where calving females are found close to the coast (Bannister *et al.*, 1996). The southern right whale was grossly targeted by pelagic and shore-based whaling operations particularly in the 1800's, but still into the 1960's, such that only a remnant population remained which is only slowly increasing as breeding is only once every three years (Bannister *et al.*, 1996).

Current threats to cetaceans in the Burnett Mary region include

There is limited knowledge of the biology and status of most Australian cetaceans consequently it is extremely difficult to assess whether populations are declining, stable or increasing (GBRMPA, 2007) or evaluate the extent to which the following threats actually impinge on a species or population of cetaceans (Bannister *et al.*, 1996). Perhaps the biggest threat to cetacean populations are off-shore as a result of either overseas fisheries targetting cetaceans such as drive fishery operates in the Solomon Islands and gill netting Philippine or as bycatch in overseas fisheries in Taiwan, Thailand, the Philippines and the eastern tropical Pacific that use gill-nets or purse-seine nets. These threats are not considered in this assessment of current threats to cetaceans in the Burnett Mary region.

The Shark Control Program (SCP) was the main cause of mortality to cetaceans in Queensland between 2008 and 2011 (Meager *et al.*, 2012) with *D. delphis* and *Tursiops spp* the predominant dolphin species caught and humpback whales also being caught. There are also incidences of illegal and incidental catches of cetaceans in the GBRMP (Meager *et al.*, 2012).

The current threats to cetaceans in the Burnett Mary region are:

Habitat destruction and degradation

Anthropogenic changes such as dredging and estuarine and coastal infrastructure are likely to impact cetaceans that are dependent on coastal and offshore habitats in the Burnett Mary region, in particular inshore coastal species such as the Indo-Pacific humpback dolphin and Australian snubfin dolphin (GBRMPA, 2007). Species such as the humpback whale do not feed in Hervey Bay are, however, present as lactating females which may make them more susceptible to habitat disturbance (GBRMPA, 2007).

Direct disturbance of cetaceans on their migratory path, as in Hervey Bay, can occur as a result of whale watching and research vessels/aircraft, pleasure craft, swimmers and divers. To mimimise such disturbance the GBRMPA has implemented operational guidelines under the *Great Barrier Reef Marine Park Regulations 1983* (GBRMPA, 2007). Increased maritime traffic increases noise pollution which may be detrimental to cetaceans which communicate and navigate by sonar and such interference may be the cause of strandings (Bannister *et al.*, 1996).

Overfishing of prey species

Cetaceans generally feed on patchy resources of fishes and cephalopods (mainly squid) throughout the water column in estuarine and marine environments however some dolphins in the GBR are known to also eat benthic and pelagic organisms (Lawler *et al.*, 2007). Decreases in the availability or abundance of prey species will influence cetacean distribution as they are large, mobile marine vertebrates in high trophic levels, consuming relatively large quantities of food relative to their body size (Lawler *et al.*, 2007) Conversely they can also ‘profoundly affect their prey populations, which in turn may result in significant influence on food-web interactions (ie trophic cascades), and ecosystem function and structure’ (Lawler *et al.*, 2007, p.500). Overfishing of prey species in this region is irrelevant to some species, such as humpback whales and southern right whales, as they are not known to feed in this region.

Water Quality

Pollution in the Burnett Mary region is probably the most significant threat to cetaceans including chemical and heavy metal contamination, oil spills, plastic debris at sea. As cetaceans are mid- to high trophic level predators in the food web, they are particularly vulnerable to any broad-scale changes that have medium to long-term adverse effects on marine environments (Bannister *et al.*, 1996). High levels of mercury (natural contamination) and DDT, Dieldrin and PCBs have been recorded for spinner dolphins (*S.longirostris)* from outside Australian waters (Bannister *et al.*, 1996).

Organochlorines (particularly PCBs) from agricultural areas are a serious potential threat, especially to coastal species such as the Australian snubfin dolphin (*Orcaella heinsohni*) and the Indo-Pacific humpback dolphin (*Sousa chinensis*) (Bannister *et al.*, 1996). Bioaccumulation of toxic substances in cetacean body tissues and very high levels of organochlorines, probably sufficiently high to kill a female’s first calf, occur in South African animals (Bannister *et al.*, 1996). Similar high pollutant loads may occur in Australian dolphins in resident populations close to major urban, industrial and agricultural centres, such as Moreton Bay however the highest levels reported in Australia to date (few available) are an order of magnitude less than those recorded in South Africa (Bannister *et al.*, 1996).

Pathogen pollution has been shown to have negative effects on populations of coastal marine mammals for example between 2000 and 2001 three humpback dolphin carcasses (*Sousa chinensis)* were recovered in the Townsville region and all were infected by *Toxoplasma gondii* (Bowater *et al.*, 2003). *Toxoplasma gondii* is a terrestrial parasite which is thought to be transported to the coastal environment by water contaminated with oocysts from cat faeces or litter (Miller *et al.*, 2002).

Climate Change

The risk of ocean acidification to marine mammals is considered minor however may have an indirect effect on the distribution of prey species such as squid, a preferred food source of many cetaceans, which are extremely sensitive to changes in pH (Pörtner et al, 2004 in (Lawler *et al.*, 2007)). It is difficult to predict species-specific responses to changes in sea temperature, due to limited knowledge of the seasonal distribution of cetaceans in the Great Barrier Reef, however distributional shifts and changes in social behaviour have been documented elsewhere (Lawler *et al.*, 2007).

More intense cyclones, predicted with climate change, are only likely to affect coastal species which are not able to avoid physical disturbance by diving and are more likely to be stranded should storm surges occur, particularly where high density populations of coastal species coincide with a high tide (Lawler *et al.*, 2007).

Dolphins in the GBR are opportunistic-generalist feeders, eating a wide variety of coastal, estuarine and reefal fishes, cephalopods (mainly squid) and benthic and pelagic crustaceans. Their distribution is dependent on prey availability so climate change effects on prey species will result to changes to their distribution making coastal species particularly vulnerable (Lawler *et al.*, 2007).

Threat Table 6. Cetaceans in the Burnett Mary region.

Threat	Level of Impact*	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
Sediment	VL	5
Nutrients	VL	5
Pesticides	VL	5
Coastal Development inc. Habitat destruction and	L	15
Shipping	L	10
Climate Change	L	20
Other: Overfishing of prey species	H	40
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

TURTLES

Status and Trends of Turtles in the Burnett Mary region:

- Six of the world's seven sea turtle species have been recorded in the Burnett Mary region
- The most significant loggerhead turtle (Endangered) nesting population in the South Pacific Ocean region and successful breeding here is critical for species survival. Approximately 300 females nest at Mon Repos, Bundaberg every year.
- The southern stock of Green turtle (Vulnerable) nests primarily in the Capricorn/Bunker group with an average annual nesting population estimated at 8000 females.
- low density nesting of Flatback turtles (Vulnerable) occur on the Bundaberg coast.
- The olive ridley turtle (Endangered) and hawksbill turtle (Vulnerable) have also been recorded in the region and the leatherback turtle (Endangered) has been recorded as nesting in the region (rare).

Six of the world's seven sea title species have been recorded in the Burnett Mary region (Table 9). Sea turtles are protected under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) and various State and Northern Territory legislation (Australian Government, 2014). Aboriginal and Torres Strait Islander people may legally hunt turtles for personal, domestic or non commercial communal needs under Section 211 of the *Native Title Act 1993. The National Recovery Plan for Marine Turtles in Australia* was adopted in July 2003 which 'provides for research and management actions necessary to stop the decline and support the recovery of marine turtles so that their chances of long-term survival in nature are maximised' (Australian Government, 2014).

Internationally these species are listed in the *IUCN (World Conservation Union) Red List of Threatened Animals*, *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), and *Convention on the Conservation of Migratory Species of Wild Animals* (CMS, also known as the Bonn Convention) (Australian Government, 2014). Australia is also a signatory to the *CMS Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia* (IOSEA MoU) the purpose of which is to facilitate national and transboundary actions to conserve turtle populations and their habitats (Australian Government, 2014).

Table 9. Conservation Status of Marine Turtles in the Burnett Mary region.

Common Name	Species Name	Conservation Status[1*]	# breeding females in BMR
Family: Cheloniidae			
Flatback turtle	*Natator depressus*	Vulnerable	Low
Green turtle	*Chelonia mydas*	Vulnerable	~8,000
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable	No
Loggerhead turtle	*Caretta caretta*	Endangered[1*]	~ 500
Olive Ridley turtle	*Lepidochelys olivacea*	Endangered[1*]	No
Family: Dermochelidae			
Leatherback turtle	*Dermochelys coriacea*	Endangered[1*]	Unlikely/Low

Endangered - these species may become extinct if the threats to their survival continue.
Vulnerable - may become endangered if threats continue.

Source: (Australian Government, 2014; GBRMPA, 2011a).

Turtle species

Loggerhead turtles (*Caretta caretta*) have a large head and thick jaw which is used to crush crustaceans and molluscs (GBRMPA, 2011a) in their foraging grounds of coral and rocky reefs, seagrass beds and muddy bays and deeper soft-bottomed habitats of the continental shelf (Australian Government, 2014). Extensive foraging area surveys have been conducted at Heron Island Reef (commenced in 1974) and the number of loggerhead turtles feeding here has been found to decline by ~3% per year (Limpus et al., 1994 in Chaloupka, 2003; Chaloupka and Limpus, 2001).

Two of their three major nesting areas of loggerhead turtles in Queensland are Mon Repos, and adjacent beaches of the Woongarra Coast and Wreck Rock Beach, and the Capricorn-Bunker Group islands (Australian Government, 2014). In 2000 it was estimated that there were 500 nesting females per year in eastern Australia and adult females comprise approximately 20% of the population and their actual annual breeding rates have been found to vary between 0 and 73% (Limpus & Limpus, 2003 in (Australian Government, 2014)). Females tagged at these rookeries have been recorded in waters off Indonesia, Papua New Guinea, Solomon Islands, New Caledonia, Northern Territory, Queensland and NSW (Limpus 2008a in (Australian Government, 2014)).

Green turtles (*Chelonia mydas*) have a smooth, high-domed carapace and are the most abundant marine turtle species on the GBR where there are two genetic stocks; a southern and a northern stock (GBRMPA, 2011a). They are found in subtidal and intertidal coral and rocky reefs and seagrass meadows of the continental shelf and are mostly herbivorous as adults, eating algae, seagrass, mangrove fruit and jellyfish (GBRMPA, 2011a). The Capricorn Bunker group, Hervey Bay and Great Sandy Straits are important foraging grounds and juvenile habitat for green turtles in Queensland (Australian Government, 2014).

In the Burnett Mary region the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) are in the Capricorn Bunker group with an average annual nesting population estimated at 8000 females (GBRMPA, 2011a) and a smaller site is at Mon Repos (Australian Government, 2014).

Flatback turtles (*Natator depressus*) have a low domed, smooth carapace covered by a thin skin that has upturned edges and the bottom of the shell is white (Australian Government, 2014). They have a distribution limited to the tropical continental shelf waters of northern Australia, Papua New Guinea and Indonesia and are one of only two species of sea turtle without a global distribution (Australian Government, 2014). They inhabit subtidal soft-bottomed habitats of the continental shelf and feed on benthic organisms including soft corals, sea pens and jellyfish (GBRMPA, 2011a). Flatback turtles only nest in Australia and in the Burnett Mary region there is a minor nesting site located at Mon Repos near Bundaberg (Australian Government, 2014). Hatchling flatback turtles are the largest hatchlings of any marine turtle and are also unique as the hatchlings are believed to inhabit inshore areas of clear reefal waters and no oceanic pelagic phase, common to other species of sea turtle, is apparent (Australian Government, 2014). Numbers of the east coast population of flatback turtles appear to be stable however this species is listed as Vulnerable (Table 9).

Hawksbill turtles (*Eretmochelys imbricate*) have a carapace with overlapping dark-brown scutes and a narrow head with a beak-like mouth which they can use to prise food from crevices in and around coral (GBRMPA, 2011a). They feed in rocky areas and on coral reefs primarily on sponges but also on seagrasses, algae, sea cucumbers, soft corals and shellfish (GBRMPA, 2011a). Hawksbill turtles and found, but are not known to nest in, the Burnett Mary region.

Olive Ridley turtles (*Lepidochelys olivacea*) are the smallest of the marine turtles and have a heart shaped carapace (GBRMPA, 2011a). They feed in continental shelf waters on organisms such as crabs, echinoderms, shellfish and gastropods in soft-bottomed, shallow, protected waters (GBRMPA, 2011a). They are uncommon in the GBR and no nesting of this species occurs in the Burnett Mary region.

Leatherback turtles (*Dermochelys coriacea*) are the largest sea turtle species with adult females having a mean curved carapace length of 1.6 m and has a soft leathery skin with five ridges running down its back (GBRMPA, 2011a). They feed in temperate waters but breed in tropical areas and nesting has occasionally occurred in the Burnett Mary region at Wreck Rock, near Deepwater National Park north of Bundaberg and adjacent beaches near Bundaberg (GBRMPA, 2011a), however, there is a strong likelihood that no Leatherback Turtles have nested in Queensland since 1996 (Hamann et al. 2006 in (Australian Government, 2014).

Threats

All marine turtle species are experiencing serious threats to their survival. The main threats are pollution and changes to important turtle habitats, especially coral reefs, seagrass beds, mangrove forests and nesting beaches. Other threats include accidental drowning in fishing gear, over-harvesting of turtles and eggs, and predation of eggs and hatchlings by foxes, feral pigs, dogs and goannas. (Australian Government, 2014).

Threat Table 7. Turtles in the Burnett Mary region.

Threat	Level of Impact	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
Sediment	M	10
Nutrients	M	10
Pesticides	M	10
Coastal Development	H	25
Shipping	L	5
Climate Change	M	10
Other: Netting	M	15
Predation of eggs by introduced spp.	M	15
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

SEABIRDS

Status and Trends of Seabirds in the Burnett Mary region:

- Internationally and nationally important wetlands habitat for shorebirds, waterbirds, waders and seabirds particularly in the Great Sandy Strait.
- Approximately 400 species of birds in Great Sandy Strait. Counts between 30 000 and up to 40 000 shorebirds were recorded in 1990 including in excess of 20 000 migratory shorebirds.
- Of these seabirds 22 are considered nationally threatened species and approximately 50 are considered Migratory Marine, Terrestrial or Wetland species.
- At least 30 species are listed under each international JAMBA, CAMBA, ROKAMBA agreement.

The Burnett Mary region encompasses the Great Sandy Strait which is recognised as a wetland of international significance in the '*Convention on Wetlands of International Importance*' or '*Ramsar Convention*' (Davis, 1994). It is an exceptionally important feeding ground, supporting in excess of 20 000 migratory shorebirds and also important for many other non-migratory shorebirds, waterbirds, waders and seabirds (Queensland Government, 1999). Counts between 30 000 and up to 40 000 shorebirds were recorded in 1990 (Queensland Government, 1999). They are recognised as among the most important roosting areas for migratory trans-equatorial shorebirds in Australia (Queensland Government, 1999). Intertidal areas cover large areas and are particularly important for waders, particularly near seagrass beds (Queensland Government, 1999). Locations of high tide roosting sites in the Great Sandy Strait (Figure 33) have been identified by the Queensland Wader Study Group (QWSG) (Harding et al, 2005).

There are approximately 400 species of birds in the Great Sandy Stait (Appendix 2). At least 22 of the marine species are considered nationally threatened species and approximately 50 are considered Migratory Marine, Terrestrial or Wetland species (Table 10). At least 30 of these species are listed under each international JAMBA, CAMBA, ROKAMBA agreement which are treaties between Australia and Japan, China and Korea respectively.

The wetlands support substantial numbers of particular shorebird species with 17 species with 4% or more of their State totals being recorded for the region and maximum numbers recorded for several species including Grey-tailed Tattler (42%), Eastern Curlew (33%), Bar-tailed Godwit (27%), Greenshank (24%) and Terek Sandpiper (21%) (Queensland Government, 1999). The area also supports a high percentage of the world population of several species including Eastern Curlews (19.6%), Grey-tailed Tattlers (16.2%), Lesser Sand Plovers (5.5%), Terek Sandpipers (5.0%), Whimbrels (3.8%), Bar-tailed Godwits (3.7%), Pied Oystercatchers (3.2%), Greenshanks (2.6%) and Grey Plovers (1.6%) (Queensland Government, 1999).

Wetlands along Great Sandy Strait support an appreciable number of yearling eastern curlews (*Numenius madagascariensis*) which do not migrate in their first winter and are listed as Rare under the *Nature Conservation Act 1992 (Queensland).* The Great Sandy Strait is a site of international significance for this species with the highest number of non-breeding eastern curlews being recorded here on their southern migration (Australian Government, 2014). In Queensland they are listed as a Near Threatened species and are, at a national level, recorded on the following legislative instruments; *List of Migratory Species* (13/07/2000); *Environment Protection and Biodiversity Conservation Act 1999 - List of Marine Species* (Section 248), *Environment Protection and Biodiversity Conservation Act 1999 - Listed Migratory Species - Approval of an International Agreement (Bonn, 1979)*.

Other coastal locations in the Burnett Mary region, such as Rodds Bay, are likely to provide roosting and feeding grounds for many of the same species found in the Great Sandy Strait however limited data is available for these sites.

Table 10: Nationally threatened and Migratory Marine, Terrestrial and Wetland bird species.

Common Name	Species Name	[c]Status	[b]Resource Information	Species					Australian Treaty		
				[c]Threat-ened	Migratory						
					[d]Marine	[e]Terrestrial	[f]Wetland	[g]Listed	[h]JAMBA	[i]CAMBA	[j]ROKAMBA
Albatross, Antipodean	*Diomedea exulans antipodensis*	*Vulnerable*	*B*	✓	✓			✓			
Albatross, Black-browed	*Thalassache melanophris*	*Vulnerable*	*B*	✓	✓			✓			
Albatross, Campbell	*Thalassache melanophris impavida*	*Vulnerable*	*B*	✓	✓			✓			
Albatross, Chatham	*Thalassache eremita*	*Endangered*	*B*	✓	✓			✓			
Albatross, Gibson's	*Diomedea exulans gibsoni*	*Vulnerable*	*B*	✓	✓			✓			
Albatross, Salvin's	*Thalassache cauta salvini*	*Vulnerable*	*B*	✓	✓			✓			
Albatross, Shy	*Thalassache cauta cauta*	*Vulnerable*	*B*	✓	✓			✓			
Albatross, Tristan	*Diomedea exulans exulans*	*Endangered*	*B*	✓	✓			✓			
Albatross, Wandering	*Diomedea exulans (sensu lato)*	*Vulnerable*	*B*	✓	✓			✓			
Albatross, White-capped	*Thalassache cauta steadi*	*Vulnerable*	*D*	✓	✓			✓			
Avocet, Red-necked	*Recurvirostra novaehollandiae*		*F*					✓			
Bee-eater, Rainbow	*Merops ornatus*		*B*					✓			
Bittern, Australasian	*Botaurus poiciloptilus*	*Endangered*	*A*	✓							
Curlew, Eastern	*Numenius madagascariensis*		*F*				✓	✓	✓	✓	✓
Curlew, Little (Little Whimbrel)	*Numenius minutus*		*F*				✓	✓	✓	✓	✓
Dowitcher, Asian	*Limnodromus semipalmatus*	*Threatened*	*F*					✓		✓	✓
Egret, Cattle	*Ardea ibis*		*E*				✓	✓	✓	✓	
Egret, Great, White Egret	*Ardea alba*		*E*				✓	✓	✓	✓	
Fantail, Rufous	*Rhipidura rufifrons*		*A*					✓			
Fig-Parrot, Coxen's	*Cyclopsitta diophthalma coxeni*	*Endangered*	*A*	✓					✓		
Finch, Star (eastern and southern)	*Neochmia ruficauda ruficauda*	*Endangered*	*C*								
Finch, Black-throated (Southern)	*Poephila cincta cincta*	*Endangered*	*C*	✓							
Flycatcher, Satin	*Myiagra cyanoleuca*		*A*					✓			
Giant-Petrel, Northern	*Macronectes halli*	*Vulnerable*	*B*	✓	✓			✓			
Giant-Petrel, Southern	*Macronectes giganteus*	*Endangered*	*B*	✓	✓			✓			
Godwit, Bar-tailed	*Limosa lapponica*		*F*				✓	✓	✓	✓	✓
Godwit, Black-tailed	*Limosa limosa*		*F*				✓	✓	✓	✓	✓
Goshawk, Red	*Erythrotriorchis radiatus*	*Vulnerable*	*A*	✓					✓		
Knot, Great	*Calidris tenuirostris*	*Threatened*	*F*				✓	✓	✓	✓	✓
Knot, Red Knot	*Calidris canutus*		*F*				✓	✓	✓	✓	✓
Magpie Goose	*Anseranas semipalmata*		*B*					✓			
Monarch, Black-faced	*Monarcha melanopsis*		*A*					✓			
Monarch, Spectacled	*Monarcha trivirgatus*		*A*					✓			
Needletail, White-throated	*Hirundapus caudacutus*		*A*					✓		✓	✓
Osprey	*Pandion haliaetus*		*E*					✓			
Petrel, Kermadec (western)	*Pterodroma neglecta neglecta*	*Vulnerable*	*D*	✓							
Plover, Double-banded	*Charadrius bicinctus*		*F*				✓	✓			
Plover, Greater Sand, (Large Sand Plover)	*Charadrius leschenaultii*		*F*				✓	✓	✓	✓	✓
Plover, Grey	*Pluvialis squatarola*		*F*				✓	✓	✓	✓	✓

Common Name	Species Name	[c]Status	[b]Resource Information	Species					Australian Treaty		
				[c]Threat-ened	Migratory						
					[d]Marine	[e]Terrestrial	[f]Wetland	[g]Listed	[h]JAMBA	[i]CAMBA	[j]ROKAMBA
Plover, Lesser Sand (Mongolian Plover)	*Charadrius mongolus*		*F*				✓	✓	✓	✓	✓
Plover, Pacific Golden	*Pluvialis fulva*		*F*				✓	✓			
Plover, Red-capped	*Charadrius ruficapillus*		*F*					✓			
Practincole, Oriental	*Glareola maldivarum*		*F*				✓	✓	✓	✓	
Sanderling	*Calidris alba*		*F*				✓	✓	✓	✓	✓
Sandpiper, Broad-billed	*Limicola falcinellus*		*F*				✓	✓	✓	✓	✓
Sandpiper, Common	*Actitis hypoleucos*		*F*				✓	✓	✓	✓	✓
Sandpiper, Curlew	*Calidris ferruginea*		*F*				✓	✓	✓	✓	✓
Sandpiper, Marsh (Little Greenshank)	*Tringa stagnatilis*		*F*				✓	✓	✓	✓	✓
Sandpiper, Pectoral	*Calidris melanotos*		*F*					✓	✓		✓
Sandpiper, Sharp-tailed	*Calidris acuminata*		*F*				✓	✓	✓	✓	✓
Sandpiper, Terek	*Xenus cinereus*		*F*				✓	✓	✓	✓	✓
Sandpiper, Wood	*Tringa glareola*		*F*				✓	✓		✓	✓
Sea-Eagle, White-bellied	*Haliaeetus leucogaster*		*E*			✓		✓		✓	
Shearwater, Flesh-footed	*Puffinus carneipes*		*A*		✓			✓	✓		✓
Skua, Great	*Catharacta skua*		*B*					✓			
Snipe, Australian Painted	*Rostratula australis*	*Endangered*	*C*	✓			✓	✓		✓	
Snipe, Latham's ((Japanese Snipe)	*Gallinago hardwickii*		*F*				✓	✓	✓	✓	✓
Snipe, Pin-tailed	*Gallinago stenura*		*F*					✓	✓	✓	✓
Snipe, Swinhoe's	*Gallinago megala*		*F*					✓		✓	✓
Squatter Pigeon (southern)	*Geophaps scripta scripta*	*Vulnerable*	*A*								
Stilt, Black-winged	*Himantopus himantopus*		*F*					✓			
Stint, Long-toed	*Calidris subminuta*		*F*					✓	✓	✓	✓
Stint, Red-necked	*Calidris ruficollis*		*F*				✓	✓	✓	✓	✓
Storm-Petrel, White-bellied (Australasian	*Fregetta grallaria grallaria*	*Vulnerable*	*C*	✓							
Swallow, Barn	*Hirundo rustica*		*B*					✓	✓	✓	✓
Swift Parrot	*Lathamus discolor*	*Endangered*	*C*	✓				✓			
Swift, Fork-tailed	Apus pacificus	*Threatened*	*C*		✓			✓	✓	✓	✓
Tattler, Grey-Tailed	*Heteroscelus brevipes*		*F*				✓	✓	✓	✓	
Tattler, Wandering	*Heteroscelus incanus*		*F*					✓	✓		
Tern, Little	*Sterna aibifrons*		*B*					✓	✓	✓	✓
Turnstone, Ruddy	*Arenaria interpres*		*F*				✓	✓		✓	✓
Whimbrel	*Numenius phaeopus*		*F*				✓	✓	✓	✓	✓
Total	73			22	17	2	29	65	35	36	32

[a]Under Migratory Wetland Species listed as Painted Snipe *(Rostratula benghalensis (sens lato))*

[b] *A. Species or species habitat known to occur within area. B. Species or species habitat may occur within area. C. Species or species habitat likely to occur within area. D. Foraging, feeding or related behaviour may occur within area. E. Breeding known to occur within area. F. Roosting known to occur within area.*

[c] Derived from: Matters of Environmental Significance: Threatened Species.

[d] Derived from: Matters of Environmental Significance: Migratory Species: Migratory Marine Birds

[e] Derived from: Matters of Environmental Significance: Migratory Species: Migratory Terrestrial Species

[f] Derived from: Matters of Environmental Significance: Migratory Species: Migratory Wetland Species

[g] Derived from: Other Matters Protected by the EPBC Act: Listed Marine Species

[h] JAMBA

[i] CAMBA

[j] ROKAMBA

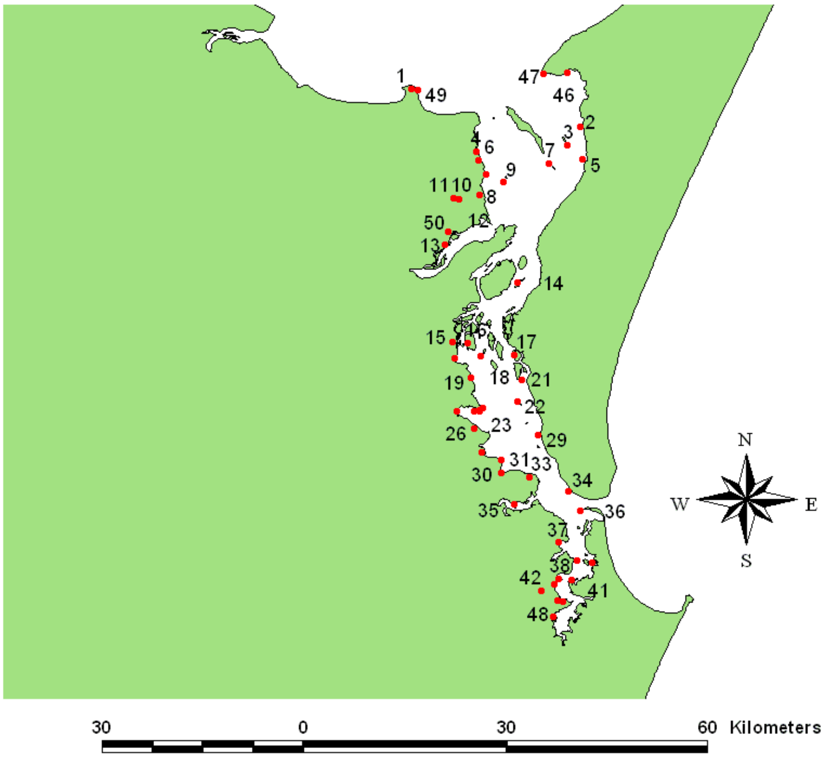


Figure 33. Map of the high tide shorebird roosts in Great Sandy Strait.

Source: (Harding et al, 2005).

The Capricorn-Bunker group of islands also contains nationally and internationally significant seabird breeding populations and represent 73 – 75% of the seabird biomass of the GBR (Congdon *et al.*, 2007). Over 97% of the black noddy population of the GBR is located in the Capricorn-Bunker group and the largest breeding colony in the Pacific Ocean of wedge-tailed shearwaters is also found there (Congdon *et al.*, 2007).

Threats

The most significant threat to seabirds in the Burnett Mary region is considered to be coastal development (Threat Table 8). Seabirds are also highly susceptible to slight changes in climate which effects timing of breeding, breeding pairs, year to year recruitment and hatching success (Congdon *et al.*, 2007). Temperature, sea level and rainfall changes are all likely to impact seabirds and their prey species as well as the increased frequency and intensity of tropical storm and cyclone events (Congdon *et al.*, 2007) so climate change is also considered a threat to seabirds in the Burnett Mary region. Occurrence of terrestrial pollutants is likely to effect the abundance and diversity of prey species available so is also considered a threat

Threat Table 8. Seabirds in the Burnett Mary region.

Threat	Level of Impact	Effect on Asset (%)
Terrestrial Pollutants (Water Quality)		
Sediment	VL	10
Nutrients	VL	10
Pesticides	VL	10
Coastal Development	H	40
Shipping	VL	10
Climate Change	M	20
Other:		
Total		**100**

VL - Very Low, L - Low, M - Medium, H - High, VH - Very High

PRESSURES AND THREATS TO COASTAL AND MARINE ASSETS

The major pressures and threats to coastal and marine assets in the Burnett Mary region include terrestrial pollutants (sediment, nutrients and pesticides), coastal development, shipping (and boating) and climate change (Threat Table 9). The effect that each of these threats have on each asset are presented in the relevant sections above.

Threat Table 9. Summary of threats to coastal and marine assets in the Burnett Mary region.

Threat	Effect on Asset (%)								Effect on all Coastal and Marine Assets %
	Estuaries, coastal wetlands and mangroves	Inshore Coral Reefs	Offshore Coral Reefs	Seagrass	Dugong	Cetaceans	Turtles	Seabirds	
Terrestrial Pollutants (Water Quality)									
Sediment	15	40	5	30	30	5	10	10	18
Nutrients	10	10	10	20	15	5	10	10	11
Pesticides	25	5	5	20	15	5	10	10	12
Coastal Development	30	20	5	10	5	15	25	40	19
Shipping	5	5	5	10	15	10	5	10	8
Climate Change	15	20	70	10	5	20	10	20	21
Other:									
Netting: SCP and commercial					15		15		4
Overfishing of prey species						40			5
Predation of eggs by introduced spp.							15		2
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Increases in terrestrial pollutants affects all coastal and marine habitats, particularly inshore coral reefs and seagrass meadows which, in turn, affect all species of conservation concern (dugong, cetaceans, turtles and seabirds) in the region. Water quality is the greatest concern for the long-term health and resilience of seagrasses in the GBR (Brodie *et al.*, 2013). This is even truer for seagrasses in the semi-enclosed areas of Hervey Bay and the Great Sandy Straits, where water exchange can take up to 65 days (Grawe *et al.*, 2009).Terrestrial pollutants are the result of land use changes in the adjacent river catchments. Collectively terrestrial pollutants are considered to have the most effect on coastal and marine assets in the region, however, an increase in terrestrial pollutants is not considered a threat to offshore coral reefs.

Coastal development through disturbance and/or removal of habitat affects estuaries, coastal wetlands and mangroves. Species of conservation concern may also be affected by coastal development, for example due to increased boating and fishing pressure in the area and increased light in built up areas which effects marine turtles. Coastal development is considered a significant threat to estuaries, coastal wetlands and mangroves and turtles and seabirds in the Burnett Mary region.

Climate change is the most significant threat to offshore coral reefs in the Burnett Mary region is climate change the effects of which includes increased water temperature, increased light and ultraviolet radiation, ocean acidification, sea level changes and increased frequency and severity of tropical storms and flooding events (Hoegh-Guldberg *et al.*, 2007). This is also the case for inshore coral reefs however these have the additional threat of increases in terrestrial pollutants. Increases in water temperature push corals beyond their thermal tolerance and corals under thermal stress are more highly sensitive to light and ultraviolet radiation levels (Hoegh-Guldberg *et al.*, 2007). Ocean acidification significantly reduces the skeleton forming capacity of corals and may impact the ability of coral reefs to 'keep up with' sea level rises (Hoegh-Guldberg *et al.*, 2007). Increased frequency and severity of destructive storms reduces the opportunity of reef communities to recover from storm events.

KNOWLEDGE GAPS AND RECOMMENDATIONS

The following knowledge gaps have been identified for inshore coral reefs and seagrass meadows in the Burnett Mary region.

Coral reef and seagrass distribution and abundance monitoring

Monitoring of hard and soft coral communites and seagrass meadows should take place on a regular basis throughout the region to monitor recovery from recent flooding and to measure impacts of future large floods. For inshore coral reefs underwater photo/video transects should be used comparable to the methods used by Butler et al.(2013) though preferably with the use of fixed transects, as is the case with long term monitoring sites in the offshore coral reefs conducted by AIMS (2014). The impacts of flooding can be patchy and the use of the latest high resolution satellite/aerial imagery for monitoring coral reef and seagrass distribution, similar but higher resolution to that used by Zann (2012), would also be beneficial for assessing marine habitats over wider areas. Potentially such imagery would enable direct comparisons of flood plume and/or water quality imagery with coral and seagrass health and abundance measurements at the same location.

There is currently limited information on the distribution and health of extensive deepwater seagrass meadows in Hervey Bay. Establishment of an annual/biannual monitoring program of deepwater seagrass habitat in the region would address limited understanding of this habitat**.** Likewise a robust monitoring program to better understand the status of intertidal seagrass habitat in the Great Sandy Straits is vital to better understand the dynamics of seagrass meadows in this internationally significant RAMSAR listed site. Potentially citizen based monitoring programs could be supported and enhanced by establishing complementary monitoring sites within Great Sandy Strait which are also monitored through the Marine Monitoring Program.

Water quality monitoring

High nutrient levels have also been identified as a likely major cause of negative impacts to coral communities in the region (Bennett, 2004; Butler *et al.*, 2013; DeVantier, 2010; FRC, 2007; Gräwe *et al.*, 2010; McKenzie *et al.*, 2003; Zann, 2012). Although DSITIA undertakes monthly water quality testing in GSMP, for example, the testing takes place in deeper, more offshore areas and is not capable of assessing short term changes in water quality through daily tidal cycles nor is it capable of detecting acute events such as flood plumes or storms. Water quality is generally very different at inshore locations and it can vary widely over the course of a day (e.g. wind resuspension, tidal effects, submarine ground water). High frequency water quality monitoring should take place at a variety of depths at offshore and inshore locations, including coral reef areas, to better understand background changes of water quality parameters through tidal and seasonal cycles. Once the variability in background levels are better understood, it will then be possible to assess the true changes in water quality associated with not only acute events, but over the long term as changes occur to catchments.

Long term turbidity monitoring

Turbidity, the transport of sediments and resuspension have been identified as a likely major cause of negative impacts to coral communities in the region (Bennett, 2004; Butler *et al.*, 2013; DeVantier, 2010; FRC, 2007; Gräwe *et al.*, 2010; McKenzie *et al.*, 2003; Zann, 2012) and to a lesser extent to seagrass meadows (Ref,). Though the dynamics of sediment movement and turbidity are speculated on, and certainly during floods the turbidity remains elevated for extended periods, there are few data with which to understand the day to day behaviour of turbidity and to potentially link high turbidity with long term impacts to the marine habitat. Turbidity should be monitored at a number of inshore and offshore locations (e.g. coral reef, seagrass meadows) by establishing turbidity/light monitoring stations which sample repeatedly to better understand background levels of turbidity and changes of turbidity through tidal and seasonal cycles. This should also be part of a wide ranging water quality testing program to monitor changes of water quality into the future as the WQIP takes effect. It is also important to understand the response of seagrass meadows to resuspension events outside of extreme weather events.

Flood plume water quality and post flood coral abundance monitoring

Flood plumes are a known cause of acute, significant coral mortality in the region (Butler *et al.*, 2013). Flood plumes are also believed to be the primary avenue of transport of sediment and nutrients to coral reef areas in the BMR. In conjunction with water quality monitoring, extra effort should be made during flooding events to measure the water quality in coral reef areas, the duration of the altered conditions that result from the flooding, the duration of coral stress (e.g. bleaching) and the post-flood change in coral abundance. There is also evidence of a major output of submarine groundwater several months after a flooding event (Butler, pers com) and this should be factored into the long term monitoring as the water may travel from very long distances in the catchment.

Marine ecosystem health

Better understanding of how loss of seagrass meadows affects dependent faunal populations such as dugong, turtles and fisheries could be achieved by multidisciplinary studies.

CONCLUSIONS

The Burnett Mary region is rich in internationally and nationally significant coastal assets; estuaries, coastal wetlands and mangroves and coastal islands. The majority of estuaries in the region are considered near pristine (35.3%) or largely unmodified (47.1%) and encompass thirteen declared Fish Habitat Areas. The Kolan River estuary is considered modified and the Burnett and Mary River estuaries are considered extensively modified. Diverse habitats represented in these estuaries include flood and ebb tidal deltas, intertidal flats, mangroves, saltflats and tidal sand banks which are significant habitats for species of conservation concern. Coastal wetlands and mangroves include Great Sandy Strait (93 160 hectares) which is a RAMSAR listed wetland of international significance particularly because of the seabird populations found there. There are other coastal wetlands along the coastline that are included in various Marine Parks and Conservation Parks; six of which are of National Significance. Coastal Islands are limited to Rodds Bay in the north and the Great Sandy Strait in the south where Fraser Island, a World Heritage Area is located.

The Burnett Mary region is also rich in internationally and nationally significant marine assets. Hervey Bay is the current known southern limit for consolidated reef formation along the mainland of eastern Australia with 102 hard and soft coral taxa identified. Inshore coral reefs in this area are relatively healthy but from 2010 to 2013 have experienced a 60% decrease in coral abundance most likely due to the increased terrestrial runoff load from the coast. Offshore Coral Reefs are at the southern end of the Great Barrier Reef and have experienced significant temporal changes in hard coral cover (between 0-100%) during recent surveys attributed to storm events. The most significant threat to the viability of offshore coral reefs is considered to be climate change.

Seagrass Meadows are a key ecosystem within the Burnett Mary region supporting populations of dugong, turtle, fisheries of commercial and recreational importance and seabirds. There is a recorded history of loss and recovery of seagrasses within this region from 1992 mainly from monitoring of estuarine seagrass meadows. Deepwater seagrass meadows are well represented in this region but their current status is unknown due to a lack of monitoring. Likewise the current status of seagrass meadows in the Great Sandy Strait is difficult to due to insufficient data and limited community monitoring. Deteriorating water quality associated with flood plumes has been strongly linked to seagrass decline in the region and is considered to be the most significant threat to their viability.

The most significant species of conservation concern in the Burnett Mary region are dugong, cetaceans, turtles and seabirds. The Hervey Bay region is the most important dugong habitat on the urban coast of

Queensland and two Dugong Protection Areas are declared in the region; Hervey Bay and Rodd's Bay. They are reliant on healthy seagrass meadows for their survival and high mortality rates due to extreme weather events (cyclones and floods) and associated seagrass pasture disturbances have been recorded. There are approximately 30 species of whales and dolphins that are likely to occur in the Burnett Mary region, four of which are considered high priority species by GBRMPA. Several of the coastal dolphin species are considered particularly vulnerable to decline in water quality.The Southern right whale, not recorded from the GBRMP is one of the most commonly sighted whales in the Burnett Mary region. Six of the world's seven sea turtle species have been recorded in the Burnett Mary region

The most significant nesting population in the South Pacific Ocean of the endangered loggerhead turtle is at Mon Repos, Bundaberg where approximately 300 females nest annually and is critical for their survival. The southern stock of the vulnerable Green turtle also nests in this region, primarily in the Capricorn/Bunker group, with an estimated average annual nesting population of 8000 females. The Burnett Mary region includes internationally and nationally significant wetlands habitat for shorebirds, waterbirds, waders and seabirds particularly in the Great Sandy Strait which is RAMSAR listed. In excess of 20 000 migratory shorebirds have been recorded in the Great Sandy Strait.

The major pressures and threats to coastal and marine assets in the Burnett Mary region include terrestrial pollutants (sediment, nutrients and pesticides), coastal development, shipping (and boating) and climate change. Climate change, coastal development and increases in terrestrial pollutants are all considered serious threats to each coastal and marine asset, to varying degrees. The cumulative effect of all of these threats will be significant. Addressing increases in terrestrial pollutants as part of the Water Quality Improvement Plan is likely to result in healthier inshore coral reefs and seagrass meadows which will be more resilient to the likely impacts of climate change.

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APPENDICES

Appendix 1: Seagrass-Watch monitoring sites and statistics in the Burnett Mary region.

Locality	Location	Site Code	Latitude	Longitude	Species	Last Monitored
Baffle Creek	Rodds Bay	RD1	-24.5802	151.65548	ZC	Nov-13
Baffle Creek	Rodds Bay	RD2	-24.8110	151.66264	ZC	Nov-13
Hervey Bay	Burrum Heads	BH1	-25.18813	152.62562	HU/HO/ZC	Feb-14
Hervey Bay	Burrum Heads	BH2	-25.19743	152.63122	HU/ZC	Feb-14
Hervey Bay	Burrum Heads	BH3	-25.21031	152.63932	HU/ZC	Feb-14
Hervey Bay	Dundowran	DD1	-25.26351	152.74080	HU	Dec-11
Hervey Bay	Dundowran	DD2	-25.26400	152.75943	HU	Mar-14
Hervey Bay	Dundowran	DD3	-25.26326	152.77254	HU	Mar-14
Hervey Bay	Toogoom	TG1	-25.25843	152.70487	HU	Jun-10
Hervey Bay	Toogoom	TG2	-25.24794	152.68376	NO INFO	Jun-10
Hervey Bay	Toogoom	TG3	-25.26131	152.71467	ZC	Jun-10
Hervey Bay	Urangan	UG1	-25.30088	152.90681	ZC	Mar-14
Hervey Bay	Urangan	UG2	-25.30328	152.90607	ZC/HO	Mar-14
Hervey Bay	Booral	UG3	-25.36097	152.91838	NO INFO	Jul -08
Hervey Bay	Booral	UG4	-25.36096	152.91838	NO INFO	Jul -08
Great Sandy Strait	Brown's Gutter	BG1	-25.74305	153.00058	ZC	Oct-13
Great Sandy Strait	Brown's Gutter	BG2	-25.75004	153.00311	ZC	Oct-13
Great Sandy Strait	Brown's Gutter	BG3	-25.76155	153.00830	ZC	Dec-10
Great Sandy Strait	Boonooroo	BN1	-25.66866	152.90736	ZC/HO/HU	Nov-13
Great Sandy Strait	Boonooroo	BN2	-25.68208	152.89377	ZC/HU/HO	Oct-12
Great Sandy Strait	Boonooroo	BN3	-25.64812	152.90670	ZC/HO	Nov-13
Great Sandy Strait	Kauri Creek	KC1	-25.79597	152.98675	NO INFO	Oct-12
Great Sandy Strait	Tin Can Inlet (Inskip Point)	PB1	-25.81285	153.04767	ZC/HO	Nov-13
Great Sandy Strait	Tin Can Inlet (Pelican Bay)	PB2	-25.82231	153.06244	ZC	Jun-05
Great Sandy Strait	Tin Can Bay	TB1	-25.90615	153.01533	ZC/HO	Mar-14
Great Sandy Strait	Poona	PN1	-25.70853	152.92433	HU/HO	Apr-12
Great Sandy Strait	Poona	PN2	-25.71847	152.91953	ZC/HU/HO	Apr-12
Great Sandy Strait	Poona	PN3	-25.72980	152.92285	HU/HO	Jun-10
Great Sandy Strait	Reef Islands	RI1	-25.65463	152.95354	NO INFO	Oct-12
Great Sandy Strait	Reef Islands	RI2	-25.65899	152.94900	NO INFO	Oct-13
Great Sandy Strait	Reef Islands	RI3	-25.67718	152.95652	NO INFO	Oct-13
Great Sandy Strait	Tootoowah Creek	TC1	-25.69122	152.98925	NO INFO	Jun-02
Great Sandy Strait	Tootoowah Creek	TC2	-25.69295	152.98495	NO INFO	Jun-02
Great Sandy Strait	Tinnanbar	TN1	-25.75617	152.95235	ZC/HO	Nov-12
Great Sandy Strait	Tinnanbar	TN2	-25.75827	152.96378	HU/ZC/HO	Nov-13
Great Sandy Strait	Tinnanbar	TN3	-25.75807	152.96788	HU/ZC	Nov-13
Great Sandy Strait	Wanggoolba & Bennett’s Creek	WC1	-25.41610	153.00559	NO INFO	Jul-04
Great Sandy Strait	Wanggoolba & Bennett’s Creek	WC2	-25.44732	152.98397	NO INFO	Jul-04

Appendix 2: Birds recorded in the Great Sandy Strait

Family	*Scientific Name*	Common Name	Status
Acanthizidae	*Gerygone palpebrosa*	Fairy gerygone	C
Acanthizidae	*Gerygone mouki*	Brown gerygone	C
Acanthizidae	*Sericornis frontalis*	White-browed scrubwren	C
Acanthizidae	*Sericornis citreogularis*	Yellow-throated scrubwren	C
Acanthizidae	*Gerygone albogularis*	White-throated gerygone	C
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped thornbill	C
Acanthizidae	*Acanthiza reguloides*	Buff-rumped thornbill	C
Acanthizidae	*Chthonicola sagittata*	Speckled warbler	C
Acanthizidae	*Smicrornis brevirostris*	Weebill	C
Acanthizidae	*Acanthiza nana*	Yellow thornbill	C
Acanthizidae	*Sericornis magnirostra*	large-billed scrubwren	C
Acanthizidae	*Acanthiza lineata*	Striated thornbill	C
Acanthizidae	*Acanthiza pusilla*	Brown thornbill	C
Acanthizidae	*Gerygone levigaster*	Mangrove gerygone	C
Accipitridae	*Elanus axillaris*	Black-shouldered kite	C
Accipitridae	*Haliastur sphenurus*	Whistling kite	C
Accipitridae	*Pandion cristatus*	Eastern osprey	SL
Accipitridae	*Aquila audax*	Wedge-tailed eagle	C
Accipitridae	*Hamirostra melanosternon*	Black-breasted buzzard	C
Accipitridae	*Erythrotriorchis radiatus*	Red goshawk	E
Accipitridae	*Circus approximans*	swamp harrier	C
Accipitridae	*Aviceda subcristata*	Pacific baza	C
Accipitridae	*Accipiter fasciatus*	Brown goshawk	C
Accipitridae	*Haliastur indus*	Brahminy kite	C
Accipitridae	*Milvus migrans*	Black kite	C
Accipitridae	*Lophoictinia isura*	Square-tailed kite	NT
Accipitridae	*Accipiter cirrocephalus*	Collared sparrowhawk	C
Accipitridae	*Haliaeetus leucogaster*	White-bellied sea-eagle	SL
Accipitridae	*Circus assimilis*	Spotted harrier	C
Accipitridae	*Hieraaetus morphnoides*	Little eagle	NT
Accipitridae	*Accipiter novaehollandiae*	Grey goshawk	NT
Acrocephalidae	*Acrocephalus australis*	Australian reed-warbler	SL
Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar	C
Alaudidae	*Mirafra javanica*	Horsfield's bushlark	C
Alcedinidae	*Ceyx azureus*	Azure kingfisher	C
Anatidae	*Anas gracilis*	Grey teal	C
Anatidae	*Cygnus atratus*	Black swan	C
Anatidae	*Dendrocygna arcuata*	Wandering whistling-duck	C
Anatidae	*Biziura lobata*	Musk duck	C
Anatidae	*Anas castanea*	Chestnut teal	C
Anatidae	*Anas superciliosa*	Pacific black duck	C
Anatidae	*Aythya australis*	Hardhead	C
Anatidae	*Chenonetta jubata*	Australian wood duck	C
Anatidae	*Nettapus pulchellus*	Green pygmy-goose	C
Anatidae	*Anas platyrhynchos*	Northern mallard	Y
Anhingidae	*Anhinga novaehollandiae*	Australasian darter	C
Anseranatidae	*Anseranas semipalmata*	Magpie goose	C
Apodidae	*Apus affinis*	House swift	C
Apodidae	*Collocalia esculenta*	Glossy swiftlet	C
Apodidae	*Hirundapus caudacutus*	White-throated needletail	SL
Apodidae	*Aerodramus terraereginae*	Australian swiftlet	NT
Apodidae	*Apus pacificus*	Fork-tailed swift	SL
Ardeidae	*Botaurus poiciloptilus*	Australasian bittern	C

Family	*Scientific Name*	Common Name	Status
Ardeidae	*Ixobrychus dubius*	Australian little bittern	C
Ardeidae	*Butorides striata*	Striated heron	C
Ardeidae	*Ardea pacifica*	White-necked heron	C
Ardeidae	*Egretta novaehollandiae*	White-faced heron	C
Ardeidae	*Ardea modesta*	Eastern great egret	SL
Ardeidae	*Ardea intermedia*	Intermediate egret	C
Ardeidae	*Ardea ibis*	Cattle egret	SL
Ardeidae	*Nycticorax caledonicus*	Nankeen night-heron	C
Ardeidae	*Ixobrychus flavicollis*	Black bittern	C
Ardeidae	*Ardea sumatrana*	Great-billed heron	C
Ardeidae	*Egretta garzetta*	Little egret	C
Ardeidae	*Egretta sacra*	Eastern reef egret	SL
Artamidae	*Cracticus torquatus*	Grey butcherbird	C
Artamidae	*Artamus leucorynchus*	White-breasted woodswallow	C
Artamidae	Artamus sp. 1		
Artamidae	*Artamus personatus*	Masked woodswallow	C
Artamidae	*Cracticus nigrogularis*	Pied butcherbird	C
Artamidae	*Artamus superciliosus*	White-browed woodswallow	C
Artamidae	*Artamus minor*	Little woodswallow	C
Artamidae	*Strepera graculina*	Pied currawong	C
Artamidae	*Artamus cinereus*	Black-faced woodswallow	C
Artamidae	*Artamus cyanopterus*	Dusky woodswallow	C
Artamidae	*Cracticus tibicen*	Australian magpie	C
Burhinidae	*Esacus magnirostris*	Beach stone-curlew	V
Burhinidae	*Burhinus grallarius*	Bush stone-curlew	C
Cacatuidae	*Calyptorhynchus lathami*	Glossy black-cockatoo	V
Cacatuidae	*Eolophus roseicapillus*	Galah	C
Cacatuidae	*Nymphicus hollandicus*	Cockatiel	C
Cacatuidae	*Calyptorhynchus banksii*	Red-tailed black-cockatoo	C
Cacatuidae	*Cacatua galerita*	Sulphur-crested cockatoo	C
Cacatuidae	*Cacatua tenuirostris*	Long-billed corella	Y
Cacatuidae	*Calyptorhynchus funereus*	Yellow-tailed black-cockatoo	C
Cacatuidae	*Cacatua sanguinea*	Little corella	C
Campephagidae	*Lalage sueurii*	White-winged triller	C
Campephagidae	*Coracina maxima*	Ground cuckoo-shrike	C
Campephagidae	*Coracina papuensis*	White-bellied cuckoo-shrike	C
Campephagidae	*Lalage leucomela*	Varied triller	C
Campephagidae	*Coracina novaehollandiae*	Black-faced cuckoo-shrike	C
Campephagidae	*Coracina tenuirostris*	Cicadabird	SL
Campephagidae	*Coracina lineata*	Barred cuckoo-shrike	C
Caprimulgidae	*Caprimulgus macrurus*	Large-tailed nightjar	C
Casuariidae	*Dromaius novaehollandiae*	Emu	C
Charadriidae	*Vanellus miles*	Masked lapwing	C
Charadriidae	*Charadrius ruficapillus*	Red-capped plover	C
Charadriidae	*Vanellus miles novaehollandiae*	Masked lapwing (southern subspecies)	C
Charadriidae	*Elseyornis melanops*	Black-fronted dotterel	C
Charadriidae	*Charadrius mongolus*	Lesser sand plover	SL
Charadriidae	*Charadrius bicinctus*	Double-banded plover	SL
Charadriidae	*Vanellus miles miles*	Masked lapwing (northern subspecies)	C
Charadriidae	*Pluvialis squatarola*	Grey plover	SL
Charadriidae	*Charadrius leschenaultii*	Greater sand plover	SL
Charadriidae	*Charadrius hiaticula*	Ringed plover	SL
Charadriidae	*Pluvialis fulva*	Pacific golden plover	SL
Charadriidae	*Charadrius veredus*	Oriental plover	SL

Family	*Scientific Name*	Common Name	Status
Charadriidae	*Vanellus tricolor*	Banded lapwing	C
Ciconiidae	*Ephippiorhynchus asiaticus*	Black-necked stork	NT
Cisticolidae	*Cisticola exilis*	Golden-headed cisticola	C
Climacteridae	*Cormobates leucophaea metastasis*	White-throated treecreeper (southern)	C
Climacteridae	*Climacteris picumnus*	Brown treecreeper	C
Climacteridae	*Cormobates leucophaea*	White-throated treecreeper	C
Columbidae	*Ptilinopus regina*	Rose-crowned fruit-dove	C
Columbidae	*Lopholaimus antarcticus*	Topknot pigeon	C
Columbidae	*Streptopelia chinensis*	Spotted dove	Y
Columbidae	*Macropygia amboinensis*	Brown cuckoo-dove	C
Columbidae	*Geopelia striata*	Peaceful dove	C
Columbidae	*Columba leucomela*	White-headed pigeon	C
Columbidae	*Ptilinopus magnificus*	Wompoo fruit-dove	C
Columbidae	*Ocyphaps lophotes*	Crested pigeon	C
Columbidae	*Ptilinopus superbus*	Superb fruit-dove	C
Columbidae	*Columba livia*	Rock dove	Y
Columbidae	*Geopelia cuneata*	Diamond dove	C
Columbidae	*Phaps elegans*	Brush bronzewing	C
Columbidae	*Geopelia humeralis*	Bar-shouldered dove	C
Columbidae	*Phaps chalcoptera*	Common bronzewing	C
Columbidae	*Chalcophaps indica*	Emerald dove	C
Columbidae	*Leucosarcia picata*	Wonga pigeon	C
Coraciidae	*Eurystomus orientalis*	Dollarbird	C
Corcoracidae	*Corcorax melanorhamphos*	White-winged chough	C
Corvidae	*Corvus orru*	Torresian crow	C
Corvidae	*Corvus coronoides*	Australian raven	C
Cuculidae	*Scythrops novaehollandiae*	Channel-billed cuckoo	C
Cuculidae	*Chalcites minutillus minutillus*	Little bronze-cuckoo	C
Cuculidae	*Cacomantis variolosus*	Brush cuckoo	C
Cuculidae	*Chalcites lucidus*	Shining bronze-cuckoo	C
Cuculidae	*Cacomantis pallidus*	Pallid cuckoo	C
Cuculidae	*Centropus phasianinus*	Pheasant coucal	C
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed cuckoo	C
Cuculidae	*Chalcites osculans*	Black-eared cuckoo	C
Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo	C
Cuculidae	*Cuculus optatus*	Oriental cuckoo	SL
Cuculidae	*Eudynamys orientalis*	Eastern koel	C
Dicruridae	*Dicrurus bracteatus*	Spangled drongo	C
Diomedeidae	*Thalassarche carteri*	Indian yellow-nosed albatross	V
Diomedeidae	*Thalassarche chrysostoma*	Grey-headed albatross	V
Diomedeidae	*Diomedea exulans*	Wandering albatross	V
Diomedeidae	*Thalassarche bulleri*	Buller's albatross	V
Diomedeidae	*Phoebetria palpebrata*	Light-mantled sooty albatross	SL
Diomedeidae	*Phoebetria fusca*	Sooty albatross	V
Diomedeidae	*Thalassarche cauta*	Shy albatross	V
Diomedeidae	*Thalassarche melanophris*	Black-browed albatross	SL
Estrildidae	*Stagonopleura guttata*	Diamond firetail	C
Estrildidae	*Taeniopygia bichenovii*	Double-barred finch	C
Estrildidae	*Lonchura castaneothorax*	Chestnut-breasted mannikin	C
Estrildidae	*Neochmia temporalis*	Red-browed finch	C
Estrildidae	*Lonchura punctulata*	Nutmeg mannikin	Y
Eurostopodidae	*Eurostopodus mystacalis*	White-throated nightjar	C
Eurostopodidae	*Eurostopodus argus*	Spotted nightjar	C
Falconidae	*Falco berigora*	Brown falcon	C

Family	Scientific Name	Common Name	Status
Falconidae	*Falco longipennis*	Australian hobby	C
Falconidae	*Falco subniger*	Black falcon	C
Falconidae	*Falco peregrinus*	Peregrine falcon	C
Falconidae	*Falco cenchroides*	Nankeen kestrel	C
Fregatidae	*Fregata minor*	Great frigatebird	SL
Fregatidae	*Fregata ariel*	Lesser frigatebird	SL
Fringillidae	*Carduelis carduelis*	European goldfinch	Y
Glareolidae	*Glareola maldivarum*	Oriental pratincole	SL
Gruidae	*Grus rubicunda*	Brolga	C
Haematopodidae	*Haematopus fuliginosus*	Sooty oystercatcher	NT
Haematopodidae	*Haematopus longirostris*	Australian pied oystercatcher	C
Halcyonidae	*Dacelo novaeguineae*	Laughing kookaburra	C
Halcyonidae	*Todiramphus chloris*	Collared kingfisher	
Halcyonidae	*Todiramphus pyrrhopygius*	Red-backed kingfisher	C
Halcyonidae	*Dacelo leachii*	Blue-winged kookaburra	C
Halcyonidae	*Todiramphus sanctus*	Sacred kingfisher	C
Halcyonidae	*Todiramphus macleayii*	Forest kingfisher	C
Hirundinidae	*Hirundo rustica*	Barn swallow	SL
Hirundinidae	*Petrochelidon ariel*	Fairy martin	C
Hirundinidae	*Petrochelidon nigricans*	Tree martin	C
Hirundinidae	*Cheramoeca leucosterna*	White-backed swallow	C
Hirundinidae	*Hirundo neoxena*	Welcome swallow	C
Jacanidae	*Irediparra gallinacea*	Comb-crested jacana	C
Laridae	*Sterna paradisaea*	Arctic tern	C
Laridae	*Procelsterna cerulea*	Grey ternlet	C
Laridae	*Chroicocephalus novaehollandiae*	Silver gull	C
Laridae	*Anous stolidus*	Common noddy	SL
Laridae	*Sterna striata*	White-fronted tern	C
Laridae	*Sternula albifrons*	Little tern	E
Laridae	*Onychoprion anaethetus*	Bridled tern	SL
Laridae	*Thalasseus bergii*	Crested tern	C
Laridae	*Gygis alba*	White tern	C
Laridae	*Chlidonias hybrida*	Whiskered tern	C
Laridae	*Anous minutus*	Black noddy	C
Laridae	*Larus pacificus*	Pacific gull	C
Laridae	*Gelochelidon nilotica*	Gull-billed tern	C
Laridae	*Thalasseus bengalensis*	Lesser crested tern	SL
Laridae	*Hydroprogne caspia*	Caspian tern	SL
Laridae	*Larus dominicanus*	Kelp gull	C
Laridae	*Sterna dougallii*	Roseate tern	SL
Laridae	*Sterna hirundo*	Common tern	SL
Laridae	*Sterna sumatrana*	Black-naped tern	SL
Laridae	*Chlidonias leucopterus*	White-winged black tern	SL
Laridae	*Onychoprion fuscata*	Sooty tern	C
Laridae	*Leucophaeus pipixcan*	Franklin's gull	C
Laridae	*Sternula nereis*	Fairy tern	CV
Maluridae	*Malurus lamberti*	Variegated fairy-wren	C
Maluridae	*Malurus melanocephalus*	Red-backed fairy-wren	C
Maluridae	*Stipiturus malachurus*	Southern emu-wren	V
Maluridae	*Malurus cyaneus*	Superb fairy-wren	C
Megaluridae	*Megalurus timoriensis*	Tawny grassbird	C
Megaluridae	*Cincloramphus cruralis*	Brown songlark	C
Megaluridae	*Megalurus gramineus*	Little grassbird	C
Megaluridae	*Cincloramphus mathewsi*	Rufous songlark	C

Family	*Scientific Name*	Common Name	Status
Megapodiidae	*Alectura lathami*	Australian brush-turkey	C
Meliphagidae	*Anthochaera carunculata*	Red wattlebird	C
Meliphagidae	*Sugomel niger*	Black honeyeater	C
Meliphagidae	*Entomyzon cyanotis*	Blue-faced honeyeater	C
Meliphagidae	*Lichmera indistincta*	Brown honeyeater	C
Meliphagidae	*Gavicalis fasciogularis*	Mangrove honeyeater	C
Meliphagidae	*Melithreptus gularis*	Black-chinned honeyeater	NT
Meliphagidae	*Ptilotula fuscus*	Fuscous honeyeater	C
Meliphagidae	*Melithreptus albogularis*	White-throated honeyeater	C
Meliphagidae	*Nesoptilotis leucotis*	White-eared honeyeater	C
Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern spinebill	C
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked honeyeater	C
Meliphagidae	*Anthochaera chrysoptera*	Little wattlebird	C
Meliphagidae	*Caligavis chrysops*	Yellow-faced honeyeater	C
Meliphagidae	*Grantiella picta*	Painted honeyeater	V
Meliphagidae	*Philemon corniculatus*	Noisy friarbird	C
Meliphagidae	*Plectorhyncha lanceolata*	Striped honeyeater	C
Meliphagidae	*Manorina melanocephala*	Noisy miner	C
Meliphagidae	*Myzomela obscura*	Dusky honeyeater	C
Meliphagidae	*Philemon citreogularis*	Little friarbird	C
Meliphagidae	*Myzomela sanguinolenta*	Scarlet honeyeater	C
Meliphagidae	*Anthochaera phrygia*	Regent honeyeater	E
Meliphagidae	*Meliphaga lewinii*	Lewin's honeyeater	C
Meliphagidae	*Melithreptus lunatus*	White-naped honeyeater	C
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland honeyeater	C
Meliphagidae	*Phylidonyris niger*	White-cheeked honeyeater	C
Meliphagidae	*Lichenostomus melanops*	Yellow-tufted honeyeater	C
Meliphagidae	*Melithreptus brevirostris*	Brown-headed honeyeater	C
Meliphagidae	*Conopophila rufogularis*	Rufous-throated honeyeater	C
Meropidae	*Merops ornatus*	Rainbow bee-eater	SL
Monarchidae	*Myiagra cyanoleuca*	Satin flycatcher	SL
Monarchidae	*Myiagra inquieta*	Restless flycatcher	C
Monarchidae	*Myiagra rubecula*	Leaden flycatcher	C
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	C
Monarchidae	*Monarcha melanopsis*	Black-faced monarch	SL
Monarchidae	*Symposiarchus trivirgatus*	Spectacled monarch	SL
Monarchidae	*Carterornis leucotis*	White-eared monarch	C
Monarchidae	*Myiagra alecto*	Shining flycatcher	C
Motacillidae	*Anthus novaeseelandiae*	Australasian pipit	C
Motacillidae	*Motacilla alba*	White wagtail	SL
Nectariniidae	*Nectarinia jugularis*	Olive-backed sunbird	C
Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird	C
Neosittidae	*Daphoenositta chrysoptera*	Varied sittella	C
Oceanitidae	*Pelagodroma marina*	White-faced storm-petrel	C
Oceanitidae	*Oceanites oceanicus*	Wilson's storm-petrel	SL
Oceanitidae	*Fregetta grallaria*	White-bellied storm-petrel	C
Oriolidae	*Oriolus sagittatus*	Olive-backed oriole	C
Oriolidae	*Sphecotheres vieilloti*	Australasian figbird	C
Orthonychidae	*Orthonyx temminckii*	Australian logrunner	C
Otididae	*Ardeotis australis*	Australian bustard	C
Pachycephalidae	*Colluricincla megarhyncha*	Little shrike-thrush	C
Pachycephalidae	*Colluricincla harmonica*	Grey shrike-thrush	C
Pachycephalidae	*Pachycephala rufiventris*	Rufous whistler	C
Pachycephalidae	*Falcunculus frontatus*	Crested shrike-tit	C

Family	*Scientific Name*	Common Name	Status
Pachycephalidae	*Pachycephala pectoralis*	Golden whistler	C
Pardalotidae	*Pardalotus punctatus*	Spotted pardalote	C
Pardalotidae	*Pardalotus striatus*	Striated pardalote	C
Passeridae	*Passer domesticus*	House sparrow	Y
Pelecanidae	*Pelecanus conspicillatus*	Australian pelican	C
Petroicidae	*Petroica rosea*	Rose robin	C
Petroicidae	*Microeca fascinans*	Jacky winter	C
Petroicidae	*Tregellasia capito*	Pale-yellow robin	C
Petroicidae	*Eopsaltria australis*	Eastern yellow robin	C
Phaethontidae	*Phaethon rubricauda*	Red-tailed tropicbird	V
Phaethontidae	*Phaethon lepturus*	White-tailed tropicbird	SL
Phalacrocoracidae	*Phalacrocorax carbo*	Great cormorant	C
Phalacrocoracidae	*Microcarbo melanoleucos*	Little pied cormorant	C
Phalacrocoracidae	*Phalacrocorax varius*	Pied cormorant	C
Phalacrocoracidae	*Phalacrocorax sulcirostris*	Little black cormorant	C
Phasianidae	*Excalfactoria chinensis*	King quail	C
Phasianidae	*Phasianidae Coturnix ypsilophora*	Brown quail	C
Phasianidae	*Phasianidae Coturnix pectoralis*	Stubble quail	C
Pittidae	*Pitta versicolor*	Noisy pitta	C
Podargidae	*Podargus ocellatus plumiferus*	Plumed frogmouth	V
Podargidae	*Podargus strigoides*	Tawny frogmouth	C
Podargidae	*Podargus ocellatus marmoratus*	Marbled frogmouth	C
Podicipedidae	*Podiceps cristatus*	Great crested grebe	C
Podicipedidae	*Poliocephalus poliocephalus*	Hoary-headed grebe	C
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe	C
Pomatostomidae	*Pomatostomus temporalis*	Grey-crowned babbler	C
Procellariidae	*Pachyptila salvini*	Salvin's prion	C
Procellariidae	*Pachyptila belcheri*	Slender-billed prion	C
Procellariidae	Pachyptila sp. 4		
Procellariidae	*Procellaria parkinsoni*	Black petrel	SL
Procellariidae	*Ardenna bulleri*	Buller's shearwater	C
Procellariidae	*Ardenna carneipes*	Flesh-footed shearwater	SL
Procellariidae	*Puffinus huttoni*	Hutton's shearwater	C
Procellariidae	*Pterodroma solandri*	Providence petrel	SL
Procellariidae	*Puffinus assimilis*	Little shearwater	C
Procellariidae	*Macronectes halli*	Northern giant-petrel	V
Procellariidae	*Pterodroma leucoptera*	Gould's petrel	C
Procellariidae	*Pterodroma cervicalis*	White-necked petrel	C
Procellariidae	*Pachyptila vittata*	Broad-billed prion	C
Procellariidae	*Fulmarus glacialoides*	Southern fulmar	C
Procellariidae	*Ardenna pacifica*	Wedge-tailed shearwater	SL
Procellariidae	*Pterodroma nigripennis*	Black-winged petrel	C
Procellariidae	*Pterodroma inexpectata*	Mottled petrel	C
Procellariidae	*Macronectes giganteus*	Southern giant-petrel	E
Procellariidae	*Pachyptila desolata*	Antarctic prion	C
Procellariidae	*Daption capense*	Cape petrel	C
Procellariidae	*Pachyptila turtur*	Fairy prion	C
Procellariidae	*Lugensa brevirostris*	Kerguelen petrel	C
Procellariidae	*Ardenna grisea*	Sooty shearwater	SL
Procellariidae	*Pterodroma macroptera*	Great-winged petrel	C
Procellariidae	*Ardenna tenuirostris*	Short-tailed shearwater	SL
Procellariidae	*Halobaena caerulea*	Blue petrel	C
Procellariidae	*Procellaria westlandica*	Westland petrel	SL
Procellariidae	*Pterodroma lessonii*	White-headed petrel	C

Family	*Scientific Name*	Common Name	Status
Procellariidae	*Pterodroma leucoptera leucoptera*	Gould's petrel (Australian subspecies)	SL
Procellariidae	*Pseudobulweria rostrata*	Tahiti petrel	C
Procellariidae	*Macronectes sp. 1*		
Procellariidae	*Puffinus gavia*	Fluttering shearwater	C
Procellariidae	*Calonectris leucomelas*	Streaked shearwater	SL
Psittacidae	*Trichoglossus chlorolepidotus*	Scaly-breasted lorikeet	C
Psittacidae	*Cyclopsitta diophthalma coxeni*	Coxen's fig-parrot	E
Psittacidae	*Glossopsitta pusilla*	Little lorikeet	C
Psittacidae	*Platycercus adscitus*	Pale-headed rosella	C
Psittacidae	*Alisterus scapularis*	Australian king-parrot	C
Psittacidae	*Melopsittacus undulatus*	Budgerigar	C
Psittacidae	*Trichoglossus haematodus rubritorquis*	Red-collared lorikeet	C
Psittacidae	*Pezoporus wallicus wallicus*	Ground parrot	V
Psittacidae	*Neophema pulchella*	Turquoise parrot	NT
Psittacidae	*Aprosmictus erythropterus*	Red-winged parrot	C
Psittacidae	*Platycercus elegans*	Crimson rosella	C
Psittacidae	*Psephotus pulcherrimus*	Paradise parrot	PE
Psittacidae	*Trichoglossus haematodus moluccanus*	Rainbow lorikeet	C
Psophodidae	*Psophodes olivaceus*	Eastern whipbird	C
Psophodidae	*Cinclosoma punctatum*	Spotted quail-thrush	C
Ptilonorhynchidae	*Sericulus chrysocephalus*	Regent bowerbird	C
Ptilonorhynchidae	*Ailuroedus crassirostris*	Green catbird	C
Ptilonorhynchidae	*Ptilonorhynchus violaceus*	Satin bowerbird	C
Rallidae	*Lewinia pectoralis*	Lewin's rail	NT
Rallidae	*Fulica atra*	Eurasian coot	C
Rallidae	*Gallinula tenebrosa*	Dusky moorhen	C
Rallidae	*Porphyrio porphyrio*	Purple swamphen	C
Rallidae	*Amaurornis moluccana*	Pale-vented bush-hen	C
Rallidae	*Gallirallus philippensis*	Buff-banded rail	C
Rallidae	*Porzana pusilla*	Baillon's crake	C
Rallidae	*Porzana tabuensis*	Spotless crake	C
Recurvirostridae	*Himantopus himantopus*	Black-winged stilt	C
Recurvirostridae	*Recurvirostra novaehollandiae*	Red-necked avocet	C
Rhipiduridae	*Rhipidura leucophrys*	Willie wagtail	C
Rhipiduridae	*Rhipidura rufifrons*	Rufous fantail	SL
Rhipiduridae	*Rhipidura albiscapa*	Grey fantail	C
Scolopacidae	*Xenus cinereus*	Terek sandpiper	SL
Scolopacidae	*Limosa limosa*	Black-tailed godwit	SL
Scolopacidae	*Limosa lapponica*	Bar-tailed godwit	SL
Scolopacidae	*Numenius madagascariensis*	Eastern curlew	NT
Scolopacidae	*Arenaria interpres*	Ruddy turnstone	SL
Scolopacidae	*Calidris alba*	Sanderling	SL
Scolopacidae	*Tringa brevipes*	Grey-tailed tattler	SL
Scolopacidae	*Limicola falcinellus*	Broad-billed sandpiper	SL
Scolopacidae	*Tringa nebularia*	Common greenshank	SL
Scolopacidae	*Numenius phaeopus*	Whimbrel	SL
Scolopacidae	*Calidris tenuirostris*	Great knot	SL
Scolopacidae	*Calidris canutus*	Red knot	SL
Scolopacidae	*Calidris acuminata*	Sharp-tailed sandpiper	SL
Scolopacidae	*Actitis hypoleucos*	Common sandpiper	SL
Scolopacidae	*Calidris ruficollis*	Red-necked stint	SL
Scolopacidae	*Calidris ferruginea*	Curlew sandpiper	SL
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	SL
Scolopacidae	*Calidris melanotos*	Pectoral sandpiper	SL

Family	***Scientific Name***	**Common Name**	**Status**
Scolopacidae	*Tringa incana*	Wandering tattler	SL
Scolopacidae	*Numenius minutus*	Little curlew	SL
Scolopacidae	*Tringa stagnatilis*	Marsh sandpiper	SL
Spheniscidae	*Eudyptula minor*	Little penguin	C
Stercorariidae	*Stercorarius antarcticus*	Brown skua	C
Stercorariidae	*Stercorarius parasiticus*	Arctic jaeger	SL
Stercorariidae	*Stercorarius pomarinus*	Pomarine jaeger	SL
Strigidae	*Ninox connivens*	Barking owl	C
Strigidae	*Ninox strenua*	Powerful owl	V
Strigidae	*Ninox boobook*	Southern boobook	C
Sturnidae	*Aplornis metallica*	Metallic starling	C
Sturnidae	*Sturnus vulgaris*	Common starling	Y
Sturnidae	*Sturnus tristis*	Common myna	Y
Sulidae	*Morus serrator*	Australasian gannet	C
Sulidae	*Sula dactylatra*	Masked booby	SL
Sulidae	*Sula leucogaster*	Brown booby	SL
Threskiornithidae	*Platalea flavipes*	Yellow-billed spoonbill	C
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked ibis	C
Threskiornithidae	*Platalea regia*	Royal spoonbill	C
Threskiornithidae	*Threskiornis molucca*	Australian white ibis	C
Timaliidae	*Zosterops lateralis*	Silvereye	C
Turdidae	*Zoothera heinei*	Russet-tailed thrush	C
Turdidae	*Zoothera lunulata*	Bassian thrush	C
Turdidae	*Turdus merula*	Common blackbird	Y
Turnicidae	*Turnix varius*	Painted button-quail	C
Turnicidae	*Turnix pyrrhothorax*	Red-chested button-quail	C
Turnicidae	*Turnix melanogaster*	Black-breasted button-quail	V
Turnicidae	*Turnix velox*	Little button-quail	C
Turnicidae	*Turnix maculosus*	Red-backed button-quail	C
Tytonidae	*Tyto novaehollandiae novaehollandiae*	Masked owl (southern subspecies)	C
Tytonidae	*Tyto tenebricosa tenebricosa*	Sooty owl	NT
Tytonidae	*Tyto novaehollandiae*	Masked owl	C
Tytonidae	*Tyto javanica*	Eastern barn owl	C
Tytonidae	*Tyto longimembris*	Eastern grass owl	C
TOTAL		**408**	

Queensland conservation status of each taxon under the *Nature Conservation Act 1992*.

PE - Extinct in the Wild
E - Endangered
V - Vulnerable
NT - Near Threatened
C - Least Concern
() - Not Protected
Y - Introduced to Queensland and has naturalised.

Source: (Queensland Government, 2014d)