Technical Paper

Burnett Mary Regional Assessment

Coastal & Marine Biodiversity

Submitted to

Burnett Mary Regional Group for Natural Resource Management

by

John M. Kirkwood[1]

and

John N.A. Hooper[2]

[1]Southern Fisheries Centre
Queensland Department of Primary Industries & Fisheries
PO Box 76, Deception Bay, Qld 4508

[2]Queensland Museum
PO Box 3300, South Brisbane, Qld 4101

July 2004

Table of Contents

Current resource status

Introduction1

The Burnett-Mary Region (BMR) contains a diverse range of marine and coastal habitats, including coral reefs, continental shelf, sand, mud and rock substrata and vegetated habitats such as mangrove forests, saltmarshes, seagrass beds and algal beds. This region also covers a large geographic range over a transition zone between temperate and tropical faunas on the east coast of Australia. As a result of this large diversity of habitats in a zone which includes both temperate and tropical faunas, the BMR has a very high diversity of marine organisms. It also possesses significant tidal wetlands which provide roosting grounds for a diverse range of birds, and contains several areas that have been recognised internationally for their high biodiversity values (Hervey Bay Marine Park, Fraser Island World Heritage Area, Woongarra Marine Park, Great Sandy Straits RAMSAR Site and part of the Great Barrier Reef World Heritage Area).

The marine biodiversity of the BMR has been patchily documented, with some taxa in some areas having been extensively researched (e.g. the fishes of the Capricorn-Bunker Group), and others virtually unknown (e.g. the marine algae of the region). The most complete overall documentation of the biodiversity of the BMR is the Queensland Museum (QM) faunal database, which provides an extensive list of the marine, aquatic and terrestrial fauna that has been collected from the region and lodged with the museum. This database contains approximately 32,000 records of taxa from the BMR, comprising about 3,700 species belonging to 14 phyla (Appendix 1). However, this database is incomplete and the actual number of species and phyla present in the region is certainly far greater than those present in the QM collections. In fact, the marine sediments within the BMR almost certainly house representatives of at least 30 animal phyla.

The BMR includes significant type localities for 33 crustaceans (mostly freshwater), 131 'worm' species (from various phyla), 1 mollusc, 169 arachnids, 616 beetles (Coleoptera) and 380 vertebrates (mostly marine fish) (Appendix 1). Amongst those are type localities for the following marine and estuarine species:
Crustaceans: Colobomatus cribbi (Copepod); Enigmaplax littoralis, Heteropanope longipedes, Ilyoplax strigicarpu and Perisesarma semperi longicristatum (Decapods); Platylepas coriacea, Tubicinella cheloniae (Thoracicans); Actaecia formida (Isopod).
Mollusc: Apixystus rippingalei (from Lady Musgrave Island).
Fish: Bembras macrolepis, Erosa iridea, Choerodon frenatus, Encheliophis houlti, Alepes apercna, Craterocephalus marjoriae, Arenigobius leftwichi, Lepidotrigla umbrosa, Pristotis virescens, Halichoeres vestalis, Gymnocranius affinis, Suggrundus jugosus, Tathicarpus appeli, Torquigener tuberculiferus, Pseudopataecus taenianotus.

[1] For the purposes of this report, estuarine environments are included within the marine environment as a whole.

1.1. Invertebrate fauna

Introduction

Compared with nearby regions to the north (e.g., Heron Island) and south (e.g., Moreton Bay), few surveys have been conducted of marine invertebrate fauna in the BMR. However, there have been some collections from the region that have provided a total of 880 marine invertebrate species for the Queensland Museum (Appendix 1). Significant amongst those are 267 species of sponges (Porifera), including 40 species that have not been recorded elsewhere (apparent endemics). Collections from the BMR also include 265 species of cnidarian (corals, soft corals, hydroids, anemones and jellyfish), of which approximately 150 species are reef-building hard corals; 53 species of free-living and parasitic worms (Platyhelminthes, Nematoda, Annelida); 38 species of gastropod and bivalve molluscs; 299 species of crustacean (crabs, prawns, lobsters, scallops, barnacles etc.); 48 species of echinoderm (sea stars, sea urchins and sea cucumbers); 11 minor 'higher worm' phyla (lophophorates, peanut worms, lancets, lamp shells, acorn worms); and 99 species of sea squirts and salps (Ascidiacea) (Appendix 1).

The list of 880 species in the QM collections is undoubtedly a very small proportion of the marine invertebrate biodiversity of the region. For instance, the QM collections contain only 13 species of polychaete worm, yet Grassle (1973) collected 103 species of polychaete from just one sample of coral rock. Further, some entire phyla known to be well-represented in the region (e.g. Bryozoa) are not represented in the QM collections. The true number of marine invertebrate species in the BMR can only be guessed at, but is probably in the range of 104-106. Further efforts to generate a more complete list would add many species, but any such list would still be incomplete as there has been little sampling of marine invertebrates in the region. To even approach a complete list of marine invertebrates for the BMR would require several lifetimes of work.

Threatened and declining species

The invertebrate fauna of the BMR is insufficiently well known for the conservation status of any individual species to be determined. Significant threats to the marine invertebrates of the region include trawling, sedimentation and nutrient enrichment from terrestrial runoff and global warming. Trawling represents a particular threat to soft-bottom dwelling animals such as sponges, ascidians and echinoderms which are significant components of trawl by-catch.

Exotic species

No exotic marine or estuarine invertebrate species have recorded from the BMR. However, there has been no dedicated survey of exotic species in the region, and it is possible that some exotic species are present in the region and have yet to be detected. An initial baseline survey of introduced marine species in the Gladstone Port Area, just north of the BMR, found only nine species of introduced marine invertebrate: five bryozoans, two ascidians, one hydrozoan and one isopod crustacean (Lewis *et al*. 2001). None of those species found is classified as a pest species (i.e. they do not threaten endemic species, the natural ecology of the harbour, fisheries or human health) and none of them are among the target species identified by the Australian Ballast Water Management Advisory Committee. In spite of the absence of identified pest species, introduced marine pests remain a threat to the marine fauna and flora of the BMR given the large number of small ports, marinas, anchorages and boat harbours in the region.

Invertebrates of cultural, recreational or commercial value

Many of the invertebrate species in the QM collections have significant economic and cultural values. For instance, the reef-building corals are one of the primary structural components of the coral reefs in the BMR, which draw large numbers of tourists to the region and provide habitat for a wide range of other species. Other invertebrates are primary targets for pharmaceutical screening of bioactive compounds (particularly the sponges and ascidians).

The invertebrate fisheries within the BMR include some of the most valuable fisheries in Queensland. A wide variety of invertebrate species are targeted by commercial and recreational fishers; with the major species being:
Crustaceans
Crabs
Spanner Crab (Ranina ranina)
Mud Crab (Scylla serrata)
Blue Swimmer Crab (Portunus pelagicus)
Prawns
Banana Prawn (Penaeus merguiensis)
Eastern King Prawn (Penaeus plebijus)
Tiger Prawn (Penaeus esculentus)
Grooved Tiger Prawn (Penaeus semisulcatus)
Giant Tiger Prawn (Penaeus monodon)
Endeavour Prawn (Metapenaeus endeavouri)
Red Endeavour Prawn (Metapenaeus ensis)
Greasyback Prawn (Metapenaeus bennetti)
School Prawn (Metapenaeus macleayi)
Hardback Prawns (Trachypenaues spp.)
Others
Moreton Bay Bugs (Thenus spp.)
Balmain Bugs (Ibacus spp.)
Slipper Lobsters (Scyllaroides spp.)
Yabby (Trypaea australiense)
Molluscs
Gastropods
Trochus shell (Trochus niloticus)
Many species for shell collections
Bivalves
Ballot's Saucer Scallop (Amusium japonicum balloti)
Oysters (Saccostrea spp.)
Cephalopods
Pencil Squid (Photololigo spp.)
Northern Calamari (Sepioteuthis spp.)
Arrow Squid (Nototodarus spp., Ommastrephos bartramii & Stenoteuthis oualaniensis)
Mitre Squid (Loligo chinensis)
Echinoderms
Several species of holothurians (sea cucumbers)
Polychaetes
Beach worm (Australonuphis spp.)
Blood worm (Marphysa sanguina)

The most valuable commercial invertebrate fisheries in the BMR are the Scallop, Spanner Crab and Prawn Fisheries (Table 1).

Table 1: Estimated commercial catches of the six most valuable invertebrate species in the Burnet-Mary Region in 1995 (Spanner Crabs) or 2000 (other species). Calculated from information provided in Brown *et al*. (1999) and Williams (ed.) (2002).

Common name	Catch weight (tonnes)	Value (million $)
Scallop	370	7.3
Spanner Crab	1,292	7.0
Eastern King Prawn	282	3.4
Blue Swimmer Crab	188	1.5
Mud Crab	106	1.1
Banana Prawn	52	0.5

An average of about 235 tonnes of scallop meat (c. 22% of the Queensland catch) is harvested from the BMR each year, although annual production is highly variable (Dredge & Williams 2002). In 2000 the harvest was 370 tonnes with a wholesale value of $7.3 million (Table 1). The Spanner Crab fishery expanded rapidly in the mid 1990's, reaching a peak of 3,592 tonnes in 1995 (Brown et al. 1999). A major reason for this increase was the development and rapid expansion of the fishery in the BMR, where 1,292 tonnes (42% of the Queensland catch) were harvested in 1995 (Walker 1997), with an estimated wholesale value of around $7 million. Prawn fisheries harvest ten different species of prawn in the BMR using a combination of beam trawling (in estuaries) and otter trawling (offshore). In terms of catch weight, the most important species is the Eastern King Prawn. The 2000 commercial harvest from the region was around 282 tonnes, with a wholesale value of $3.4 million (Courtney & Williams 2002).

The most significant recreationally harvested marine invertebrates in the BMR are the Mud and Blue Swimmer Crabs. Mud crabs are taken using baited traps (or 'pots') which are set below low-tide level over soft mud substrata in mangrove-lined estuaries, whilst blue swimmer crabs (= sand crabs) are taken in more open sandy areas.

Knowledge gaps
Biodiversity of invertebrates
Impacts of trawling on soft-sediment invertebrates
Impacts of global warming on coral reefs
Presence of exotic species

Fish fauna

Introduction2

The marine and estuarine fish fauna of the BMR is extraordinarily diverse, with over 1,500 species having been recorded in the study area (Appendix 2). This represents approximately 37% of all marine fish species found off Australia's coastline, and about 11% of all marine fish species in the world. In fact, the fish species diversity of the BMR exceeds that of the entire Great Barrier Reef, partially because the region includes some of the GBR, but also because:

the region is situated in an area of overlap that contains both tropical and temperate fish faunas,

the region contains a wide diversity of habitats (particularly coral reefs, but also rock & artificial reefs, continental shelf, exposed & sheltered coastlines, estuaries, algal beds, seagrass beds, mangroves & mud flats),

there have been a large number of surveys of fish in the region (and on coral reefs to the immediate north), and

research on trawl by-catch is being conducted in the region, with all fish species collected being lodged at the QM.

The present list of 1,512 fish species is not complete, and new records are being reported each year. For the Capricorn-Bunker group alone, the number of reported fish species increased by a mean of almost 25 species per year from 1978 to 1993 (Figure 1). New species are being added to the list all the time, largely due to an ongoing study of trawl by-catch being conducted by QDPI and QM. Of the 1,512 marine fish species currently recorded from the region, just over a third (519 species) are housed in the QM collections (Appendix 1, Appendix 2).

[2] This section of the report includes the fish fauna of the Capricorn-Bunker group of reefs. This is because no separate list of the fish fauna of reefs within the Burnett-Mary Region (Lady Elliot, Lady Musgrave, Fairfax, Hoskyn and Boult reefs) has been published. The fish fauna of those reefs is likely to be virtually identical to that of the more extensively studied reefs (Heron & One Tree Reefs) because adjacent reefs of similar geomorphology and environmental conditions can be expected to have similar fish faunas. Most of the 1111 fish species on the Great Barrier Reef are present along the entire length of the reef (Randall *et al*., 1990). This reflects the fact that almost all coral reef fish have planktonic larval stages that disperse amongst reefs.

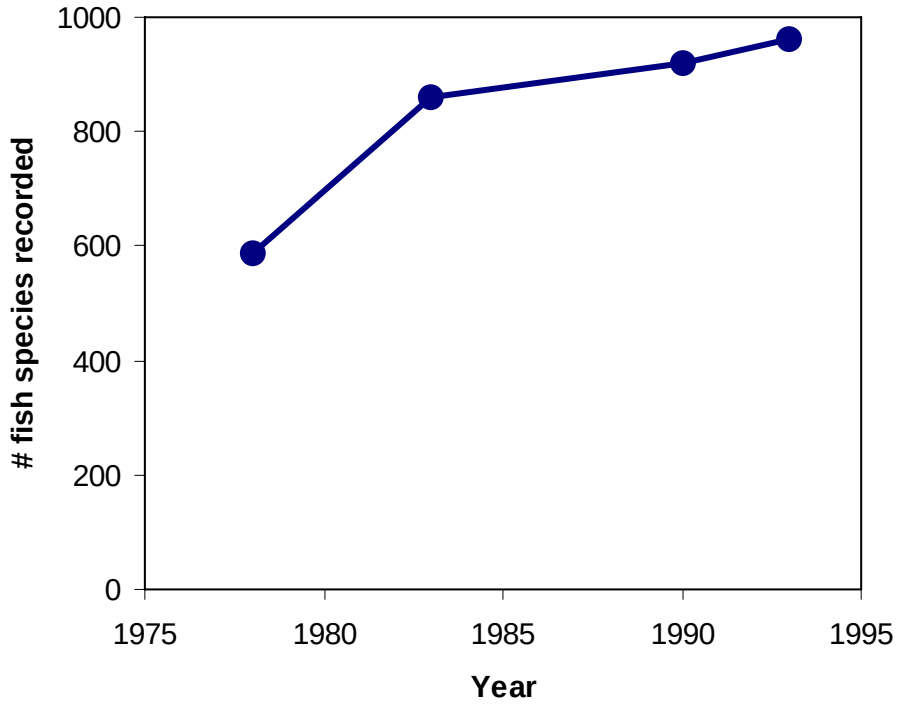


Figure 1: The number of fish species recorded in the Capricorn-Bunker Group increased by more than 60% from 1978 to 1993 (Anonymous 1978, Russell 1983, Lowe & Russell 1991, Mather & Bennett 1993).

The 1,512 marine fish species recorded from the BMR belong to 191 families (Appendix 2). However, over 50% of those species belong to the 15 most common families (Table 2). The family with the greatest number of species is the Gobiidae (gobies) which is also the largest fish family in the world. Gobies are generally small fish that usually live on or in the sea bottom, frequently hiding in holes or amongst corals and other structure forming invertebrate animals. Because of their small size and cryptic habitat, these fish are not well known amongst lay-people, and they are not exploited by recreational or commercial fishermen (apart from small numbers collected for the aquarium trade). Probably the most well-known gobies in the region are the 'shrimp gobies' (Amblyeleotris, Cryptocentris, Ctenogobius and Vanderhostia spp.) which live in small burrows excavated by shrimps, acting as sentinals and protecting the shrimps from predators. Most of the other common fish families are associated with coral reefs, although several families of pelagic fish are also well-represented in the region (e.g., Carangidae, Carcharinidae). The Labridae (wrasses) is one of the more diverse fish families in the world, with individual species ranging in size from 5cm up to 2.29 m and 190 kg (Hump-headed maori wrasse). Wrasses are commonly exploited by the aquarium fish trade, as are pomacentrids (damsel fish), apogonids (cardinal fish), chaetodontids (coral fish) and acanthurids (surgeon fish).

Table 2: The top 15 families of marine fish contain 758 of the 1512 species recorded from the Burnet-Mary Region.

Rank	Family	Common Name	# Species
1	Gobiidae	Gobies	141
2	Labridae	Wrasses	93
3	Pomacentridae	Damsel Fish	75
4	Serranidae	Groupers	60
5	Apogonidae	Cardinal Fish	58
6	Blenniidae	Blennies	52
7	Garangidae	Trevallies	43
8	Chaetodontidae	Coral Fish	39
9	Scorpaenidae	Scorpion Fish	33
10	Tetradontidae	Puffer Fish	33
11	Acanthuridae	Surgeon Fish	29
12	Muraenidae	Moray Eels	27
13	Scaridae	Parrot Fish	26
14	Syngnathidae	Pipe Fish	26
15	Carcharinidae	Whaler sharks	23

Threatened and declining species

Pogonoski et el. (2002) list 46 species of marine fish that have been recorded from the BMR as endangered, vulnerable or potentially threatened to some extent (Table 3). More than half of those species are sharks and rays, including the Grey Nurse Shark (Endangered), Green Sawfish (Endangered), Colclough's Blind Shark (Vulnerable) and the Great White Shark (Vulnerable). The only bony fish classified as Vulnerable to extinction is the Black Rock Cod (Epinephelus daemelii).

The east coast population of Grey Nurse Sharks is estimated to be less than 500 (Anonymous, 2002). There is a resident population of Grey Nurse Sharks at Wolf Rock, off Double Island Point, which has been classified as a Critical Habitat Site for this species. This is the northernmost known aggregation site for the temperate Grey Nurse Sharks on the east coast of Australia. This species has declined dramatically since the 1960's due to the combined effects of commercial and recreational fishing, beach protective shark meshing and deliberate attempts at extermination (Lupton 1962, Cropp 1964, Ley 1964, Pollard et al. 1996, Pogonoski et al. 2002, Anonymous 2002).

The Green Sawfish was once a very common inhabitant of shallow muddy bottoms and estuaries along the entire east coast of Queensland. Although not dangerous in the wild, this sawfish was regarded as a serious hazard for inshore net fishermen targeting barramundi (Last & Stevens 1994, Pogonoski *et al*. 2002). However, because it was readily caught in gill and trawl nets, this species has undergone a dramatic decline and has rarely been recorded on the east coast in the last 30 years.

Table 3: Conservation status of threatened or endangered fish species recorded from the BMR. CD = Conservation Dependent, NT = Near Threatened, LC = Least Concern. After Pogonoski et al. (2002).

Species	Common name	IUCN Status
Carcharias taurus *	Grey Nurse Shark	Endangered
Pristis zijsron	Green Sawfish	Endangered
Brachaelurus colcloughi	Colclough's Blind Shark	Vulnerable
Carcharodon carcharias	Great White Shark	Vulnerable
Epinephelus daemelii	Black Rockcod	Vulnerable
Cheilinus undulatus	Humphead Maori Wrasse	Lower Risk (CD)
Chromileptes altivelis	Barramundi Cod	Lower Risk (CD)
Epinephelus lanceolatus	Queensland Groper	Lower Risk (CD)
Carcharhinus plumbeus	Sandbar Shark	Lower Risk (NT)
Dasyatis fluviorum	Estuary Stingray	Lower Risk (NT)
Hippocampus dahli	Pipefish	Lower Risk (NT)
Thunnus maccoyii	Southern Bluefin Tuna	Lower Risk (NT)
Urogymnus asperrinus	Porcupine Ray	Lower Risk (NT)
Aetobatus narinari	White-spotted Eagle Ray	Lower Risk (LC)
Carcharhinus amblyrhynchos	Grey Reef Shark	Lower Risk (LC)
Carcharhinus brevipinna	Spinner Shark	Lower Risk (LC)
Carcharhinus falciformes	Silky Shark	Lower Risk (LC)
Carcharhinus leucas	Bull Shark	Lower Risk (LC)
Epinephelus coioides	Estuary Cod	Lower Risk (LC)
Epinephelus cyanopodus	Purple Rockcod	Lower Risk (LC)
Epinephelus fuscoguttatus	Flowery Cod	Lower Risk (LC)
Epinephelus malabaricus	Malabar Grouper	Lower Risk (LC)
Epinephelus tauvina	Greasy Rockcod	Lower Risk (LC)
Hypogaleus hyugaensis	Pencil Shark	Lower Risk (LC)
Manta birostris	Manta Ray	Lower Risk (LC)
Mustelus antarcticus	Gummy Shark	Lower Risk (LC)
Prionace glauca	Blue Shark	Lower Risk (LC)
Rhynchobatos djiddensis	White-spotted Guitarfish	Lower Risk (LC)
Sphyrna lewini	Scalloped Hammerhead Shark	Lower Risk (LC)
Sphyrna mokarran	Great Hammerhead Shark	Lower Risk (LC)
Taeniura lymma	Blue-spotted Fantail Ray	Lower Risk (LC)
Triaenodon obesus	Whitetip Reef Shark	Lower Risk (LC)
Bolbometopon muricatum	Hump-headed Parrotfish	Data Deficient
Carcharhinus limbatus	Common Blacktip Shark	Data Deficient
Dalatias licha	Black Shark	Data Deficient
Epinephelus ergastularius	Rockcod	Data Deficient
Hexanchus griseus	Bluntnose Sixgill Shark	Data Deficient
Hippocampus hendriki	Pipefish	Data Deficient
Hippocampus queenslandicus	Pipefish	Data Deficient
Ogilbyina novaehollandiae	Multicoloured Dottyback	Data Deficient
Orectolobus ornatus	Banded Wobbegong Shark	Data Deficient
Rhincodon typus	Whale Shark	Data Deficient
Solegnathus dunckeri	Pipefish	Data Deficient
Solegnathus hardwickii	Pipefish	Data Deficient
Syngnathoides biaculeatus	Double-ended Pipefish	Data Deficient

Xiphias gladius	Swordfish	Data Deficient

The rare Colclough's Blind Shark is a small shark that has a limited range in shallow waters off the south Queensland coast. This species is threatened by the trawl fishery which takes these sharks as by-catch and also damages their inshore reef habitats (Pogonoski et al. 2002). Great White Sharks are generally found in colder waters, although individuals do occasionally enter the region, and have been found as far north as Mackay. A total of 670 Great White Sharks were caught between Rockhampton and the Gold Coast by the Queensland Shark Control Program from 1962 to 2002, with numbers declining steadily over that period. Outside of Queensland, the greatest threats to this species are commercial fishing in southern Australia and beach meshing in NSW (Pogonoski et al. 2002).

The Black Rock Cod is a warm temperate species that has been recorded off Breaksea Spit and close to Bundaberg (Pogonoski et al., 2002). This species has suffered marked declines, largely due to spearfishing (Lincoln-Smith et al. 1989, Leadbitter 1992), but is not currently protected in Queensland.

Exotic species

No exotic marine or estuarine fish species have recorded from the BMR.

Fish of cultural, recreational or commercial value[3]

The BMR contains some of the most productive commercial fishing grounds in Queensland, and is second only to Moreton Bay as a destination for recreational fishermen. The main fish species taken by recreational anglers varies according to habitat, as follows:

Estuaries and sheltered inshore waters:
Whiting (Sillago ciliata, S. maculata & S. analis),
Sea Mullet (Mugil cephalus),
Yellow-fin Bream (Acanthopagrus australis), and
Flathead (Platycephalus fuscus & P. indicus).

Exposed headlands and beaches:
Tailor (Pomatomus saltatrix),
Dart (Trachinotus russelli & Trachinotus blochii),
Jewfish (Argyrosomus hololepidotus)
Whiting (S. ciliata, S. maculata & S. analis), and
Yellow-fin Bream (A. australis).

Inshore reefs:
Yellowtail Kingfish (Seriola lalandi),
Mackerel (Scomberomorus commerson, S. munroi, S. quenslandicus & S. semifasciatus),
Trevally (Carangidae – several spp.),
Cod (Serranidae – several spp.),
Snapper (Pagrus auratus), and
Tuskfish (Choerodon spp. - incorrectly called Parrot Fish).

Offshore reefs:
Coral Trout (Plectropomus leopardus & P. maculatus),
Red Throat Emperor (Lethrinus miniatus),
Sweetlip (Haemulidae – several spp.),
Cod (Serranidae – several spp.),
Emperors (Lethrinidae – several spp.), and

[3] This section covers only the finfish fishery. Fisheries based on invertebrates are treated above.

Sea Perch (Lutjanidae – several spp.).

Commercial ‘finfish’ fishing operations in the BMR consist of the following operations:

- Ocean beach net fishery:

Major targets
Mullet (Mugil cephalus) and
Tailor (Pomatomus saltatrix).
Minor species
Yellow-fin Bream (Acanthopagrus australis),
Whiting (Sillago ciliata, S. maculata & S. analis), and
Dart (Trachinotus russelli & Trachinotus blochii).

- Estuarine net fishery:

Whiting (Sillago ciliata, S. maculata & S. analis),
Sea Mullet (Mugil cephalus),
Yellow-fin Bream (Acanthopagrus australis),
Flathead (Platycephalus fuscus & P. indicus), and
Barramundi (Lates calcarifer).

- Coral Reef line fishery:

Coral Trout (Plectropomus leopardus & P. maculatus),
Red Throat Emperor (Lethrinus miniatus),
Sweetlip (Haemulidae – several spp.),
Cod (Serranidae – several spp.),
Emperors (Lethrinidae – several spp.), and
Sea Perch (Lutjanidae – several spp.).

- Rocky Reef line fishery:

Snapper (Pagrus auratus),
Cod (Serranidae – several spp.),
Snapper (Pagrus auratus), and
Tuskfish (Choerodon spp.).

- Pelagic line fishery:

Yellowtail Kingfish (Seriola lalandi),
Mackerel (Scomberomorus commerson, S. munroi, S. quenslandicus & S. semifasciatus),
Trevally (Carangidae – several spp.),
Tailor (Pomatomus saltatrix), and
Sharks (Carcharinus spp.).
Trawl fishery:
Major targets
Stout Whiting (Sillago robusta) and
Red-spot whiting (Sillago flindersi).
Minor trawl species
Southern Yellowtail Scad (Trachurus novaezealandii),
Goatfish (Mullidae – several spp.),
Pinkies (Nemipteridae – several spp.), and
Pipefish (Solegnathus dunckeri & S. hardwickii).
Aquarium fish fishery:
Wide range of smaller reef fish, including pomacentrids (damsel fish), labrids (wrasses), apogonids (cardinal fish), chaetodontids (coral fish), acanthurids (surgeon fish),

scorpaenids (scorpion fish), some serranids (anthias), pseudochromids (dottybacks), pomacanthids (angel fish) and muraenids (moray eels).

From the above lists, it can be seen that there is considerable overlap in the fish species harvested by each sector. As fish stocks in the region are generally fully exploited, there is considerable conflict between the sectors over the resource. Fish stocks may vary substantially from year to year due to variable recruitment success and a range of other factors. Longer term declines in heavily fished species (such as Tailor) may also be attributed to heavy exploitation. Given the limited an variable supply of the resource, it is not surprising that there is competition and some animosity between recreational and commercial fishers.

Recreational fishing is a major part of the lifestyle of many people in the Burnet Mary Region, and draws many thousands of tourists to the region each year. For instance in Hervey Bay, 75% of anglers surveyed in 1986 were from outside the region (Moore 1986). Since Moore's study, large numbers of people have settled in the Hervey Bay area, so the proportion of local fishers is likely to have increased. Recreational fishing is also a major draw card to Fraser Island, which attracts about 360,000 visitors per annum, generating an estimated $277 million for the region (Anonymous 2002b). The study did not separate the value of recreational fishing from that of other activities on the island. Recreational fishing is also an important contributor to the economy of other coastal communities throughout the region.

As for recreational fishing, no overall estimate of the value of commercial fishing to the BMR has been published. However, the total commercial fishing harvest for all species apart from aquarium fish, shells and bait species averages about 4,275 tonnes per annum, which is about 17.8% of the average annual total commercial harvest for Queensland (24,000 tonnes, Williams 2002). Assuming that the value of fish caught in the BMR is not hugely different from the mean value of fish caught throughout the state, this equates to an annual wholesale value of roughly $52 million.

Knowledge gaps
Impacts of trawling on by-catch species
Sustainability of current fisheries management practices
Conservation status of 'Data Deficient' species
Abundance, biology and ecology of species listed as Vulnerable or Endangered (especially the Green Sawfish and Colclough's Blind Shark)
Marine reptiles

Introduction
Thirteen species of sea snakes and five species of marine turtle have been collected from the BMR and housed in the QM collections (Appendix 1). The sea snake fauna represents an average diversity for tropical-subtropical waters (from an Australian fauna of approximately 30 species). None of these 13 species represent remarkable records for the region, and none are indigenous or unique. They occupy a range of ecological niches from shallow water reef to the pelagic zone (many eating non-commercial fishes, some very specialist in their diets). The major threat to the sea snakes of the region is trawling, which may damage the habitat of the snakes and their prey and capture snakes as a component of the by-catch.

The five marine turtle species known from the BMR occupy a wide range of ecological niches. Adult loggerhead turtles (Caretta caretta) are carnivores, feeding mostly on sandy bottom and reef habitats. Adult green turtles (Chelonia midas) are herbivores feeding on seagrasses and algae of sandy bottoms and reefs. The hawksbill turtle (Eretmochelys imbricata) is most commonly found on reefs and predominantly feeds on sponges. The flatback turtle (Natator depressus) lives on muddy bottoms and feeds on soft corals and other sessile invertebrates, mostly in the deeper inter-reefal zone. The leatherback turtle (Dermochelys coriacea) is a pelagic jellyfish eater, with the widest geographic range of any reptile.

Threatened and declining species

All five marine turtle species collected from the BMR and housed in the QM collections are classified as endangered or vulnerable by the Queensland Environmental Protection Agency (EPA) and Environment Australia (EA) and are protected by legislation (Table 4). Globally, the giant leatherback is considered to be the most threatened of all turtle species. Of local significance, the BMR contains one of the largest nesting areas the endangered loggerhead turtle on the Australian mainland at Mon Repos. The east coast population of this species has experienced a sharp decline until recent years. However, there appears to have been a slowing in the decline of nesting loggerhead turtles in Queensland that is consistent with a response to reduced trawl based mortality with the introduction of compulsory TEDs in 2000 (Col Limpus, personal communication).

Threats to marine turtles include trawling, boat strike, drowning in buoy lines, ghost fishing by crab pots (loggerheads only), capture by shark control gear, entanglement in discarded fishing gear, ingestion of plastic bags and the effects of pollutants. The threat from trawling has been substantially reduced in with the implementation of the Fisheries East Coast Trawl Management Plan 1999 which requires all trawlers operating outside coastal streams on the east coast of Queensland to use approved TEDs. Fibro-papilloma disease is a common disease amongst turtles in some areas, and this may be related to high industrial or agricultural runoff. Turtle populations nesting on the mainland coast are also under threat from feral species such as foxes and dogs.

Table 4: Conservation status of threatened or endangered sea turtles recorded from the BMR, according to the Queensland Environmental Protection Agency (EPA) and Environment Australia (EA).

Species	Common name	EPA	EA
Caretta caretta	Loggerhead	Endangered	Endangered
Dermochelys coriacea	Leatherback	Endangered	Vulnerable
Chelonia mydas	Green	Vulnerable	Vulnerable
Eretmochelys imbricata	Hawksbill	Vulnerable	Vulnerable
Natator depressus	Flatback	Vulnerable	Vulnerable

Marine reptiles of cultural, recreational or commercial value

Mon Repos is the largest nesting site for marine turtles on the east coast of Australia. Large numbers of tourists visit this beach each year between November and March to watch green, loggerhead and flatback turtles come ashore to lay their eggs, and then to observe the hatchlings race down to the water.

Knowledge gaps
How to reduce by-catch of loggerhead turtles in crab pots

Seabirds

Introduction
Appendix 1 provides a list of birds collected from the BMR and housed in the QM collections, some of which are listed as rare and threatened (see below). This list is not comprehensive, particularly with respect to birds associated with the islands of the Great Barrier Reef, but contains a large number of species found in significant coastal, estuarine and true marine habitats. Twyford & Hobson (1996) and Driscoll (1998) reported 25 waders, thirteen pelagic birds and five coastal bird species that are not in the QM collections from the BMR (Table 5).

Table 5 Marine birds reported from the Fraser Island World Heritage Area and the Great Sandy Straits (Twyford & Hobson 1996, Driscoll 1998). Waders listed by number sighted between 1989 and 1996 (Driscoll (1998), other groups listed by Family.

* = species on Queensland Museum database.

EPBC = species listed under EPBC Act.

Wading Birds

Family	Species	Common name	EPBC	**Number**
Scolopacidae	Limosa lapponica *	Bar-tailed Godwit	yes	143,963
Scolopacidae	Numenius madagascarensis	Eastern Curlew	yes	32,197
Scolopacidae	Heteroscelus brevipes *	Grey-tailed Tattler	yes	22,824
Charadriidae	Charadrius mongolus	Lesser Sand Plover	yes	17,574
Scolopacidae	Calidris ruficollis	Red-necked Stint	yes	15,993
Scolopacidae	Calidris tenuirostris	Great Knot	yes	5,893
Charadriidae	Charadrius leschenaultii	Greater Sand Plover	yes	5,512
Scolopacidae	Numenius phaeopus *	Whimbrel	yes	4,340
Scolopacidae	Xenus cinereus	Terek Sandpiper	yes	3,150
Charadriidae	Charadrius ruficapillus *	Red-capped Plover	yes	2,697
Haematopodidae	Haematopus longirostris	Pied Oystercatcher		2,053
Scolopacidae	Calidris ferruginea	Curlew Sandpiper	yes	2,036
Scolopacidae	Calidris canutus	Red Knot	yes	1,588
Recurvirostridae	Himantopus himantopus	Black-winged Stilt		1,488
Scolopacidae	Tringa nebularia	Common Greenshank	yes	1,395
Charadriidae	Pluvialis squatarola	Grey Plover	yes	1,369
Scolopacidae	Calidris acuminata *	Sharp-tailed Sandpiper	yes	823
Scolopacidae	Arenaria interpes	Ruddy Turnstone	yes	784
Charadriidae	Pluvialis fulva *	Pacific Golden Plover	yes	447
Charadriidae	Vanellus miles *	Masked Lapwing		378
Scolopacidae	Tringa stagnatalis	Marsh Sandpiper	yes	247
Charadriidae	Charadrius bicinctus	Double-banded Plover	yes	149
Recurvirostridae	Recurvirostra novaehollandiae	Red-necked Avocet	yes	103
Scolopacidae	Limosa limosa	Black-tailed Godwit	yes	39
Charadriidae	Erythrogonys conctus	Red-kneed Dotterel		20
Charadriidae	Elseyornis melanops *	Black-fronted Plover		15
Scolopacidae	Gallinago hardwickii *	Latham's Snipe	yes	10
Scolopacidae	Heteroscelus incanus *	Wandering Tattler		10
Burhinidae	Esacus neglectus	Beach Stone-curlew		6
Scolopacidae	Limicola falcinellus	Broad-billed Sandpiper	yes	2
Scolopacidae	Limnodromus semipalmatus	Asian Dowitcher	yes	2
Charadriidae	Charadrius hiaticula	Ringed Plover		-
Haematopodidae	Haematopus fuliginosus	Sooty Oystercatcher		-
Scolopacidae	Actis hypoleucos	Common Sandpiper		-
Scolopacidae	Calidris alba *	Sanderling		-
Scolopacidae	Calidris melanotus	Pectoral Sandpiper		-
Scolopacidae	Numenius minutes *	Little Curlew	yes	-

Table 5 (continued)
Pelagic Birds

Family	Species	Common name	EPBC
Diomedeidae	Diomedea cauta	Shy Albatross	
Diomedeidae	Diomedea chlororhynchos	Yellow-nosed Albatross	
Diomedeidae	Diomedea chrysostoma	Grey-headed Albatross	
Diomedeidae	Diomedea exulans *	Wandering Albatross	
Diomedeidae	Diomedea melanophris	Black-browed Albatross	
Diomedeidae	Phoebetria palpebrate *	Light-mantled Sooty Albatross	
Fregatidae	Fregeta ariel	Lesser Frigatebird	
Fregatidae	Fregeta minor	Great Frigatebird	
Hydrobatidae	Oceanites oceanicus *	Wilson's Storm Petrel	
Laridae	Anous minutes *	Black Noddy	yes
Laridae	Anous stolidus *	Common Noddy	yes
Laridae	Childonias hybrida	Whiskered Tern	
Laridae	Childonias leucoptera	White-winged Black Tern	
Laridae	Gygis alba *	White Tern	
Laridae	Larus novaehollandiae *	Silver Gull	yes
Laridae	Stercorarius pomarinus	Pomarine Jaeger	
Laridae	Sterna albifrons *	Little Tern	
Laridae	Sterna anaethetus *	Bridled Tern	yes
Laridae	Sterna bengalensis	Lesser Creasted Tern	
Laridae	Sterna bergii *	Crested Tern	yes
Laridae	Sterna caspia	Caspian Tern	yes
Laridae	Sterna dougallii *	Roseate Tern	yes
Laridae	Sterna fuscata *	Sooty Tern	
Laridae	Sterna hirundo *	Common Tern	
Laridae	Sterna nilotica	Gull-billed Tern	
Laridae	Sterna sumatrana *	Black-naped Tern	yes
Phaethontidae	Phaethon lepturus *	White-tailed Tropicbird	
Phaethontidae	Phaethon rubricauda	Red-tailed Tropicbird	yes
Procellariidae	Daption capense *	Cape Petrel	
Procellariidae	Halobaena caerula *	Blue Petrel	
Procellariidae	Lugensa brevirostris *	Kerguelen Petrel	
Procellariidae	Macronectes giganteus *	Southern Giant Petrel	yes
Procellariidae	Pachyptila belcheri *	Slender-billed Prion	
Procellariidae	Pachyptila desolata *	Antarctic Prion	
Procellariidae	Pachyptila salvini *	Salvin's Prion	
Procellariidae	Pachyptila turtur *	Fairy Prion	
Procellariidae	Pseudobulweria rostrate *	Tahiti Petrel	
Procellariidae	Pterodroma lessoni *	White-headed Petrel	
Procellariidae	Pterodroma leucoptera *	Gould's Petrel	
Procellariidae	Pterodroma nigripennis *	Black-winged Petrel	
Procellariidae	Pterodroma solandri *	Providence Petrel	
Procellariidae	Puffinus carneipes *	Flesh-footed Shearwater	
Procellariidae	Puffinus gavial *	Fluttering Shearwater	
Procellariidae	Puffinus griseus *	Sooty Shearwater	
Procellariidae	Puffinus pacificus *	Wedge-tailed Shearwater	yes

Procellariidae	Puffinus tenuirostris *	Short-tailed Shearwater	
Sulidae	Morus serrator *	Australasian Gannet	
Sulidae	Sula dactylatra *	Masked Booby	
Sulidae	Sula leucogaster *	Brown Booby	yes

Table 5 (continued)
Coastal Birds

Family	Species	Common name	EPBC
Accipitridae	Haliaetus leucogaster	White-bellied Sea Eagle	yes
Accipitridae	Haliastur indus *	Brahminy Kite	
Anhingidae	Anhinga melanogaster *	Darter	
Ardeidae	Egretta sacra *	Eastern Reef Heron	
Burhinidae	Burhinus grallarius *	Bush Stone-curlew	
Pelecanidae	Pelecanus conspicillatus *	Australian Pelican	
Phalacrocoracidae	Phalacrocorax carbo	Great Cormorant	
Phalacrocoracidae	Phalacrocorax melanoleucos	Little Pied Cormorant	
Phalacrocoracidae	Phalacrocorax sulcirostris	Little Black Cormorant	
Phalacrocoracidae	Phalacrocorax varius	Pied Cormorant	

The most abundant wading bird in the Great Sandy Straits is the Bar-tailed Godwit, which made up over 50% of the waders counted by the QWSG (Table 5). Other very abundant waders were the Eastern Curlew, Grey-tailed Tattler, Lesser Sand Plover and Red-necked Stint. The great majority of waders in the Great Sandy Straits are migratory species, so their numbers vary considerably throughout the year. Driscoll (1998) did not notice any significant increase or decrease in the total number of wading birds between 1990 and 1997. Twyford & Hobson (1996) list 92 species of seabirds

The QM collections also contain large numbers of species found predominantly in mangroves (e.g. shining fly-catcher (Myiagra alecto), Collared kingfisher (Todiramphus chloris)), Lewin's rail (Rallus pectoralis)) and pelagic feeders (e.g. Caspian tern (Hydroprogne caspia), White billed storm petrel (Fregetta grallaria), Roseate tern (Sterna dougallii)). Several rare, threatened or endangered species of birds are significant to this region. The Northern giant-petrel (Macronectes halli) and the Southern giant-petrel (Macronectes giganteus), represent their northern-most distributions, and the Radjah shelduck (Tadorna radjah), reaches its most southeasterly distribution. Threats to bird species include mangrove habitat destruction, acid sulphate soils, erosion and pollution of estuarine regions, hooking and entanglement in fishing gear and entanglement and ingestion of plastics in the marine flotsam.

Threatened and declining species
Six marine bird species in the QM collections from the BMR are classified as threatened or declining by the Queensland Environmental Protection Agency (EPA) (Table 6).

Table 6: Conservation status of threatened or endangered sea birds in the QM collections from the BMR, according to the Queensland Environmental Protection Agency (EPA).

Species	Common name	EPA
Sterna albifrons	Little Tern	Vulnerable
Macronectes halli	Northern Giant Petrel	Vulnerable
Accipiter novaehollandiae	Grey Goshawk	Rare
Tadorna radjah	Radjah shellduck	Rare
Ephippiorhynchus asiaticus	Black-necked Stork	Rare
Rallus pectoralis	Lewin's Rail	Rare
Macronectes giganteus	Southern Giant Petrel	Rare

Marine mammals

Introduction
Appendix 1 provides a list of marine mammals collected from the BMR and housed in the QM collections. The list also includes several non-marine species that live in coastal habitats, such as possums and rats (including the vulnerable false water-rat, Xeromys myoides). It should be noted that the QM records of marine mammals (dugongs and cetaceans) represent strandings only, and in some cases whales may have washed in from beyond the continental shelf. Thus, the list does not contain all cetacean fauna from the BMR. Two species that are known to exist in the region, but are not in the stranding records are Risso's dolphin (Grampus griseus) and the Indopacific humpbacked dolphin (Sousa chinensis: classified as threatened).

The rare Irrawaddy River Dolphin reaches its most southern distribution off Brisbane with populations in the south threatened by recreational boating and fishing. False water-rats represent an ongoing problem, being threatened by pesticides, urban development, recreational four-wheel driving, pollution, acid sulphate soils and feral predators. Patches of significant mangroves in the region are important habitats for false water-rats, and habitat destruction to mangrove communities (e.g. urban development, sand mining, aquaculture) are potential major threats to these populations. False water-rats also require supra-tidal habitat (where they build their nesting mounds), and this habitat is threatened by coastal development and sea level rise.

Significant marine mammals

1.1.1.1. Dugong
Dugongs are found throughout the coastal marine area of the BMR, with the highest concentrations in southern Hervey Bay and the Great Sandy Straits. Estimates of the total number of dugongs within the region have fluctuated dramatically since aerial

surveys commenced in 1986/'87. Between the initial surveys in 1986-'88 and a subsequent region-wide survey in 1994, the estimated total number of dugongs in the region fell from 2,555 to 911 (- 64%) (Marsh & Lawler 2001). Then in five years from 1994 to 1999, the estimated number of dugongs increased to 1,708 (+ 87%), a mean rate of 13.4% per annum. Even more dramatic fluctuations in estimated dugong numbers have occurred in areas of dugong concentration within the region (Figure 2). For instance, the estimated number of dugongs in southern Hervey Bay dropped by over 99% between the 1988 and 1992 surveys, but recovered to 50% of the 1988 estimate by 1999 (Marsh & Lawler 2001). Over the same period of the massive decline in southern Hervey Bay, there was a 70% decline in estimated dugong numbers in Rodd's Bay but a 250% increase in the Great Sandy Straits (Figure 2).

Massive changes in dugong population estimates between surveys have also been reported for the Great Barrier Reef (Marsh et al. 1995, Marsh & Lawler 2001) and Moreton Bay (Lanyon & Morrice 1997, Lanyon 2003). Preen & Marsh (1995) attributed the 1992 population crash in southern Hervey Bay to both emigration and mortality following the smothering of seagrasses in the area as a result of a large flood in the Mary River in 1992. The emigration idea was supported by the increase in dugong numbers in the Great Sandy Straits at the same time. However, the causes of other population changes are less clear, and the subject of considerable controversy. Some of the apparent population declines are clearly unsustainable for a slow reproducing species such as the dugong (Marsh 1995, Boyd et al. 1999), and represent a cause for serious concern. However, some of the apparent population increases are impossible for such a slow reproducing species, so must reflect either errors in population estimation or large-scale movements of dugongs. Such movements may include tidal migrations or longer distance movements over longer time-scales.

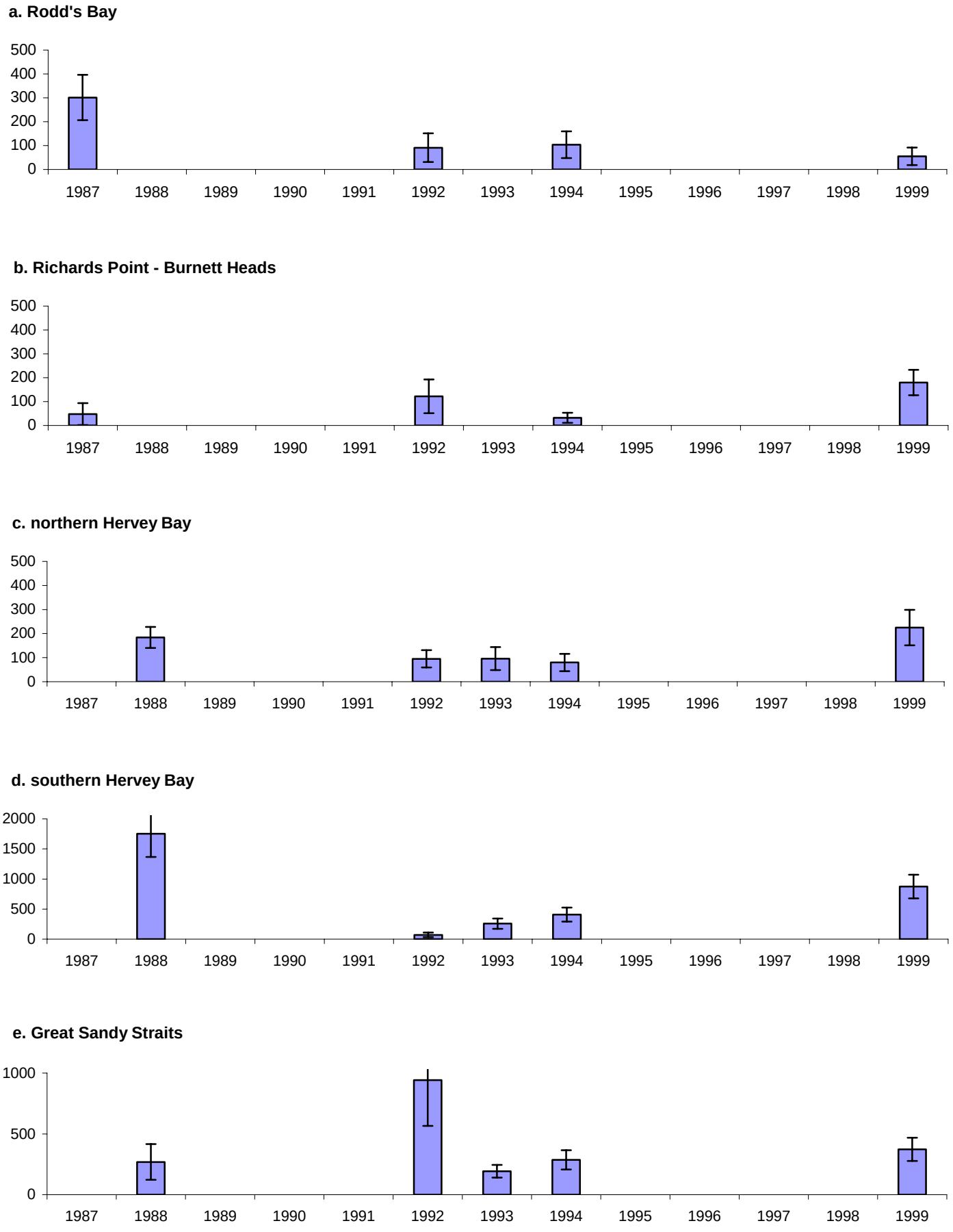
Sources of error within the survey design; such as variation in sighting conditions (due to glare, weather or sea state), unavailability of experienced observers or extrapolation errors due to low sampling intensity (11.66% of the survey area in the case of Marsh & Lawler (2001)) may contribute to errors in population estimates. However, Helene Marsh (pers. comm.) believes that these population fluctuations are largely due to large-scale movements of dugong populations between surveys. Another possible explanation is that the migration of dugongs to deeper waters at low tide makes invisible from aircraft, thus leading to substantial underestimation of dugong numbers on surveys conducted at low tide. Janet Lanyon (unpublished data) has shown that a dugong survey conducted at low tide in Moreton Bay yielded a dugong count that was 43% less than the count from a high tide survey on the same day.

There is a clear need to identify the causes for the large variability in dugong population estimates, and to ensure that the causes of any population declines in this vulnerable species are addressed through appropriate management. Threats to dugongs include set nets (for fishing and shark control), boat strikes, indigenous hunting and loss of seagrass biomass. The largest recorded die-off of dugongs occurred in Hervey Bay in 1992, and was attributed to seagrass loss as a result of high sediment loads washing down the Mary River in a flood event (Preen & Marsh 1995). That sediment load was presumably exacerbated by previous land clearing, inappropriate farming practices and the loss of riparian vegetation.

Management responses in the region include the establishment of Dugong Protection Areas (DPAs) in Hervey Bay and Rodd's Bay. These areas include an estimated 75.1% of the dugongs estimated to be within the BMR by Lawler & Marsh (2001). DPAs were

established to address the threat to dugong numbers posed by gill net fishing, and require fishers to remain with their nets so that they may release any dugongs that are caught. Marsh (2000) has raised some doubts as to the effectiveness of DPAs in protecting dugongs from set nets. Furthermore, several recent prosecutions by the Queensland Boating and Fisheries Patrol have demonstrated that illegal net fishing is not uncommon within DPAs. An further 16.9% of the region's estimated dugong numbers were within the Hervey Bay Marine Park, but outside the Dugong Protection Area.

Figure 9 Estimated dugong populations in five areas within the Burnett Mary Region (+/- se), showing large fluctuations between surveys. NB: scale varies between



some graphs.

1.1.1.2. Humpback Whale

Humpback whales pass through the BMR from May-July on their northerly migration and again from August to October on their southerly migration. During their southern migration, large numbers of humpback whales enter Hervey Bay, forming the basis for a major tourist whale-watching operation in the bay. It is not known why humpbacks enter Hervey Bay, with some people speculating that the northward-facing funnel shape of the bay acts as a natural trap for whales migrating southwards along the Australia coast and others speculating that the whales enter the bay to rest. Whatever the case, some whales do spend up to several weeks in the bay before exiting to the north (often crossing very shallow water over the Breaksea Spit) and resuming their southward migration.

The Australian east coast humpback whale population (= Antarctic Area V stock) was heavily exploited by whaling in Antarctica and from shore-based stations in Australia from 1952 to 1962. This hunting reduced the Australian east coast population from an estimate 10,000 in 1950 to around 100 in 1962. Since then, the population has shown a strong recovery and now stands at around 4,000. This represents an overall rate of recovery of just over 9%, with estimates of the recovery rate in recent years being generally higher (e.g. 10.1 – 14.4 %, IWC official estimate). This remarkable recovery rate has also been recorded for humpback whales off Western Australia.

1.1.1.3. Indo-Pacific Humpback Dolphin

The Indo-Pacific Humpbacked Dolphin is a tropical species, found in the Indian and west Pacific Oceans, including along the east coast of Australia as far south as New South Wales. They live in shallow waters (less than 20 m) that are frequently turbid, and so are at risk from boat strike and propeller injuries. In the 1950's an Indo-Pacific Humpbacked Dolphin was severely injured by the propeller of a trawler. This dolphin (named 'Scarry') was retrieved by the fishermen and recovered on the deck of the trawler and in a holding pen at Tin Can Bay. Since her release, Scarry has returned to Tin Can Bay almost every day to be hand-fed, and has frequently been accompanied by up to seven other Indo-Pacific Humpbacked Dolphins (including her calf 'Mystique'). This dolphin feeding has been a relatively minor tourist attraction, although visitor numbers have increased in recent years bringing economic benefit to the small coastal community.

There are several problems with this dolphin feeding activity, including conflicts with other human users of the small area of foreshore where the feeding occurs, aggressive interactions between dolphins and people and concerns about the effects of feeding wild animals. The feeding area is between a boat fuelling facility (which is a local source of pollution that may affect the dolphin's health) and a busy boat ramp (where reversing boats pose a risk to people observing dolphin feeding).

Threatened and declining species

Including the False Water Rat, four marine mammal species in the QM collections from the BMR are classified as threatened or declining by the Queensland Environmental Protection Agency (EPA) (Table 7). However, the International Union for the Conservation of Nature (IUCN) lists a further 12 species that have been recorded from the region as threatened or endangered in its redlist. Three marine mammals that have been stranded in the BMR are not included on either the EPA or IUCN lists, but are listed here as their conservation status is uncertain.

Table 7: Conservation status of threatened or endangered coastal and marine mammals recorded from the BMR, according to the Queensland Environmental Protection Agency (EPA) and the IUCN redlist (http://www.redlist.org).

Species	Common name	EPA	IUCN
Sirenia			
Dugong dugon	Dugong	Vulnerable	Vulnerable
Odontocete (Toothed) Whales			
Globicephala macrorhynchus	Short-finned Pilot Whale		Lower Risk
Orcaella brevirostris	Irrawaddy River Dolphin	Rare	Data Deficient
Sousa chinensis	Indo-Pacific Humpbacked Dolphin		Data Deficient
Grampus griseus	Risso's Dolphin		Data Deficient
Lagenodelphis hosei	Fraser's Dolphin		Data Deficient
Tursiops truncatus	Bottlenose Dolphin		Data Deficient
Mesoplodon densirostris	Blainville's Beaked Whale		Data Deficient
Mesoplodon layardii	Strap-toothed Whale		Data Deficient
Ziphius cavirostris	Cuvier's Beaked Whale		Data Deficient
Unlisted Odontocete (Toothed) Whales			
Kogia breviceps	Pygmy Sperm Whale		
Peponocephala electra	Melon-headed Whale		
Pseudorca crassidens	False Killer Whale		
Mysticete (Baleen) Whales			
Balaenoptera borealis	Sei Whale		Endangered
Physeter macrocephalus	Sperm Whale		Vulnerable
Megaptera novaeangliae	Humpback Whale	Vulnerable	Vulnerable
Balaenoptera acutorostrata	Minke Whale		Lower Risk
Balaenoptera edeni	Bryde's Whale		Data Deficient
Rodentia			
Xeromys myoides	False Water Rat	Vulnerable	

Marine habitat diversity
The BMR includes oceanic, neritic, estuarine and intertidal marine environments. Each of those environments includes a range of broad habitat types, depending upon the physical, geological and biological processes involved in its formation.

The oceanic environment refers to the environment beyond the continental shelf, and includes the pelagic environment and benthic environments of the continental slope and deep seas. Habitats in these environments are every bit as diverse as the more well known habitats of shallower waters. However, they are extremely poorly known so will not be described here.

The neritic environment refers to the pelagic and benthic environments of the continental shelf, and generally at depths of less than 200 metres. Estuarine environments refer to those environments in which salt and freshwaters mix, and generally have land on two or more sides such as coastal rivers and streams (e.g., Mary, Burrum, Elliott, Burnett & Kolan Rivers and Baffle Creek), bays (e.g., Tin Can Bay, Hervey Bay) and other semi-enclosed coastal waterways (e.g., Great Sandy Straits). Intertidal habitats can be classified in terms of wave energy into high energy (exposed) or low energy (sheltered) shorelines. There is a range of exposure levels along the mainland coast of Hervey Bay as the amount of exposure gradually increases towards the north. Intertidal habitats can also be classified in terms of predominant geological processes into erosional (rocky) or depositional (sand &/or mud) shorelines. Sheltered depositional shorelines may be either vegetated (mangrove, saltmarsh or seagrass), or unvegetated (sandflat, mudflat, saltpan).4

Subtidal Habitats (neritic & estuarine)

1.1.1.4. Pelagic
The pelagic environment is that environment above the sea floor. In terms of the actual total number of species, the pelagic marine environment almost certainly contains the greatest biodiversity on Earth. Organisms in this environment include the neuston (organisms that live in association with the surface film, e.g. Physalia physalis: the 'blue-bottle'), plankton (organisms that drift with the currents) and the nekton (actively swimming organisms, e.g. squid, turtles, sea snakes, whales & most fish). The planktonic component consists of bacteria and cyanobacteria ('blue-green algae'), phytoplankton (unicellular, photosynthetic organisms, e.g. diatoms, dinoflagellates, euglenoids & many algae) and zooplankton (usually minute or very small animals, e.g. hydromedusae, jellyfish, ctenophores, salps, most copepods, amphipods, mysids, isopods, tanaids, many polychaetes). Another major component of the plankton is the larvae of virtually all benthic and nektonic species, including algal spores and the larval stages of invertebrates and fish. The only exceptions to this are the terrestrially-derived vertebrates (e.g., whales, turtles, sea snakes), and some fish and invertebrates that brood their young (e.g., sea horses). The major threats to organisms in the pelagic environment are reduced water quality due to run-off from land-based activities, global climate change and species specific threats mentioned above.

[4] Seagrass and intertidal vegetated habitats (mangroves, saltmarsh) are covered in Prange & Duke (2004).

1.1.1.5. Benthic (sea floor)

(a) Hard Substrata

Biogenic (e.g., coral reefs)

The BMR contains some significant coral reefs, including several of the Bunker Group reefs at the southern end of the Great Barrier Reef World Heritage Area (Boult, Hoskyn, Lady Fairfax & Lady Musgrave Reefs), Lady Elliott Reef and a number of isolated sub-tidal bommies. There are also a number of coral outcrops on rocky shores along the mainland coast and the Pancake Creek Reef which is regarded as one of Australia's best estuarine reefs. All of these coral reefs contain a huge diversity of invertebrate and fish species, and several of them also form the raw materials from which several coral cays have been formed. Coral reefs should strictly be referred to as coral-algal reefs as reef-building corals can only build reefs if they live in association with symbiotic dinoflagellates known as zooxanthellae. Because this association depends upon the ability of the zooxanthellae to photosynthesis, coral reefs require warm, clear water. Furthermore, corals are unable to form aragonite I the presence of high levels of phosphates, so cannot exist in areas with high levels of phosphate pollution.

The Australian Institute of Marine Science (AIMS) has monitored live coral cover at Lady Musgrave Reef since 1986. In that period, live coral cover declined drastically from over 80% in 1988 to less than 10% in 1993, before increasing to around 50% in the late 1990's/early 2000's (AIMS 2004). Scientists from AIMS believe that these changes resulted from storms in the late 1980's/early 1990's, with a subsequent recovery.

Geological (hard rock, indurated sand)

Sub-tidal hard rock substrata are uncommon within the BMR, but several known outcrops form important aggregation areas for fish (including exploited species such as tailor and endangered species such as the grey nurse shark). These rock substrata are also likely to support distinct assemblages of invertebrates and algae, although there are no published studies of these groups in the BMR. Vertical and near-vertical rock substrata are likely to be dominated by sessile, suspension-feeding invertebrates, whereas more gentle slopes are likely to be dominated by macroalgae, with associated assemblages of mobile invertebrates. Indurated sand substrata (= beach rock or 'coffee rock') are also present both subtidally and intertidally in the BMR. These substrata are frequently surrounded by mobile sand substrata, and undergo regular ablation, fragmentation and erosion, so tend not to support long-lived sessile invertebrates. They are likely to support small communities of macroalgae and (mostly motile) invertebrates. As for other sub-tidal structure, indurated sand substrata also attract fish.

Human (artificial reefs)

There are several artificial reefs in the BMR, including two large reefs: Roy Rufus Artificial Reef (off Big Woody Island at the northern end of the Great Sandy Straits) and Cochrane Artificial Reef (off Elliot Heads) (Jebreen 2001). The Roy Rufus Artificial Reef covers an area of 32 ha at about 25o16'S, 152o58'E, and consists of eight ships, >2,000 car bodies, 10,000 car tyres, 400 t of concrete rubble, and assortment of steel shapes and 12 concrete fish houses (Jebreen 2001). The Cochrane Artificial Reef also extends over 32 ha at about 24o54'S, 152o32'E. This reef also consists of a wide variety of concrete and metal, including one ship, two planes, a large steel tank, and an assortment of steel and concrete pipes, concrete blocks and complex

steel shapes (prisms) (Jebreen 2001). There is also a small collection of artificial reefs off Woodgate Beach, consisting of stacks of Besser™ blocks or car tyres tied together and scattered over a wide area. Many of those stacks have come apart, and regional community groups have been active in collecting and removing the resulting debris.

These reefs were established to attract fish for recreational fishing and/or create interesting dive sites. Community groups (Bundaberg And Districts Artificial Reefs Association, BADARA, & Maryborough Skin Diver's Association) have conducted Underwater Visual Censuses (UVC) of the fish assemblages attracted to Cochrane and Roy Rufus Reefs, respectively. BADARA have recorded 78 fish species from Cochrane Artificial Reef, with the greatest diversity and abundance of fish occurring above and around the sunken dredge 'Ceratodus' (Jebreen 2001). The Roy Rufus Artificial Reef also supports over 70 fish species (Pollard 1989, Wright 1990). DPI recorded a total of 72 fish species in a study of the fish assemblages attracted to individual reef units of various types at the southern end of Cochrane Artificial Reef (Jebreen 2001).

(b) Soft Substrata (sand & mud)

The sub-tidal benthic environment of the BMR is dominated by sand, which originated from the Great Dividing Range and was swept northwards by coastal currents. Soft sediment substrata cover around 80% of continental shelves globally, and an even greater percentage of the BMR continental shelf. These substrata are moved and shaped by currents, so that location and size of sandy shoals (e.g. Herald Patches, Sandy Cape Shoal) are not fixed. Because they are mobile, sand substrata tend to be dominated by mobile invertebrates; mostly of microscopic size, but including larger, well-known animals such as scallops and spanner crabs. Most species live within the sediments (= infauna), but there are also many species that live on the sediment surface (= epifauna). Soft substratum invertebrates form the major food supply for a number of large vertebrates, including hammerhead sharks, stingrays and loggerhead turtles.

(c) Macro-algae

Benthic macro-algae (or seaweeds) are most abundant on horizontal or gently sloping hard substrata, but are also found on soft substrata and vertical hard substrata. Like seagrasses (Prange & Duke 2004), seaweeds require adequate light availability for photosynthesis to occur. Under conditions of elevated nutrients, filamentous green seaweeds and cyanobacteria may out-compete and over-grow seagrasses (see Cyanobacteria below). Benthic macro-algae have similar ecological effects as seagrass in that they reduce current velocity, increase sediment deposition, provide a substrate for attached organisms (e.g., epiphytes) and provide habitat for mobile organisms (e.g., fish, prawns). As for seagrasses, few organisms consume macro-algae directly.

There has been no survey of benthic macro-algae in the BMR, and neither the Queensland Museum, Queensland Herbarium or University of Queensland have any collections from the region (Julie Phillips, Alan Cribb, pers. comms.).

(d) Cyanobacteria

Although sometimes referred to as "blue-green algae", cyanobacteria are not algae. They frequently grow as long chains of cells surrounded by a mucous sheath, forming fine filamentous masses or dense slimy mats. Cyanobacteria frequently also contain

toxic compounds that make them difficult for animals to digest, and may pose a health risk for humans.

The best known cyanobacterium in the BMR is Lyngbya majuscula, which may form large blooms in central Hervey Bay and off Indian Head. Large outbreaks of Lyngbya have generated considerable alarm in Moreton Bay, but there has been much less concern in the BMR. This is reflects the fact that the most intense outbreak in Moreton Bay is apparently more intense than in previous years, is very close to a developing urban area (Sandstone Point) and has been blamed on human factors (e.g., pine plantations, canal developments, nutrient enrichment). Over 30 different toxic compounds have been isolated from Lyngbya worldwide, with two of concern in Moreton Bay: Lyngbyatoxin A and Aplysiatoxin. These toxins may cause skin rashes if handled by humans and may pose a more serious risk if inhaled. In Moreton Bay, Lyngbya outbreaks have smothered mangrove seedlings and seagrass, and may pose a health risk to seagrass consumers such as dugongs and green turtles. There is no indication that Lyngbya outbreaks in the BMR are as severe as this, although fishermen have reported some flaking of skin on sensitive areas after handling Lyngbya.

Unvegetated Intertidal Habitats

Unvegetated intertidal habitats in the BMR include rocky, sandy and muddy shores as well as claypans, which occur at the top of the tidal range. Compared with vegetated habitats, there has been little work on the habitat values of unvegetated habitats. There are numerous, relatively small exposed rocky intertidal habitats in the BMR. From the south, these include rocky headlands at Double Island Point, Indian Head, Waddy Point, Elliot Heads, Barolin Rocks, Bargara, Burnett Heads, Middle Rock, Flat Rock, Red Rock, Rocky Point, Agnes Water and Round Hill Head. There is also a relatively extensive sheltered rocky habitat at Point Vernon, and numerous artificial rocky habitats at various marinas and breakwaters in the BMR. These rocky shores house a diversity of marine invertebrates that can tolerate exposure to the air to varying degrees. The great majority of the coastline in the BMR is sandy beach, ranging from sheltered shorelines of estuaries to exposed surf beaches. Sheltered intertidal sand/mud flats support a diverse range of infaunal invertebrates and some epifauna, and provide valuable feeding areas for fish at high tide and seabirds at low tide. Claypans are rarely utilized as habitat by marine species because they are rarely inundated. However, they may provide some nutrient inputs into marine systems through surface algal production when inundated.

2. Pressures and risks

Pressures on the marine and coastal environment of the BMR come from both direct and indirect (upstream) sources, as well as the impacts of global factors such as changes in climate and sea-level (Table 8).

Any activity that impacts upon terrestrial or freshwater environments also impacts upon downstream aquatic environments; both estuarine and marine. These upstream activities are generally managed by agencies with little or no responsibility or understanding of their potential effects on marine environments or biodiversity. There is a clear need to improve communication between marine scientists and people involved in upstream activities that may impact upon marine biodiversity. There is also a need to reverse, rather than merely halt, activities on land that adversely affect marine systems (such as clearing of riparian vegetation).

Table 8: Outline of pressures on marine biodiversity, and associated risks.

Activity	Pressure/s	Risk/s
land clearing	increased sediment runoff	reduced light penetration, reduced coral growth, damage/death to suspension feeders, change in mangrove distribution (encroachment or dieback), seagrass smothering/loss
	loss of riparian zones	- increased nutrient & sediment runoff, loss of buffer against pollutants, bank erosion
use of fertilisers	increased nutrient runoff	eutrophication, reduction in coral growth, increased algal growth, toxic algal blooms
use of pesticides	terrestrial application	poisoning, reduced health and death of organisms (e.g. mangrove dieback)
	intertidal application	poisoning, reduced health and death of organisms (e.g. mass die-off of mangrove crabs)
impoundment	reduced water flow	reduced food supply
	loss of seasonal spates	loss of spawning signals, loss of floodplain habitat
	restriction of movement	loss of fisheries production, loss of access to upstream habitats, reduced growth & survival
	release of bottom water (cold, low O2, high nutrient)	cold stress, nutrient effects, reduced health & death of organisms
excavation in near coastal areas	exposure of Acid Sulphate Soils	poisoning, reduced health and death of organisms (e.g. red-spot disease, fish kills)
terrestrial construction, urban	soil sealing (e.g. by roads, buildings, concrete)	increased run-off, loss of filters/buffers,

& industrial development		habitat loss
	increased human population	increased effluent discharge increased demand for resources increase in wide range of pressures
	increased industrial activity	increased industrial discharge increase in wide range of pressures
port & marina construction	construction phase	habitat damage & loss, increased run-off, bank erosion
	post-construction	reduced light penetration, increased boating, increased dredging
dredging	sediment re-suspension	reduced light penetration, damage to suspension-feeders, changes to currents, bank erosion
fishing	habitat destruction by trawling	loss of crucial habitat
	overexploitation	population declines, loss of production
	by-catch	unknown population declines, loss of production
	ghost fishing & marine debris	entrapment and killing of marine vertebrates, including endangered species of mammals, birds & reptiles
	illegal harvesting	population declines, loss of production
shark control	killing of large marine vertebrates	population declines, threatens endangered & vulnerable species (e.g. grey nurse shark, dugong, humpback whale, loggerhead turtle)
boating	antifouling chemicals (e.g. tributyltin)	poisoning, reduced health and death of organisms (e.g. mangrove dieback)
	anchoring	habitat damage, loss of coral cover
	running aground	habitat damage, loss of coral cover
	oil/fuel spills	poisoning, reduced health and death of organisms (e.g. mangrove dieback)
	boat strike	death or injury to large animals
	vessel wash	habitat damage (e.g. exposure of mangrove roots, bank erosion)
recreational vehicles	driving in intertidal areas	habitat damage/loss, crushing of burrowing crabs, nesting birds, turtles
rubbish dumping	toxic materials	poisoning, reduced health and death of organisms (e.g. mangrove dieback)
	non-toxic materials	habitat damage/loss
aquaculture	construction phase	habitat damage/loss

Aquaculture (cont.)	nutrient discharge	eutrophication, reduction in coral growth, increased algal growth, toxic algal blooms
	use of non-indigenous species	introduced species/races
climate change	increase sea temperatures	distributions changed
	sea-level rise	inundation of coastal habitats, loss of habitat
	changes to circulation	distributions changed

3. Current responses and legislative instruments

The management of marine biodiversity in the BMR is complicated by the overlapping responsibilities of many local, Queensland and Commonwealth Government agencies, and by the need for each of these levels of government to abide by international agreements and conventions to which Australia is a signatory (Table 9). These arrangements include conventions that protect marine water quality (e.g. MARPOL), marine habitats (e.g. World Heritage Convention, RAMSAR Convention) and those that protect particular species (e.g. IWC, CITES).

The Commonwealth Government takes a strong role in the management of the marine environment through Environment Australia (EA) and the National Oceans Office (NOO). The most significant federal legislation affecting the management of biodiversity in the BMR are the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC) and the Great Barrier Reef Marine Park Act 1975. Under the EPBC Act, the Commonwealth Government conducts a rigorous assessment of actions that are likely to have significant impacts on matters of national environmental significance. This Act provides protection for listed species and communities including Marine Protected Areas (Table 9), wildlife and wildlife products subject to international trade (including fisheries), all cetaceans and listed marine species (Table 10).

Marine Protected Areas (MPAs) in the BMR include part of the Mackay/Capricorn Section of the Great Barrier Reef Marine Park, Hervey Bay Marine Park, Woongarra Marine Park, two Dugong Protection Areas (DPAs) and 23 Fish Habitat Areas (FHAs) (Table 10). The Great Barrier Reef Marine Park has undergone a very significant recent change recently with the introduction of the Great Barrier Reef Marine Park Zoning Plan 2003 on 1 July 2004. The aims of this plan are to define what activities can occur at what locations within the Great Barrier Reef World Heritage Area (GBRWHA), separate potentially conflicting activities and to balance human use with conservation. Specifically, this plan increases both the extent & habitat diversity of areas in which fishing (apart from traditional use) is prohibited (Marine National Park zones). Six of those Marine National Park zones are within the BMR, as follows:
MNP-23-1168: Hoskyn, Fairfax and part of Lady Musgrave Reefs, as well as intervening shelf waters,
MNP-23-1169: large area of shelf, including Lady Elliot Reef,
MNP-23-1170: small area off Rodd's Peninsula,
MNP-24-1171: coastal area from 24o23'S (Rocky Point) to 24o23'S,
MNP-24-1172: NW of Breaksea Spit, and
MNP-24-1173: ENE of Baffle Creek.

A potential highly significant change in the management of marine biodiversity is the proposed declaration of the Great Sandy Marine Park (Table 9). This proposed park will include the current Woongarra and Hervey Bay Marine Parks in a much larger park that will extend along the coast from the southern limit of the GBRWHA to the Noosa River. If this proposed park goes ahead as planned, then the entire coastline of the BMR will be either Commonwealth or State marine park. This Great Sandy Marine Park will include all of Hervey Bay as well as waters within three nautical miles of the coast from near Moore Park to Baffle Creek and from Sandy Cape south to the Noosa River. The only parts of the BMR marine area that will; not fall within a marine park are a 10 nautical mile wide strip that runs across the continental shelf between Hervey

Bay and the GBRWHA (24o30’ to 24o40’S), and waters further than 3 nautical miles offshore south of Sandy Cape (out to 154oE).

Table 9. International arrangements and Commonwealth and Queensland legislation, policy, statutory bodies and inter-governmental arrangements relevant to marine biodiversity in the BMR.

International arrangements	Purpose	Effects in BMR
ANZECC Guidelines for Water Quality	Establish minimum standards for water quality	Little monitoring for compliance in marine environment
China Australia Migratory Bird Agreement	Protect migratory birds	Migratory birds protected throughout range
Convention on International Trade in Endangered Species (CITES)	Stop trade in endangered species	A driver of the EPBC Act
International Convention for the Prevention of Pollution from Ships (MARPOL)	Prevent pollution by oil from ships	Shipping channels, oil spill response guidelines
International Whaling Convention (IWC)	Manage whaling activities	Recovery of Humpback Whales
Japan Australia Migratory Bird Agreement	Protect migratory birds	Migratory birds protected throughout range
London Sea Dumping Convention (1975)	Control & prevention of marine pollution	Dumping of hazardous materials prohibited
RAMSAR Convention	Protect wetlands of international importance, especially as bird habitat	Great Sandy Straits wetlands protected
UN Convention on Biological Diversity	Provides for conservation & sustainable use of biodiversity, while promoting equitable benefit sharing	
UN Convention on the Law of the Sea (1982)	Provide legal basis for marine activities (shipping, exploitation, environment & research); settle disputes	Enforces EEZ, prevention of marine pollution & protection of marine environment
World Heritage Convention	Protect the World's Natural & Cultural Heritage	Fraser Island & Great Barrier Reef World Heritage Areas protected

Key Commonwealth Legislation	Purpose	Effects in BMR
Environmental Protection & Biodiversity Conservation Act 1999 (EPBC)	Conserve biodiversity by protecting listed species (see Table 10) & communities, all cetaceans, protected areas, critical habitat & wildlife subject to international trade (including fish, crustaceans, molluscs & other exploited marine species). Protect the environment, promote ecologically sustainable development, implement international responsibilities, identify key threatening processes, plan & regulate exports & imports of wildlife & wildlife products, promote a co-operative approach & recognise role of indigenous people.	All export fisheries currently being assessed to ensure sustainable practices in place. Consolidates legislation dealing with biodiversity.
Great Barrier Reef Marine Park Act 1975	Establish Great Barrier Reef Marine Park for sustainable multiple use; establish management regime for the park, including establishment of the Great Barrier Reef Marine Park Authority (GBRMPA)	Regulation of activities in GBRWHA, including prohibition of mining, limitations on fishing activity, management of shipping, research, recreation & commercial activity
Native Title Act 1993	Resolve land management issues & recognise indigenous property rights & indigenous common law; establish procedures to protect native title	Indigenous rights recognised in legislation; traditional use allowed in non-fishing areas orf GNRWHA; commercial fishing, research & tourism all require prior approval by native title claimants

Table 9. (continued)

Other Commonwealth Legislation

Australian Heritage Commission Act 1975	Biological Control Act 1984	Environment Protection (Impact of Sea Dumping) Act
National Environment Protection Council Act 1994	Natural Heritage Trust of Australia Act 1997	World Heritage Properties Conservation Act 1983
Environmental Reform (Consequential Provisions) Act 1999	Protection of the Sea (Prevention of Pollution from Ships) Act 1983	Wildlife Protection (Regulation of Exports & Imports) Act 1982

Selected major Commonwealth policy initiatives

Great Barrier Reef Marine Park Zoning Plan 2003	GBRMPA Water Quality Protection Plan	Australia's Ocean Policy
Coasts & Cleans Seas Program	National Greenhouse Strategy	Wetlands Policy of the Commonwealth Government
National Strategy for Ecologically Sustainable Development	National Strategy for Conservation of Australian Species & Communities Threatened with Extinction	National Framework for the Management & Monitoring of Australia's Native Vegetation
National Reserves System Program	Endangered Species Program (ESP)	National Strategy for Managing Acid Sulfate Soils
Action Plan for Australian Birds	Australian Biological Resources Study (ABRS)	Biodiversity Convention & Strategy Program
Strategic Plan of Action for the National Representative System of Marine Reserves	National Policy on Fisheries Bycatch (NPFB)	

Selected statutory & other bodies including non-government stakeholders

Biodiversity Advisory Committee (BDAC)	Indigenous Advisory Committee	Australian Landcare Council
Threatened Species Scientific Committee	Council for Sustainable Vegetation Management	National Oceans Advisory Group

Key intergovernmental institutional arrangements involving the Commonwealth

Australian & New Zealand Environment & Conservation Council (ANZECC)	Council of Australian Governments (COAG) water reform framework	Great Barrier Reef Marine Park Authority (GBRMPA)
Intergovernmental Agreement on the Environment		

Table 9. (continued)

Queensland Government

Key Legislation

Acquisition of Land Act 1967	Integrated Planning Act 1997	Petroleum (Submerged Lands) Act 1982
Beach Protection Act 1968	Land Act 1994	Queensland Heritage Act 1992
Canals Act 1958	Local Government (Planning & Environment) Act	River Improvement Trust 1940
Coastal Protection & Management Act 1995	Local Government Act 1993	Rural Lands Protection Act 1985
Cultural Records Act 1987	Marine Parks Act 1982	Transport Infrastructure Act 1994
Environmental Protection Act 1994	Native Title (Queensland) Act 1993	Transport Operations (Marine Pollution) Act 1994
Fisheries Act 1994	Nature Conservation Act 1992	Vegetation Management Act 1999
Harbours Act 1955	Offshore Minerals Act 1998	Water Resources Act 1989

Selected major policy initiatives

Establishment of Environmental Protection Agency (incorporating Parks & Wildlife Service)	State Policy for Vegetation Management on Freehold Land	Fisheries Closures (e.g. Fraser Island – Tailor, Hervey Bay – scallop)
Areas of High Environmental Value listing	Regional Vegetation Management Plans (RVMP)	Fish Habitat Areas
Biodiversity strategy	Statewide Landcover & Trees Study	Fisheries Act 1995
Coastal Contingency Action Plan	Environmental Health Monitoring Program	Dugong Protected Areas

Selected statutory bodies

Beach Protection Authority	Landcare & Catchment Management Council	Queensland Scientific Committee
Coastal Protection Advisory Council	Natural Resource Management Policy Council	

Table 10: Current and proposed Marine Protected Areas (MPAs) in the Burnett-Mary Region (BMR).

Marine Parks	Area (ha)	Lat (oS)	Long (oE)
Great Barrier Reef	1,217,600*	24.00	152.50
Hervey Bay	197,794	25.00	153.00
Woongarra	10,706	24.80	152.50
Total Marine Parks	1,426,100		
Proposed Marine Parks			
Great Sandy (Northern Section)	660,000	25.00	152.80
Great Sandy (Southern Section)	4,650*	26.00	153.20
Total Proposed Marine Parks	664,650		
Dugong Protection Area (A)			
Hervey Bay - Great Sandy Strait	173,501	25.20	152.80
Dugong Protection Area (B)			
Rodds Bay	26,500*	24.00	151.50
Total Dugong Protection Areas	200,000		
Fish Habitat Areas (A)			
Rodds Harbour	7,148	24.05	151.64
Collosseum	5,334	24.05	151.45
Bustard	4,700	24.07	151.74
Innes	4,800	24.08	151.55
Eurimbula	599	24.17	151.81
Seventeen Seventy-Round Hill	1,022	24.20	151.86
Baffle Creek	2,317	24.52	151.99
Kinkuna	775	25.05	152.52
Burrum-Isis	2,120	25.18	152.58
Beelbi	1,043	25.23	152.66
Susan River	4,501	25.44	152.87
Maaroom	22,875	25.54	152.93
Kauri Creek	7,044	25.83	153.00
Tin Can Inlet	1,443	25.94	153.03
Total Fish Habitat Areas (A)	65,721		
Fish Habitat Areas (B)			
Wild Cattle	1,123	24.00	151.41
Boyne Creek	590	24.04	151.51
Turkey	195	24.08	151.65
Seventeen Seventy-Round Hill	459	24.18	151.88
Kolan River	1,897	24.68	152.20
Fraser Island	9,693	24.97	153.21
Gregory	88	25.15	152.49
Burrum-Toogoom	2,235	25.20	152.66
Cherwell-Burrum	315	25.26	152.55
Total Fish Habitat Areas (B)	16,595		
Total Fish Habitat Areas	82,316		

Table 11. Listed marine species under the EPBC Act that may occur in the BMR.

Fish

Acentronura tentaculata	Hairy Pygmy Pipehorse
Campichthys tryoni	Tryon's Pipefish
Choeroichthys brachysoma	Short-bodied Pipefish
Corythoichthys amplexus	Brown-banded Pipefish
Corythoichthys flavofasciatus	Network Pipefish
Corythoichthys haematopterus	Reef-top Pipefish
Corythoichthys intestinalis	Australian Messmate Pipefish
Corythoichthys ocellatus	Ocellated Pipefish
Corythoichthys paxtoni	Paxton's Pipefish
Corythoichthys schultzi	Schultz's Pipefish
Doryrhamphus excisus	Blue-stripe Pipefish
Festucalex cinctus	Girdled Pipefish
Filicampus tigris	Tiger Pipefish
Halicampus dunckeri	Red-hair Pipefish
Halicampus grayi	Mud Pipefish
Halicampus nitidus	Glittering Pipefish
Halicampus spinirostris	Spiny-snout Pipefish
Hippichthys cyanospilos	Blue-spotted Pipefish
Hippichthys heptagonus	Reticulated Freshwater Pipefish
Hippichthys penicillus	Steep-nosed Pipefish
Hippocampus bargibanti	Pygmy Seahorse
Hippocampus kelloggi	Kellogg's Seahorse
Hippocampus kuda	Yellow Seahorse
Hippocampus planifrons	Flat-face Seahorse
Hippocampus whitei	Crowned Seahorse
Hippocampus zebra	Zebra Seahorse
Lissocampus runa	Javelin Pipefish
Maroubra perserrata	Sawtooth Pipefish
Micrognathus andersonii	Shortnose Pipefish
Micrognathus brevirostris	Thorn-tailed Pipefish
Microphis manadensis	Manado Pipefish
Nannocampus pictus	Painted Pipefish
Solegnathus dunckeri	Duncker's Pipehorse
Solegnathus hardwickii	Pipehorse
Solegnathus spinosissimus	Australian Spiny Pipehorse
Solenostomus cyanopterus	Robust Ghost Pipefish
Solenostomus paradoxus	Harlequin Ghost Pipefish
Stigmatopora nigra	Wide-bodied Pipefish
Syngnathoides biaculeatus	Double-ended Pipehorse
Trachyrhamphus bicoarctatus	Bend Stick Pipefish

Diomedea dabbenena	Tristan Albat
Gallinago hardwickii	Latham's Sni
Haliaeetus leucogaster	White-bellied Eagle
Heteroscelus brevipes	Grey-tailed T
Hirundapus caudacutus	White-throat Needletail
Hirundo rustica	Barn Swallow
Larus novaehollandiae	Silver Gull
Lathamus discolor	Swift Parrot
Limosa lapponica	Bar-tailed Go
Macronectes giganteus	Southern Gia
Macronectes halli	Northern Gia
Monarcha melanopsis	Black-faced
Monarcha trivirgatus	Spectacled M
Myiagra cyanoleuca	Satin Flycatc
Nettapus coromandelianus albipennis	Australian C Pygmy-goos
Numenius madagascariensis	Eastern Curle
Numenius minutus	Little Curlew Whimbrel
Numenius phaeopus	Whimbrel
Phaethon rubricauda	Red-tailed Tr
Pluvialis fulva	Pacific Golde Plover
Pluvialis squatarola	Grey Plover
Puffinus pacificus	Wedge-tailed Shearwater
Rhipidura rufifrons	Rufous Fanta
Rostratula benghalensis	Painted Snip
Sterna anaethetus	Bridled Tern
Sterna bergii	Crested Tern
Sterna caspia	Caspian Tern
Sterna dougallii	Roseate Tern
Sterna sumatrana	Black-naped
Sula leucogaster	Brown Boob
Thalassarche chlororhynchos	Yellow-nose Albatross
Thalassarche impavida	Campbell Al
Tringa nebularia	Common Gre
Xenus cinereus	Terek Sandpi

Mammals

Dugong dugon	Dugong
Balaenoptera acutorostrata	Minke Whale
Balaenoptera bonaerensis	Antarctic Mi Whale
Balaenoptera borealis	Sei Whale
Balaenoptera edeni	Bryde's Wha
Balaenoptera musculus	Blue Whale

Urocampus carinirostris	Hairy Pipefish
Vanacampus margaritifer	Mother-of-Pearl Pipefish

Reptiles

Acalyptophis peronii	Horned Sea snake
Aipysurus duboisii	Dubois' Sea snake
Aipysurus eydouxii	Spine-tailed Sea snake
Aipysurus laevis	Olive Sea snake
Astrotia stokesii	Stokes' Sea snake
Caretta caretta	Loggerhead Turtle
Chelonia mydas	Green Turtle
Crocodylus porosus	Salt-water Crocodile
Dermochelys coriacea	Leatherback Turtle
Disteira kingii	Spectacled Sea snake
Disteira major	Olive-headed Sea snake
Emydocephalus annulatus	Turtle-headed Sea snake
Eretmochelys imbricata	Hawksbill Turtle
Hydrophis elegans	Elegant Sea snake
Lapemis hardwickii	Spine-bellied Sea snake
Laticauda colubrina	a sea krait
Laticauda laticaudata	a sea krait
Natator depressus	Flatback Turtle
Pelamis platurus	Yellow-bellied Sea snake

Birds

Anous minutus	Black Noddy
Anous stolidus	Common Noddy
Anseranas semipalmata	Magpie Goose
Catharacta skua	Great Skua
Charadrius mongolus	Lesser Sand Plover

Balaenoptera physalus	Fin Whale
Delphinus delphis	Common Do
Eubalaena australis	Southern Rig Whale
Feresa attenuata	Pygmy Killer
Globicephala macrorhynchus	Short-finned Whale
Grampus griseus	Risso's Dolph Grampus
Kogia breviceps	Pygmy Sperm
Kogia simus	Dwarf Sperm
Lagenodelphis hosei	Fraser's Dolp
Lagenorhynchus obscurus	Dusky Dolph
Megaptera novaeangliae	Humpback W
Mesoplodon densirostris	Blainville's B Whale
Mesoplodon ginkgodens	Gingko-tooth Whale
Mesoplodon grayi	Gray's Beake
Mesoplodon layardii	Strap-toothed
Orcaella brevirostris	Irrawaddy Do
Orcinus orca	Killer Whale
Peponocephala electra	Melon-heade
Physeter macrocephalus	Sperm Whale
Pseudorca crassidens	False Killer W
Sousa chinensis	Indo-Pacific Humpback D
Stenella attenuata	Spotted Dolp
Stenella coeruleoalba	Striped Dolp
Stenella longirostris	Long-snouted Spinner Dolp
Steno bredanensis	Rough-tooth Dolphin
Tursiops aduncus	Spotted Bottl Dolphin
Tursiops truncatus	Bottlenose D
Ziphius cavirostris	Cuvier's Beal Whale

Marine species listed under the EPBC Act for the BMR include vertebrate species that may occur in the region, not only those that have been recorded for the region (Table 11). This list contains 134 species: 42 fish (all from the Family Syngnathidae: pipefish & seahorses), 19 reptiles (13 sea snakes, 5 turtles and the saltwater crocodile), 39 birds and 34 mammals (33 Cetaceans and the Dugong). Curiously, of the 46 species of marine fish that have been recorded from the BMR that are classified as endangered, vulnerable or potentially threatened (Table 3), only three are listed species under the EPBC Act (Table 11). None of those three species are classified as endangered or vulnerable.

Seventeen Dugong Protection Areas (DPAs) have been established along the Queensland coast. Those areas are zoned as either Zone A (8 areas) or Zone B (9 areas), according to the level of protection, with Zone A generally providing more stringent safeguards than Zone B. Two DPAs fall within the BMR: The Hervey Bay – Great Sandy Strait DPA (Zone A) and about 40% of the Rodd's Bay DPA (Zone B). Set nets are still permitted in both of those areas, with modifications and restrictions aimed at reducing the incidence of dugongs being drowned by the nets. In the latest survey, about 72.5% of all dugongs seen in the Hervey Bay region were seen within the Hervey Bay – Great Sandy Strait DPA (Marsh and Lawler 2001). That same survey reported that 51.6% of dugongs seen in the southern Great Barrier Reef were within DPAs (Zone A) and a further 21.7% were within DPAs (Zone B). Thus, despite the fact that dugongs do move in and out of DPAs, these areas appear to provide some protection to dugongs over about 73% of their habitat in the southern Great Barrier Reef and Hervey Bay. However, the efficacy of DPAs that still allow set netting has been questioned by Marsh (2000), and more research is needed to determine whether these areas provide sufficient reduction in dugong mortality.

Fish Habitat Areas (FHAs) are declared to protect intertidal habitats upon which many fish and other aquatic fauna depend (Beumer et al. 1997). They do not restrict legal fishing activities, apart from those activities that may cause habitat damage (such as worm digging). FHAs are zoned as either Zone A (14 areas in BMR) or Zone B (9 areas in BMR), according to the level of protection, with Zone A generally providing more severe restrictions on development than Zone B (Table 10).

4. Limitations and constraints

4.1. Issues beyond regional control

- Marine systems are open systems, with physical and biological conditions dependant upon global and other large-scale events (e.g., climate change, global warming). Thus, marine biodiversity within the BMR is influenced by large-scale processes as well as processes that occur within the region.

- Many organisms move in and out of the region as they undergo larval or juvenile development (e.g., turtles, invertebrate larvae), perform regular or spawning migrations (e.g., tailor, coral trout, turtles, humpback whales) or conduct large-scale movements that are poorly understood (e.g., dugongs, billfish). Thus, management of marine biodiversity within the region relies upon co-operation with outside agencies, state and commonwealth governments and the international community.

4.2. Limited knowledge

- Knowledge of the extent and condition of marine resources in the BMR is at a basic level compared to some other areas of the state. There has been very little research conducted on marine biodiversity in the BMR, especially in comparison to the Great Barrier Reef to the north and Moreton Bay to the south.

- Documentation of marine invertebrate diversity is very preliminary.

- Knowledge of the values of habitats other than mangroves and seagrasses is very limited.

- In the absence of dedicated research, it is difficult to assess the effects of particular activities amongst the multiple potential impacts on marine biodiversity.

Education/communication

- There needs to be more effective communication of the effects of terrestrial and upstream activities (e.g., land clearing, dams and water extraction, urban development, use of pesticides) on estuarine and coastal marine systems.

4.3. Economic and cultural constraints

- Activities such as water extraction, land clearing and allowing cattle to access river banks have caused ongoing problems for downstream environments (especially in relation to sedimentation and nutrient run-off). However, those activities bring economic benefit to land holders and industry, so that there is resistance to changing practices to benefit marine biodiversity.

- Fishing interests are opposed to any management that restricts access to fish stocks or requires gear modification. There is strong community support for

terrestrial national parks in which hunting is not permitted, but many people oppose the same concept in the marine environment.

Funding

- There is limited funding for stakeholders to compensate for economic losses that may accrue as a result rehabilitation of coastal habitats and mitigation of upstream impacts.

4.4. Institutional constraints

- There are multiple agencies/levels of government responsible for managing impacts on the marine environment. Most impacts come from outside the marine environment (e.g., land clearing, coastal development, global warming), over which managers of the marine environment have limited or no control.

- Legislation cannot cover all possible eventualities. For instance, under the Coastal Management Act, residential development cannot proceed below Highest Astronomical Tide (HAT), which is defined as 1.5m above the Australian Height Datum (AHD) for Boonaroo in the Great Sandy Straits. However, residential development has been proposed for lands above 1.5m AHD at Boonaroo which are actually tidal (Jamie Cockburn, Maryborough City Council, pers.comm..).

5. Options for Burnett Mary NRM planning responses

Policy Principles
The policy response of the Burnett Mary NRM group should include:
An adequate zoning plan for the proposed Great Sandy Marine Park to enable multiple use while conserving biodiversity. Such zoning needs to include strong protection for sites of high environmental value, such as wading bird roosting and feeding areas, dugong feeding areas and habitats utilised by endangered or vulnerable species (e.g. humpback whale, loggerhead turtle, grey nurse shark, green sawfish).
A list of key threatening processes for species classified as endangered or vulnerable and other species of high biodiversity value.
A whole of catchment approach to managing impacts on the marine environment.
An extension/education plan to inform the community of the effects of land-based activities on estuarine and marine environments.
A plan to rehabilitate and protect riparian zones and coastal wetlands.
An action plan to respond to the likely impacts of predicted environmental changes (e.g. the impact of sea level rise on coastal habitats), and to be prepared for unpredictable impacts.

Research Needs

Introduction

Historically, there has been much less marine research conducted in the BMR than in adjacent areas to the north and south. Within Queensland, marine research has tended to concentrate on the Great Barrier Reef (because of its cultural and economic significance and its known biodiversity), with considerable research also being conducted in Moreton Bay (because of its proximity to Brisbane and major research centres). As this report has shown, the BMR also contains an enormous diversity of marine life, with considerable cultural and economic significance. However, these features alone are not sufficient to attract research, which is driven by the need to attract funding from granting bodies. In order to attract more biodiversity research to the region, the BMRG needs to establish strong links with research providers.

One incentive that would attract more marine research to the BMR is the provision of seed funding for projects that are of high priority for the BMRG. By providing relatively small amounts of money (of the order of $10,000 p.a.), community groups enable researchers to leverage many times more money (of the order of $100,000 p.a.) from granting bodies. Those granting bodies (e.g., Australian Research Council, Fisheries Research & Development Corporation) look to fund research that has direct benefit to the community, so look very favourably on research involving strong community support.

Other incentives that may attract more research to the BMR include collaboration with members of the local community (e.g. through volunteer programs), provision of resources (e.g. accommodation) and support of post-graduate students (e.g. through a scholarship or prize).

In recent years, there has been a strong tendency for government agencies to commission so called ‘desktop studies’ to answer questions that can only be addressed through field-based research. For instance, Environment Australia requires an assessment of the impacts and ecological sustainability of fisheries practices before allowing the fishery in question to export product. These assessments are generally done as ‘desktop studies’ because of a lack of time and resources to actually answer the questions. Such ‘desktop’ assessments are of limited value as they are based on little or no actual data. They may identify areas for research, but they do not replace that research. The research needs listed here all require field research not just ‘desktop studies’.

Biodiversity Research

Determination of the conservation status (abundance, distribution, biology, ecology and exposure to risk) of all species classified as threatened or endangered. This research should not be restricted to the BMR, but the region does contain some sites of specific importance to many of these species. Species and suggested research questions, methodologies include:

Green sawfish (Pristis zijsron): How many are left? Where? What are their habitat requirements? How can they be protected?

Colclough's blind shark (Brachaelurus colcloughi): How many are left? Where? What are their habitat requirements? How can they be protected?

Grey nurse shark (Carcharias taurus): Are there additional congregation sites & where?

Loggerhead turtle (Caretta caretta): How can we reduce mortality due to human impacts? Impacts of ecotourism (see below).

Wading birds: Regular standardised monitoring of abundance.

Dugong (Dugong dugon): What causes high variability in aerial survey counts? Need tagging to investigate large-scale movements (& provide data on growth, health & population size) and repeat short-term surveys to investigate tidal migrations.

Humpback whale (Megaptera novaeangliae): Impacts of ecotourism (see below).

Indo-Pacific humpbacked dolphin (Sousa chinensis): Impacts of ecotourism (see below).

False water rat (Xeromys myoides): Impacts of pesticides on food species & health. Identification of supra-tidal burrow habitat.

Documentation of the biodiversity of marine invertebrates of the region.

Documentation of the biodiversity of marine algae of the region.

Habitat Research

Assessment of the biodiversity and fisheries values of sub-tidal habitats.

Assessment of the biodiversity and fisheries values unvegetated intertidal habitats and saltmarshes.

Documentation of the extent and condition of intertidal habitats, coastal wetlands and low-lying lands.

Human Impacts Research

Global change

Assessment of the potential effects of climate change (especially seawater temperature rise) on coral reefs.

Assessment of the potential fate of intertidal habitats, coastal wetlands and low-lying lands under different scenarios of climate change and sea-level rise.

Land-based activities

Assessment of the effects of land management activities (e.g. revegetation) on marine biodiversity. This research should concentrate on the impacts of increased sedimentation and nutrient enrichment, in both flood and non-flood conditions.

Assessment of the impacts of pesticides and herbicides on marine and coastal biodiversity. This should concentrate on:

the impacts of deliberate application of pesticides in coastal wetlands on intertidal invertebrates (e.g. crabs) and their dependent foraging species (e.g. false water rat, wading birds, fish), and

the downstream impacts of land-based herbicides on mangrove tress (particularly Avicennia marina).

Fisheries

Assessment of the impacts of trawling on benthic habitats and communities, (particularly soft-sediment invertebrates) as well as on non-target species.

Assessment of the impacts of fishing and shark-control apparatus on marine biodiversity, particularly on species that are already endangered and known to be at risk (e.g. loggerhead turtle, grey nurse shark, green sawfish, dugong).

Assessment of the sustainability of current fisheries management practices in terms of their impacts on whole ecosystems, not just on target species.

Other marine activities

Assessment of the impacts of ecotourism on the behaviour and health of species of interest (e.g. humpback whales at Platypus Bay, Indo-Pacific humpback dolphins at Tin Can Bay, marine turtles at Mon Repos). This research could also include impacts on humans (e.g. economic cost/benefit, exposure to risk), and flow-on impacts to other components of the ecosystem (e.g. impacts of attracting large predators to a particular area).

Assessment of the impacts of boat strike on dugongs.

6. References

(used in preparation of this paper, but not necessarily cited)

Allen, GR (1997) Marine fishes of tropical Australia and South-East Asia. Western Australian Museum, Perth, 292pp.

Allen, GR, SH Midgley & M Allen (2002) Field guide to the freshwater fishes of Australia, Western Australian Museum, Perth, 394pp.

Allen, GR, RC Steene, P Humann & N DeLoach (2003) Reef fish identification: tropical Pacific. New World Publications, Jacksonville, 457pp.

Allen, GR & R Swainston (1988) The marine fishes of north-western Australia: a field guide for divers and divers. Western Australian Museum, Perth, 201pp.

Anonymous (1978) Commercial fishing industry in the Capricorn/Bunker area. Unpublished report by Fisheries Division, Department of Primary Industries, Canberra and Queensland Fisheries Service, Brisbane, 43pp + maps.

Anonymous (1989) Hervey Bay Marine Park zoning plan, September 1989. Queensland Government, Brisbane, 15pp.

Anonymous (1990a) Department of Environment and Heritage submission to the commission of enquiry into the conservation, management and use of Fraser Island and The Great Sandy Region. Queensland Government, Brisbane, 317pp.

Anonymous (1990b) Department of Primary Industries submission to the commission of enquiry into the conservation, management and use of Fraser Island and The Great Sandy Region. Part C: Division of Fisheries and Wetlands Management submission. Queensland Government, Brisbane, 8pp + maps.

Anonymous (1990c) Commission of enquiry into the conservation, management and use of Fraser Island and The Great Sandy Region. Final Discussion Paper. Volume I: Background. Queensland Government, Brisbane, 297pp + appendices.

Anonymous (1990d) Commission of enquiry into the conservation, management and use of Fraser Island and The Great Sandy Region. Final Discussion Paper. Volume II: Issues. Queensland Government, Brisbane, 320pp + glossary.

Anonymous (1990e) Commission of enquiry into the conservation, management and use of Fraser Island and The Great Sandy Region. Final Discussion Paper. Volume III: Issues. Queensland Government, Brisbane, 356pp + appendices.

Anonymous (1991) Commission of enquiry into the conservation, management and use of Fraser Island and The Great Sandy Region. Report. Queensland Government, Brisbane, 129pp + glossary.

Anonymous (1994) Great Sandy Region management plan. Queensland Government, Brisbane, 188pp + maps.

Anonymous (1999) State of the environment Queensland 1999. Queensland Environmental Protection Agency, Brisbane.

Anonymous (2001) State coastal management plan – Queensland's coastal policy. Queensland Environmental Protection Authority, Brisbane, 92pp.

Anonymous (2002a) Recovery plan for the grey nurse shark (*Carcharias taurus*) in Australia. Environment Australia, Canberra, 45pp.

Anonymous (2002b) Tourism and recreation values of the Daintree and Fraser Island. Unpublished report prepared for the Australian Tropical Research Foundation by Kleinhardt-FGI, 58pp.

Ayling, AM & AL Ayling (1986) A biological survey of selected reefs in the Capricorn section of the Great Barrier Reef Marine Park. Unpublished report to the Great Barrier Reef Marine Park Authority, Townsville, 61pp + appendices.

Beumer, J & I Halliday (1994) Effects of habitat disturbance on coastal fisheries resources of Tin Can Bay/Great Sandy Strait. Report to the Fisheries Research and Development Corporation, 52pp.

Beumer, J, L Carseldine & B Zeller (1997) Declared fish habitat areas in Queensland. Department of Primary Industries Fish Habitat Management Operational Policy Series: supplement to FHMOP 002, Queensland Government, Brisbane, 178pp.

Brodie, J (1991) Urban impact on the Great Barrier Reef. Pp 18-26 in Yellowlees, D (ed.) Land use patterns and nutrient loading of the Great Barrier Reef region. Proceedings of the workshop held at James Cook University of North Queensland, 17-18 November 1990, 234pp.

Bruinsma, C & K Danaher (2000) Queensland coastal wetland resources Round Hill Head to Tin Can Bay Inlet. Queensland Department of Primary Industries Information Series QI99081, Queensland Government, Brisbane, 101pp.

Campbell, SJ & LJ McKenzie (2001) Seagrass-Watch: community based monitoring of seagrass meadows in Hervey Bay and Whitsunday regions: 1998-2001. Queensland Department of Primary Industries Information Series QI01090, Queensland Government, Brisbane, 34pp.

Driscoll, P (1998) Summary report on wader surveys 1989 to 1997 in the Great Sandy Strait. Unpublished report to Queensland Department of Environment, 27pp.

Field, EJ, IC Johnson & NL Bruce (1983) Survey of the Mary River macrofauna,: supplementary report. Unpublished report to the Queensland Water Resources Commission, 30pp.

Grant, EM (1985) Guide to fishes. Department of Harbours and Marine, Brisbane, 896pp.

Hyland, SJ (1993) Fisheries resources of the Hervey Bay region. Queensland Fish Management Authority, Brisbane, 44pp.

Jebreen, E (2001) Artificial reefs: their effects on fish stocks. Queensland Department of Primary Industries Information Series QI01031, Queensland Government, Brisbane, 78pp.

Johnson, IC, EJ Field & NL Bruce (1982) Survey of the Mary River macrofauna, with comments on the likely effects of barrage construction. Unpublished report to the Queensland Water Resources Commission, 57pp.

Koskela, T (2001) Burrum River fisheries survey. Final report: wet and dry season survey. Unpublished report by Gutteridge Haskins & Davy Pty Ltd. 42pp + appendices.

Kuiter, RH (1996) Guide to sea fishes of Australia. New Holland Publishers, Sydney, 433pp.

Lanyon, JM (2003) Distribution and abundance of dugongs in Moreton Bay, Queensland, Australia. *Wildlife Research*, **30**: 397-409.

Last, PR & JD Stevens (1994) Sharks and rays of Australia. CSIRO, Canberra, 513pp + plates.

Lee Long, WJ, RG Coles, KJ Miller, KP Vidler & KJ Derbyshire (1992) Seagrass beds and juvenile prawn and fish nursery grounds: Water Park Point to Hervey Bay, Queensland. Queensland Department of Primary Industries Information Series QI92011, Queensland Government, Brisbane, 39pp.

Lewis, C, C Hewitt & A Melzer (2001) Port survey for introduced marine species – Port Curtis. Centre for Environmental Management, Central Queensland University, Gladstone.

Lowe, GR & BC Russell (1990) Additions and revisions to the checklist of fishes of the Capricorn-Bunker Group, Great Barrier Reef, Australia. Great Barrier Reef Marine Park Authority Technical Memorandum GBRMPA-TM-19, Townsville, 27pp.

Lupton, CJ (1993) A fisheries resource assessment of the Elliot River system in the Wide Bay Burnett Region of Queensland. Queensland Department of Primary Industries Information Series QI93057, Queensland Government, Brisbane, 155pp.

Lupton, CJ & MJ Heidenreich (1996) A fisheries resource assessment of the Baffle Creek system in the Wide Bay - Burnett Region of Queensland. Queensland Department of Primary Industries Information Series QI96055a, Queensland Government, Brisbane, 135pp.

Lupton, CJ & MJ Heidenreich (1999) A fisheries resource assessment of the estuarine reaches of the Burnett River in the Wide Bay - Burnett Region of Queensland. Queensland Department of Primary Industries Information Series QI99014a, Queensland Government, Brisbane, 106pp.

McKenzie, LJ, CA Roder, AJ Roelofs & WJ Lee Long (2000) Post-flood monitoring of seagrasses in Hervey Bay and the Great Sandy Strait: implications for dugong, turtle and fisheries management. Queensland Department of

Primary Industries Information Series QI00059, Queensland Government, Brisbane, 50pp.

McKenzie, LJ & SJ Campbell (2003) Seagrass resources of the Booral Wetlands and the Great Sandy Strait. Queensland Department of Primary Industries Information Series QI03016, Queensland Government, Brisbane, 28pp.

Marsh, H, G De'ath, N Gribble & B Lane (2001) Shark control records hindcast serious decline in dugong numbers off the urban coast of Queensland. Great Barrier Reef Marine Park Authority Research Publication 70: 1-24.

Marsh, H & I Lawler (2001) Dugong distribution and abundance in the southern Great Barrier Reef Marine Park and Hervey Bay: results of an aerial survey in October-December 1999. Great Barrier Reef Marine Park Authority Research Publication 70: 25-87.

Mather, P & I Bennett (eds.) (1993) A coral reef handbook: a guide to the geology, flora and fauna of the Great Barrier Reef. Surrey Beatty & Sons, Sydney, 263pp.

Moore, N (1986) Recreational fishing in Hervey Bay and Great Sandy Strait. Queensland Department of Primary Industries, Queensland Government, Brisbane, 30pp.

Morton, RM & T Healy (1992) Fisheries resources of the Fraser Island region. Queensland Fish Management Authority, Brisbane, 36pp.

Olsen, HF, RM Dowling & D Bateman (1980) Biological resources survey (estuarine inventory): Round Hill Head to Tannum Sands, Queensland, Australia. Queensland Fisheries Service Research Bulletin No. 2, Queensland Government, Brisbane, 102pp.

O'Neill, MF (2000) Fishery assessment of the Burnett River, Maroochy River and Pumicestone Passage. Queensland Department of Primary Industries Project Report QO99012, Queensland Government, Brisbane, 112pp.

Pogonoski, JJ, DA Pollard & JR Paxton (2002) Conservation overview and action plan for Australian threatened and potentially threatened marine and estuarine fishes. Environment Australia, Canberra, 375pp.

Randall, JE, GR Allen & RC Steene (1990) Fishes of the Great Barrier Reef and Coral Sea. Crawford House Press, Bathurst, 507pp.

Russell, BC (1983) Annotated checklist of the coral reef fishes in the Capricorn-Bunker Group, Great Barrier Reef, Australia. Great Barrier Reef Marine Park Authority, Townsville, 184pp.

Stephenson, W, WT Williams & GN Lance (1970) The macrobenthos of Moreton Bay. *Ecological Monographs* **40**: 459-494.

Twyford, KL & RG Hobson (1996) Vertebrate fauna of Fraser Island World Heritage Area. Unpublished report, 24pp.

Walker, MH (1997) Fisheries resources of the Port Curtis and Capricorn regions. Queensland Fish Management Authority, Brisbane, 48pp.

Williams, LE (1989) Commercial fishing in Hervey Bay and Great Sandy Strait. Queensland Department of Primary Industries, Queensland Government, Brisbane, 21pp + appendix.

Williams, LE (2001) Queensland's fisheries resources: current condition and recent trends 1988-2000. Department of Primary Industries. Brisbane, 180pp.

Yellowlees, D (ed.) (1991) Land use patterns and nutrient loading of the Great Barrier Reef region. Proceedings of the workshop held at James Cook University of North Queensland, 17-18 November 1990, 234pp.

6.1. Web pages accessed

2003 IUCN Red List of Threatened Species
http://www.redlist.org
Australian Government, Department of Environment and Heritage
http://www.deh.gov.au/
Australian Institute of Marine Science
http://www.aims.gov.au/monmap/reefpages/CB/23082S.html
Cooloola Coastcare
http://www.cooloolacoastcare.org.au/
Fraser Island Defenders Organization
http://www.fido.org.au/Marine ParkSubmission.html
Great Barrier Reef Marine Park Authority
http://www.gbrmpa.gov.au/corp_site/info_services/publications/research_publications/index.html
Queensland Government, Environmental Protection Agency
http://www.epa.qld.gov.au/
Queensland Government, Department of Primary Industries & Fisheries
http://www.dpi.qld.gov.au/home/default.html
Woongarra Marine Park
http://www.widebay.net/wmpme/overview.htm