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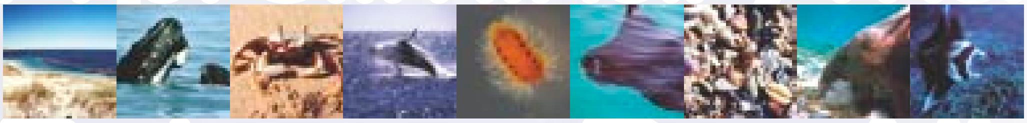

Bateman Bay, Ningaloo Reef.

Realised By :Oceanwise Environmental Scientists

in collaboration with Murdoch University

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

ABN 24 064 197 519
mobile: 0421 857 065
phone +61 8 9385 8441
email: info@oceanwise.com.au
www.oceanwise.com.au

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Contributing authors: Maxine Birkin, Sorcha Gillen, Dr Mike van Keulen, Jason Webb.

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INTRODUCTION

Ningaloo Reef is internationally recognized as a highly productive and biodiverse marine ecosystem of potential World Heritage listing. Currently, this fringing barrier reef system and its coasts are subject to significant human pressure. Unlike the Great Barrier Reef, Ningaloo Reef is particularly susceptible to visitor disturbance due to its unique proximity to the coast.

Coral Coast Marina Development Pty Ltd (CCMD) has proposed an inland marina style resort complex at Bateman Bay. The condition of the marine and coastal environment forms the central focus of attraction for this development. CCMD's baseline data collection of these integral environmental components was considered insufficient to predict potential impacts.

Due to the scale and nature of this proposal and the biodiversity significance of the Ningaloo Reef, information describing the pre-development condition of the marine environment was considered essential.

EXECUTIVE SUMMARY

- In July 2002, a collaboration of marine and environmental scientists (Oceanwise Environmental Scientists and Murdoch University) conducted a baseline marine ecological survey of Bateman Bay, Ningaloo Reef.
- A variety of methods were used including manta tow surveys, video transects and baited videos, random spot dives, intensive transects and incidental sightings or observations.
- Data were collected on the physical environment, macroalgae, seagrass, plankton, coral, molluscs, fish, the intertidal zone, turtles and marine mammals. In this summary report, their significance in the Bateman Bay ecosystem is discussed, and major threats and recommendations are identified.
- Nine monitoring sites were established within various marine habitats. Sites were established following Department of Conservation and Land Management (CALM) guidelines.

PHYSICAL ENVIRONMENT

Findings:

- Oceanographic processes that operate adjacent Bateman Bay may retain nutrients and explain the presence of large predatory billfish, sharks, manta rays or other pelagic fish.
- 4WD activity is eroding the foreshore and dunes by removal of the binding dune vegetation.
- The broad, depositional beaches of Bateman Bay are likely to be critical nesting habitat for marine turtles, particularly the *endangered* loggerhead turtle.
- Deposition of large coral fragments suggest high energy wave activity from tropical cyclones or tsunamis may have penetrated the Cardabia Passage, a gap in the reef adjacent to Bateman Bay.

Potential threats from CCMD:

- A breakwater may disrupt sediment transport and alter the ecology of the nearshore seagrasses that are important to juvenile fish.
- Seasonal rainfall or cyclonic rains are capable of transporting large amounts of nutrient-laden runoff from land based activities into the bay.

Recommendations:

- Oceanographic processes are likely to be an important determinant of the local ecology and further understanding is necessary, particularly the nearshore presence of manta rays and other species of significant tourism value.
- 4WD access along the foreshore should be prohibited, dunes revegetated, and beach access designated by authorities.
- Coastal planning should consider the potential for tropical cyclones and tsunamis in shaping the coastal landscape.

ALGAE

Findings:

- Despite the dominant sandy substrate, Bateman Bay supports a diverse algal flora that are important food sources for turtles, fish and invertebrates.
- Hotspots for diversity are the Oyster Bridge intertidal reef platform and the rubble zones inshore of the fringing reefs.

Potential threats from CCMD:

- An increase in tourists to the Oyster Bridge will exacerbate current impacts such as trampling and other forms of disturbance that can erode the reef structure.

Recommendations:

- A comprehensive survey of marine algae is required, particularly the obscure turf algae that predominate in the bay.
- Clear guidelines should be developed for tourism operations at the Oyster Bridge.

SEAGRASS

Findings:

- A preliminary 8 species of seagrass were identified, including the first record of *Halophila tricostata* in Western Australia.
- A mix of temperate and tropical species occur; *Posidonia coriacea* is at the northern limit of its geographical range.
- *Halophila ovalis* may be important food for migrating or resident dugongs and turtles.

Potential threats from CCMD:

- Sedimentation from on-going dredging will smother seagrasses that are nursery or habitat for juvenile fish of commercial and recreational value.
- Construction of breakwaters is likely to destroy the *Posidonia coriacea* meadows.

Recommendations:

- The discovery of *H. tricostata* reinforces the need for a more detailed examination of the seagrasses in Bateman Bay and the Ningaloo Reef in general.
- The significance of *P. coriacea* for juvenile fish and manta rays needs further investigation considering their local tourism significance.
- Turbidity resulting from coastal development should be avoided or mitigated as local seagrasses appear to be habitat or nursery areas for juvenile fish.

PLANKTON

Findings:

- Diatoms (phytoplankton) are the major food resource for herbivorous zooplankton that is grazed by manta rays and other filter feeders that occur in Bateman Bay.

Potential threats from CCMD:

- Nutrient-laden surface runoff and contaminated groundwater encourages algal epiphyte growth (eutrophication) that can smother seagrasses.
- Eutrophication and persistent pollutants such as heavy metals may impact the nearshore planktonic communities that form the basis of food chains.

Recommendations:

- Management plans for development should include tight controls over nutrient inputs, and should include risk assessment for algal blooms, and the costs associated with their removal.
- Land-based nutrient inputs (such as fertilizers) are inappropriate and should be prohibited from this environment.

CORAL

Findings:

- A preliminary 29 hard coral and 10 soft coral genera were observed.
- The nearshore coral communities are habitat or nursery grounds for 55 juvenile fish species, including spangled and red emperor.
- The coral eating snail *Drupella cornus* was observed in all areas of hard coral cover.
- Coral communities in the nearshore areas of the bay are damaged by anchors, fishing gear and recreational activities.

Potential threats from CCMD:

- Coral reefs exist in nutrient-poor environments. Small changes in the nutrient content of water from coastal development can adversely effect survival.
- A proposed breakwater may alter the dispersal of coral spawn by northerly driven wind currents. This process may play a role in replenishing the coral communities north of Maud Landing.
- Increased human visitation to this area may compromise the unique ecology and tourism attributes of the coral communities.

Recommendations:

- Further understanding of *Drupella cornus* ecology is required to determine if their presence in Bateman Bay is symptomatic of a human-induced ecosystem imbalance.
- Visitors should be alerted to the impacts their activities may have on coral.
- A Sanctuary Zone should be declared over the rocky intertidal and coral reef habitats (Figure 1).
- A west-ward extension of Maud Sanctuary to incorporate the deep, back reef coral habitat would protect a representative range of habitats in this area (Figure 1).

MOLLUSCS

Findings:

- This preliminary survey recorded approximately 20% of mollusc species known from the Ningaloo Reef region.
- Two mollusc species are considered rare and 19 species uncommon to the region.
- Many hard-shelled mollusc species were observed within the dominant sandy substrate.
- Current human impacts on mollusc populations at the Oyster Bridge are unsustainable.

Potential threats from CCMD:

- Eutrophication can clog the filter feeding gills of many molluscs and impact food webs.
- During the construction of the marina breakwater, 47 species of mollusc are threatened by smothering.

Recommendations:

- Research efforts should be directed towards the deep sandy gutters and basins of the bay that are likely to reveal many more mollusc species.
- A Sanctuary Zone should be declared over the rocky intertidal platforms between the Oyster Bridge and the Lagoon (Figure 1).

FISH

Findings:

- 60% of fish species that are found on Ningaloo Reef were observed.
- The nearshore seagrasses and coral reefs are nursery ground or habitat for at least 55 fish species, including the heavily targeted spangled emperor.

Potential threats from CCMD:

- Destruction of *Posidonia coriacea* adjacent to Maud Landing may effect replenishment of ecologically and/or recreationally important fish species such as spangled emperor, big eye snapper, spinefoot and goatfish.

Recommendations:

- Further research on the exploitation status of fish stocks is essential to determine the extent of current impacts. The proposed development would increase the fishing pressures on fish stocks, and requires further consideration and investigation.
- Research is needed to determine the significance of seagrass and coral as nursery grounds for juvenile fish, and their role in determining the plankton communities that form the primary food source for manta rays.

INTERTIDAL ZONE

Findings:

- A preliminary total of 35 intertidal species of flora and fauna were identified from the Oyster Bridge and Lagoon.
- Community stability is compromised by current levels of human disturbance and exploitation.

Potential threats from CCMD:

- Increases in human visitation may result in decreased species richness and ecological imbalances.
- Filter feeding mollusc species can accumulate pollution and toxins concentrated through food webs in predator-prey relationships.

Recommendations:

- A Sanctuary Zone should be declared over the rocky intertidal habitat from Oyster Bridge to Porites (Figure 1).
- Mitigation of human disturbance to these intertidal areas is required.

MARINE TURTLES

Findings:

- Loggerhead, green and hawksbill turtles were observed in the bay; these species are recognized on state, national and international levels as requiring special conservation attention.
- The foreshore of Bateman Bay is one of the last remaining mainland nesting sites in Western Australia for the *endangered* loggerhead turtle.
- Anecdotal evidence suggests the current level of human disturbance during the critical nesting period is compromising population recovery (to pre-exploitation levels).
- Previous research has confirmed that 4WDs are crushing nests, wheel ruts are disorientating loggerhead hatchlings, humans are interfering with nesting turtles and hatchlings, and foxes are consuming entire nests.

Potential threats from CCMD:

- Increased human use of beaches will further disturb nesting turtles. Genetic studies have confirmed that most species nest at their hatching place; disturbed turtles will not nest at another beach.
- Juveniles and sub-adults use Bateman Bay as feeding grounds. Increases in boat traffic increase the likelihood of death or injury by propeller strikes.
- Entanglement of turtles in fishing line or nets and ingestion of plastic bags is known from Ningaloo Reef and are likely to increase.

Recommendations:

- 4WD vehicles should be prohibited from the beach and visitors alerted to the impacts of human activities during the critical nesting period.
- The scale and extent of coastal development in this bay should be avoided.
- A 5 knot speed limit should be imposed within the Maud Sanctuary feeding and resting area.

MARINE MAMMALS

Findings:

- Humpback whales, indo-pacific humpbacked dolphins, bottlenose dolphins and dugongs were observed in the bay. Incidental observations during this survey and anecdotal evidence from charter operators indicate that Bateman Bay is an important nursing, feeding or resting ground for these animals.
- Anecdotal evidence suggests dugongs may be migrating from Shark Bay through Bateman Bay to the warmer waters of Exmouth Gulf in winter. Local seagrass may be important for dugongs in transition.
- Hillarys Boat Harbour in Perth is approximately half the size of the proposed marina; the marina may accommodate 1000 vessels in the future.

Potential threats from CCMD:

- Marina/resort developments of the scale proposed will facilitate increases in boat traffic from recreational activities such as fishing boat and jet-ski hire, para-sailing, water skiing, dive charters and sight seeing cruises.
- Small inshore dolphins and slow-moving dugongs are particularly vulnerable to boat strikes from fast, high powered launches and jet skis.
- Dugongs are vulnerable to human disturbance because of their life history characteristics and their dependency on seagrass. Persistent boat activity can cause displacement from seagrass and separation of cow/calf pairs.
- Marinas restrict water circulation and are known to accumulate pollution.
- Persistent contaminants such as heavy metals and pesticides pose a threat to marine mammals by biomagnification through food webs.
- Coastal development has the potential to reduce the quality of Bateman Bay as marine mammal habitat. This may have implications for local ecology and the wildlife based tourism charters that operate in the bay.

Recommendations:

- Further research on the habitat needs of marine mammals and other ‘megafauna’ is required to quantify current and potential threats (particularly for *endangered* and *vulnerable* species that may be using Bateman Bay as feeding and resting grounds on long migratory routes).
- Regulation of wildlife-based tourism operations in this region is required.
- An education program should be implemented for boat users. People should be alerted to the potential effects of many forms of disturbance and pollution.
- A 5 knot speed limit should be imposed within Maud Sanctuary due to the likelihood of marine mammal encounters.
- A large marina development in this bay should be avoided as it may potentially disturb the many ‘mega fauna’ that are a central focus of tourist attraction at Ningaloo Reef.

CONTRIBUTORS

OCEANWISE ENVIRONMENTAL SCIENTISTS

Ben Fitzpatrick *(CH. 1 Physical Env., CH. 5 Coral, CH. 6 Molluscs, CH. 7 Fish)*
Bachelor of Environmental Science, University of Western Australia
Ben is the founding director of 'Oceanwise' and initiated and managed this research. In 1998 he conducted a similar marine ecological survey of the Tantabiddi Lagoon at Ningaloo Reef. Ben is formerly of the Australia Institute of Marine Science (AIMS) where he worked as a benthic ecologist on the Great Barrier Reef Long Term Monitoring Project. His particular interests are coral reef ecology and Marine Protected Areas and he is currently conducting postgraduate research that combines the two.

Helen Penrose *(CH. 1 Physical Env., CH. 9 Turtles, CH. 10 Marine Mammals)*
Bachelor of Applied Science (Hons) Environmental Management, James Cook University
Helen co-directs 'Oceanwise' and is currently involved in seagrass research at the University of Western Australia. She is interested in many aspects of the marine and coastal environment. After completing an Honours degree in coastal geomorphology, she coordinated the production of the world's first dugong action plan and status report for the United Nations Environment Programme.

MURDOCH UNIVERSITY

Maxine Birkin *(CH. 8 Intertidal zone)*
Bachelor of Science (Hons) Marine Biology, Murdoch University
Maxine recently completed an Honours year that focused on the intertidal molluscs of Yallingup. She has a passion for many aspects of the marine environment and is actively developing her career in this field.

Sorcha Gillen *(CH. 4 Plankton)*
Bachelor of Science (Hons) Marine Biology, Murdoch University
Sorcha completed an Honours year investigating the zooplankton composition of coastal saline lakes in south-western Australia. Further interest has lead to the commencement of a PhD on the interaction of the fish and zooplankton prey in these coastal lakes.

Dr. Mike van Keulen *(CH. 2 Algae & CH. 3 Seagrass)*
Bachelor of Science (Hons) Biological Science/Environmental Science
Doctor of Philosophy, Murdoch University
Mike is currently a lecturer in Marine Biology at Murdoch University. He is also the coordinator of the Seagrass Rehabilitation Project and has accumulated 15 years research experience. His particular interests are the physical environmental factors affecting seagrass growth. In the future he will be directing his research efforts to the warm waters of Ningaloo Reef.

Jason Webb *(CH. 4 Plankton)*
Bachelor of Science (Hons) Marine Biology, Murdoch University
Jason recently completed an Honours year that focused on plankton, and is considering a PhD on this topic in the near future.

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This research was conducted under CALM research permit # CE000027.

CHAPTER 1: PHYSICAL ENVIRONMENT

1.1 INTRODUCTION

1.1.1 Aims

This survey aimed to provide data on:

- beach sediment and topography.

This summary provides an explanation of the interaction between the physical and ecological environment.

1.1.2 Location of Bateman Bay, Ningaloo Reef

- Ningaloo Reef extends 260 km along the west coast of the Cape Range Peninsula, approximately 1200 km north of Perth (Figure 1).
- Bateman Bay is located within the central section of Ningaloo Reef (Figure 1).

1.1.3 Climate

- Bateman Bay has a semi-arid climate. Annual rainfall of 294 mm is largely contributed by sporadic and extreme rainfall events associated with tropical cyclones.

1.1.4 Oceanography

- During winter, wind patterns are dominated by strong east to south-easterly winds, with afternoon sea breezes from the south-west.
- South to south-westerly driven swell waves prevail throughout the year.
- The tidal range within the Ningaloo Reef is mixed, predominantly semi diurnal and with a spring tide of approximately 2 m.
- Wave-induced currents dominate in this region (D'Adamo and Simpson 2001), and are strongly influenced by tidal changes in water level (Hearn and Parker 1988).
- The mixing of the Leeuwin and Ningaloo Currents occurs adjacent to Bateman Bay.
- The Leeuwin Current plays a significant role in transporting tropical species and warm water for their survival.
- The recently described Ningaloo Current is thought to influence coral larvae dispersal and retain planktonic biomass within the ecosystem (Taylor and Pearce 1999).
- Alternatively, an abundance of planktonic communities along Ningaloo Reef may indicate upwelling of cold, nutrient rich water (D'Adamo 1997).

1.1.5 Geomorphology

- Bateman Bay is a large, north facing, semi-enclosed bay formed by the discontinuous Ningaloo Reef.
- The bay extends approximately 20 km from Point Maud to Bruboodjoo Point, and is approximately 5 km in width from the shore to the reef crest.

- In contrast to the relatively calm, shallow, protected waters of the Ningaloo lagoon, Bateman Bay is open to the ocean, averages about 20 m in depth, and receives increased wave energy via the Cardabia Passage.
- The Cardabia Passage is a 5 km wide, 30 m deep gap in the reef and the entry point for sediment into the bay.
- Coastal landforms consist of broad, accreting, sandy beaches and unconsolidated Holocene sand dunes which except for binding vegetation cover, are fragile and unstable.
- Landward, low-lying supra-tidal saltflats are regularly inundated by seasonal rainfall and cyclonic flooding or storm surge (DCE 1984).

1.2 METHODS

- Six beach profile transects were conducted across the beach from the swash zone to the crest of the tertiary dune (Figure 1).
- Sediment was collected at seven sites from Point Maud to south of Oyster Bridge (Figure 1). Samples were obtained from the intertidal, midtidal and supratidal zones.

1.3 RESULTS

- Immediately north of Point Maud, large, well developed dune formations extend approximately 200 m from the base of the primary dune to the crest of the tertiary dune.
- Dune height reached approximately 12 m AHD (Australian Height Datum), with the intermediate beach ridges averaging approximately 5 m AHD.
- The beach foreshore reached widths of 50 m and was typical of a reflective, high energy beach with a relatively steep slope and plunging wave action.
- Sediment obtained between the intertidal and supratidal locations is unconsolidated and uniform in grain size.
- Beaches provide habitat for invertebrate fauna such as ghost crabs (*Ocypode ceratophthalmia*) that are distributed across the beach from the swash zone to the far side of the primary dune.
- Many species of molluscs inhabit the intertidal zone (see Ch.6).
- From Point Maud north to Oyster Bridge, remnant turtle nests were observed at the base of dune vegetation.
- Dune erosion is evident along the beach, particularly south of Maud Landing where fishing activity is concentrated.
- Deposits of large coral fragments were found scattered throughout the dunes.
- Behind the dunes, recent rainfall had pooled in the low-lying supra tidal saltflats where many unidentified bird species were observed.

1.4 DISCUSSION

1.4.1 Significance in Bateman Bay

- Prevailing winds may distribute fish larvae to the inshore seagrass habitat near Maud Landing, and coral larvae to the reef and intertidal areas of Oyster Bridge, Lagoon and Porites.
- The open and relatively deepwater nature of Bateman Bay and an abundance of planktivorous fish may indicate an upwelling of cold, nutrient rich water.
- The Leeuwin current eddies adjacent to Bateman Bay. Mixing of the Leeuwin and Ningaloo Current may retain nutrients within the vicinity.
- The presence of large predatory billfish, sharks, whale sharks, manta rays and other pelagic fish adjacent Cardabia Passage and within Bateman Bay suggest oceanographic processes strongly influence the local ecology (B. Brogan *pers comm.* 2002).
- The depositional nature of Bateman Bay with its wide, sandy beach is suitable nesting habitat for marine turtles.
- The foreshore of Bateman Bay is one of the last remaining mainland nesting sites in Western Australia for the *endangered* loggerhead turtle.
- Nesting turtles require specific sediment such as the unconsolidated sand characteristic of the bay (P. Mack *pers comm.* 2002).
- Coral fragments situated well above the high water mark suggest high energy wave activity generated by tropical cyclones or tsunamis may have penetrated the Cardabia Passage.
- Ningaloo Reef is highly prone to tropical cyclones; the sandy beaches and dune formations are likely to play an important role in buffering coastal erosion.
- During Tropical Cyclone Vance in 1999, storm surges of up to 8 m were experienced in Exmouth Gulf, resulting in erosion of primary and secondary sand dunes, the formation of gullies, and the awakening of creek beds compacted beneath development (B. Fitzpatrick *pers obs*.).
- The most recent tsunami to impact this region was in 1994, and a return time of 20 years is predicted (Commonwealth of Australia 2002).
- Reef passages (such as the Cardabia Passage adjacent Bateman Bay) are capable of funneling and amplifying tsunamis (Nott 1997).
- At Bateman Bay, the low lying, intermittent salt lakes situated behind the dunes have been considered inappropriate for development (DCE 1984). This is the location for the proposed Coral Coast Marina Development (CCMD) (Figure 1).

1.4.2 Current threats

- Of ongoing concern to coastal stability is 4WD access to the beach and dunes.
- At high tide, vehicles are forced to drive at the foot of the foredune. Without plant cover, the foredune is increasingly eroded by wind and waves.
- 4WD access is of particular concern during the turtle nesting season (November to March) (P. Mack *unpublished data*).
- Turtle nests are located near the foot of the foredune and eggs are vulnerable to crushing, particularly loggerhead turtle eggs that are deposited close to the surface (P. Mack *unpublished data*).

1.5 CONCLUSIONS

- The Cardabia Passage, a gap in the Ningaloo Reef, is the source of increased sediment and wave energy into Bateman Bay.
- The broad, sandy beaches of Bateman Bay are likely to be critical nesting habitat for marine turtles, particularly the endangered loggerhead turtle.
- Oceanography is likely to be important determinant of the local ecology. (Refer to Figure 3 for a brief ‘snapshot’ of the biodiversity found in Bateman Bay).

1.6 RECOMMENDATIONS

- 4WD access along the foreshore should be prohibited, dunes revegetated and beach access designated by authorities.
- Coastal planning should consider the potential role of tropical cyclones or tsunamis in shaping the coastal landscape of Bateman Bay.
- The significance of winds, waves and tides in the distribution of plankton, rays, and larvae needs further investigation; particularly the nearshore distribution of manta rays (see Ch. 7) and other species of significant local tourism value.

CHAPTER 2: MACROALGAE

2.1 INTRODUCTION

- Macroalgae constitute a primary source of food for turtles, dugongs, larger herbivorous fish, and innumerable invertebrates.
- Calcareous algae (those that fix calcium carbonate within their cells) are reef forming and cementing organisms.

2.1.1 Aims

This survey aimed to provide baseline data on

- macroalgae distribution and abundance; and
- the significance of macroalgae in Bateman Bay.

2.2 METHODS

- Manta tow surveys, random spot dives and intertidal transects were conducted at various locations (Figure 1).
- Specimens were collected incidentally.

2.3 RESULTS

2.3.1 Number of species

- A preliminary 37 species were identified (Appendix 1).

2.3.2 Oyster Bridge

- 29 species were observed within the intertidal zone.
- Algal cover is very dense, with the entire substrate overgrown in many places.
- A diversity of forms was observed, including all major macrophyte groups, and many structural forms, from filamentous to larger foliose growth.

2.3.3 Other data

- Throughout the bay, numerous specimens were attached to coral bombies, rubble, exposed calcarenite outcrops and indeed bare sand.
- The calcareous green alga *Halimeda cylindracea* was abundant on the sand substrate north of Oyster Bridge.

2.4 DISCUSSION

2.4.1 Significance in Bateman Bay

- Bateman Bay appears to form an overlap area for temperate and tropical species; most species have a tropical affinity, and several temperate species (e.g., *Bryopsis australis, Codium geppiorum and Jania verrucosa*) are at the northern limit of their geographical range.

- Several key calcareous species contribute to the dominant sandy substrate.
- Turf algae on the Oyster Bridge and other substrates form an important food source for numerous small reef fish that are abundant in areas such as Oyster Bridge and the Lagoon.
- Turtles, dugongs, large herbivorous fish and invertebrates consume macroalgae and were observed during this study.

2.4.2 Current threats

- Oyster Bridge and adjacent intertidal areas are popular fishing and tourist spots; trampling will damage the organisms attached to the reef and result in instability of the reef structure.
- Calcareous algae are at particular risk to human impacts because of their rigid structure.

2.5 CONCLUSIONS

- Despite the dominant sandy substrate, Bateman Bay supports diverse algal flora.
- Algae are important food sources for turtles, dugongs, fish and invertebrates and also contribute to sedimentation and reef formation.
- Particular hotspots for diversity appear to be the Oyster Bridge intertidal reef complex and the rubble zones inshore of the fringing reefs.

2.6 RECOMMENDATIONS

- A comprehensive survey is required of marine algae, particularly the more obscure turf algae that predominate.
- Clear guidelines should be developed for tourism operations at Oyster Bridge to minimise potential damage to the reef structure.

CHAPTER 3: SEAGRASS

3.1 INTRODUCTION

- Tropical seagrasses constitute a primary source of food for turtles, dugongs, larger herbivorous fish, and innumerable invertebrates.
- Larger species of seagrass provide an important shelter for fish, including several important commercial and recreational species.

3.1.1 Aims

This survey aimed to provide baseline data on:

- seagrass distribution and abundance; and
- the significance of seagrass in Bateman Bay.

3.2 METHODS

- Manta tow surveys (Bass and Miller 1996) and random spot dives were conducted throughout the bay. (Figure 1).

3.3 RESULTS

3.3.1 Number of species

- 8 species of seagrass were identified, including 3 previously identified by ATA (2000) (Appendix 1).

3.3.2 *Posidonia coriacea*

- Dense stands of *Posidonia coriacea* extend several hundred metres about 200 m north-west of the Maud Landing jetty pylons.
- Many fish were observed within these stands. In particular, large numbers of juvenile North West Snapper at the critical <10 cm life stage.
- Feeding manta rays were also observed in the vicinity of the *P. coriacea.*
- Additional patches of *P. coriacea* were observed close to shore, north of Maud Landing.

3.3.3 *Amphibolis antarctica*

- *Amphibolis antarctica* was observed on rubble substrate and on shallow sand in embayments north of Oyster Bridge.

3.3.4 *Halophila* spp.

- Small *Halophila* spp. were scattered throughout the sandy substrate in between coral bombies.
- *Halophila ovalis* was abundant in the deeper waters of Stanley Pool, sometimes with the tropical species *Halodule uninervis*.
- Of particular significance is the presence of *Halophila tricostata,* a species only previously recorded from the Great Barrier Reef.

3.3.5 Other seagrass species

- Other seagrass species were found in small numbers on sand in sheltered lagoon areas such as inshore of Oyster Bridge and at the base of coral colonies.

3.4 DISCUSSION

3.4.1 Significance in Bateman Bay

- Bateman Bay is an overlap area for temperate and tropical seagrass species, similar to that of macroalgae.
- Several temperate species have their northern distributional limits in this area; in particular, the large temperate species *P. coriacea.*
- Many of the smaller species (*Halophila and Halodule*) are favoured by turtles and dugongs as a food source.
- These seagrass species are seasonal pioneer species. Peak growth occurs in the calm weather conditions of spring and autumn, and dies back during the rougher winter weather conditions.
- Anecdotal evidence suggests that dugongs undertake winter migrations from Shark Bay through Ningaloo Reef to the warmer waters of Exmouth Gulf (Ningaloo Experience *pers comm.* 2002).
- The *Halophila* populations of Stanley Pool may constitute an important food source for migrating or resident dugongs.

3.4.2 Current threats

- In general, seagrasses are not directly impacted by humans in the bay.
- Seagrass loss may result from natural disturbance such as tropical cyclones (e.g., Exmouth Gulf, Tropical Cyclone Vance in 1999).

3.5 CONCLUSIONS

- Bateman Bay supports a diverse seagrass flora, including a mix of temperate and tropical species. Eight species were identified in this preliminary survey.
- Of particular significance is the northern limit of several temperate species such as *P. coriacea*.
- The presence of *Halophila tricostata* is a first for Western Australia.
- Seasonal growth of *Halophila* may contribute significantly to the productivity of the bay.
- *Halophila* is likely to be important food for migrating or resident dugongs and turtles.

3.6 RECOMMENDATIONS

- The discovery of *H. tricostata* reinforces the need for a more detailed examination of the seagrasses in Bateman Bay and the Ningaloo Reef region.
- A thorough survey of the seagrass communities should be undertaken in summer, when seasonal growth peaks.
- The significance of *P. coriacea* for juvenile fish needs further investigation.
- Intensive surveys should focus in the deeper basin regions and sheltered areas in the northern part of the bay; in particular the *Halophila* populations of Stanley Pool.

CHAPTER 4: PLANKTON

4.1 INTRODUCTION

- Plankton is the very diverse collection of microscopic (10 μm to 1 mm) animals (zooplankton) and plants (phytoplankton) that drift passively at various depths within the water column.
- Members of the phytoplankton are classed as algae.
- Some faunal species are only planktonic during certain early life stages (such as fish, crustaceans and echinoderms), while many, such as the copepods and amphipods are wholly planktonic.

4.1.1 Aims

This survey aimed to provide baseline data on:

- the daytime surface composition of plankton; and
- the significance of plankton in Bateman Bay.

4.2 METHODS

- Sampling occurred at 3 locations; outer reef, mid-bay and nearshore adjacent to Maud Landing (Figure 1).
- A 25 μm trawl net was used to sample phytoplankton, and a 177 μm net for zooplankton.
- Three opportunistic trawls were performed at a site north of Maud Landing immediately after manta rays were observed feeding.

4.3 RESULTS

4.3.1 Zooplankton

- Common zooplankton species include copepods (a crustacean), brachiopod larvae (the free-swimming phase of the filter feeding lamp shell), polychaete larvae, echinoid larvae (sea urchins, sand dollars and relatives), cnidaria medusa (such as jellyfish), and fish eggs (Appendix 2a).

4.3.2 Phytoplankton

- The composition of phytoplankton is typical of a tropical/temperate transition area (Appendix 2b).
- Diatoms, dinoflagellates and protozoans were common.

4.4 DISCUSSION

4.4.1 Significance in Bateman Bay

- Simplistically, phytoplankton is the major primary producer in the marine environment. They grow abundantly in oceans around the world and are the foundation of the marine food chain.
- Diatoms (phytoplankton) are the major food resource for herbivorous zooplankton that is grazed by manta rays, whale sharks and other filter feeders that occur in Bateman Bay.
- Dinoflagellates provide food for mussels and fish, and protozoans are important in their symbiotic relationship with multicellular animals such as corals and also in bacteria consumption.
- As phytoplankton requires specific conditions for growth, they frequently become the first indicator of a change in their environment.

4.4.2 Current threats

- Most tropical waters are known to be nutrient poor, and are particularly susceptible to anthropogenic inputs of nutrients.
- The nutrient inputs to the marine environment from waste treatment and/or groundwater sources can result in eutrophic conditions, with blooms of algae (phytoplankton) dominating isolated areas such as enclosed bays.
- It is possible that pollutants and nutrients generated in Coral Bay are dispersed into Bateman Bay by prevailing winds and currents.
- Eutrophication has the potential to deplete oxygen levels and result in fish kills such as that observed after coral spawning events in Bills Bay (Simpson *et al.* 1993).

4.5 CONCLUSIONS

- Eutrophication and persistent pollutants may impact the nearshore planktonic communities that form the basis of food chains.

4.6 RECOMMENDATIONS

- This preliminary research highlights the need for a more detailed assessment of plankton composition and abundance and the influence of oceanographic processes.
- Management plans for development should include tight controls over nutrient inputs, and should include risk assessment for algal blooms, and the costs associated with their removal.
- To obtain a comprehensive picture of plankton distribution, sampling should be conducted at night when plankton communities undergo vertical migration.

- Sampling at various depths is also required, particularly as manta rays have been observed ‘sweeping sediment’ from the benthos into their gill rakers (mouth) (Ningaloo Experience *pers comm.* 2002).
- A long-term research program should be implemented to monitor potential increases in nutrient input and pollution.
- Baseline toxicity levels and heavy metal concentrations within the planktonic communities are needed to assess potential effects on planktivorous vertebrates (e.g., manta rays, whale sharks, humpback whales) and filter feeding invertebrates (e.g., corals and bivalves).
- It is also crucial to establish an accurate set of seasonal abundance data for both phytoplankton and zooplankton as this will enable the monitoring of fish stocks and maintenance of water quality.

CHAPTER 5: CORAL

5.1 INTRODUCTION

- Corals exist in low-nutrient environments.
- They are primary producers, capturing energy from sunlight and introducing it to reef ecosystems.
- Corals provide shelter and food for invertebrates, fish and turtles.
- Corals dissipate wave energy and contribute sediment through the physical breakdown of coral fragments.

5.1.1 Aims

This survey aimed to provide baseline data on

- coral distribution and abundance;
- presence of *Drupella cornus*, anchor damage and other impacts; and
- the significance of coral in Bateman Bay.

5.2 METHODS

- Video transects (Page *et al.* 2001), manta tow surveys (Bass and Miller 1996), and random spot dives were conducted at various locations (Figure 1).

5.3 RESULTS

5.3.1 Number of coral species

- 29 genera of hard coral (skeletal forming) and 10 genera of soft coral (non-skeletal forming) were recorded in this preliminary survey (Appendix 3).

5.3.2 Oyster Bridge, Lagoon and Porites

- These nearshore locations had the highest percentage of hard and soft coral cover.
- Coral cover increased from 5-10% at Oyster Bridge to 40–50% at Porites.
- Juveniles of 55 fish species including spangled and red emperor were found.
- The coral is breeding habitat for cuttlefish and shelter for rays, sharks and turtles.
- Physical damage from anchors, fishing gear and recreational activities was observed.

5.3.3 South of Oyster Bridge

- Scattered limestone plates support coral recruits but are regularly smothered by sediment movement within the bay (see also ATA 2000).

5.3.4 Maud Landing

- Adjacent Maud Landing and towards the south of the bay, scattered limestone plates supporting coral recruits are interspersed with seagrass beds.

5.3.5 Maud Channel

- Coral communities were observed in turbid water to depths of 7 m.

5.3.6 Maud Sanctuary

- Coral cover decreased from 16.5% in the south to <1% towards the northwest tip of the Sanctuary.
- Evidence of illegal fishing activity was recorded.

5.3.7 North Reef

- Isolated coral bombies and outcrops occur and fish diversity is high relative to surrounding habitat.

5.3.8 Other data

- The coral eating snail *Drupella cornus* was found in all areas with hard coral cover.
- In the southern parts of the bay, mega sand ripples were distributed across the sea floor.

5.4 DISCUSSION

5.4.1 Significance in Bateman Bay

- Coral reef habitat is the most diverse ecosystem in the bay.
- The nearshore coral reef areas are likely to be important nursery ground or habitat for many species of juvenile fish.
- Compared to other reefs worldwide, the Ningaloo Reef is low in coral cover; areas of high coral cover are important to protect for replenishment within the bay.
- The distribution of coral spawn in Bateman Bay is likely to reflect the dominant south westerly wind regime.
- For example, in 1989 and 2002, prevailing sea breezes trapped coral spawn in Bills Bay, resulting in death of coral and fish life upon rotting (Simpson *et al.* 1993).
- Mega sand ripples suggest a northward, long-shore movement of water that may be crucial in replenishing the coral communities of Oyster Bridge, Lagoon and Porites.
- The abundance of *Drupella cornus* on Ningaloo Reef is not yet understood, although it has been suggested that a decrease in their natural predators (e.g., the heavily targeted spangled emperor) may have caused an imbalance (Zann 1995).

5.5 CONCLUSIONS

- 29 genera of hard coral and 10 genera of soft coral were recorded in this preliminary survey.
- The coral habitats of Bateman Bay are key basic components of the ecosystem, supporting a diversity of fish life and providing food, shelter and nutrients.
- The bay supports significant coral communities in accessible areas. These areas are limited in size and current impacts are of concern.
- This research highlights the need for management of current threats and the need to avoid further impacts.

5.6 RECOMMENDATIONS

- Understanding of oceanographic currents for the dispersal of coral recruits or pollutant dispersal is essential for coastal planning and management decisions.
- Visitors should be alerted to the impacts that different activities can have on coral.
- A Sanctuary Zone should be declared over the rocky intertidal and coral reef habitat between Oyster Bridge and Porites (Figure 1).
- A west-ward extension of Maud Sanctuary to incorporate the deep, back reef coral habitat would allow a representative range of habitats to be protected in this area (Figure 1).

CHAPTER 6: MOLLUSCS

6.1 INTRODUCTION

- Molluscs fulfill several ecological roles as primary producers, filter feeders, algae feeding herbivores and predators.

6.1.1 Aims

This survey aimed to provide baseline data on

- o mollusc distribution and abundance; and
- o the significance of molluscs in Bateman Bay.

6.2 METHODS

- Video transects (Page *et al*. 2001), manta tow surveys (Bass and Miller 1996), random spot dives, and intertidal transects were conducted at various locations (Figure 1).
- Opisthobranch molluscs such as nudibranchs and sea hares were omitted from this census, which focused almost entirely on hard shelled (collectable) species or conspicuous species such as cuttlefish.

6.3 RESULTS

6.3.1 Number of species

- A preliminary 130 species of molluscs from 54 families (Appendix 4).
- This represents approximately 20% of the 600 species that have been recorded from the Ningaloo Reef region.

6.3.2 Status

- Two mollusc species that occur in Bateman Bay are considered rare (the cowrie shell, *Cypraea leviathan gedlingae* and the watering pot shell, *Brechites vaginiferus*) (Wells and Bryce 2000).
- 19 mollusc species are considered uncommon to the region (Wells and Bryce 2000).

6.3.3 Maud Landing

- At the newly established monitoring site (Figure 1), a preliminary 47 mollusc species were recorded. A majority of these species were interstitial bivalves and mussel beds, confirming previous findings (ATA 2000).
- Many unidentified mollusc species were observed within the large seagrass wracks that extended from the Maud Landing jetty pylons to Bruboodjoo Point. Seagrass wracks are rolls of dead seagrass and other detritus formed by wave action.

6.3.4 Oyster Bridge, Lagoon and Porites

- An abundance of molluscs was recorded at these nearshore coral reef and intertidal communities, including 130 individual giant clams.
- The aptly named Oyster Bridge supports an extensive oyster bed and many intertidal species (see Ch.8), and is also cuttlefish and squid breeding habitat.
- At Oyster Bridge, oyster cover decreased from approximately 90% in the currently non-impacted areas to 10% where visitors frequent.
- Although not a focus for this study, nudibranch egg masses and baler and conch shell egg cases were observed in the vicinity of Oyster Bridge.

6.3.5 Sand substrate

- Many hard-shelled mollusc species were observed from the dominant sandy substrate.
- Feeding depressions formed by rays were observed throughout the bay.
- Mussel beds were interspersed through the sandy substrate from the sand spit to the south of Bruboodjoo Point.

6.3.6 Other data

- An abundance of the coral eating snail *Drupella cornus* was observed in all areas of hard coral growth including Maud Sanctuary, the channel adjacent Point Maud, and the nearshore coral reef from Oyster Bridge to Porites.
- Shell collecting was observed from Point Maud to the Oyster Bridge.

6.4 DISCUSSION

6.4.1 Significance in Bateman Bay

- The distribution and abundance of mollusc species found in this preliminary survey indicates an important component of the bay-wide ecosystem.
- Filter feeding molluscs are consumed by rays, sharks, turtles and recreationally important fish species including snapper and sweetlips.
- Based on observations of winds and currents, it is likely that Bateman Bay accumulates suspended sediment, organic matter and plankton from coral lagoons to the north and south, providing a basis for a well developed interstitial ecosystem.

6.4.2 Current threats

- Oyster Bridge is currently under pressure from unregulated mollusc exploitation; organised tours and independent visitors consume oysters and mussels from accessible areas.
- This disturbance can result in the domination of other fast growing, rapidly colonizing species and reduced species richness.

- At Oyster Bridge, pipis, cuttlefish, octopus and squid are also used as bait or caught for food. As cuttlefish and squid breed in this area, they are vulnerable to exploitation.
- *Drupella cornus* are found in high abundance throughout the Ningaloo Reef region. Similar to Crown of Thorns Starfish, it is unknown whether this abundance is natural or signifies human induced ecological disturbance.
- It is has been suggested that a decrease in predatory fish such as spangled emperor has allowed large increases in *Drupella* (Zann 1995).
- Shells provide a protective habitat for many intertidal species such as hermit crabs.

6.5 CONCLUSIONS

- This preliminary survey recorded approximately 20% of the mollusc species known from the Ningaloo Reef region.
- Many molluscs were found in the deep, sandy gutters and basins that dominate the seafloor.
- At Bateman Bay, molluscs are likely to be an important food source for particular species of dolphins, turtles, fish and invertebrates.
- The rocky intertidal platforms and reefs of the Oyster Bridge and the Lagoon are high in biodiversity.
- Current human impacts on mollusc populations at the Oyster Bridge may be decreasing species richness.
- Significant increases in human visitation to these accessible areas are likely and may compromise the unique ecology and tourism attributes.
- The Oyster Bridge is important for breeding cuttlefish and squid.
- Nutrient input from sewerage and fertilisers can impact mollusc populations through excess algal growth.
- Persistent pollutants such as heavy metals can have ecosystem-wide effects through bioaccumulation and magnification through food webs.

6.6 RECOMMENDATIONS

- A Sanctuary Zone should be declared over the rocky intertidal platforms and coral reef habitat between the Oyster Bridge and the Lagoon (Figure 1).
- Further research should be directed to the deep sandy gutters and basins that dominate the substrate.
- Further investigation of seagrasses is also likely to reveal many more mollusc species, particularly in the seagrass wracks observed in this study.

- Intensive surveys should be conducted at the mussel beds observed south of Bruboodjoo Point.
- In this environment, seasonal rainfall or tropical cyclones can carry large amounts of nutrient-laden runoff into the bay. As a result, land-based nutrient inputs (such as fertilizers) are inappropriate and their use should be prohibited.

CHAPTER 7: FISH

7.1 INTRODUCTION

- Fishes as a group are extremely diverse in form, physiology, behaviour, trophic position and life history.
- Fish play a central role in ocean ecosystems and are one of the most utilized resources worldwide.

7.1.1 Aims

This survey aimed to provide baseline data on

- fish species;
- fish abundance; and
- the significance of fish in Bateman Bay.

7.2 METHODS

- Visual fish censuses (Halford and Thompson 1996), random spot dives and baited videos were conducted at various locations (Figure 1).
- Elasmobranch, pelagic and deepwater species were not recorded in this preliminary survey.

7.3 RESULTS

7.3.1 Number of species

- 343 fish species were identified during this preliminary survey (Appendix 5).
- This represents 60% of the fish species known from Ningaloo Reef (Allen 1996, 1997).

7.3.2 Juvenile fish

- Juveniles of 55 fish species were observed, predominantly in nearshore habitats.
- Possible fish nursery areas include the limestone outcrops and seagrass beds of Maud Landing, coral reef habitats of Oyster Bridge and Lagoon, inshore areas south of Bruboodjoo Point, and to a lesser extent, Maud Sanctuary.
- Juvenile spangled and bigeye emperors, spinefoot and goatfish are found in seagrasses adjacent Maud Landing and throughout the bay at various stages of their lifecycle.
- Juveniles of 34 fish species were recorded in the Lagoon, including recreationally targeted fish such as golden trevally, red emperor, baldchin grouper, yellowtail emperor, barramundi and rankin cod as well as juvenile butterflyfish, parrotfish, anemone fish and wrasses.

7.3.3 North Reef and South Reef

- Many fish species identified here were not observed elsewhere in the bay.
- Rankin cod, sixbanded rockcod, striped seaperch, moses seaperch, blackspot snapper, baldchin grouper and bluespotted tuskfish were found and are targeted by fishers.

7.3.4 Maud Sanctuary

- Maud Sanctuary revealed the highest diversity of reef fish, including the highly abundant spangled emperor.
- Anchor damage and illegal fishing were observed within Maud Sanctuary.

7.3.5 Other data

- Manta rays were the largest fish species recorded.
- Manta rays were observed feeding at various locations throughout the bay, from the nearshore seagrass habitat of Maud Landing to the outer reef.

7.4 DISCUSSION

7.4.1 Significance in Bateman Bay

- Most fish represent an important component of food webs.
- Herbivorous species such as parrot and surgeonfish feed upon turfing algae and in turn, become food for invertebrates such as molluscs and echinoderms.
- Westera *et al.* (in press) have found similar patterns in spangled emperor abundance across sanctuaries of Ningaloo Reef.

7.4.2 Current threats

- In an oral history of the Ningaloo region, stated, “A common perspective among people interviewed was that fish resources had declined at Ningaloo”.
- The continued increase in tourist numbers to the region coupled with the accessibility of the reef to fishing could lead to serious overfishing effects.
- In recent years, commercial fishers working from Coral Bay have commenced operating further out to sea to maintain catch rates (A. Farrelly *pers comm*. 2002).
- Current studies at Ningaloo Reef have identified significant differences in the numbers of spangled emperors between the sanctuary and the recreationally fished areas (Westera *et al.* in press).
- Anecdotal evidence suggests increasing pressure upon recreationally targeted fish species in the area.
- Overfishing has lead to a trophic-cascade where the removal of too many predatory fish increases the abundance of invertebrate prey .
- *Drupella cornus* proliferated at Ningaloo during the 1980s and reduced live coral cover. Overfishing of Spangled emperor may have allowed *Drupella* numbers to increase.

7.5 CONCLUSIONS

- Bateman Bay supports a large diversity of fish reflecting a diversity of habitats.
- Approximately 60% of species that occur on Ningaloo Reef were found in this preliminary survey.
- The nearshore coral reef and seagrasses of Bateman Bay are nursery grounds for 55 species of reef fish, including spangled emperor.

7.6 RECOMMENDATIONS

- Further research on the exploitation status of fish stocks is essential to determine the extent of current and future impacts.
- Sustainable levels of manta ray interaction need defining. The potential effects of increasing human interaction with manta rays and increasing boat traffic through Maud Sanctuary needs consideration. Although not observed, whale sharks require consideration in this context.
- Currently little is known of the lagoonal currents operating within Ningaloo Reef. Potential changes to broad scale water movement and the distribution and composition of nearshore plankton and larval fish dispersal needs investigating.
- Presence of migratory planktivores with juvenile coral reef fish suggests a link to pelagic ecosystems and requires further research.
- Further understanding of current and potential threats toward critical fish habitat is essential to protect conservation and recreation values.
- A representative range of habitats from the nearshore coral reefs and seagrasses to the front reef slope of Ningaloo Reef should be declared Sanctuary Areas.
- An extension to Maud Sanctuary to protect both outer reef and nearshore fish nursery habitat is required (Figure 1).
- The nearshore coral reef habitat from Oyster Bridge to Porites should be declared Sanctuary status (Figure 1).

CHAPTER 8: INTERTIDAL ZONE

8.1 INTRODUCTION

- The intertidal zone is the dynamic transition area between the land and sea.
- It is inhabited by organisms with physiological adaptations to withstand the periodic exposure to heat and desiccation, salinity gradients, wave impact, or other biological and physical factors dependent on tidal variation.

8.1.1 Aims

This survey aimed to provide baseline data on

- dominant species;
- zonation patterns; and
- the significance of the intertidal zone of Bateman Bay.

8.2 METHODS

- A transect and quadrat method was used to sample the Oyster Bridge and the intertidal platform and rock pools of the Lagoon.

8.3 RESULTS

8.3.1 Number of species

- A preliminary total of 35 species of flora and fauna were identified from the Oyster Bridge and the Lagoon.

8.3.2 Dominant species

- Oysters, barnacles and mussels were observed in relatively high abundance (>30 individuals/m^2).

8.3.3 Oyster Bridge

- Typical of sheltered rocky shores in most warm and sub-tropical areas, the dominant species was the oyster (*Saccostrea cucculata*).
- A community of mussels (*Septifer bilocularis*) and other tolerant gastropod species (*Patelloida saccharina, Acanthopleura spinosa*) co-occurred with oysters.
- Zonation of algae was observed; the intertidal habitat was dominated by encrusting, turfing species (*Laurencia* sp., *Coralline* sp., *Jania* sp.), with algal abundance decreasing toward the supralittoral fringe (the upper tidal area where full tidal submergence generally does not occur).
- A sea anemone was observed with algae and encrusting invertebrates, their primary food source.
- Beachcombing or shell collecting was observed.

8.3.4 Lagoon

- Organisms within the tidal rock pools south of the Lagoon are partially isolated from the open sea and are sensitive to physical gradients of temperature, salinity, pH and oxygen.
- At the supralittoral fringe, molluscs that are tolerant to heat and desiccation were observed (e.g., the limpet, *Cellana radiata orientalis* and periwinkle, *Nodilittorina nodosa*).
- Barnacles (*Tesseropa rosea, Tetraclita purpurascens*) dominated the midshore region or eulittoral zone.
- Co-occurring with barnacles was a number of other molluscs including the littorinid snail (*Littorina unifasciata*) and the limpet (*Patelloida nigrosulcata*).
- An abundance of juvenile rock crab species including *Leptograpsus variegates* (purple rock crab) and *Grapsus albolineatus* (common rock crab), hermit crabs and tubeworms (*Galeolaria caespitosa*) were observed.
- The algae at this site were patchy and variable, likely caused by the grazing of gastropods.
- Turfing algal species form a mat-like layer over the surface of the intertidal platform.
- Beachcombing or shell collecting was also observed.

8.4 DISCUSSION

8.4.1 Significance in Bateman Bay

- Zonation patterns observed are typical of intertidal regions and suggest community stability.

8.4.2 Current threats

- Trampling is a current human disturbance that can lead to: loss of flora and fauna by crushing; dislodgment of sessile (non-moving) and sedentary (slow-moving) organisms; and habitat displacement (e.g., overturned shelters).
- This can lead to increased exposure to predation and the physical conditions typical of the intertidal zone.
- Harvesting of mussels and oysters for human consumption occurs at a number of locations, particularly Oyster Bridge.
- Analysis of video transects along the oyster beds show cover of live oyster declines from approximately 90% in non-impacted areas to approximately 10% in impacted areas.
- Removal of these edible species may result in the spatial encroachment of unexploited species (such as algae and barnacles), and cause ecological imbalance.

- Shells provide a protective habitat for many intertidal invertebrates such as hermit crabs.

8.5 CONCLUSIONS

- A preliminary 35 intertidal species of flora and fauna were observed from the Oyster Bridge and the Lagoon.
- Intertidal species zonation suggest community stability.
- The intertidal zone of Bateman Bay is under increasing pressure from human visitation and exploitation.

8.6 RECOMMENDATIONS

- This research highlights the need for the management of current threats such as the human exploitation of oyster and mussel populations.
- Long term monitoring of the intertidal region is required to detect natural from human induced changes.
- Further work is needed to identify all species inhabiting the rocky intertidal platforms and rock pools.
- Visitors should be encouraged to enjoy viewing live shells in their natural environment, without collection.

CHAPTER 9: MARINE TURTLES

9.1 INTRODUCTION

- Marine turtles play an important role in ecosystem maintenance in the form of nutrient cycling and community structure.
- Turtle hatchlings are an important seasonal food for crustaceans, birds, fish and sharks.
- Foraging green turtles enhance the community structure and nutritional attributes of tropical seagrass species (Zieman *et al*. 1984; Aragones 2000) and promote coral growth by grazing on algae.

9.1.1 Aims

This survey aimed to provide baseline data on:

- turtle species;
- turtle behaviour; and
- the significance of turtles in Bateman Bay.

9.2 METHODS

- Results are based on incidental sightings or observations.

9.3 RESULTS

9.3.1 Number of species

- Three species of marine turtle were observed; the green (*Chelonia mydas*), loggerhead (*Caretta caretta*), and hawksbill (*Eretmochelys imbricata*) (Appendix 6).

9.3.2 Abundance

- Green turtles were the most numerous, comprising 96% of sightings.
- 78 green turtles, two loggerhead turtles, and one hawksbill turtle were recorded.

9.3.3 Distribution and behaviour

- Adult and juvenile green turtles were observed feeding and traveling throughout the bay, and were most prevalent within Maud Sanctuary.
- At coastal locations such as the Oyster Bridge and the Lagoon, juvenile green and hawksbill turtles were observed.
- 12 adult green turtles were observed resting at the outer North Reef, and six at the outer south reef (adjacent Maud Sanctuary).
- An adult loggerhead turtle was observed resting within Maud Sanctuary and a juvenile loggerhead was observed feeding in the Lagoon.

9.4 DISCUSSION

9.4.1 Significance in Bateman Bay

- Western Australia is the only known mainland loggerhead nesting area within the eastern Indian Ocean (Dodd 1988).
- Within Western Australia, the sandy beaches of the Ningaloo Reef comprise the core mainland sites (Baldwin *et al.* in press).
- Since the 1950s, Bateman Bay beaches have been recognised as important nesting grounds for marine turtles (P. Mack *unpublished data*).
- Species encountered on this survey are listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*, the *Wildlife Protection (Regulations of Export and Import) Act 1982*, and the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), as *vulnerable* to extinction (green and hawksbill) and *endangered* (loggerhead).
- All three species are listed under the Conservation of Migratory Species of Wild Animals (Bonn Convention) as *endangered* migratory species, and fauna that is *rare* or likely to become *extinct* under Schedule 1 of the *Western Australian Wildlife Conservation Act 1950* (Commonwealth of Australia 2002).

9.4.2 Current threats

- Current threats towards marine turtles must be appreciated in the context of the history of this region. Between 58 000 and 60 000 turtles were hunted from the Pilbara to Ningaloo region between 1958 and 1972 (Prince *pers comm.* 2002).
- Consequently, the management of current threats from human impacts is especially important for recovery of these populations.
- Depending on species and environmental conditions, marine turtles can take 30 years to reach reproductive age. Thus, a similar lag time is required before increases in breeding adults can be expected.
- During the 1990s, the Peter Mack Turtle Conservation Foundation identified 4WD usage and turtle nest predation as the main threats to nesting turtles.
- At high tide, 4WD vehicles are forced to drive along the foot of foredunes where turtles nest (P. Mack *unpublished data*). Loggerhead nests are particularly vulnerable as eggs are deposited just 30cm beneath the surface (P. Mack *unpublished data*).
- Deep wheel ruts created by 4WDs create a significant barrier to loggerhead hatchlings on their journey to the ocean; they tend to follow wheel ruts along the beach which increases predation by crabs, birds and other animals (P. Mack *unpublished data*).

- Uncontrolled introduced predators such as the European red fox (*Vulpes vulpes*) have preyed heavily on turtle eggs since first observed in the 1950s and compromise population recovery (P. Mack *unpublished data*).
- Human activities in the vicinity of nesting turtles are currently uncontrolled throughout the Ningaloo Reef/Cape Range region.
- Anecdotal evidence suggests that night visitation by tourists results in nesting in unfavourable locations such as below the High Water Mark (P. Mack *unpublished data*).
- Disturbed nesting turtles have been observed retreating to the water and ultimately failing to nest; an individual turtle may represent upwards of 708 hatchlings (P. Mack *unpublished data*).

9.5 CONCLUSIONS

- Bateman Bay is likely to be critical resting, nesting and feeding area for the endangered loggerhead and the vulnerable green and hawksbill turtles.
- The foreshore of Bateman Bay is one of the last remaining mainland nesting sites in Western Australia for the endangered loggerhead turtle.
- The broad, sandy beaches are extremely important for nesting turtles, particularly as they return to nest at the beach where they hatch.
- The current level of human disturbance during the critical nesting period is of concern.
- Loggerhead, green and hawksbill turtles are recognised on state, national and international levels as requiring special conservation attention.

9.6 RECOMMENDATIONS

- 4WD beach access along the foreshore should be prohibited, dunes revegetated and alternative beach access designated by authorities.
- Human interaction with nesting turtles should be minimised to low-impact, small sized groups with qualified guides.
- Visitor education during the critical turtle nesting season period is essential.
- Boaters should be alert to the presence of marine turtles and be encouraged to reduce speeds in shallow areas.
- Speed limits of 5 knots should be enforced within the Maud Sanctuary feeding and resting area.
- The scale and extent of coastal development (potential human disturbance) should be minimized.

CHAPTER 10: MARINE MAMMALS

10.1 INTRODUCTION

- Marine mammals are consumers near the top of the food web.
- Due to their life history characteristics (e.g., large body size, slow growth and few offspring) they are likely to have significant effects upon the structure of pelagic ecosystems.
- Some marine mammals are thought to serve as indicators of environmental health.

10.1.1 Aims

This survey aimed to provide baseline data on

- marine mammal species;
- marine mammal behaviour;
- the significance of marine mammals in Bateman Bay.

10.2 METHODS

- Results are based on incidental sightings or observations.

10.3 RESULTS

10.3.1 Baleen whales

- A total of seven humpback whales (*Megaptera novaeangliae*) were observed over four sighting occasions (Figure 2).
- Two adult humpback whales and a calf were observed resting west of Maud Sanctuary.
- Within the northern section of Cardabia Passage, a female humpback whale was feeding her calf.
- An individual adult was observed in the southern section of Cardabia Passage and another adult at North Reef.

10.3.2 Toothed whales

- Two species of toothed whales (bottlenose and indo-pacific humpbacked dolphin) were observed (Appendix 6).
- A total of 30 bottlenose dolphins (*Tursiops truncatus*) were sighted.
- Pod size varied from 10 dolphins (including a calf) to individual sightings, with a mean group size of 6.
- 2 incidental sightings of the indo-pacific humpbacked dolphin (*Sousa chinensis*) were recorded; an adult/calf pair within Maud Sanctuary and an adult individual at the outer North Reef.

- Bottlenose dolphins were sighted in various habitats throughout Bateman Bay, including west of Maud Sanctuary.

10.3.3 Dugongs

- Two incidental sightings of the dugong (*Dugong dugon*) occurred within Maud Sanctuary (Appendix 6).

10.4 DISCUSSION

10.4.1 Significance in Bateman Bay

10.4.1.1 Migratory species

- Migratory species are exposed to a variety of threats as they travel across geographical boundaries.
- The humpback whale, bottlenose dolphin, indo-pacific humpbacked dolphin and some dugongs are migratory animals that rest, nurse or feed in Bateman Bay.
- All species encountered are listed under the Convention on the Conservation of Migratory Species (Bonn Convention).

10.4.1.2 Humpback whales

- This survey coincided with the winter migration of humpback whales from Antarctica (Commonwealth of Australia 2002).
- Sightings are increasing along the Ningaloo Reef coastline following a recovery of their pre-hunting population of between 44% and 70% (Bannister and Hedley 2001).
- Very little is known of the scale of use of this area by humpback whales during their migration, and it may be important as a resting or nursing area for females with calves, as is the case for Shark Bay to the south (Burton 2001) and Exmouth Gulf to the north (Jenner *et al.* 2001).
- The humpback whale is listed on the Bonn Convention as an endangered migratory species and as vulnerable to extinction under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) and the *Environmental Protection and Biodiversity Conservation Act 1999*.
- Under the *Western Australia Wildlife Conservation Act 1950*, the humpback whale is listed as fauna which is rare or likely to become extinct.
- Under the Commonwealth's *Wildlife Protection (Regulations of Export and Import) Act 1982*, the humpback whale is listed as endangered.

10.4.1.3 Dolphins

- Breeding aggregations of cuttlefish observed at Oyster Bridge may represent an important food source as cephalopods (including cuttlefish) form a major part of the diet of bottlenose and indo-pacific humpbacked dolphins (Bannister *et al.* 1996).

10.4.1.4 Dugongs

- The dugong is listed as vulnerable to extinction on a global scale by The World Conservation Union (Marsh *et al*. 2002).
- They are also protected in Commonwealth waters by the *Environmental Protection and Biodiversity Conservation Act 1999*.
- Within Western Australia, the dugong is listed as 'fauna in need of special protection'.
- Dugongs are shy, elusive animals that are particularly sensitive to human impacts because their reproductive biology relies on a high level of adult survivorship (Marsh *et al.* 1984; Marsh 1995).
- Anecdotal information reports of females with calves in Bateman Bay (B. Brogan *pers comm*.; Ningaloo Experience *pers comm.* 2002).
- Little is known of the Ningaloo Reef dugong populations and their movements in and out of the region.
- It is possible that some adult dugongs and calves observed in Bateman Bay in winter are migrating from Shark Bay to the warmer waters of Exmouth Gulf.
- Anecdotal evidence describing the emaciated state of dugongs passing from south to north through Coral Bay in winter (Ningaloo Experience *pers comm.* 2002) suggest the regional importance of local seagrasses.
- The coastal bays of the Ningaloo Reef region (Bateman Bay) may be important feeding and resting grounds for dugongs in transition.

10.4.2 Current threats

10.4.2.1 Wildlife-based tourism

- Human encounters with humpback whales are expected to increase along the west coast as their population numbers recover from commercial hunting.
- Presently, marine mammals of Bateman Bay support an increasing number of wildlife interaction tours that 'seek out' and interact with marine mammals.
- Bannister *et al.* (1996) and ANZECC (2000) report too many people viewing a limited number of animals can pose a significant threat.
- Disturbance may result in displacement from important feeding grounds; disruption of feeding, nursing, calving or social behaviours; abandonment of preferred habitat for less suitable locations; increased exposure to natural predators or changes to migratory pathways.
- These forms of disturbance can lead to stress, injury or increased mortality.

10.5 CONCLUSIONS

- Ningaloo Reef is situated along the migratory pathway of humpback whales, dolphins, and dugongs. Bateman Bay is likely to be important resting, feeding and calving area for these species.

- The continental shelf is narrow and wildlife such as these can be viewed close to the shore. This proximity also makes them vulnerable to human disturbance.
- Mammals are thought to have an important impact on the structuring of ecosystems.
- Australia has an international responsibility under the Bonn Convention for the conservation of the endangered humpback whale and the vulnerable bottlenose dolphin, indo-pacific dolphin and dugong.
- Large scale development in Bateman Bay has the potential to contradict these obligations.

10.6 RECOMMENDATIONS

- Further research on the habitat needs of marine mammals is required to quantify current and potential threats. This is particularly important for endangered and vulnerable species using Bateman Bay as feeding and resting ‘stop-overs’ on long migratory routes.
- Establishment or refinement of life history parameters will allow better interpretation of population trends and the effects of threats.
- Studies of the seasonal distribution patterns and residency periods of dugongs, humpback whales and other mammals found within the area are necessary.
- Regulation of wildlife tourism operations in this region is required, and an education program should be implemented for all boat users.
- This should include wildlife interaction guidelines, the effects of disturbance and the potential impacts of pollution.
- Large increases in boating activity through Bateman Bay should be minimized, and a 5 knot speed limit imposed within Maud Sanctuary due to the likelihood of marine mammal encounters.
- Further regulations should be imposed as necessary, following increased knowledge of habitat requirements.
- Development in Bateman Bay may reduce the quality of the area as marine mammal habitat and requires wise planning and management.

BATEMAN BAY, NINGALOO REEF

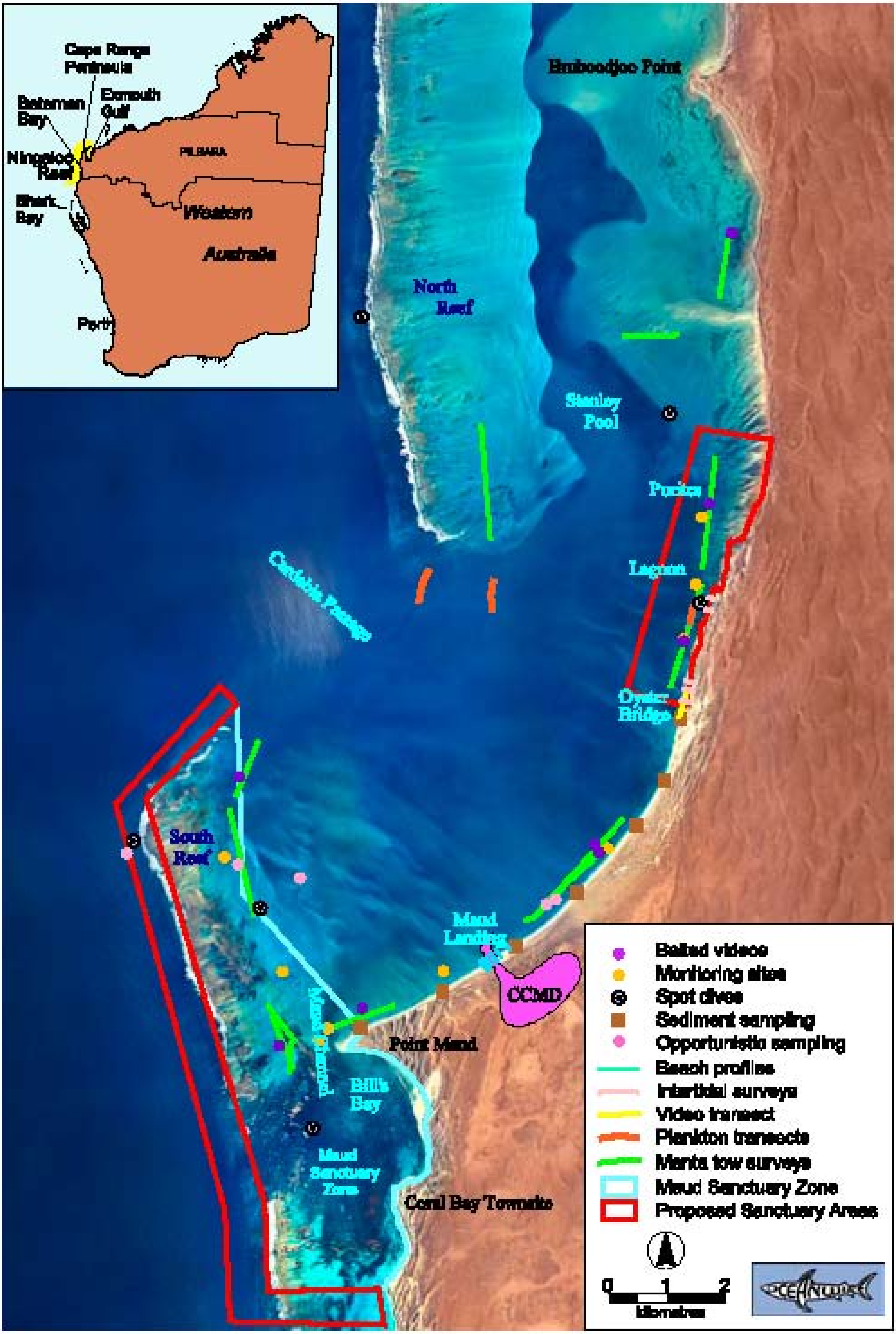

Figure 1. Location of surveys, sampling and monitoring sites.

BATEMAN BAY, NINGALOO REEF

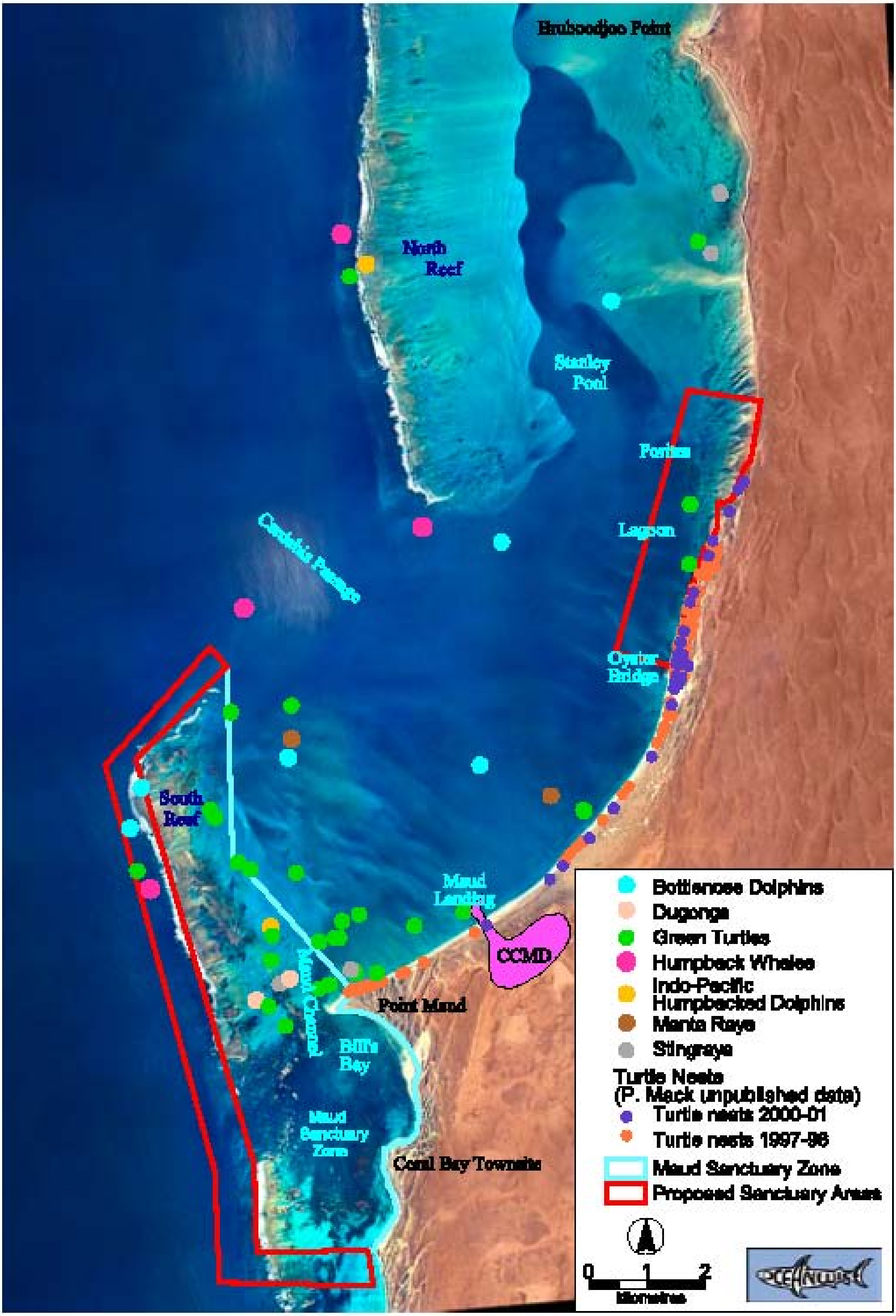

Figure 2. 'Megafauna' Sightings.

BATEMAN BAY, NINGALOO REEF

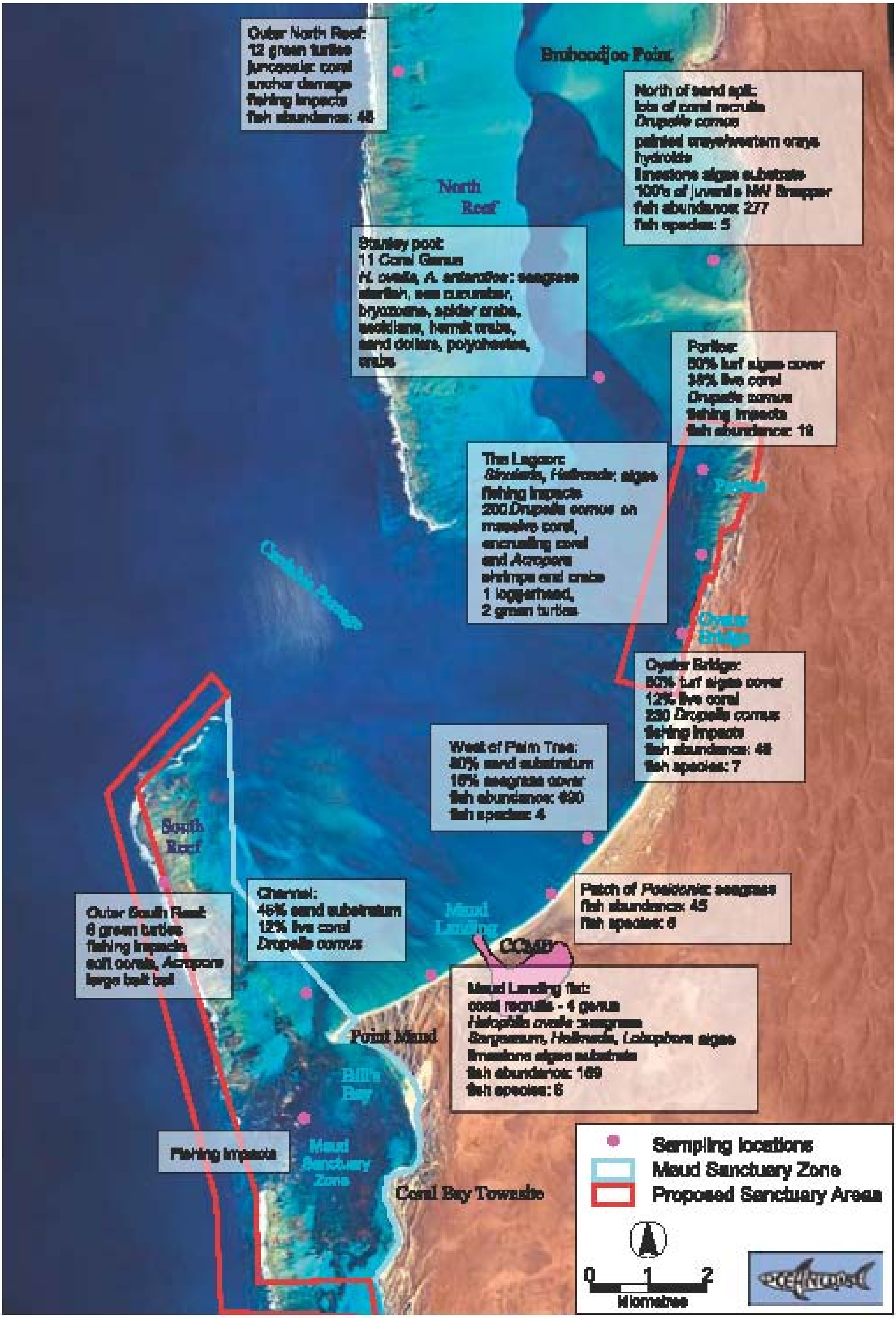

Figure 3. A 'snapshot' of biodiversity.

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PERSONAL COMMUNICATIONS

Dr Bill Brogan: Long-term Coral Bay resident and manager of Bayview Caravan Park.

Anthony Farrelly: Commercial fisher, Coral Bay.

Peter Mack: Peter Mack Turtle Conservation Foundation, Drummond Cove.

Ningaloo Experience: Commercial tourism operators, Coral Bay.

Dr Robert Prince: Team Leader, Western Australian Marine Turtle Project, CALM, Perth.

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APPENDIX 1: Flora of Bateman Bay

FLORA	SCIENTIFIC NAME
Algae	*Amphiroa fragilissima* *Betaphycus speciosum* *Boodlea composita* *Bryopsis australis* *Caulerpa racemosa* *Caulerpa serrulata* *Ceramium flaccidum?* *Cladophora prolifera?* *Codium geppiorum* *Codium spongiosum* *Colpomenia* sp. *Corynomorpha?* *Cystoseira* sp. *Cystoseira trinodis* *Dictyota ciliolata* *Enteromorpha* sp. *Eucheuma denticulata* *Galaxaura marginata* *Halimeda cuneata* *Halimeda cylindracea* *Halimeda tuna* *Hormophysa cuneiformis* *Hydroclathrus clathratus* *Hypnea pannosa* *Hypnea valentiae?* *Jania verrucosa* *Laurencia clavata?* *Laurencia cruciata?* *Laurencia majuscula* *Lithophyllum pygmaeum* *Lobophora variegata* *Padina sanctae-crucis* *Polysiphonia* sp. *Turbinaria ornata* *Ulva lactuca?* Unknown red
Seagrass	*Amphibolis antarctica* *Halodule uninervis* *Halophila minor* *Halophila ovalis* *Halophila tricostata* *Heterozostera tasmanica* *Posidonia coriacea* *Syringodium isoetifolium*

APPENDIX 2(a): Zooplankton of Bateman Bay

Zooplankton			
Nearshore	**Mid Bay**	**Off Shore**	**Manta ray feeding area**
Unidentified harpacticoid copepod	Unidentified cyclopoid copepod	*Corycaeus* sp. (copepod)	Unidentifed calanoid copepod
Unidentified calanoid copepod	Ostracod spp.	*Oikopleura* sp.	Unidientified harpacticoid copepod
Corycaeus sp. 1(copepod)	*Corycaeus* sp. (copepod)	Unidentified copepod nauplii	*Corycaeus* sp. (copepoda)
Corycaeus sp. 2 (copepod)	Decapod larvae	Unidentified cyclopoid copepod	Ostracod spp.
Oncaea sp.1 (copepod)	*Oncaea* sp.1 (copepod)	*Oncaea* sp.2	Unidentified copepod nauplii
Unidentified fish eggs	Unidentified cyclopoid nauplii	Unidentified fish eggs	Unidentified cyclopoid copepod
Oxycephalus sp. (amphipod)	Unidentified fish eggs	Polychaete sp.1	Brachiopod larva
Oikopleura sp.	*Oikopleura* sp.	Cnidaria (medusa)	Polychaete sp.1
Brachyuran larva	Gastropod larvae	Trochophore larvae	Unidentified eggs
Euphausiid nauplii	Echinoid larvae	*Lensia sp.* (Siphonophore)	Decapod larvae
Polychaete sp.1	*Euterpina* sp.	*Diphyes sp.*	*A. Halacapridae* (water mite)
Polychaete sp. 3	Cirripede nauplii	Brachiopod larvae	Echinoid larvae
Cnidaria (medusa)	Nereid larva		
Sagitta sp.	*Eucalanus* sp. (calanoid nauplii)		
.	Cnidaria (medusa)		
	Brachiopod larva		
	Arachnia Halacapridae (water mite)		

APPENDIX 2(b): Phytoplankton of Bateman Bay

Shows the dominant phytoplankton species. Only phytoplankton with a cell count of 1 X 10^4 cells per mL^{-1} are listed.

Phytoplankton (>25 micrometers)		
Diatoms	**Dinoflagellates**	**Protozoans**
Achanthus hungarica	*Alexandrium sp.*	*Tintinnididae*
Actinocyclus kutzinii	*Ceratium furca*	*Tintinnopsis* sp.
Amphora angusta	*Ceratium lineattum*	*Rhabdonella* sp.
Amphora australiensis	*Ceratium trichocerous*	
Asterionellopsis sp.	*Gymnodinum* sp.	
Chaetoceros dichaeta	*Phalacroma sp*	
Dicyocha sp.	*Peridinium* sp.	
Diploneis cherosonensis		
Fragilaria constuens		
Licmophora lyngbye		
Mastoglia elliptica		
Mastoglia smithii		
Melosira sp.		
Navicula lyra		
Navicula punctualata		
Navicula sp.3		
Navicula sp 4		
Nitzchia sp.		
Odontella sp.		
Plagiagramma pulchellum		
Rhizosolenia crassa		
Triceratium sp.		

APPENDIX 3: Coral of Bateman Bay

FAUNA	FAMILY	GENUS
Hard Coral	Acroporidae	Montipora
		Acropora
	Pocilloporidae	Pocillopora
		Stylophora
		Seriatopora
	Oculinidae	Galaxea
		Oculina
	Dendrophylliidae	Turbinaria
	Poritidae	Porites
		Goniopora
		Alveopora
	Agariciidae	Pachyseris
		Agaricia
	Fungiidae	
	Merulinidae	Merulina
		Hydnophora
		Scapophyllia
	Trachyphylliidae	Trachyphyllia
	Pectiniidae	Echinophyllia
		Mycedium
		Pectinia
	Faviidae	Echinoporidae
		Cyphastrea
		Platygyra
		Diploria
		Favites
		Favid
		Goniastrea
		Oulophyllia
Soft coral	Acanthogorgiidae	Acanthogorgia
	Alcyoniidae	Sarcophyton
		Lobophytum
		Sinularia
	Briareidae	Briareum
	Ellisellidae	junceeala
	Isididae	Isis
	Nephtheidae	Nephthea
	Tubiporidae	Tubipora
	Xeniidae	Xenia

APPENDIX 4: Molluscs of Bateman Bay

FAMILY	SCIENTIFIC NAME	CONSERVATION STATUS
Acmaeidae	*Patellaida saccharina*	common
	Acmaeidae sp	
Arcidae	*Arca navicularis*	common
	Trisidos semitorta	uncommon
Buccinidae	*Phos senticosus*	common
	Buccinidae sp	
	Pisania ignea	common
Bullidae	*Bulla sp*	
Cardiidae	*Acrosterigma sp*	
	Acrosterigma alternatum	
	Acrosterigma reeveanum	common
	Fragum fragum	
	Fragum hemicardium	
	Fragum sp	
Carditidae	*Megocardita rosulenta*	common
Cassidae	*Phalium bandatum*	uncommon
Cerithiidae	*Cerithium tenuifilosum*	abundant
	Rhinoclavis bituberculatum	common
Chitonidae	*Acanthopleura spinosa*	common
Clavagellidae	*Brechites vaginiferus australis*	rare
Columbellidae	*Pyrene testudinaria*	common
	Columbellidae sp	
Conidae	*Conus sp*	
	Conus dorreensis	common
	Conus ebraeus	common
Crassatellidae	*Eucrassatella ebraeus*	common
Conidae	*Conus terebra*	common
Cymatiidae	*Cymatium nicobaricum*	common
	Cabestana tabulata	common
Cypraeidae	*Cypraea teres*	uncommon
	Cypraea caputserpentis	abundant
	Cypraea eglantina	common
	Cypraea vitellus	common
	Cypraea annulus	abundant
	Cypraea caurica	common
	Cypraea erosa	common
	Cypraea helvola	common
	Cypraea fimbriata	common
	Cypraea leviathan gedlingae	rare
	Cypraea moneta	abundant
	Cypraea kieneri	common
	Cypraea friendii	common
Dentaliidae	*Dentalium sp*	
Donacidae	*Donax sp*	
Fimbriidae	*Fimbria souverbii*	uncommon
Fissurellidae	*Diodora jukesii*	common
	Diodora singaporensis	common
Haliotidae	*Haliotus asinina*	uncommon
	Haliotus squamata	common
Littorinidae	*Littorina undulata*	abundant
	Littorina unifasciata	abundant

	Littorina sp	
	Nodolittorina australis	common
Mactridae	*Mactra sp*	
Melongenidae	*Syrinx aruanus*	common
Mesodesmatidae	*Paphies trigonium*	uncommon
Mitridae	*Mitra scutulata*	common
Muricidae	*Brevispina macgillivrayi*	common
Mytilidae	*Stavelia horrida*	uncommon
	Septifer bilocularis	abundant
	Brachidontes ustulatus	abundant
	Mytilidae sp	
Nassariidae	*Nassarius sp*	
	Glans particeps	common
Naticidae	*Polinices powisiana*	uncommon
	Polinices conicus	common
	Polinices sp	
Neritidae	*Nerita plicata*	common
	Nerita sp	
Nudibranchia	*Phyllidia nobilis*	common
Octopodidae	*Octopus sp*	
Ovulidae	*Ovum ovum*	uncommon
Olividae	*Ancillista cingulata*	uncommon
	Oliva sp	
	Oliva caerulea	uncommon
	Oliva lignaria	common
	Ancillista cingulata	uncommon
Ostreidae	*Saccostrea cuccullata*	abundant
Patellidae	*Patella sp*	
Pectinidae	*Chlamyus australis*	common
	Chlamyus leopardus	common
	Chlamyus squamosa	uncommon
	Gloripallium pallium	common
Phasianellidae	*Phasianellidae sp*	
Pinnidae	*Pinna deltodes*	uncommon
Potamididae	*Terebralia palustris*	common
Pteriidae	*Pinctada margaritifera*	common
Sepiidae	*Sepia sp*	
Strombidae	*Lambis chiragra*	uncommon
	Strombus vittatus	common
	Strombus urceus	common
	Strombus sp	
	Strombus epidromus	uncommon
	Strombus vomer	common
	Strombus mutabilis	abundant
Tellinidae	*Tellina sp*	
	Tellina perna	common
	Tellina sp	
	Tellina virgata	common
Terebridae	*Duplicaria duplicata*	common
	Terebra babylonia	uncommon
	Terebra sp	
Thaididae	*Drupella cornus*	common
	Mancinella mancinella	common
	Thais aculeata	common
	Thais orbita	common
Tonnidae	*Malea pomum*	common

	Tonna chinensis	common
	Tonna allium	common
	Tonna variegata	uncommon
Tridacnidae	*Tridacna maxima*	common
	Tridacna squamosa	
Triviidae	*Trivia oryza*	common
Trochidae	*Angaria tyria*	Common
	Tectus fenestratus	common
	Tectus pyramis	abundant
	Trochus histrio	common
	Monilea callifera	common
	Monilea sp	
	Monodonta labio	common
	Phasianotrochus irisodontes	common
Turbinidae	*Turbo petholatus*	uncommon
	Turbo sp	
Veneridae	*Circe lenticularis*	common
	Calista impar	common
	Gomphina undulosa	common
	Tapes variegata	
Volutidae	*Melo amphora*	common
	Nivosa nivosa	common
	Amoria grayi	common

APPENDIX 5: Fish of Bateman Bay

FAMILY	SCIENTIFIC NAME	COMMON NAME
Acanthuridae	*Acanthurus dussumieri*	Ornate surgeonfish
	Acanthurus grammoptilus	Ringtailed surgeonfish
	Acanthurus lineatus	Blue-lined surgeonfish
	Acanthurus nigricans	White-cheeked surgeonfish
	Acanthurus nigricauda	Blackstreak surgeonfish
	Acanthurus nigrofuscus	Dusky surgeonfish
	Acanthurus olivaceous	Orange-spot surgeonfish
	Acanthurus triostegus	Convict surgeonfish
	Acanthurus xanthopterus	Yellowfin surgeon fish
	Ctenochaetus striatus	Lined bristletooth
	Ctenochaetus strigosus	Bristle-toothed surgeonfish
	Naso fageni	Blunt unicornfish
	Naso lituratus	Stripeface unicornfish
	Naso tuberosus	Humphead unicornfish
	Naso brevirostris	Longnosed unicornfish
	Naso unicornis	Brown unicornfish
	Zebrasoma scopas	Blue lined tang
	Zebrasoma veliferum	Sailfin tang
	Paracanthurus hepartus	Indopacific bluetang
Acanthoclinidae	*Labracinus lineatus*	Lined dottyback
Albulidae	*Albula vulpes*	Bonefish
Apogonidae	*Apogonid sp.*	Cardinal sp. (yellow)
	Cheiliodipterus lineatus	Eight-lined cardinalfish
	Cheiliodipterus macrodon	Cardinal fish eight lined
	Cheilodipterus singapurensis	Singapore cardinal fish
	Cheiliodipterus quinquilineatus	Five-lined cardinalfish
	Cheilodipterus artus	Wolf cardinal fish
	Apogon augustata	Striped cardinalfish
	Apogon aureus	Ringtailed cardinalfish
	Apogon pallidofascitus	Pale-striped cardinalfish
	Apogon rupelli	Gobbleguts
Aulostomidae	*Aulostomus chinensis*	Painted flutemouth
Balistidae	*Abalistes stellatus*	Starry triggerfish
	Balistoides viridescens	Giant triggerfish
	Melichthys niger	Ebony triggerfish
	Melichthys vidua	Paddlefin triggerfish
	Pseudobalistes fuscus	Yellowspotted triggerfish
	Rhinecanthus aculeatus	White barred triggerfish
	Rhinecanthus rectangulus	Wedgetailed triggerfish
	Sufflamen bursa	Pallid triggerfish
	Sufflamen chrysopterus	Black (Half-moon) triggerfish
	Sufflamen fraenatus	Brown triggerfish
Batrachoididae	*Batrachomoeus occidentalis*	Western Frogfish
Belonidae	*Tylosurus crocodilus*	Crocodilian long tom
	Tylosurus gavialoides	Stout longtom
Bleniidae	*Aspidontus taeniatus*	False Cleanerfish
Caesonidae	*Caesio cuning*	Red-bellied fusilier
	Caesio xanthonota	Yellowback fusilie
	Pterocaesio digramma	Black tipped fusilier
	Pterocaesio chrysozona	Goldband fusilier
Carangidae	*Caranx ignobilis*	Giant trevally
	Gnathanodon speciosus	Golden travally
	Carangoides orthogrammus	Thicklip trevally
	S. commersonnianus	Talang queenfish
	Scomberoides tol	Needleskin queenfish
	Selar crumenthalmops	Purse-eyed scad
	Trachinotus botla	Common dart

	Trachinotus blochii	Snub-nosed dart
Carcharhinidae	*Carcharhinus amblyrhynchos*	Grey reef shark
	Carcharhinus melanopterus	Black tipped reef shark
	Triaenodon obesus	White-tip shark
Chaetodontidae	*Chaetodon assarius*	Western butterflyfish
	Chaetodon aureofasciatus	Golden striped butterflyfish
	Chaetodon auriga	Threadfin butterflyfish
	Chaetodon citrinellus	Speckled butterflyfish
	Chaetodon ephippium	Saddled butterflyfish
	Chaetodon kleinii	Kleins butterflyfish
	Chaetodon lineolatus	Lined butterflyfish
	Chaetodon lunula	Racoon butterflyfish
	Chaetodon meyeri	Meyers butterflyfish
	Chaetodon oxycephalus	Spotsnape butterflyfish
	Chaetodon plebeius	Bluespot butterflyfish
	Chaetodon punctatofasciatus	Spot-banded butterflyfish
	Chaetodon selene	Yellowdotted butterflyfish
	Chaetodon speculum	Ovalspot butterflyfish
	Chaetodon trifascialis	Chevroned butterflyfish
	Chaetodon trifasciatus	Redfin butterflyfish
	Chaetodon ulietensis	Doublesaddle butterflyfish
	Chaetodon unimaculatus	Teardrop butterflyfish
	Chelmon marginalis	Margined coralfish
	Chelmon rostratus	Beaked coralfish
	Forcipiger flavissimus	Longnosed butterflyfish
	Heniochus acuminatus	Long fin bannerfish
	Heniochus diphreutes	Schooling bannerfish
Chirocentridae	*Sardinella gibbosa*	Goldstripe sardine
Cirrhitidae	*Paracirrhites arcatus*	Ring-eyed Hawkfish
Dasyatidae	*Taeniura lymma*	Blue spotted fantail stingray
	Taeniura melanospila	Black blotched stingray
	Dasyatis thetidis	Black stingray
	Pastinachus sephen	Cowtail stingray
Diodontidae	*Diodon liturosus*	Porcupine fish blotched
	Diodon holocanthus	Freckled porcupinefish
Echineidae	*Echeneis naucrates*	Slender Sucker Fish
	Remora remora	Remora
Ephippidae	*Platax batavianus*	Humped batfish
	Platax teira	Teira batfish
	Platax pinnatus	Long-finned batfish
Fistularidae	*Fistularia commersonii*	Smooth flutemouth
	Fistularia petimba	Rough flutemouth
Gerreidae	*Pentaprion longimanus*	Long-finned silver biddy
Ginglymostomatidae	*Nebrius ferrugineus*	Tawny nurse shark
Gobiidae	*Amblygobius phalaena*	Banded goby
	Aspidontis taeniatus	False cleanerfish
	Goboidon quinquestrigatus	Five-bar Coralgoby
	Istigobius ornatus	Ornate goby
	Meiacanthus grammistes	Black-banded blenny
	Valenciennea muralis	Striped goby
	Valenciennea longipinnis	Long-finned goby
Harpodontidae	*Saurida undosquamis*	Large-scaled grinner
Haemulidae	*Diagramma labiosum*	Painted sweetlips
	Diagramma pictum	Yellowdot sweetlips
	Plectorhincus chaetodontoides	Many spotted sweetlips
	Plectorhincus chrysotaenia	Celebes sweetlips
	Plectorhincus flavomaculatus	Gold spotted sweetlips
	Plectorhincus multivittatum	Many lined sweetlips

	Plectorhincus schotaf	Minstrel sweetlips
Hemirhamphidae	Hyporhamphus affins	Tropical Garfish
	Hemirhamphus robustus	Robust garfish
Hemiscillidae	Hemiscillium ocellatum	Epaulette shark
Hemigaleidae	Triaenodon obesus	Whitetip shark
Holocentridae	Sargocentron rubrum	Red squirrelfish
	Myripristis hexagonatus	Doubletooth squirrelfish
	Myripristis murdjan	Crimson squirrelfish
Kyphosidae	Kyphosus bigibbus	Southern drummer
	Kyphosus cornelii	Western buffalo bream
	Microcanthus strigatus	Stripey
Labridae	Anampses caeruleopunctatus	Spotted chiseltoothed wrasse
	Anampses geographicus	Scribbled chiseltoothed wrasse
	Anampses lennardi	Blue and yellow wrasse
	Anampses melanurus	Blacktail wrasse
	Anampses meleagrides	Yellowtailed wrasse
	Bodianus axilliaris	Coral pigfish
	Bodianus mesothorax	Splitlevel pigfish
	Bodianus perditio	Saddleback pigfish
	Cheilinus chlorurus	Yellow dotted maori wrasse
	Cheilinus fasciatus	Banded maori
	Cheilinus trilobatus	Tripletail maori wrasse
	Cheilio inermis	Cigar wrasse
	Choerodon anchorago	Anchor tuskfish
	Choerodon cephalotes	Purple tuskfish
	Choerodon cauteroma	Bluespotted tuskfish
	Choerodon cyanodus	Blue tuskfish
	Choerodon rubescens	Baldchin groper
	Choerodon schoenlenii	Blackspot tuskfish
	Coris aygula	Hump headed wrasse
	Coris caudimacula	Spotted tail wrasse
	Coris gaimardi	Redfinned rainbowfish
	Coris pictoides	Black striped wrasse
	Epibulus insidiator	Slingjaw wrasse
	Gomphosus varius	Clubnosed wrasse
	Halichoeres biocellatus	Redlined wrasse
	Halichoeres hortulanus	Fourspot wrasse
	Halichoeres malanochir	Purple wrasse
	Halichoeres marginatus	Speckled rainbowfish
	Halichoeres nebulosis	Nebulous wrasse
	Halichoeres trimaculatus	Threespot wrasse
	Hemigymnus fasciatus	Five banded wrasse
	Hemigymnus melapterus	Thicklipped wrasse
	Hologymnosus annulatus	Ringed slender wrasse
	Hologymnosus doliatus	Pastel ringwrasse
	Labrichthys unilineatus	Tube mouth (onelined) wrasse
	Labroides dimidiatus	Cleanerfish
	Labroides pectoralis	Breastspot cleanerfish
	Leptojulis cyanopleura	Weedy wrasse
	Novaculichthys taeniurus	Carpet wrasse
	Pseudojuloides elongatus	Long green wrasse
	Stethojulis bandanensis	Red spot wrasse
	Stethojulis strigiventer	Silverstreaked wrasse
	Thalassoma amblycephalum	blue-headed wrasse
	Thalassoma hardwickei	Sixbar (six banded) wrasse
	Thalassoma lunare	Moon wrasse
	Thalassoma lutescens	Green moon wrasse
	Thalassoma purpureum	Red and green wrasse

	Xenojulis margaritaceous	Pearly rainbow fish
	Xiphocheilus typus	Blue-toothed tuskfish
Lethrinidae	*Lethrinus atkinsoni*	Yellowtailed emperor
	Lethrinus laticaudis	Blue lined emperor
	Lethrinus nebulosis	Spangled emperor
	Lethrinus nebulosis	Spangled emperor Juveniles
	Lethrinus olivaceus	Longnosed emperor
	Lethrinus letjan	Purpleheaded emperor
	Lethrinus miniatus	Sweetlip emperor
	Lethrinus rubrioperculatus	Spotcheeked emperor
	Lethrinus variegatus	Variegated emperor
	Lethrinus nematacantus	Threadfin emperor
	Gymnocranius robinsoni	Robinsons seabream
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove jack
	Lutjanus bohar	Red bass
	Lutjanus carponotatus	Stripey seaperch
	Lutjanus casmira	Blue striped seaperch
	Lutjanus fulviflamma	Blackspot snapper
	Lutjanus lemniscatus	Darktailed seaperch
	Lutjanus monostigma	One-spot seaperch
	Lutjanus russelli	Moses seaperch
	Lutjanus sebae	Red emperor
	Lutjanus vitta	Striped seaperch
	Symphorus nematophorus	Chinaman fish
	Aprion virescens	Green jobfish
Mobulidae	*Manta birostris*	Manta ray
Myliobatidae	*Aetobatus narniari*	Spotted eagleray
Monacanthidae	*Cantherhines fronticinctus*	Spectacled leatherjacket
	Oxymonacanthus longirostris	Longnose filefish
	Paramonacanthus choirocephalus	Hair-finned leatherjacket
	Pervagor janthinosoma	Redtailed leatherjacket
Mugiloididae	*Parapercis clathrata*	Spothead grubfish
Mugilidae	*Mugil cephalus*	Sea mullet
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish
	Mulloidichthys vanicolensis	Yellowfin goatfish
	Parupeneus barberinoides	Swarthy headed goatfish
	Parupeneus bifasciatus	Doublebar goatfish
	Parupeneus cyclostomus	Yellow saddled goatfish
	Parupeneus heptacanthus	Spotted golden goatfish
	Parupeneus indicus	Indian goatfish
	Parupeneus pleurostigma	Sidespot goatfish
	Parupeneus spilurus	Blackspot goatfish
	Upeneus moluccensis	Goldband goatfish
	Upeneus multifasciatus	Banded goatfish
	Upeneus tragula	Bar tailed goatfish
Muraenidae	*Echidna nebulosa*	Starry eel
	Gymnothorax flavimarginatus	Yellow edged moray
	Gymnothorax javanicus	Giant moray
	Gymnothorax eurostus	Spotted moray
	Siderea grisea	Grey eel
Nemipteridae	*Scolopsis bilineatus*	Bridled monocle bream
	Pentapodus vitta	Western butterfish
	Pentapodus emeryii	Purple threadfin bream
	Scolopsis monogramma	Monocle bream
	Scolopsis xenochrous	Pearl-streaked monocle bream
	Scaevius milii	Coral monocle bream
	Nemipterus furcosus	Rosy threadfin bream

Orectolobidae	*Orectolobus ornatus*	Tassled wobbegong
Ostraciidae	*Arothron nigropunctatus*	Black Spotted toadfish
	Ostracion cubicus	Yellow boxfish
	Ostracion meleagris	Spotted boxfish
	Lactoria cornuta	Longhorn cowfish
Pempheridae	*Pempheris schwenkii*	Striped bullseye
	Pempheris analis	Bronze bullseye
	Parapriacanthus unwini	Northern slender bullseye
Platycephalidae	*Platycephalus endrachtensis*	Bar-tailed flathead
Plotosidae	*Paraplotosus sp.*	Sailfin catfish
	Plotosus lineatus	Striped catfish
Pomacanthidae	*Centropyge tibicen*	Keyhole angelfish
	Centropyge bicolour	Bicolour angelfish
	Pomacanthus imperator	Emperor angelfish
	Pomacanthus semicirculatus	Blue angelfish
	Pomacanthus sextriatus	Sixbanded angelfish
Pomacentridae	*Abudefduf bengalensis*	Narrow banded sergeant major
	Abudefduf sexfasciatus	Scissortail sergeant
	Abudefduf sordidus	Blackspot sergeant major
	Abudefduf vaigiensis	Sergeant major
	Amphiprion clarkii	Clarkes anemonefish
	Amphiprion melanopterus	Black anemonefish
	Amphiprion perideraion	Pink anemonefish
	Amphiprion rubricinctus	Red anenomefish
	Chromis atripectoralis	Black axel chromis
	Chromis viridis	Blue green chromis
	Dascyllus aruanus	Humbug dascyllus
	Dascyllus reticulatus	Reticulated dascyllus
	Dascyllus trimaculatus	Threespot damsel
	Dischistodus prosopotaenia	Honeyhead damsel
	Neoglyphidodon melas	Black damsel
	Neoglyphidodon nigroris	Behn's damsel
	Neopomacentrus filamentosus	Brown demoiselle
	Neopomacentrus cyanomos	Regal damoiselle
	Plectroglyphidodon johnstonianus	Johnston damsel
	Plectroglyphidodon lacrymatus	Jewel damsel
	Pomacentrus amboinensis	Ambon damsel
	Pomacentrus coelestis	Neon damsel
	Pomacentrus milleri	Millers damsel
	Pomacentrus moluccensis	Lemon damsel
	Pomacentrus vaiuli	Princess damsel
	Stegastes lividus	Blunt-snout gregory
	Stegastes nigricans	Dusky gregory
	Stegastes obreptus	Western gregory
Pomatomidae	*Pomatomus saltator*	Tailor
Priacanthidae	*Priacanthus cruentatus*	Duskyfin Bigeye
	Priacanthus hamrur	Lunar-tailed bigeye
	Priacanthus tayenus	Threadfin bigeye
Pseudochromidae	*Anthias rubrizonatus*	Deepsea Fairy Basslet
	Labracinus lineatus	Lined dottyback
	Pseudanthias tuka	Purple anthias
Racycentridae	*Rachycentron canadus*	Cobia
Rhinobatidae	*Rhinobatos sp*	Golden-eyed shovelnose ray
Scaridae	*Calotomus spinidens*	Spinytooth parrotfish
	Cetoscarus bicolor	Red speckled parrotfish
	Hipposcarus longiceps	Longnosed parrotfish
	Leptoscarus vaigiensis	Blue-spotted parrotfish

	Scarus chameleon	Chameleon parrotfish
	Scarus dimidiatus	Saddled parrotfish
	Scarus frenatus	Sixbanded parrotfish
	Scarus gibbus	Steephead parrotfish
	Scarus ghobban	Bluebarred parrotfish
	Scarus globiceps	Violet-linned parrotfish
	Scarus microhinos	Steephead parrotfish
	Scarus niger	Swarthy parrotfish
	Scarus oviceps	Blue parrotfish
	Scarus prasiognathos	Dusky parrotfish
	Scarus psittacus	Palenose parrotfish
	Scarus rivulatus	Surf parrotfish
	Scarus rubroviolaceus	Ember parrotfish
	Scarus schlegeli	Schlegels parrotfish
	Scarus sordidus	Greenfinned parrotfish
Scombridae	*Scomberomorus commerson*	Narrowbarred spanish mackerel
	Grammatorcynus bicarinatus	Shark mackerel
	Grammatorcynus bilineatus	Double-lined mackerel
Scorpaenidae	*Pterois antennata*	Ragged-finned firefish
	Pterois volitans	Red firefish
	Pterois russelli	Spotless firefish
	Inimicus didactylus	Demon stinger
Serranidae	*Cromileptes altivelis*	Barramundi cod
	Epinephelus bilobatus	Frostback cod
	Epinephelus fasciatus	Black tipped cod
	Epinephelus lanceolatus	Queensland groper
	Epinephelus multinotatus	Rankin cod
	Epinephelus polyphekadion	Small toothed cod
	Epinephelus rivulatus	Chinaman rockcod
	Epinephelus sexfasciatus	Sixbanded rockcod
	Epinephelus tukula	Potato cod
	Cephalpholis miniata	Coral cod
	Plectropomus leopardus	Coral trout
Sillaginidae	*Sillago analis*	Golden-lined Whiting
Siganidae	*Siganus doliatus*	Doublebar spinefoot
	Siganus lineatus	Golden-linned spinefoot
	Siganus fuscescens	Black spinefoot
	Siganus margaratiferus	Pearly spotted rabbitfish
	Siganus punctuatus	Spotted spinefoot
	Siganus canaliculatus	Smudge spot spinefoot
	Siganus trispilos	Threespot spinefoot
Sphyraenidae	*Sphyraena qenie*	Military seapike
	Sphyraena barracuda	Barracuda
	Sphyraena obtusata	Striped seapike
	Sphyraena jello	Giant seapike
Synodontidae	*Synodus variegatus*	Variegated lizardfish
Tetraodontidae	*Arothron hispidus*	Stars and stripes toadfish
	Arothron manillensis	Narrow-lined toadfish
	Arothron reticularis	Reticulated pufferfish
	Arothron stellatus	Starry pufferfish
	Canthigaster valentini	Black saddled toby
	Legalocephalus scleratus	Silver toadfish
Tetrapontidae	*Tetrapon puta*	Three Lined Grunter
Triacanthodidae	*Halimochirurgus centriscoides*	Longsnout spikefish
Tripterygiidae	*Heleogramma decurrens*	Black-throated threefin
Zanclida	*Zanclus cornutus*	Moorish idol

APPENDIX 6: Marine Mammals and Turtles of Bateman Bay

COMMON NAME	SCIENTIFIC NAME	CONSERVATION STATUS
Humpback whale	*Megaptera novaeangliae*	*Endangered* migratory species (Bonn Convention[1])
		Endangered migratory species and *vulnerable* to extinction (CITES[2])
		Endangered migratory species and *vulnerable* to extinction (EPBC Act[3])
		Endangered (*Wildlife Protection Act*[4])
		Rare or likely to become *extinct* (WAWC Act[5])
Bottlenose dolphin	*Tursiops truncatus*	*Migratory* species (Bonn Convention[1])
Indo-pacific humpbacked dolphin	*Sousa chinensis*	*Migratory* species (Bonn Convention[1])
Dugong	*Dugong dugon*	*Migratory* species (Bonn Convention[1])
		Vulnerable to extinction (IUCN[6])
		Protected in Commonwealth waters (EPBC Act[3])
		Fauna in need of special *protection* (WAWC Act[5])
Loggerhead turtle	*Caretta caretta*	*Endangered* migratory species and *vulnerable* to extinction (CITES[2])
		Endangered migratory species and *vulnerable* to extinction (EPBC Act[3])
		Endangered migratory species (Bonn Convention[1])
		Endangered (*Wildlife Protection Act*[4])
		Rare or likely to become *extinct* (WAWC Act[5])
Green turtle	*Chelonia mydas*	*Vulnerable* to extinction (CITES[2])
		Vulnerable to extinction (EPBC Act[3])
		Endangered migratory species (Bonn Convention[1])
		Vulnerable (*Wildlife Protection Act*[4])
		Rare or likely to become *extinct* (WAWC Act[5])
Hawksbill turtle	*Eretmochelys imbricata*	*Vulnerable* to extinction (CITES[2])
		Vulnerable to extinction (EPBC Act[3])
		Endangered migratory species (Bonn Convention[1])
		Vulnerable (*Wildlife Protection Act*[4])
		Rare or likely to become *extinct* (WAWC Act[5])

[1] Bonn Convention: Conservation of Migratory Species of Wild Animals

[2] CITES: Convention on International Trade in Endangered Species of Wild Flora and Fauna

[3] EPBC Act: Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*

[4] Wildlife Protection Act: Commonwealth's *Wildlife Protection (Regulations of Export and Import) Act 1992*

[5] WAWC Act: *Western Australian Wildlife Conservation Act 1950*

[6] IUCN: The World Conservation Union