Shute Harbour Marina EIS

Aquatic Ecology

Prepared for:

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Introduction

This report presents the findings of field surveys and associated studies of the Shute Bay aquatic environment, on behalf of Shute Harbour Marina Development Pty Ltd. It contributes to Section 4.8 (Nature Conservation – Aquatic Biology) of the Terms of Reference for the Environmental Impact Statement (EIS) for the proposed marina.

Ecological, Fisheries and Conservation Values of Shute Bay

Shute Bay supports extensive seagrass meadows and macroalgal beds, fringing mangrove forest and fringing coral communities. These communities are described and discussed in regional and historical contexts. Each of these communities has relatively low regional significance. Shute Bay also has relatively low direct value to recreational and commercial fishers.

A consideration of key ecological processes concludes that the northern shore of Shute Bay (the proposed development site) is likely to have a lesser ecological value than the southern and western shores.

Shute Bay and the proposed development site lie within the Great Barrier Reef Coast Marine Park, the Great Barrier Reef World Heritage Area and the Great Barrier Reef Wetland of National Significance. However, no Ramsar site or declared Fish Habitat Area is located in Shute Bay. Shute Bay supports a number of species of conservation significance that are recognised under state and commonwealth legislation.

Likely Impacts and Opportunities for Impact Mitigation

Construction of the marina (through excavation / dredging) will result in the direct loss of approximately 14.59 ha of relatively sparse seagrass; 1.84 ha of fringing mangrove; 35 ha of sparse macroalgal beds; and a small number of small coral colonies. The predicted seagrass loss equates to approximately 10% of the seagrass of Shute Bay and represents the most significant habitat loss.

The constructed marina will provide approximately 1.8 km of breakwater habitat, and associated pylons and pontoons.

Relocation and conversion of a number of swing moorings to the more environmentally friendly 'ezy-ride' moorings will reduce the impact of the proposed development on seagrass and macrophyte communities.

Construction activities including: excavation (dredging), spoil consolidation, and pile driving, may result in:

- increased suspended sediment levels and consequent sediment deposition within the bay and adjoining waters
- a release of nutrients from the disturbed sediments
- spills of hydrocarbons and other contaminants
- disturbance of acid sulfate or potential acid sulfate sediments (ASS / PASS)
- increased human activity, including changes to light and noise levels, and
- altered hydrodynamics and consequently altered patterns of sediment deposition and erosion.

Plume modelling predicts that the likely extent of waters, which will experience elevated turbidity and sediment deposition with dredging, is relatively small, and will be primarily confined to the northern, developed shore of the bay. Impacts to seagrass, macroalgae, coral and benthic infauna are likely to be acute and reversible.

Should disturbed sediments release nutrients, tidal flushing is likely to effect dispersion and dilution: any impact is likely to be minor and reversible.

A construction management plan will be developed to effectively manage, and provide contingencies for, construction–related oil spillage and acid sulfate sediments.

Increased human activity in an area already supporting a busy tourist terminal is unlikely to have any significant further impact[1].

Altered hydrodynamics are predicted to result in sediment deposition in the lee of the marina, and scouring of the southern shore of the bay. Whilst these physical impacts are likely to influence the community structure of seagrass meadows and the local recruitment of mangroves, there is likely to be no significant net effect.

Potential Impacts associated with marina operation include maintenance dredging and chronic, low level, localised hydrocarbon contamination. The impact of maintenance

[1] The impact of development and operation on dugong, turtles and dolphins is considered by others.

dredging will be similar to that of capital dredging: localised and reversible. Chronic hydrocarbon contamination is likely to prevent the colonisation of fauna and flora that are highly sensitive, whilst still enabling a diverse and healthy floral and faunal community to develop.

Construction and operation of the proposed marina will not significantly impact on the values of the Great Barrier Reef World Heritage Area.

Current 'best practice' assessment and engineering practices offer significant opportunities to minimise the impacts associated with both the construction and operation of the proposed marina.

An ecological monitoring program will be designed and implemented by the Proponent to assess the veracity of predicted impacts, and to inform the project's Construction and Operation Environmental Management Plans so that timely remedial action can be taken.

1 Introduction

This report presents the findings of field surveys and associated studies of the Shute Bay aquatic environment, on behalf of Shute Harbour Marina Development Pty Ltd. This report contributes to Section 4.8 (Nature Conservation) of the Terms of Reference (ToR) for the EIS. It specifically addresses Section 4.8.1.3 of the ToR (Aquatic Biology), and provides a desciption of: the marine flora and fauna of Shute Bay and adjacent waters (see Sections 3 to 10); the conservationally significant marine habitats and species of Shute Bay and adjacent waters (see Section 12); and the potential impacts of the project on aquatic ecosystems and opportunities to minimise impact (See Section 13).

This report provides a description of the intertidal and subtidal communities within the footprint of the proposed Shute Bay Marina, and in adjacent waters (Figure 1.1). The study focuses on the distribution and characteristics of the bay's seagrasses, macroalgae, mangroves, saltmarshes, corals, benthic in- and epifauna, fish, fisheries, and conservationally significant species. An assessment of the potential and likely impacts of the proposed marina on these communities has also been undertaken, and opportunities for impact mitigation are discussed.

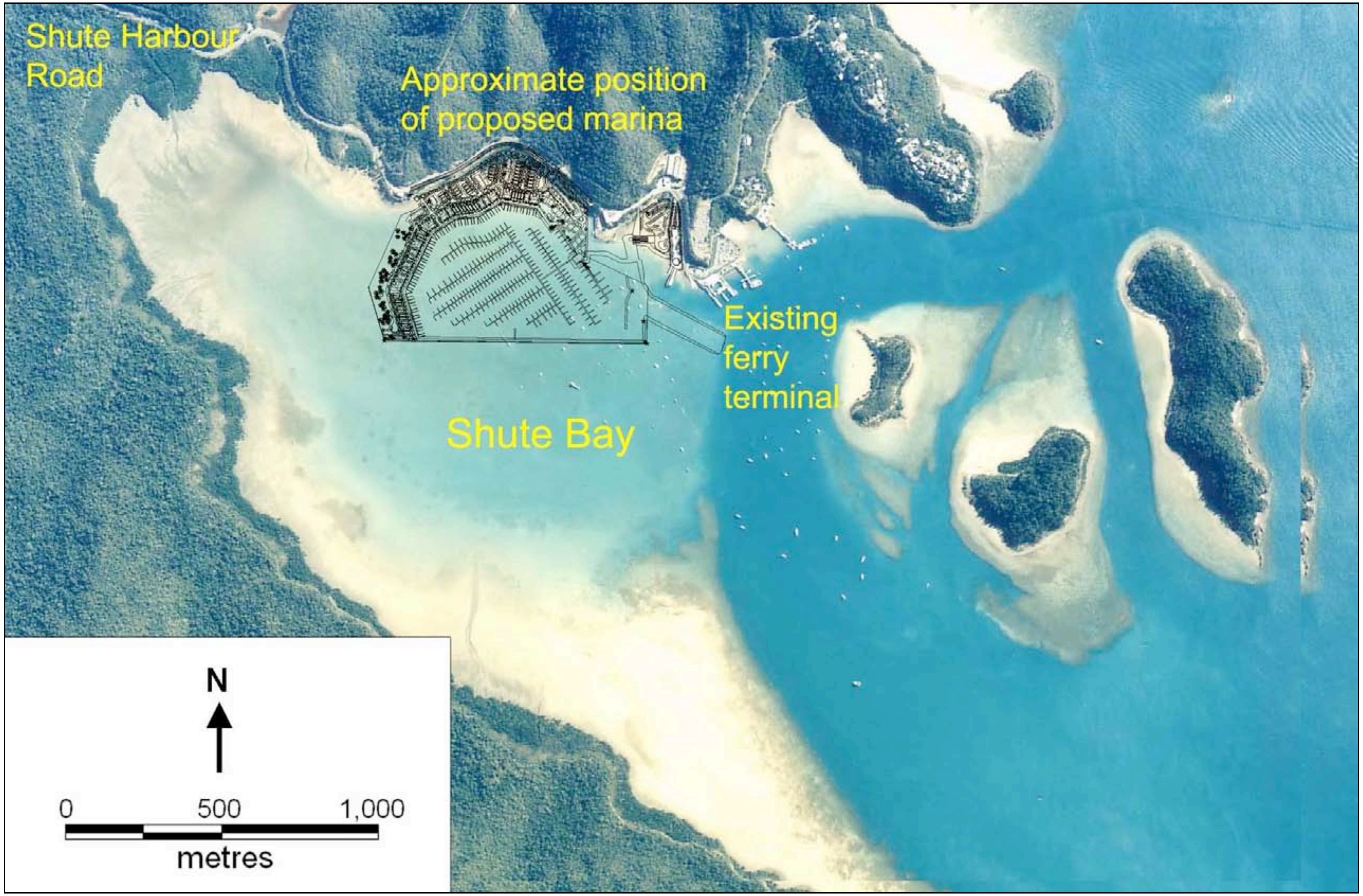


Figure 1.1 Aerial photograph showing Shute Bay, nearby islands and natural channels, the existing Shute Harbour Ferry Terminal, with a stylised representation of the proposed marina and resort.

2 Study Methodologies

2.1 Scope of Work

frc environmental have undertaken a detailed assessment of the marine fauna and flora of the region, targeting habitats, species and communities that are of both particular conservation significance and ecological importance, and that may be impacted by the proposed development. Surveys were conducted in June 2004, and April 2007, to allow an assessment of temporal variation. The surveys specifically considered[2]:

- seagrass communities
- macroalgal communities
- mangrove communities
- saltmarsh communities
- benthic infaunal communities
- coral communities
- fish communities
- fisheries
- the flora and fauna associated with the existing marina structures, and
- conservationally significant habitats and species.

The methods and results of these investigations are described in Appendices A - G.

We interviewed key stakeholders and reviewed existing information on the region to support the discussion of ecological values of the area in local, regional and historical contexts. Based on our field investigations, interviews and literature reviews, we conclude by assessing the potential impacts of the proposed development, and discussing opportunities for the minimization and mitigation of these impacts.

[2] Turtles, dugong, dolphins and other marine mammals have been considered by others.

3 Description of the Site and Project

3.1 Description of the Site

The proposed marina site and access channel are located in Shute Bay, within an embayment to the west of the existing Shute Harbour Ferry Terminal (Figure 1.1).

Shute Bay is approximately 7 km east-south-east of the resort town of Airlie Beach in the Whitsunday Shire, North Queensland. It is located between Pioneer Bay to the north-west and Repulse Bay to the south. Shute Bay is part of the Commonwealth Great Barrier Reef Marine Park (GBRMP) and the Queensland Great Barrier Reef (GBR) Coast Marine Park. Within the GBRMP, the bay is designated as a Habitat Protection Zone and the three small islands at the mouth of the bay (Repair, Tancred and Shute) are zoned Conservation Park.

Repair, Tancred and Shute Islands', at the mouth of Shute Bay, cause the natural channel to the Shute Harbour Ferry Terminal to bifurcate before joining the Molle Channel, which separates the mainland from the Molle Islands. The channel extension that is proposed as part of the Shute Marina development will join an existing dredged channel serving the Ferry Terminal and barge ramp.

Much of Shute Bay is intertidal. Sediments grade from coarse sand and rocks in the shallow subtidal areas, to fine silt in the centre of the marina footprint. In the intertidal and shallow subtidal areas there are seagrass and macroalgal communities, with patchy corals occurring to the east of the existing ferry terminal. A more extensive coral community extends along a spit on the south-western side of the bay. Mangrove communities dominated by *Rhizophora* sp. fringe the shoreline, and support a benthic fauna that is dominated by crabs and gastropods. Patches of saltmarsh can be found over the mostly rocky ground to landward of mangroves. Beyond this intertidal zone, the land rises in a relatively steep slope to Shute Harbour Road. The bay is surrounded by the Conway National Park.

3.2 Description of the Project

The proposed Shute Harbour Marina Development (SHMD) covers an area on the northern side of Shute Harbour, which extends from a subtidal depth of approximately 2.0 m below lowest atronomical tide (LAT) across the intertidal zone to encompass an area of terrestrial land on both sides of Shute Harbour Road (Figure 1.1).

The proposed development includes a multi-use marina, and commercial, tourism, and residential precincts. It will provide 669 vessel berths, a four-star tourist resort with 117 lots of high quality resort dwellings, and a base for tourism activities.

Construction of the marina will require substantial excavation within the footprint of the proposed marina and the access channel. The majority of these activities will be undertaken in a 'dry' environment, with sheet piling used to confine excavation works in suitable depths. However these works are unlikely to confine all dredge spoils. The resultant dredge plume is likely to impact on marine flora and fauna, including seagrass, macroalgae, corals, soft sediment benthic invertebrates and fish, that occur within the area of predicted plume dispersal. Plume modelling (Cardno Lawson & Trealoar 2007) shows that the dredge plume will be confined to the area between the marina and the boat ramp (Figure 3.1), with a peak concentration of approximately 150 mg/L. The plume is greatest closest to the bed, although the concentration of suspended solids is less nearer to the bed. This modelling represents a conservative assessment based on 100 % dredge works; given that the majority of works will be confined by sheet piling peak concentrations may be lower.

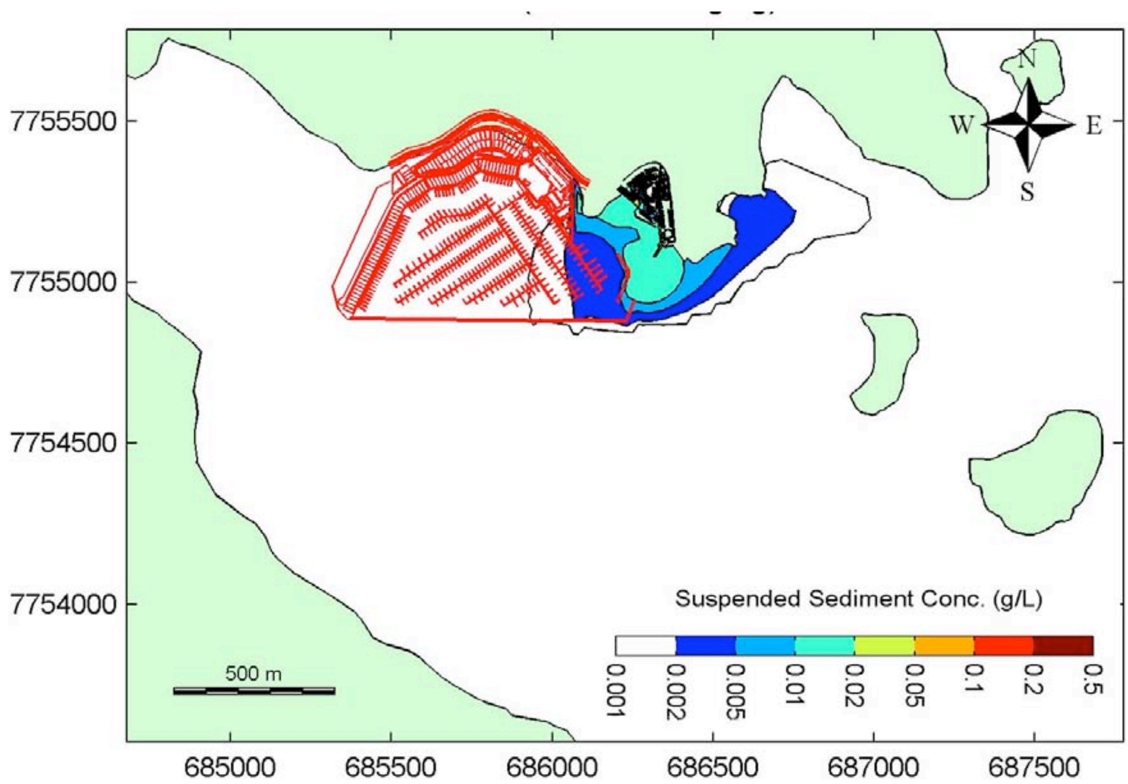


Figure 3.1 End of dredging (18:00) plume prediction (bed layer) (adapted from Cardno Lawson Treloar 2007).

The marine floral and faunal communties that occur within the area of predicted plume dispersal are described in Sections 4 to 9 of this report. The potential impacts of the dredge plume on these communities are discussed in Section 13.

4 Distribution and Characteristics of Seagrass

4.1 In Shute Bay

In June 2004, patches of sparse seagrass covered approximately 80 ha of the subtidal sediment within Shute Bay. The composition of seagrass communities was highly spatially variable and consisted of *Halodule uninervis*, *Halophila ovalis* and *Cymodocea serrulata*. *Halophila ovalis* dominated communities in the middle of the bay. There were sparse patches of *C. serrulata* on the reef flat at the southern entrance to Shute Bay. *Cymodocea serrulata* was also found in the channel subtidally below the reef slope.

Seagrass cover was generally very low (< 5%) within Shute Bay in June 2004 (Figure 4.1). However, there were patches of denser seagrass along the western side of the spit that fringes the southern entrance to the bay. *Halodule uninervis*, *H. ovalis* and *C. serrulata* grew in this area. The patches were all less than 5 m^2 in size, and ranged in cover from less than 5% to approximately 50%.

Figure 4.1

Sparse seagrass patches covering the intertidal zone in the bight of Shute Bay, June 2004.

Seagrasses of the central bay were dominated by morphologies (i.e. short, narrow leaves) that are likely to be reflective of the relative harshness of conditions in this part of the bay. Seagrass from the southern side of the bay had larger, longer leaves and more extensive rhizomes, indicating that individual plants may be older and / or less disturbed in this area.

In April 2007, seagrass covered much of the sediment within Shute Bay (approximately 147 ha, Table 4.1, Figure 4.2). The composition of seagrass communities was highly spatially variable, and consisted of *H. uninervis*, *H. ovalis* and *Zostera muelleri*[3]. No *C. serrulata* was observed during the 2007 survey.

Table 4.1 Approximate area of each seagrass community in Shute Bay, April 2007.

Community Type	**Area (ha)**
Sparse *Halodule uninervis*	44.18
Moderate *Halodule uninervis*	27.84
Dense *Halodule uninervis*	-
Sparse *Halophila ovalis*	19.35
Moderate *Halophila ovalis*	1.85
Dense *Halophila ovalis*	-
Sparse *Zostera muelleri*	2.29
Moderate *Zostera muelleri*	4.70
Dense *Zostera muelleri*	0.19
Sparse mixed seagrass	18.70
Moderate mixed seagrass	25.35
Dense mixed seagrass	2.59
Total	**147.04**

Sparse (< 5%) and moderate (5 – 59%) *H. uninervis* dominated seagrass communities in the middle of the bay, in April 2007. Moderately dense (up to 60% cover) *Z. muelleri* communities were found fringing the mangroves on the southern side of the bay, where seagrass was observed growing right up to the mangrove fringe, and in many cases, growing under the canopy. Towards the south-eastern side of the bay, these communities became more mixed, with *H. ovalis* interspersed with *Z. meulleri*. Dense mixed seagrasses occur closer to the mouth, along the southern side of the bay. Sparse *Z. muelleri* was recorded fringing the mangroves along the western side of the bay, however these communities did not grow in as close a proximity to the mangroves as those along the southern fringe.

[3] Until recetly this species was known as *Zostera capricorni.*

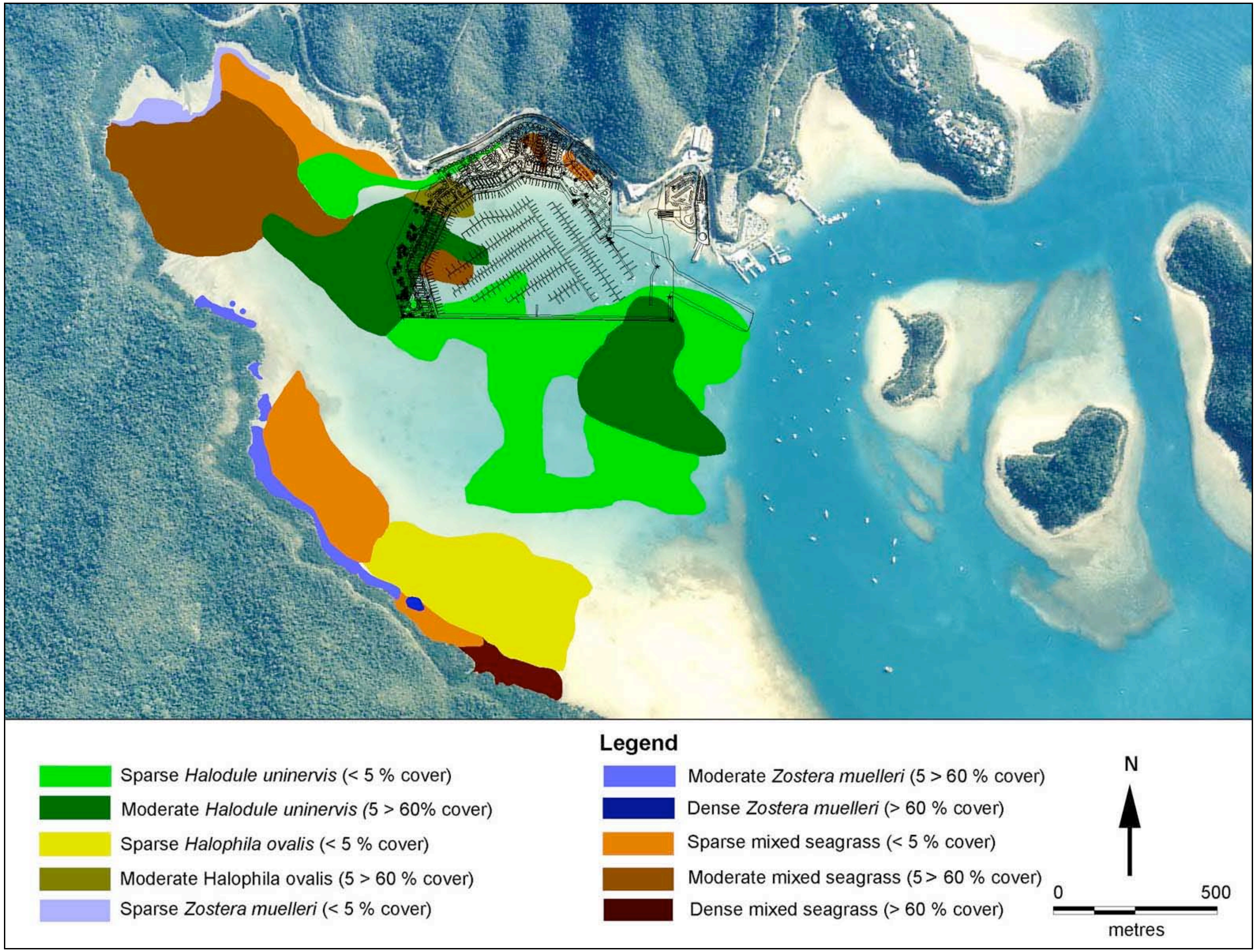


Figure 4.2 Seagrass distribution in Shute Bay, April 2007, with a stylised representation of the proposed marina and resort.

Moderately dense mixed seagrass covered the majority of the intertidal zone in the bight on the western side of Shute Bay (Figure 4.3). Communities were typically dominated by *H. uninervis, H. ovalis* and *Z. muelleri*. Sparse mixed seagrass was found in the intertidal zone along the northern side of the bight of the bay.

Figure 4.3

Moderately dense mixed seagrass covered the majority of the bight of Shute Bay, April 2007.

In places, all species were covered with epiphytic and free-floating filamentous algae. A cover of epiphytic and filamentous algae is relatively common on seagrass beds in the region (frc environmental 2005), and is frequently much denser than that recorded during this study.

Mixed seagrass communities (comprised of *Z. muelleri*, *H. ovalis* and *H. uninervis*) were observed growing to a maximum height of 1.46 m above Lowest Astronomical Tide (LAT).

Within and Adjacent to the Marina Footprint

Traverses of the proposed marina footprint, channel extension and adjacent areas, found predominantly bare substrate. Patches of sparse *H. ovalis* and *H. uninervis* encroach on the marina's southern breakwater, whilst a moderately dense bed of *H. uninervis* encroaches on the marina's southern breakwater (Figure 4.4). Approximately 14.59 ha of sparse – moderately dense seagrass was recorded within the marina footprint during the April 2007 survey (Table 4.2).

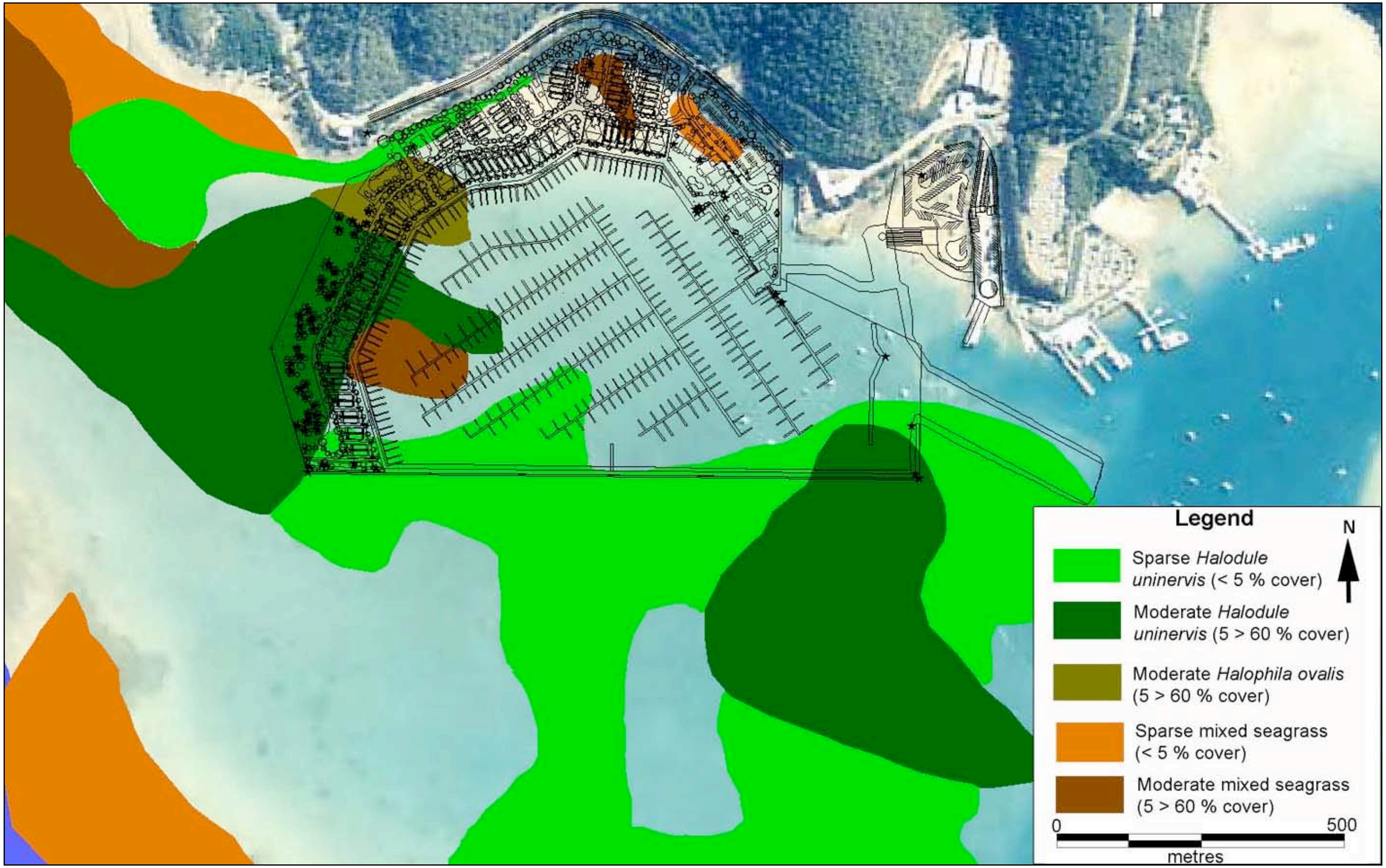


Figure 4.4 Seagrass communities within the development footprint, April 2007, with a stylised representation of the proposed marina and resort.

Table 4.2 Approximate area of each seagrass community in the footprint of the proposed marina, April 2007.

Community Type	Area (ha)
Sparse *Halodule uninervis*	5.68
Moderate *Halodule uninervis*	4.90
Dense *Halodule uninervis*	-
Sparse *Halophila ovalis*	-
Moderate *Halophila ovalis*	1.71
Dense *Halophila ovalis*	-
Sparse *Zostera muelleri*	-
Moderate *Zostera muelleri*	-
Dense *Zostera muelleri*	-
Sparse mixed seagrass	0.46
Moderate mixed seagrass	1.84
Dense mixed seagrass	-
Total	**14.59**

The biomass of seagrass within, and adjacent, to the marina footprint was estimated to be relatively low for the species represented, and for tropical seagrasses generally. At all five seagrass biomass sampling sites (see Appendix A), the mean above ground dry weight, and the mean below ground dry weight of *H. ovalis* and *H. uninervis* were both less than 1.0 g DW m^{-2}.

Within the Predicted Dredge Plume

A small amount of sparse (< 5% cover) and moderate (5 – 60% cover) *H. uninervis* (3.12 and 1.06 ha, respectively) occurs within the area of the predicted dredge plume (refer Figure 3.1).

Methods used in 2004 and 2007 surveys of seagrass (and macroalgae) are described in Appendix A.

4.2 Historical Distribution and Health of Seagrass in Shute Bay

The seagrasses of Shute Bay have been surveyed on five previous occasions: in 1987, 1999 and 2000 by the Department of Primary Industries (DPI), in 1991 by Marine Bio Logic, and in 1999 by frc environmental.

Historically, *H. ovalis* and *H. uninervis* have been the dominant seagrasses in Shute Bay. *Cymodocea serrulata* and *Z. muelleri* have been less common. *Halophila spinulosa* and *Syringodium isoetifolium* have only been recorded at the entrance to the bay. Overall, the cover of seagrass in Shute Bay appears to have increased since January 1987.

In January 1987, seagrass was recorded only from the southern entrance of Shute Bay (Coles et al. 1987) (Figure 4.5). The mixed community contained *H. spinulosa*, *H. uninervis* and *S. isoetifolium*.

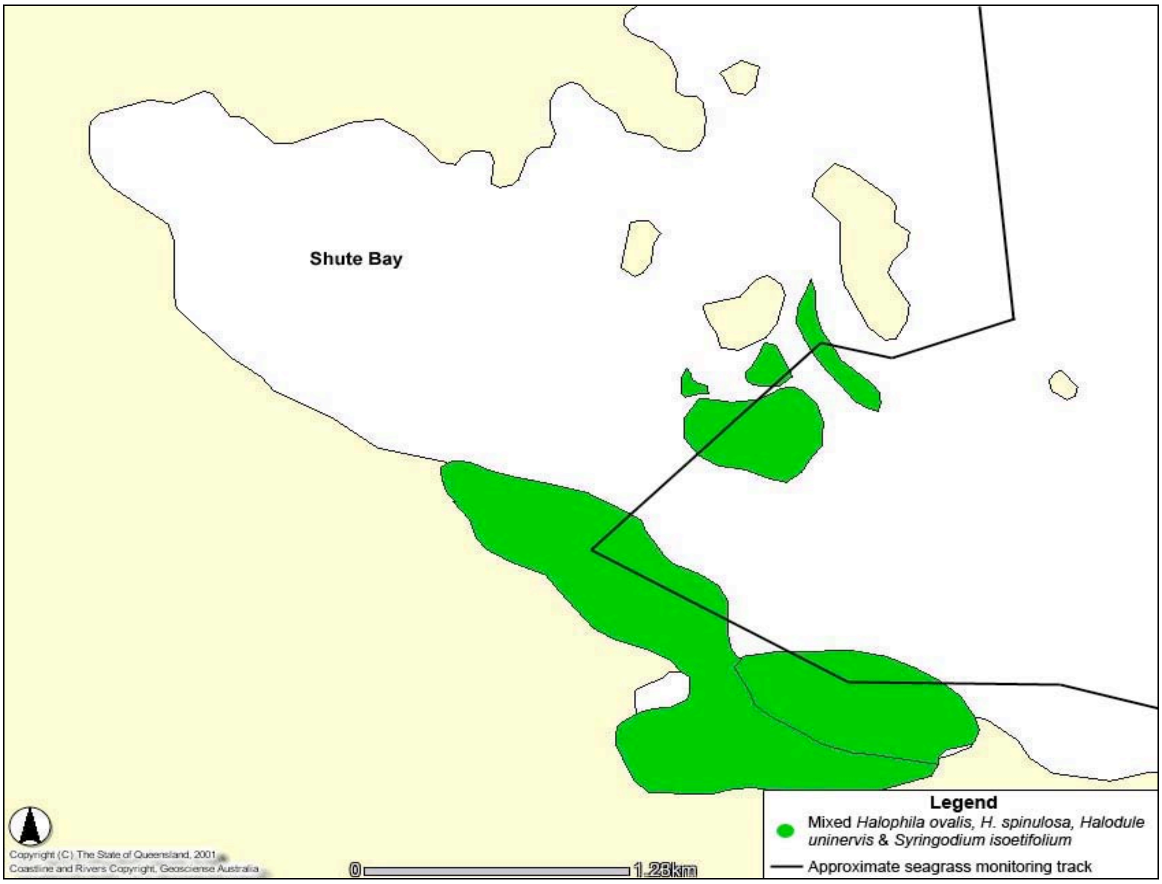


Figure 4.5 Seagrass distribution within Shute Bay, 1987 (DPI 2007, as mapped by Coles et al. 1987).

In 1991, the dominant seagrasses of the intertidal area were *C. serrulata* and *H. uninervis*; *H. ovalis* was less abundant (Marine Bio Logic 1991). At this time, a small area of seagrass (approximately 10 m^2 was recorded on the eastern margin of the proposed development site (Marine Bio Logic 1991).

In August 1999, the seagrass community of Shute Bay was comprised of *H. uninervis*, *H. ovalis* and *Z. muelleri* (Figure 4.6) (frc environmental 1999). At this time, a sparse community of *Z. muelleri* and *H. ovalis* occurred in the bight of the bay and along the southern shoreline, and a denser community of *H. uninervis* occurred in the centre of the bay.

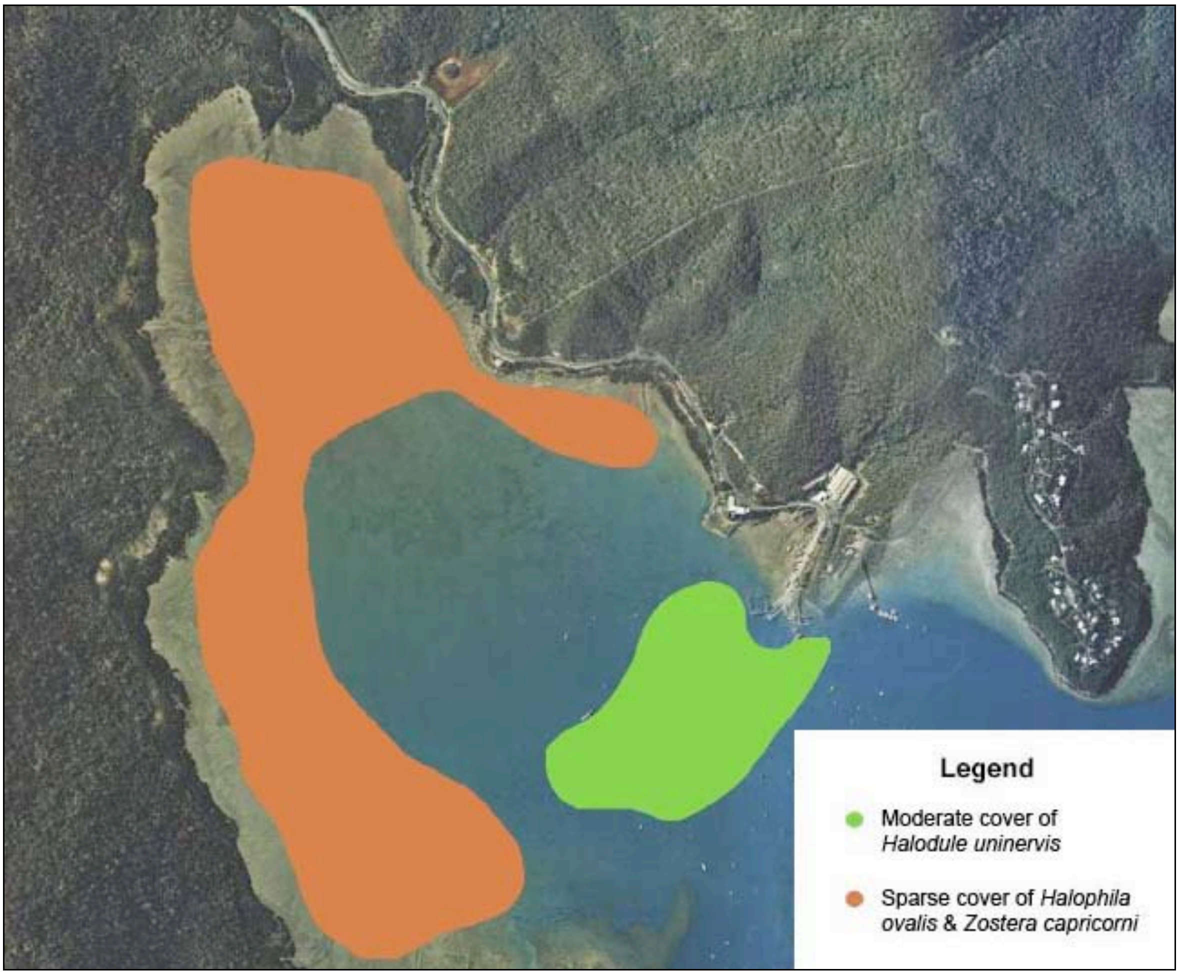


Figure 4.6 Distribution of seagrass and macroalgae in Shute Bay in August 1999. *Zostera capricorni* recently renamed as *Z. muelleri* (frc environmental 1999).

In January of 1999 and 2000, *H. uninervis*, *H. ovalis* and *Z. muelleri* covered approximately 258.6 ha of Shute Bay (Figure 4.7) (Campbell et al. 2002). A mixed community of *H. ovalis* and *H. uninervis* covered much of the subtidal area in the bay. *Zostera muelleri, H. ovalis* and *H. uninervis* were sparsely distributed over the intertidal and shallow subtidal sediments at the bight of the bay. Sparse *H. uninervis* also occurred adjacent to the northern edge of the embayment, in the vicinity of the proposed marina access channel at this time.

No historical information exists on the depth distribution of seagrass from Shute Bay.

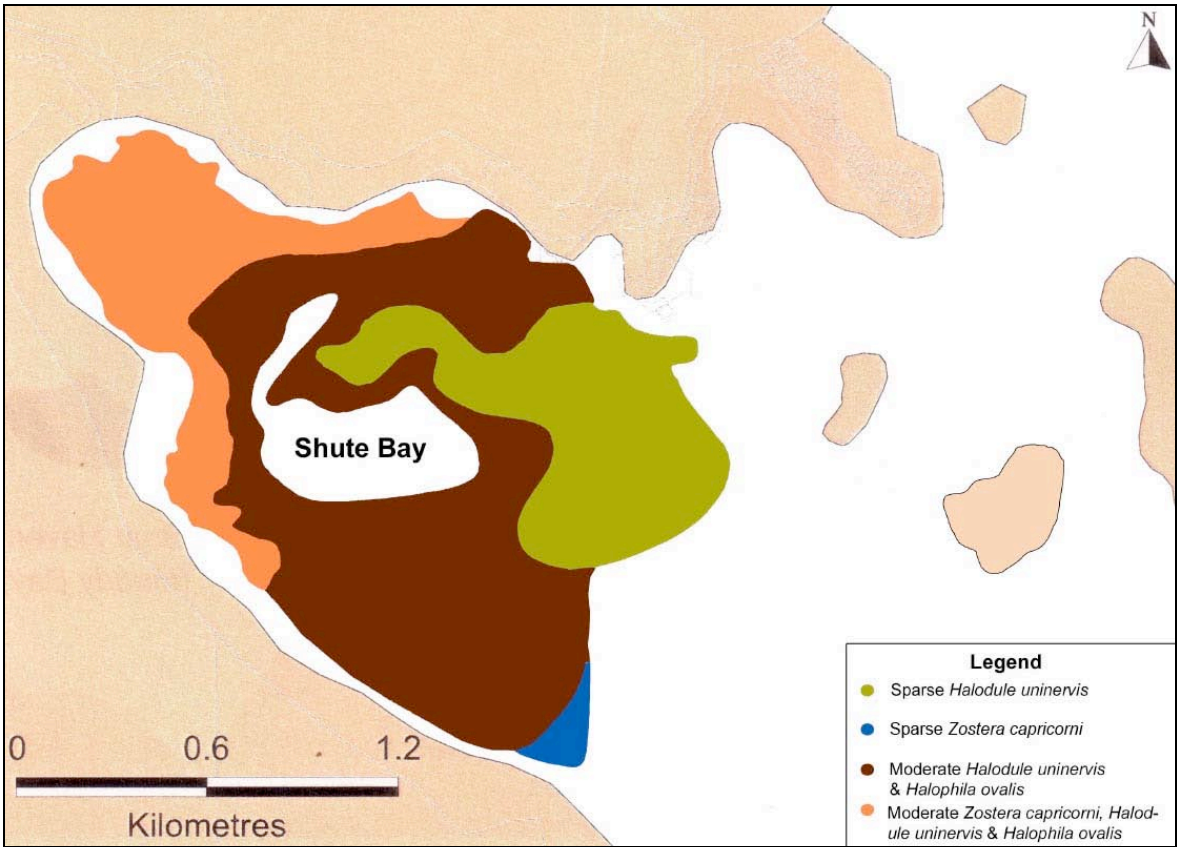


Figure 4.7 Distribution of seagrass in Shute Bay in January 1999 and 2000. *Zostera capricorni* recently renamed as *Z. muelleri* (adapted from Campbell et al. 2002).

4.3 Temporal Variation in Seagrass Distribution and Abundance

The distribution, community composition, and density of seagrass communities within Shute Bay are all highly dynamic. Whilst on Australia's tropical east coast, seasonal influences typically result in lower biomass in winter and highest biomass in spring (the end of the dry season) (Mellors et al. 1993; McKenzie 1994; Lanyon & Marsh 1995), the seagrasses of the Whitsunday region do not always exhibit this pattern, suggesting that on occasion, seasonal influences are tempered by other factors (frc environmental 1999; 2005). Seagrass communities can also vary over a longer timescale, with episodic events such as cyclones, storms and floods causing severe impacts at a local scale (Carruthers et al. 2002; Preen et al. 1995). Seagrass communities in Shute Bay are particularly dynamic, with large variation in distribution and density occuring inter- and intra-annually.

The current extent of seagrass in Shute Bay represents a near maximal extent of cover. Over the past decade, and in other seasons, there has generally been less (and on occasion considerably less) seagrass in Shute Bay than that recorded during April 2007. The surveys conducted in April 2007 are considered to be the most comprehensive, in terms of area of seabed covered and time spent underwater, and may therefore be the most accurate in terms of determining the extent of seagrass. Earlier estimates of seagrass distribution developed by the DPI have been limited by a lesser number of transects and spot dives, and by extrapolations from helicopter surveys and aerial photographs. Using these survey methods may result in false positives, as morphologically similar algae (e.g. *Caluerpa talifolia*) or accumulations of detritus may be confused for seagrass during aerial observations (Coles et al. 1993), thus falsely increasing the extent of seagrass in Shute Bay.

Physical Influences on Distribution and Abundance

The variation in the distribution of seagrasses within the Whitsunday region between years is likely to be primarily limited by physical disturbance (e.g. desiccation, disturbance by wave action etc.) above the low tide mark, and by light availability subtidally (Carruthers et al. 2002). In Pioneer and Boat Haven Bays' (to the north of Shute Bay), sediment resuspension and deposition have also had a significant influence. The lower depth limit of seagrass is commonly determined by the amount of light reaching the substrate. If the amount of light reaching the substrate is reduced, then the depth distribution decreases. Additionally, seagrasses undergo morphological and physiological changes with changing light intensity. For example, *Z. muelleri* grown in high light conditions has smaller shoots and higher biomass and productivity than when grown in low light conditions (Abal et al. 1994).

Light availability is principally influenced by the turbidity of the water and by shading by either phytoplankton or epiphytes. Elevated nutrient concentrations can increase the growth of phytoplankton and epiphytes. The availability of nutrients can also directly affect the growth, distribution, morphology and seasonal cycling of seagrass communities (Short & Wyllie-Echeverria 1996).

Biological Strategies to Cope with Distribution

Seagrasses are flowering plants that set seeds to disperse (Waycott et al. 2004). In addition, some seagrass can grow and disperse using vegetative growth from fragments of rhizome (Waycott et al. 2004). *Halodule uninervis* and *H. ovalis* are 'pioneer' species that colonise quickly after disturbance events (such as pulses of high turbidity) (Coles et al. 2004; Waycott et al. 2004). *Halophila ovalis* is well adapted for life in unstable environments and can rapidly recolonise from rhizome fragments and seeds after disturbance events, when conditions become suitable (den Hartog 1970). *Halophila ovalis* flowers almost continuously throughout the year in some areas (Waycott et al. 2004), and consequently can rapidly colonise available areas. At Seagrass-Watch monitoring sites in the Whitsunday region, the abundance of *Halodule* seeds was higher in early spring (August / September) than in winter (May / June) (Campbell et al. 2002), with seeds in the Whitsundays being more abundant than those recorded in the Hervey Bay region (Campbell et al. 2002).

Zostera muelleri usually flowers during spring, although the timing of flowering can vary (Waycott et al. 2004). *Zostera muelleri* can often withstand small-scale disturbances by using vegetative growth (Coles et al. 2004). However, after prolonged periods of decreased light availability, stable beds of *Z. muelleri* may be replaced by ephemeral beds of *H. ovalis* or *Halodule,* which are quick to colonise during periods of higher light availability (e.g. spring time, before the wet season), although they disappear again when turbidity increases. Ephemeral, sparse meadows of *H. ovalis* characterise the offshore area of the Airlie coast.

The dominance of *H. uninervis* and *H. ovalis* within Shute Bay is indicative of a frequently disturbed environment.

4.4 Seagrass of the Whitsunday Coast, A Regional Perspective

Seagrass meadows in the sheltered inshore waters of the Whitsunday region are some of the largest on the eastern Australian coast (McKenzie et al. 2000). The meadows support marine and estuarine foodwebs and provide extensive habitat for prawns, fish, turtles, and dugong (Lanyon et al. 1989, Coles et al. 1993). In 1999 and 2000 approximately 5, 553 ha (+/- 1, 182 ha) of seagrass was recorded in the Whitsunday region (from Midge Point north to Hydeaway Bay) (Campbell & McKenzie 2001). This figure is likely to be an underestimate, as surveys did not include all seagrass habitat in the region (Campbell & McKenzie 2000).

The seagrass species recorded from Shute Bay are common within the Whitsunday region (Table 4.3), and more generally within shallow, sheltered, inshore environments of Australia's tropical east coast (Campbell et al. 2002; Coles et al 1987; Coles et al. 2004; frc environmental 2002a; Lanyon 1986). Six of the ten seagrasses that have been recorded from the Whitsunday region have been recorded from Shute Bay.

Table 4.3 Seagrass species recorded in the Whitsunday Region (Campbell & McKenzie 2001) and in Shute Bay.

Species	Recorded in Region	Recorded in Shute Bay
Cymodoceaceae		
Cymodocea serrulata	°	°
Cymodocea rotundata		
Halodule uninervis	°	°
Syringodium isoetifolium	°	°
Hydrocharitaceae		
Halophila decipiens		
Halophila ovalis	°	°
Halophila spinulosa	°	°
Halophila tricostata	°	
Thalassia hemprichii	°	
Zosteraceae		
Zostera muelleri	°	°

The species composition, distribution, density and biomass of seagrass communities in the Whitsunday region fluctuate significantly over time (Bruinsma & Danaher 2001; Campbell & McKenzie 2001; Campbell et al. 2002; Dennison et al. 1995; frc environmental 2005). These fluctuations often occur on both seasonal and annual cycles (See Section 4.3). Studies of the seagrass communities of nearby Boat Haven Bay have show both the distribution and abundance of seagrass to vary considerably with time. For example, *H. spinulosa* was first recorded in Boat Haven Bay in November 2000. Whilst none was recorded in the bay in June 2001, by November 2001, it had become both abundant and extended its depth range. Again, in June 2002 no *H. spinulosa* was recorded in the bay. It was found in the bay again in April 2003, and in November 2003 its distribution was the greatest recorded (frc environmental 2004). However, in November 2004, it was only recorded in a small area in the eastern bay. Similarly, the presence of *Z. muelleri* is typically highly variable within Boat Haven Bay. *Zostera muelleri* has only been recorded in 4 of the 12 surveys by frc environmental over 6.5 years.

DPI's 1987 and 1999 / 2000 surveys of seagrass of the Whitsunday region, indicate that the segrasses of the mainland coast fluctuate significantly in extent over time (Coles et al. 1987; Campbell et al 2002). In 1987, Shute Bay supported a relatively small area of seagrass when compared to other locales within the region, and in particular, when compared to Pioneer Bay to the north and Repulse Bay to the south (Figure 4.8).

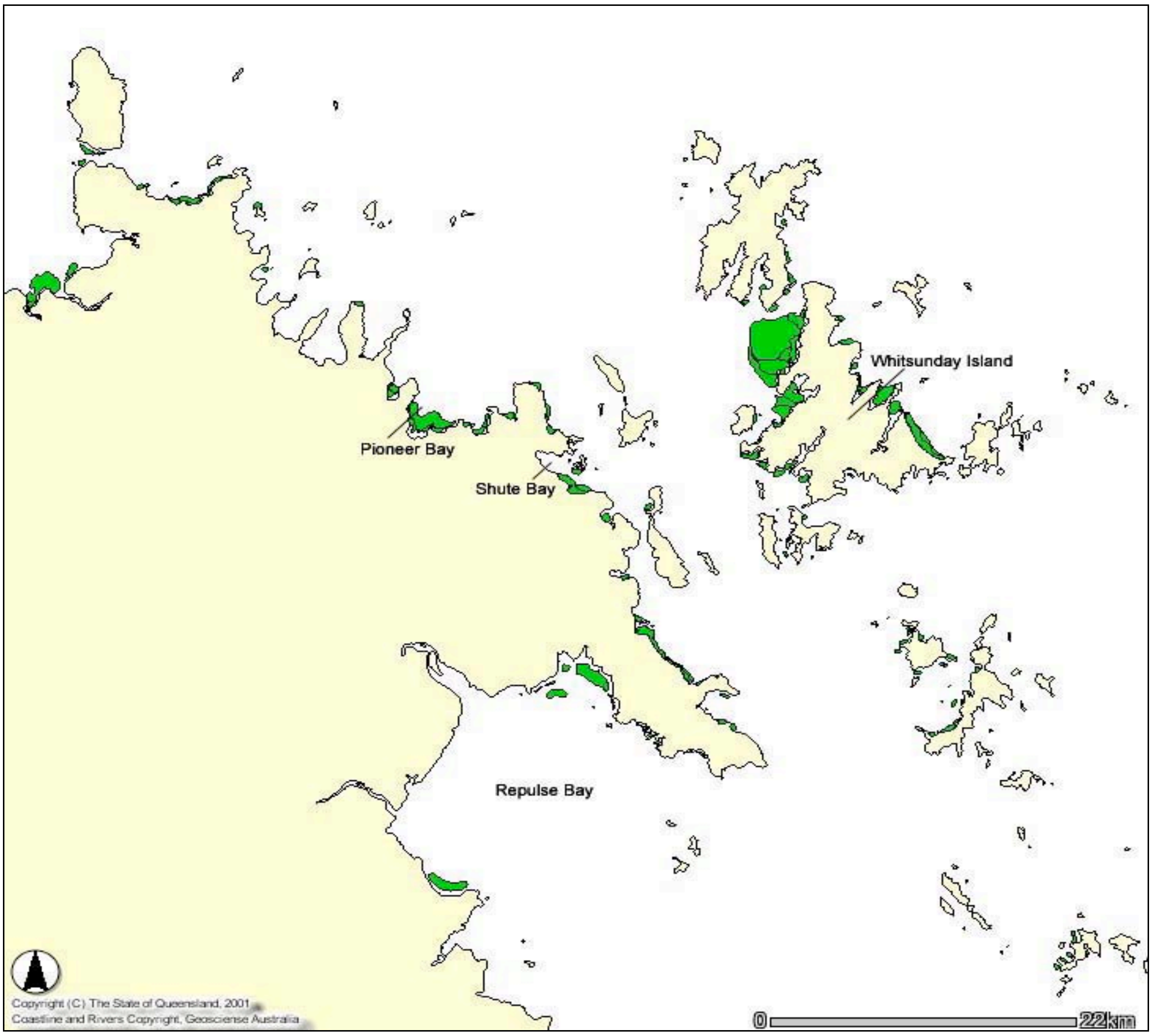


Figure 4.8 Distribution of seagrass in the Whitsunday region in 1987 (DPI 2007, mapped by Coles et al. 1987).

However in 2000, a much larger area of seagrass was mapped in Shute Bay (Figure 4.9). The aerial extant of seagrass meadows within Shute Bay in January of 2000 was approximately 258.6 ha (Table 4.4) (Campbell et al. 2002), approximately twice that of Pioneer Bay (1,41.1 ha), but still far lower than in Repulse Bay (1,514.7 ha) to the south (Table 4.4).

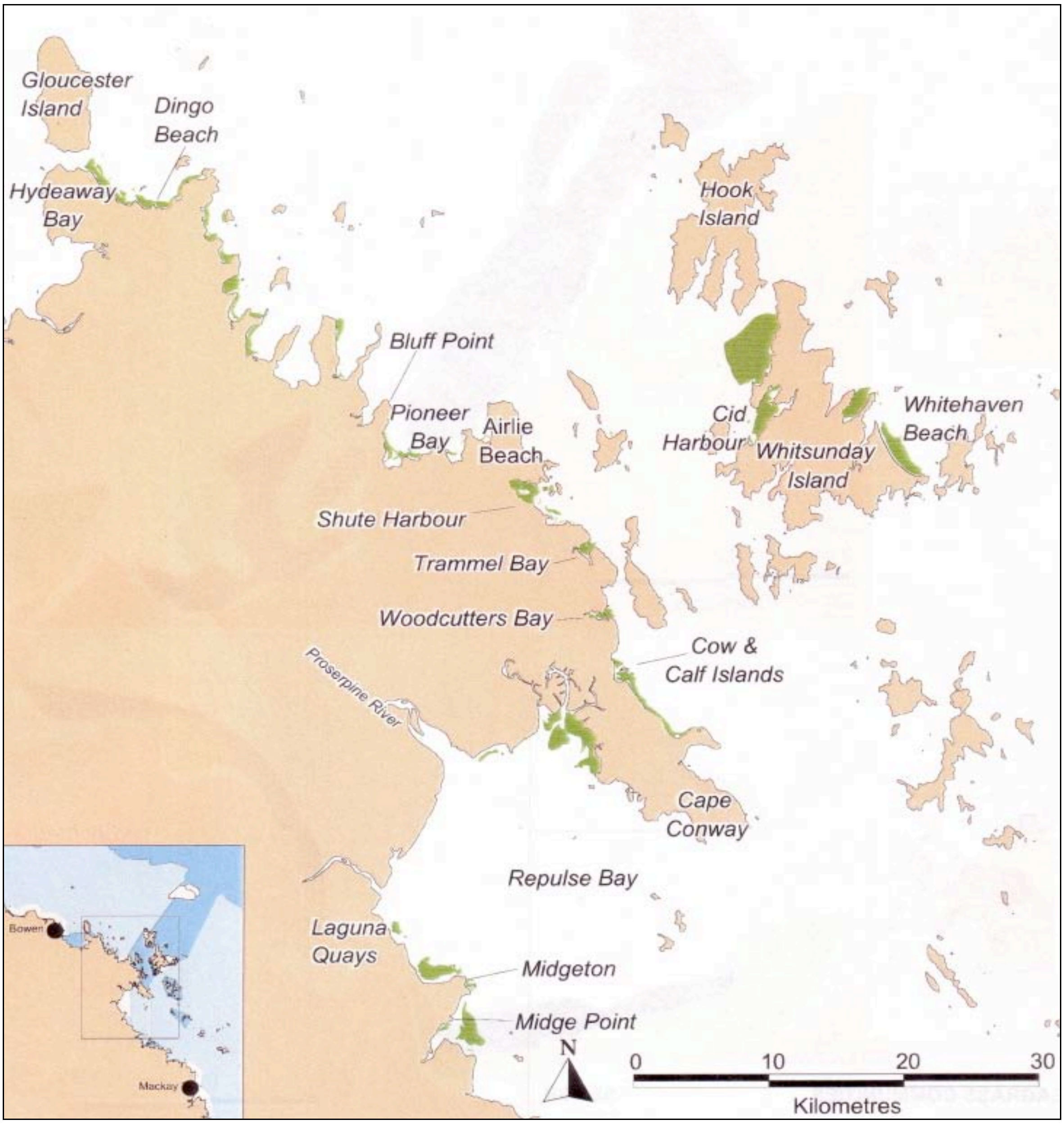


Figure 4.9 Distribution of seagrass in the Whitsunday region in January 2000 (Campbell et al. 2002).

Table 4.4 Mean above-ground biomass (g DW m^{-2}) and the aerial extant of seagrass for 14 locations in the Whitsunday region (Campbell et al. 2002).

Location	Mean Above Ground Biomass (g DW m^{-2})	Aerial Extent (ha)
Hydeaway Bay / Dingo Bay	2.95	388.9
George Point to Earlando	3.11	243.9
Earlando to Woodwark Bay	0.53	233.6
Pioneer Bay to Funnel Bay	0.59	141.1
Shute Harbour	**1.35**	**258.6**
Trammel & Woodcutters Bays	4.03	122.4
Cow & Calf Islands to Cape Conway	2.86	271.5
Northern Repulse Bay	0.31	822.4
Southern Repulse Bay	0.14	692.3
Cid Harbour	7.25	340.2
North west coast of Whitsunday Island	14.77	1, 432.7
Tongue Inlet	10.71	241.6
Whitehaven Beach	7.73	363.6
South Molle Island	0.01	4.0
Mean Biomass (all locations)	**5.5**	
Total Aerial Extent		**5, 553**

In January 2000, the mean above-ground biomass of seagrass in Shute Bay (1.35 g DWm^{-2}) was representative of coastal seagrass meadows in the Whitsunday area (Campbell et al. 2002). However, it was considerably greater than recorded in either Pioneer (0.59 g DW m^{-2}) or Repulse Bay (0.31 & 0.15 g DW m^{-2}) at this time (Table 4.4; Campbell et al. 2002).

In June 2004, the mean above ground dry weight of seagrass in Shute Bay (< 1.0 g DWm^{2}) was similar to that found in Pioneer, Boat Haven and Charlies Bays in April 2004 (frc environmental 2002a, 2005).

5 Distribution and Characteristics of Mangroves and Saltmarsh

5.1 In Shute Bay

Mangrove communities throughout Shute Bay are dominated by the red mangrove (*Rhizophora stylosa*), with lower abundances of the grey mangrove (*Avicennia marina*), river mangrove (*Aegiceras corniculatum*), myrtle mangrove (*Osbornia octodonta*), blind-your-eye mangrove (*Excoecaria agallocha*), mangrove apple (*Sonneratia alba*) and yellow mangrove (*Ceriops tagal*) also found throughout the bay. The black mangrove (*Lumnitzera* sp.) was scattered throughout the mangrove forest in the bight of the Bay, while the mangrove fern (*Acrostichum speciosum*) and mangrove lily (*Crinum pedunculatum*) were recorded from the landward edge of the forest on the southern side of the bay.

The mangrove communities on the western and southern sides of Shute Bay cover a significantly greater area (being less constrained by higher land) than those within, or to the east of, the area of the proposed marina (Figure 5.1).

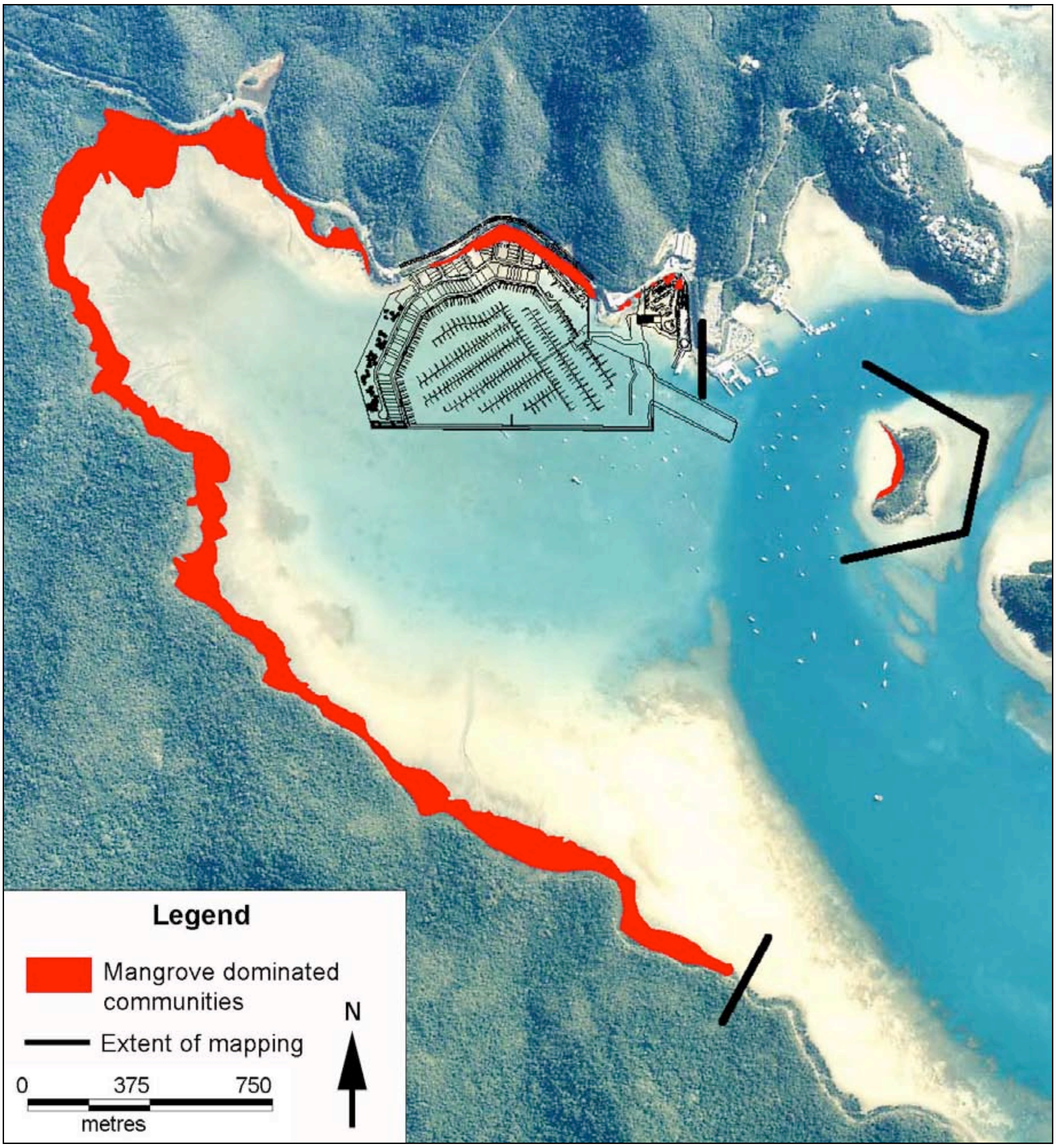


Figure 5.1 Distribution of mangroves in Shute Bay, with a stylised representation of the proposed marina and resort.

Within and Adjacent to the Marina Footprint

In April 2007, approximately 1.84 ha was present within the footprint of the proposed marina. The shoreline within the footprint of the proposed marina, as with most of Shute Bay, is fringed by mangroves (Figure 5.2). Within, and to the east of, the proposed marine, mangroves give way to the landward, to patches of saltmarsh on mostly rocky ground, which then rises in a relatively steep bank to Shute Harbour Road. To the west, the mangroves continue landward into a wider swampy area without saltmarsh, before meeting the steep bank to Shute Harbour Road (Figure 5.3).

Figure 5.2

Rhizophora stylosa-dominated mangrove community within the footprint of the proposed marina.

Figure 5.3

Mangroves to the west of the proposed Marina footprint.

Rhizophora stylosa dominates the seaward fringe of the mangrove community in the footprint of the proposed marina, forming a band approximately 15 m wide and an open canopy approximately 4 m high. *Avicennia marina* and *A. corniculatum* are intermixed throughout this community, becoming most abundant to the west where the substrate is coarsest. Further to the landward, the community is dominated by *Ceriops* sp., intermixed with *O. octodonta, S. alba*, and *E. agallocha*. This landward mangrove community forms an open canopy that is approximately 2.5 m high. Slightly landward of the *Ceriops*, and sometimes intermixed with them, are small patches of saltmarsh (mainly *Suaeda australis* and *Sporobolus virginicus*) on coarse rocky ground with almost no pooled water (Figure 5.4).

Figure 5.4

A mangrove community of *Ceriops tagal* and *Osbornia octodonta*, with *Suaeda australis* in the foreground, on the landward side of the mangrove fringe within the footprint of the proposed marina.

The mangrove community within, and adjacent to, the marina footprint appears relatively healthy (no evidence of 'die-back' was observed in April 2007). However, due to the narrow fringe, mangroves in this area are of relatively low value to fisheries, when compared to the mangroves in the west and south of the bay. Towards the western end of the footprint of the proposed marina, where they are most exposed to the prevailing south-easterly winds and the substrate is coarsest, the mangroves are increasingly stunted.

Within the Predicted Dredge Plume

Approximately 0.19 ha of mangroves are found within the predicted area of the dredge plume (refer Figure 3.1). The mangroves community in this area is comprised mainly of *R. stylosa*, and forms a narrow fringe to Shute Harbour Road (Figure 5.5).

Figure 5.5

The existing foreshore in the area of the predicted dredge plume. Note the *Rhizophora stylosa* communities in the background.

5.2 A Regional Perspective

Mangrove species recorded in the region are shown in Table 5.1, and their regional distribution is shown in Figure 5.6. Compared to Repulse Bay to the south, and to a lesser extent to Pioneer Bay in the north, Shute Bay supports a relatively small area of mangroves. Each of the mangrove species recorded from Shute Bay is typical of, and common within the region.

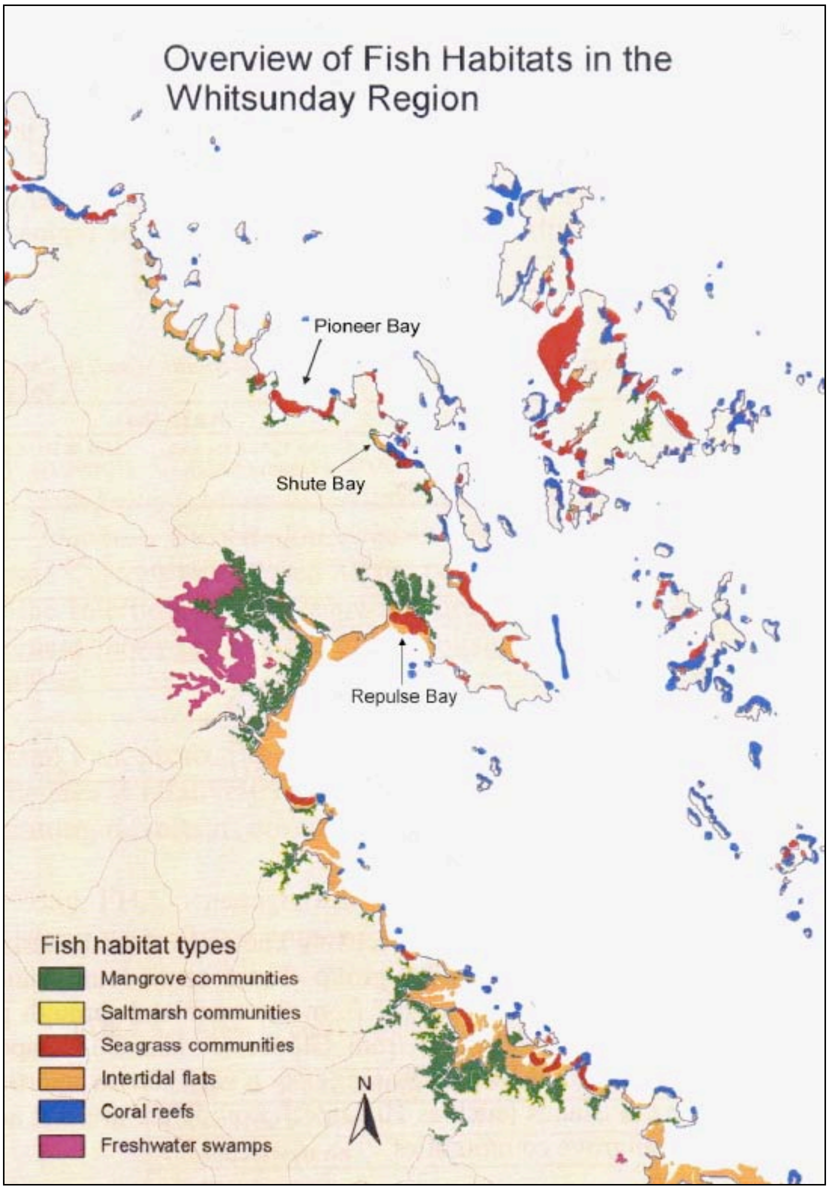


Figure 5.6 Distribution of mangrove, saltmarsh, seagrass, intertidal flats, coral reefs and freshwater swamps in the Whitsunday region (Bruinsma & Danaher 2001). Seagrass communities are as mapped by Hyland (1987).

Table 5.1 Mangrove species recorded within the region, and in Shute Bay.

Species	Common Name	Recorded in Region	Recorded in Shute Bay
Acanthus ilicifolius	holly mangrove	KCM	
Aegialitis annulata	club mangrove	KCM, Sailport, EMG	
Aegiceras corniculatum	river mangrove	Sailport, EMG, FRCa, WBM	+
Avicennia marina	grey mangrove	Sailport, EMG, KCM, FRCa, WBM	+
Bruguiera sp.	orange mangrove	Sailport, EMG, KCM, FRCa, WBM	+
Ceriops sp.	yellow mangrove	KCM, Sailport, EMG, FRCa, WBM	+
Excoecaria agallocha	milky mangrove	KCM, Sailport, EMG, FRCa, WBM	+
Heritiera littoralis	looking-glass mangrove	KCM, Sailport, EMG, FRCa, WBM	
Hibiscus tiliaceus	cotton tree	KCM, FRCa	
Lumnitzera racemosa	white-flowered black mangrove	KCM, Sailport, EMG, FRCa, WBM	
Osbornia octodonta	myrtle mangrove	FRCa	+
Rhizophora sp.	red mangrove	KCM, Sailport, EMG, FRCa, WBM	+
Xylocarpus granatum	cannonball mangrove	KCM, WBM, FRCa	
Sonneratia sp.	mangrove apple	FRCa	+
Crinum pedunculatum	mangrove lily	FRCa	+

KCM – Kinhill Cameron McNamara (1990)
EMG – E M Grant Pty Ltd (1998)
Sailport – Sailport Pty Ltd (1987)
WBM – WBM (1998)
FRCa – FRC Environmental (2002a)
\+ – FRC Environmental (this study)

5.3 Historical Stability of the Mangrove and Saltmarsh Communities

Construction of the Shute Harbour Road in 1960 resulted in the death of several hectares of mangroves and saltmarsh to the north of the road, to the west of the proposed marina.

Since this disturbance, the distribution of mangroves in Shute Bay has generally increased (note the increasingly wider fringes in Figure 5.7). Density of trees within the communities also appears to have increased.

With the exception of mangroves to the north of Shute Harbour Road, the mangroves of Shute Bay generally do not appear to have been recently or significantly disturbed. Mangroves of the bay generally appear healthy, with no signs of die-back or disease. A small area of mangroves has been removed from the intertidal zone along the western margin of the existing barge jetty loading facility (as indicated by the arrow in Figure 5.7). In 1991, Marine Bio Logic recorded approximately 35 ha of mangroves in Shute Bay, which reflects a similar status to the present distribution.

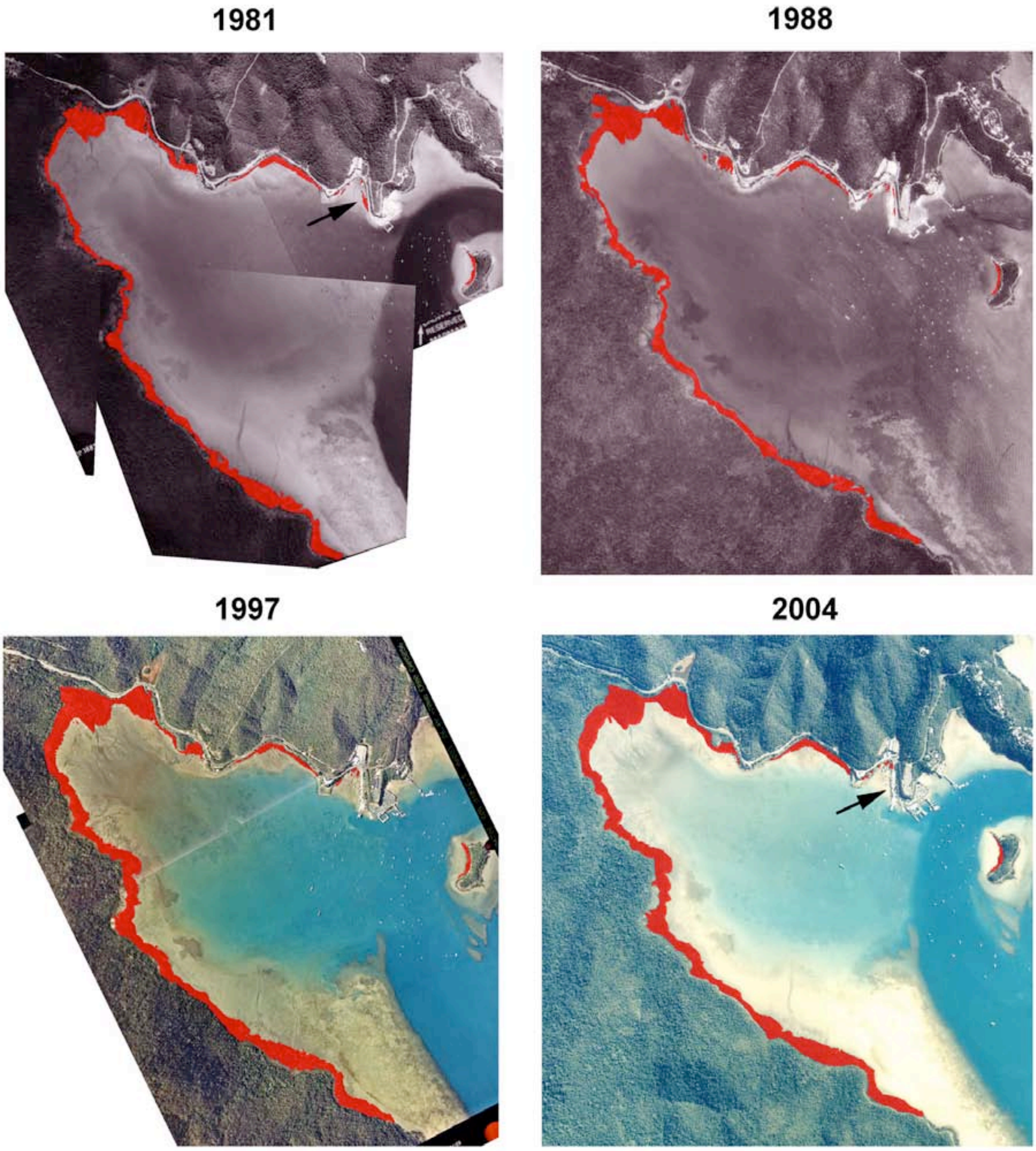


Figure 5.7 Historical distribution of mangroves (red shaded areas) in Shute Bay (1981 to 2004).

6 Distribution and Characteristics of Macroalgae

6.1 In Shute Bay

Mixed macroalgae communities were found throughout much of the subtidal area of Shute Bay. The mixed communities were typically comprised of the brown algae *Padina* sp. and *Sargassum* sp., red algae, including *Laurencia majuscula, Hypnea valentiae* and *Asparagopsis taxiformis,* and green algae, including *Udotea argentea*, *Halimeda cylindracea* and *H. macroloba*. Cover across the bay was generally low, not exceeding 30% total cover. Macroalgal distribution significantly overlaps seagrass distribution.

A large *L. majuscula* dominated communities was recorded from the middle of the bay (Figure 6.1). A small patch of *Caulerpa taxifolia*, approaching 100% cover, was recorded in a deeper depression in the middle of the bay. Generally the northern side of the bay supported more abundant macroalgae communities than the southern side. No macroalgae was recorded from the bight in the western side of the bay.

The spit at the south-eastern side of Shute Bay supported the highest density of macroalgae within the bay. The top of the spit is covered in dense brown algae (*Padina* sp.), whilst the shallow slope of the spit supports dense patches of the brown algae *Padina* and small amounts of the green alga *H. macroloba and H. cylindracea,* and the brown algae *Sargassum* sp.

Approximately 133 ha of macroalgae were recorded from Shute Bay during the 2007 surveys.

Within and Adjacent to the Marina Footprint

In April 2007, a low cover of mixed macroalgae characterised the marina footprint (35 ha) (Figure 6.1). Mixed communities were typically dominated by the brown algae *Padina* sp., and *Sargassum* sp.*,* the red algae *L. majuscula, H. valentiae,* and *A. taxiformis,* and the green algae *U. argentea, H. cylindracea* and *H. macroloba.*

Patches of *H. macroloba* and *H. cylindracea* at < 10% cover were recorded along the intertidal zone in the marina footprint. A large (approximately 2.8 ha) patch of *Sargassum* sp. was recorded within the marina footprint. Again, cover in this patch was low (less than 10% total).

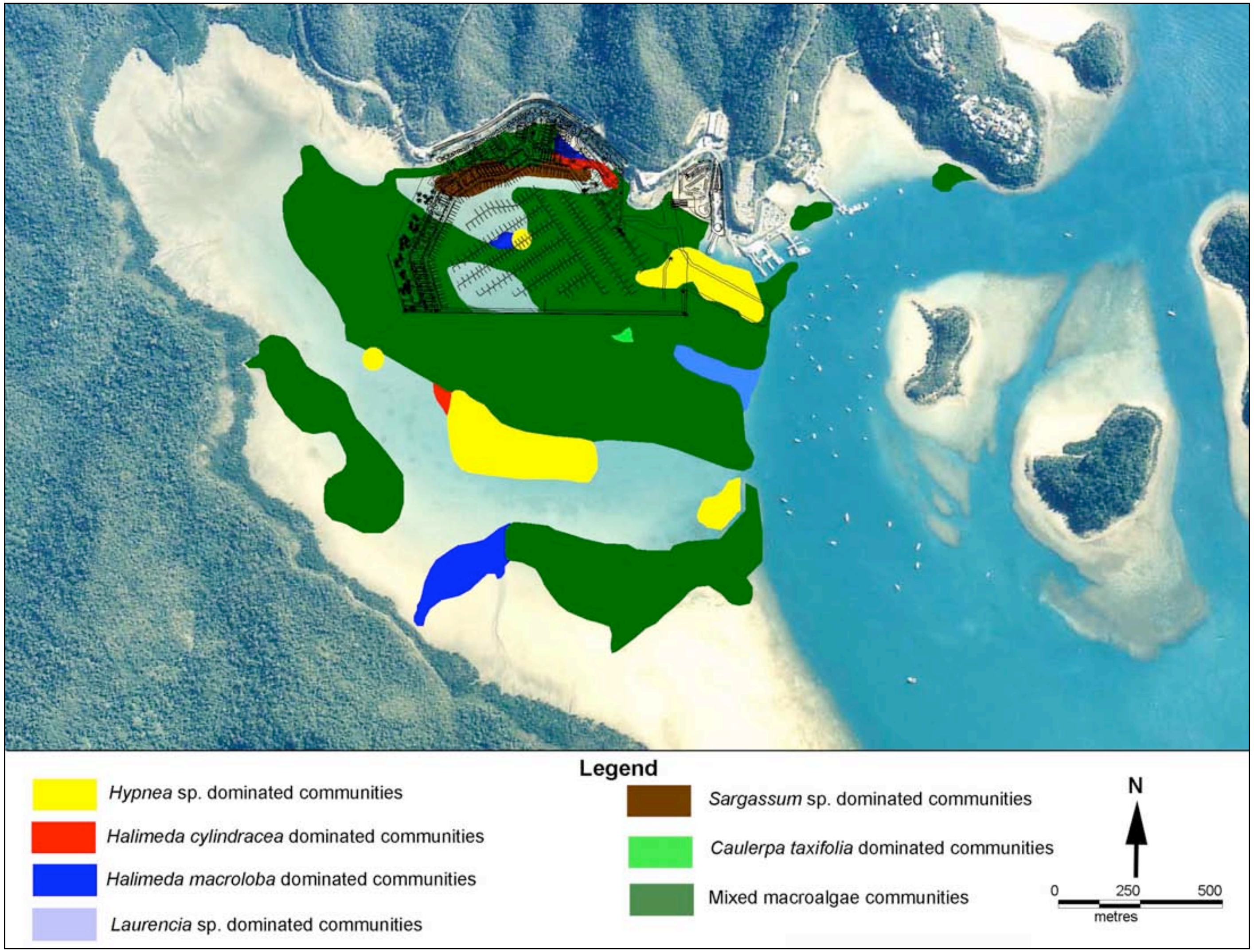


Figure 6.1 Macroalgae communities of Shute Bay, April 2007, with a stylised representation of the proposed marina and resort.

Within the Predicted Dredge Plume

Approximately 9.06 ha of low cover (<20%), mixed macroalgae communities, and 3.41 ha of *Hypnea* sp. dominated communities occur within the area of the predicted dredge plume (refer Figure 3.1).

6.2 A Regional Perspective

The algal species recorded within Shute Bay are common within the Whitsunday region (frc environmental 1998, 2002b), and more generally within shallow, sheltered, inshore environments of Australia's tropical east coast. The high macroalgae cover associated with the coral community on the spit in Shute Bay is characteristic of many of Queensland's fringing reefs (McCook et al. 1997; Umar et al. 1998).

6.3 The Cyanobacteria *Lyngbya*

Lyngbya majuscula (lyngbya) is a naturally occurring, toxic, filamentous, cyanobacteria (blue-green algae), that is found worldwide in tropical and subtropical estuarine and coastal habitats (EPA 2002, Arthur et al. 2006). *Lyngbya* grows epiphytically on rock, coral, seagrass, macroalgae, and anthropogenic structures forming matted masses of dark filamentous material (Humm and Wicks 1980, cited in Arthur et al. 2006; Dennison et al. 1999, cited in Arthur et al. 2006). Gas bubbles, formed from rapid photosynthesis, can accumulate in the matted mass causing *Lyngbya* to float to the surface, forming large surface aggregations (EPA 2002, Albert et al. 2005). *Lyngbya* growth has resulted in a loss of seagrass beds, and may have reduced turtle and dugong feeding grounds, in Moreton Bay (Watkinson et al. 2005). *Lyngbya* can also cause severe eye and skin irritations to humans, as well as asthma like symptoms (Osborne et al. 2001). Economic effects of *Lyngbya* can be manifest in commercial and recreational fisheries and tourism.

The exact cause of *Lyngbya* blooms is unknown, but warm water, high light intensity, enhanced nutrient loading and availability of essential metals, are all factors that can contribute to a bloom (EPA 2002; Albert et al 2005; Arthur et al. 2006). Changes in catchment land use, as seen at Deception Bay near Brisbane, or seabird distributions, as seen at Hardy Reef, can lead to alterations of the inputs of dissolved organics, iron, and phosphorus into a system, which can in turn lead *Lyngbya* blooms (Arthur et al. 2006). Ahern et al. (2007) found that nutrients, particularly organically chelated iron, phosphorus, and nitrogen can promote prolific growth of *Lyngbya*. These studies and others indicate that there is commonly an association between *Lyngbya* blooms and development (Ahern et al. 2007)

Nuisance *Lyngbya* blooms have been recorded along the east coast of Queensland at Moreton Bay, Hervey Bay, Shoalwater Bay, the Whitsundays, Hinchinbrook Island, and Cape Kimberly (Albert et al. 2005). Although the historical distribution and frequency of blooms is unknown within the Whitsundays, *Lyngbya* has been recorded at Whitehaven Beach (2001), Hardy Reef (date unknown), Pioneer Bay (2000, 2005), Charlies Bay (2004), and Boat Haven Bay (2004) (Queensland Seagrass Watch 2001; EPA 2002; frc environmental 2005; Campbell & McKenzie 2001). No *Lyngbya* was observed during frc environmental's June 2004 or April 2007 surveys.

6.4 Historical Stability of Macroalgae Communities

Macroalgal communities respond to a variety of physical and biological parameters. Many algae, such as the brown alga *Sargassum*, are seasonal, being more abundant in summer and dying off in winter (Jompa & McCook 2002). The abundance of macroalgae can also change over time in response to impacts of sediments and nutrients. High levels of suspended sediments have been observed to reduce algal abundance, recruitment and growth (Cheshire et al. 1999; frc environmental 2005; Umar et al. 1998). The impact of elevated nutrients on macroalgae is not always obvious (frc environmental 2002b; McCook 1999), and whilst increased nutrients may increase algal abundance, this may be reduced by the grazing actions of herbivorous fish and sea urchins (Hatcher & Larkum 1983; Hughes 1994; McCook 1999). Biotic factors, such as competition with hard corals and predation, can also affect macroalgae cover and growth over short and long time periods (Jompa & McCook 2002; Tanner 1995).

In 1991, macroalgae (especially *Sargassum, Padina* and *Turbinaria*) occupied 28% of the substrate of the fringing reef on the spit in the southern part of the bay (Marine Bio Logic 1991), a similar proportion to that occupied by macroalgae in the 2004 and 2007 surveys.

7 Distribution and Characteristics of Coral Communities

7.1 In Shute Bay

Coral forms an extensive spit that partially encloses the bay's southern entrance (Figure 7.1). This community extends from an intertidal reef flat, which is extensively covered by the brown alga *Padina* sp., to a gradual reef slope that meets a sandy seabed at approximately 5.5 m below LAT. Coral communities also fringe Repair, Tancred and Shute Islands, at the entrance to Shute Bay.

Coral cover on the spit is highest on the seaward side, where tidal flushing is greatest, bringing food and clear water to the community. The point of the spit has an intermediate level of cover; the embayment side, which is less exposed, has lower coral cover and more fine silt covering bare substrate (see Appendix C). Sparse patches of seagrass (*Halophila ovalis*) occur over the sandy bottom on the inshore side of the spit (see Section 4.1).

The hard and soft coral genera and other sessile invertebrates that were recorded on the spit, and their relative abundance, are presented in Appendix B. The relative abundance of each hard coral genus is typical of inshore coral communities in the Whitsundays region, with sediment tolerant genera such as *Goniopora, Porites* and *Turbinaria* dominating (van Woesik et al. 1999).

Mixed coral communities also fringe the southern end of Coral Point, and Repair, Tancred and Shute Islands.

Within and Adjacent to the Marina Footprint

Approximately 10 coral colonies were recorded from the intertidal zone in the footprint of the proposed marina (Figure 7.1), covering <2% of the substrate over an area of approximately 0.44 ha. Corals in this region were small (with diameters generally no greater than 30 cm), and distributed intermittently along the intertidal. Colonies were represented by the families Faviidae and Mussidae (Figure 7.2 & Figure 7.3), and appeared healthy, with no sign of bleaching or stress.

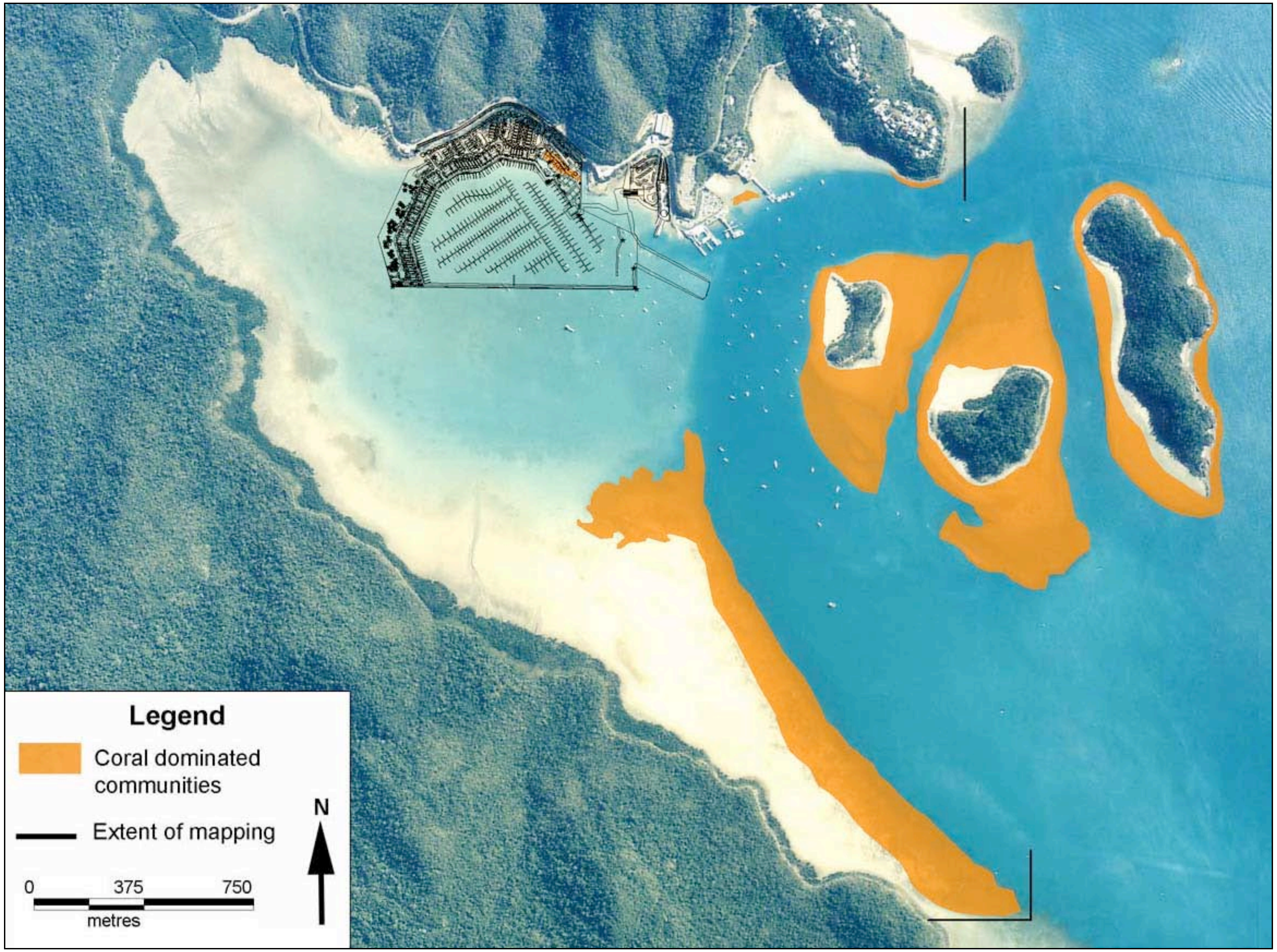


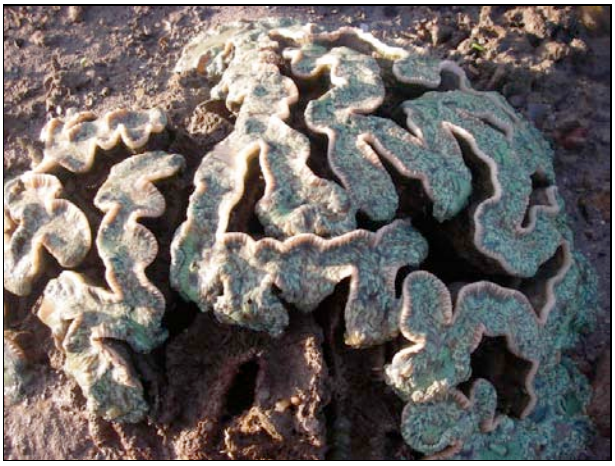
Figure 7.1 Coral communities of Shute Bay, including neighbouring bays and Repair, Tancred and Shute islands, with a stylised representation of the proposed marina and resort.

Figure 7.2

Favites sp. (Faviidae) recorded within the development footprint.

Figure 7.3

Lobophyllia sp. (Family: Mussidae) recorded within the development footprint.



Within the Predicted Dredge Plume

Coral communities in the small unnamed bay, to the east of the proposed development (Figure 7.1), lie within the predicted path of the dredge plume (refer Figure 3.1). Corals cover an area of approximately 0.22 ha in this bay; cover is patchy with approximately 25% total cover within patches; communities are dominated by *Acropora* and *Goniopora* corals. Hard and soft corals also grow on the wooden pilings and rock groyne around the existing Shute Harbour Ferry Terminal (see Appendix F).

7.2 A Regional Perspective

There is a discontinuous fringe of coral communities along the rocky shores of the Whitsunday coast, whilst the Whitsunday Islands support more extensive coral communities (Figure 5.6). In comparison to these communities, the coral community found on the spit on the south-western side of Shute Bay is relatively small. The cover and taxonomic composition of the hard and soft corals, other benthic fauna, and macroalgae found on the spit are typical of inshore coral communities of the region (frc environmental 2002a; van Woesik et al. 1999; WBM 1998).

7.3 Historical Stability of the Coral Communities

Hard coral communities typically develop over extended periods of relatively stable environmental conditions. The living corals of the Shute Bay spit are likely to represent a community that has existed for centuries or longer. The living hard coral colonies on the spit are mostly of small to medium size for each genus, indicating that the community is primarily composed of relatively young colonies. The lack of very large colonies, as well as the relatively low hard coral cover, and low numbers of hard coral recruits observed, reflects the relatively stressful conditions of this turbid environment, under which the community can survive but is unable to flourish. The composition of the hard coral community is also likely to be reflective of these stressful conditions, with the sediment-tolerant genera *Goniopora*, *Porites* and *Turbinaria* dominating the community. These genera commonly dominate inshore turbid coral communities (van Woesik et al. 1999; Veron 2000). However, the presence of medium sized *Acropora* corals, often associated with less turbid conditions, indicates that turbidity and sediment levels are not exceedingly high and have been within levels acceptable for this genus for at least approximately thirty years.

In the last 20 years, there has been an increase in the incidence of coral bleaching throughout tropical waters. These events are triggered by episodes of warmer than normal water and may be linked to greenhouse warming trends (Hoegh-Guldberg 1999). Extensive coral bleaching within the region was reported in 1998 and 2002 and was associated with warmer water temperatures. This had significant impacts on inshore coral communities in the Whitsunday region (frc environmental 2002a) and throughout the Great Barrier Reef, and may have reduced, at least in the short-term, the cover of coral in Shute Bay.

8 Distribution and Characteristics of Benthic Invertebrates

8.1 In Shute Bay

The sediments of Shute Bay are largely characterised by mobile silty sands and sandy silts. Layers of coarse coral rubble integrated with finer sediments exist towards the centre of the bay, and shell and rubble fragments are abundant along the south-western shoreline.

The infaunal macro-invertebrate communities of Shute Bay are characterised by a diverse and moderately abundant fauna, characteristic of intertidal communities in the Whitsunday region (WBM 1998). Previous studies of benthic infauna indicate that communities are relatively homogenous throughout the bay. Nematode worms, lucinid bivalves, capitellid polychaetes and ghost crabs are common in finer sediments in the central bay, whilst small filter feeding bivalves (*Eucrates* sp., *Macoma* sp.) and detrital feeding whelks (Nassariidae and Potamididae) are associated with coarser substrates (frc environmental 1998; WBM 1998). A complete list of invertebrates recorded from Shute Bay during the present study is presented in Appendix C. Other mobile macrobenthos previously recorded from Shute Bay include *Calappa* sp. and *Camposcia* sp. crabs, estuary shrimp (*Palaemonetes* sp.), bay prawns (*Metapenaeus* sp.), brown tiger prawns (*Penaeus esculentus*) and squat lobsters (Galatheidae) (frc environmental 1998).

The mangrove community of the bight of the bay (several hundred metres to the west of the proposed development site) is wider with a greater abundance of crab burrows than within the development site. Broad-fronted mangrove crabs, furry-clawed crabs, mangrove mud creepers and scabra periwinkles were all common in this area. Telescope mud creepers (*Telescopium telescopium*) and striate mud creepers (*Terebralia sulcatus*) were also abundant in the upper intertidal, as were the characteristic burrows of mangrove crabs (*Sesarma* spp.) and mangrove lobsters (*Thalassina* sp.).

Within and Adjacent to the Marina Footprint

The subtidal substrate within the marina footprint is predominantly silty sand and contains abundant shell and rubble fragments. Benthic infaunal communities are dominated by lucinid bivalves and polychaete worms from the families Capitellidae, Eunicidae, Glyceridae, Lumberinidae, Maldanidae, Nereidae and Terebellidae.

Foraminifera are highly abundant within the sediments, and anemones and sea pens (*Pteroeides* sp.) are common components of the epibenthic fauna. Deep burrows, probably belonging to one or more species of mantis shrimp (Squillidae) were common (approximately one per three square metres) within the less densely vegetated fine substrate.

Larger fragments of rubble within the embayment support a variety of benthic invertebrate fauna, including sponges (Demospongiae), ascidians (Ascidiacea), bryozoa, and tube worms (Sabellidae). All individuals / colonies are small, indicating a physically unstable environment.

Within the adjacent mangrove forest, mangrove mud creepers (*Cerithidea anticipata*), broad-fronted mangrove crabs (*Metopograpsus frontalis*) and scabra periwinkles (*Littoraria scabra*) were abundant. Barnacles and hooded rock oysters (*Saccostrea cucculata*) were also common on the stilt roots of *Rhizophora* mangroves. Furry-clawed crabs (*Austraplax tridentata*), sentinel crabs (*Macropthalamus* sp.) and lineate nerites (*Nerita balteata*) were present in lower numbers.

Occasional rocky outcrops within the intertidal zone support a community of microalgal-grazing gastropods, including corniwinks (*Bembicium* sp.), pyramid nodiwinks (*Nodolittorina pyramidalis*) and waved nerites (*Nerita undata*). Carnivorous whelks (*Morula marginalba*), striate mud creepers and small barnacles were also in these areas.

Within the Predicted Dredge Plume

The benthic infauna in the area of the predicted dredge plume (i.e. of the access channel and adjoining substrate)(refer Figure 3.1) is dominated by mactrid and lucinid bivalves and polychaete worms from the families Capitellidae, Eunicidae, Glyceridae, Lumberinidae, Maldanidae, Nereidae, Onuphidae, Sabellaridae and Terebellidae. Foraminifera, anemones, sea pens (*Pteroeides* sp.); mantis shrimps (as evidenced by their burrows) are also common in this area.

8.2 A Regional Perspective

Shute Bay is characterised by shallow water, coarse reefal and fine terrigenous sediments supporting a moderate abundance of benthic epi- and infauna, including bivalve molluscs, worms, burrowing crustacea, abundant foraminifera, and occasional small sponges and sea pens. Such a benthic faunal community is typical of shallow water, mobile sediment substrates along the north Queensland coast. Within the suite of habitats present within the Shute Bay region, this benthic faunal community is not of outstanding ecological significance: it lacks the physical scale and complexity of nearby reefal habitat, and supports a less dense community of infauna than the fine sediments of nearby bays (frc environmental 1998).

The Whitsundays region includes a large number of embayments that are characterised by intertidal and shallow subtidal soft sediments (ranging from rubbles through sands to fine silts), commonly fringed by mangroves, supporting seagrass, and some rocky outcrops. The shallow soft sediments of Shute Bay comprise only a small proportion of this habitat within the region. Given the planktonic larval stages of many of the benthic species recorded from Shute Bay, it is reasonable to conclude that each species of benthic fauna recorded from Shute Bay is likely to be widely distributed and common within the region.

8.3 Historical Stability of the Benthic Infaunal Communities

Infaunal invertebrate assemblages are characterised by extreme temporal instability. The composition of macro-benthic communities varies at a variety of temporal scales, from hours to years, with fluctuations in a range of biotic and abiotic factors (e.g. Barry & Dayton 1991; Morrisey et al. 1992; Wilson et al. 1998). These include sediment type, water movement, water depth, tidal cycles, flooding, salinity, temperature, predation, competition and recruitment (e.g. Barry & Dayton 1991; Morrisey et al. 1992; Skilleter 1998, and references cited therein).

There is little published information concerning the temporal scales that account for variability in benthic communities (Morrisey et al. 1992; Wilson et al. 1998). Short-term variations usually result from factors acting at small spatial scales, whilst factors affecting larger spatial scales would be expected to have a longer impact on communities (Morrisey et al. 1992).

No temporal data is available on benthic invertebrate temporal variation for Shute Bay.

9 Fish and Fisheries of Shute Bay

9.1 Fish

The coral, mangrove and seagrass communities of Shute Bay support a diverse assemblage of fishes.

Coral communities in Shute Bay support a variety of fin-fish including butterfly fish (Chaetodontidae), seaperch (*Lutjanus* spp.), rabbitfish (*Siganus* spp.), damselfish (Pomacentridae), angelfish (Pomacanthidae), groupers (Serranidae), surgeonfish (*Acanthus nigicauda*), emperors (*Lethrinus* spp.), yellowfin bream (*Acanthopagrus australis*), painted sweetlip (*Diagramma picta*), tuskfish (*Choerodon* spp.), and other wrasses (Labridae).

A total of 15 families of fin-fish and 2 families of commercially important crustacea were recorded from the mangrove communities of Shute Bay during our April 2007 survey. Recreationally and commercially important species recorded from the mangroves of Shute Bay include, trevally (*Caranx* sp.), queenfish (*Scomberoides commersonianus*), black spot seaperch (*Lutjanus fulviflamma*), sea mullet (*Mugil cephalus*) and whiting (*Sillago analis*). Two commercially and recreationally important crustaceans were recorded: brown tiger prawns (*Metapenaeus esculentus*) and mud crabs (*Scylla serrata*).

Mangrove communities in the west and south of the bay supported greater total abundances and a higher species richness of fin-fish than those communities in the footprint of the proposed marina (Appendix D). The fish assemblages of the mangrove communities in the footprint of the proposed marina were characterised by mobile, transient species offering little direct commercial or recreational value, in particular hardyheads (*Atherinidae* spp.) and silverbiddies (*Gerres subfasciatus*). No commercially or recreationally important species were recorded from the mangroves communities in the north of the bay (in the proposed marina footprint). No species of conservation significance were recorded from the mangrove communities of Shute Bay during the 2007 or 2004 surveys.

Seagrass communities within Shute Bay provide nursery habitat for larval and juvenile fishes from a variety of commercially and recreationally important species, including trevally (*Carangoides* sp.), queenfish (*Scomberoides commersonianus*), dusky flathead (*Platycephalus fuscus*) and flounder (*Pseudorhombus* sp.). The seagrass communities of Shute Bay also provide critical habitat for populations of blennies, gobies, hardyheads, ponyfish and silverbiddies, which are an important food source for commercially and recreationally important fish species. They also provide critical habitat for conservationally significant species, including the mangrove pipefish (*Hippichthys penicillus*).

As with mangrove communities, seagrass communities in the west and south of the bay supported a greater total abundance and higher species richness than those communities in the footprint of the proposed marina (Appendix D). The relative low abundance and diversity of the fish assemblages from both the mangrove and seagrass communities in the north of the bay, may reflect differences in the proximity of the two community types, with seagrasses in the north of the bay being more distant to significant mangroves than seagrasses in the west and south of the bay. Proximity of mangroves has been demonstrated to strongly influence the assemblages of seagrass communities (e.g. Jelbart et al. 2007, Skilleter et al. 2005). Jelbart et al. (2007) recorded significantly greater densities of fish species and juvenile fish species in seagrass beds in close proximity to mangroves compared to beds further away. Skilleter et al. (2005) demonstrated that the abundances of two species of penaeid prawns were greater in seagrass beds nearer mangroves, regardless of seagrass shoot density, concluding that the influence of habitat connectivity was more important than structural complexity.

Greater habitat fragmentation may also result in the lower abundances and diversity of fish and crustacean species that were recorded from the seagrass communities in the north of the bay. Seagrass communities in the north of the bay are generally small, and highly fragmented, typically occurring in association with depressions and channels of small tributary creeks running from the mangroves. Fragmentation of seagrass beds has been demonstrated to influence the diversity and abundance of infauna and epifauna utilising the habitat (Reed & Hovel 2006; Jelbart et al. 2006), with increased fragmentation typically leading to lower abundance and diversity of species within a patch (Jackson et al. 2006; Connolly & Hindell 2006).

A full list of the fish (including crustacea) species recorded from the mangrove, seagrass and coral communities of Shute Bay, during the June 2004 and April 2007 surveys, is presented in Appendix D.

A Regional Perspective

Fishes sighted around the rocky reef and coral outcrops in Shute Bay are typical of inshore tropical reefs. Coastal reefs, such as that partially enclosing Shute Bay, are thought to be important as nurseries for a variety of reef fishes. In particular, inshore reefs are often regarded as important nursery sites for the juveniles of a number of seaperch species, including *Lutjanus carponotatus*, *L. fulviflamma*, *L. fulvus*, and *L.*

russelli, with larvae recruiting to these inshore reefs from offshore breeding sites, and sub-adults subsequently migrating offshore.

Seagrass areas of the coastal Whitsunday region have been demonstrated to support populations of flathead (*Platycephalus* spp.), garfish (Hemiramphidae), mullet (Mugilidae), trevally (Carangidae), whiting (*Sillago* spp.) and yellowfin bream (*Acanthopagrus australis*) (EMG 1988; frc environmental 2002a; WBM 1998). Mangroves in the Airlie Beach area are known to support cod (*Epinephelus* spp.), mangrove jack (*Lutjanus argentimaculatus*), threadfin salmon (*Polynemus sheridani*), trevallies (*Caranx* spp.) and mud crabs (*Scylla serrata)* during high tide (EMG 1988; frc environmental 2002a; WBM 1998). Seagrass meadows serve as nursery grounds for a variety of species that subsequently migrate to offshore habitat (see Sections 10.1 and 11.2).

Sub-adult king and tiger prawns are known to utilize seagrass and adjacent unvegetated areas in the Shute region (prior to migration to offshore habitat), and juvenile banana prawns have been recorded in high densities from local mangrove forests (again prior to migrating offshore as adults) (frc environmental 2002a; SKM 1988; WBM 1998).

9.2 Fisheries

Recreational Fisheries

Recreational fishers regularly take excellent catches of queenfish (*Scomberoides* spp.), cobia (*Rachycentron canadus*), and trevally (*Caranx* spp.; *Carangoides* spp.) off the Shute Harbour wharf complex, and by boat in adjoining waters (B. Humphreys [Harbour Side Boat Hire] 1999, pers. comm). Cast netting for baitfish (*Nematalosa* spp. and other Clupeids) is conducted in the shallow waters of Shute Harbour, adjacent to boatramps and the jetty complex. Anglers fishing the fringing reefs of the area target coral trout (*Plectropomus leopardus*) and report good catches over the winter months. Barramundi (*Lates calcarifer*), salmon (*Eleutheronema* spp.) and grunter (*Pelates* spp.) are taken in small numbers within Shute Bay over the summer months.

Shute Bay is not considered a ‘prime’ fishing location by local anglers, and the creeks that run to Shute Bay are regarded by many locals as being too small to provide significant nursery sites (B. Humphreys [Harbour Side Boat Hire] 1999, pers. comm).

Commercial Fisheries

Commercial netting is prohibited within Shute Bay and adjoining waters; commercial line fishers may occasionally fish the offshore reefs (J. Fisher [Queensland Commercial Fisheries Organisation] 1999, pers. comm.).

The Whitsunday's region supports important trawl fisheries for scallops and prawns (Williams 1997). The majority of trawl fishing in the Whitsunday's occurs in Repulse Bay, and some fishing occurs in coastal bays north of Pioneer Bay. The commercial catch is predominantly barramundi, blue threadfin, king threadfin, grunter, whiting, mullet, bream, garfish, dusky flathead and trevally (Williams 1997).

Indigenous Fishing

No indigenous fishing has been reported from Shute Bay.

10 Relative Fisheries Values of Mangrove and Seagrass Habitats of Shute Bay

10.1 Mangroves and Seagrass as Habitat

Marine vegetated habitats, such as mangroves and seagrasses, typically have extremely high rates of primary and secondary productivity. They provide a range of ecologically valuable ‘services’ and are thought to be of particular importance for maintaining biodiversity and supporting both local and offshore fisheries (Beck et al. 2001, Skilleter & Loneragan 2003).

Mangroves and seagrass often support a high abundance and diversity of fish and invertebrates, which are harvested by inshore fisheries. In addition to sustaining these adult populations, they provide juvenile fin-fish and crustaceans with rich and productive areas in which to forage and escape predators (Robertson & Duke 1987; Chong et al. 1990; Laegdsgaard & Johnson 2001). Mangroves and seagrasses are widely recognised for their role as ‘nurseries’ for juvenile fish, crabs and prawns, and their subsequent contribution through recruitment to the productivity of offshore fisheries (Beck et al. 2001; Laegdsgaard & Johnson 1995).

The primary characteristics of mangrove and seagrass habitats that are thought to contribute to their value in supporting and maintaining fish stocks and estuarine fisheries include: the availability of enhanced food supply in the form, of elevated primary and secondary productivity; the provision of refuges from predation; and a reduced physical harshness and lower turbulence when compared with habitats with lower structural relief (Laegdsgaard & Johnson 2001; Skilleter & Loneragan 2003). These characteristics function synergistically, and positively influence the growth and survival of juvenile fish and crustaceans.

Estuarine systems are a ‘seascape’ of interconnected patches of habitat, linked actively through the movement of organisms and passively through the waterborne transport of primary production (Loneragan et al. 1997; Micheli & Petersen 1999; Rapoze & Oviatt 2000; Skilleter et al. 2005). A change in the size, physical complexity, fragmentation or relative position of adjacent habitats can influence the structure of local populations and the function of linkages between adjacent habitats, which may in-turn effect the nursery value of the estuary and consequently the productivity of offshore fisheries (Kareiva, 1990; Robbins & Bell 1994; Skilleter et al. 2005).

10.2 Mangrove and Seagrass Habitat of Shute Bay

The mangroves on the western and southern shores of Shute Bay have a relatively high value to fisheries. Mangroves in these areas typically exhibited high: canopy cover (typically 60 - 80%); canopy height (8 -12 m); numbers and densities of seedlings; cover of litter (particularly for communities in the western bay); cover of mangrove algae; and abundance of infauna, typically decapod crustaceans and whelks (Appendix E). In contrast, mangroves in the north of Shute Bay (in the footprint of the proposed marina) exhibit a low value to fisheries. These communities typically had lower canopy height and cover, a lower amount of benthic structure (as evidenced by a lower number of trees per 100 m^2, a lower abundance and density of aerial roots and seedlings), and a lower cover of littler and mangrove algae than communities in the western and southern shores. Mangroves in the north of Shute Bay also supported the lowest abundance of infauna, particularly whelks and crabs (as evidenced by a lower number of crab burrows per m per 1 m^2) (Appendix E). These communities were also found to support lower total abundances and lower species richness of fish and commercially and recreationally important crustaceans, than those communities in the west and south of the Bay (see Appendix D). The fish assemblages of these communities were largely characterised by transient, mobile species with little direct commercial or recreational value, further highlighting the relatively low value of these mangroves habitat to fisheries.

The relatively low value to fisheries of the mangroves in the north of Shute Bay is further influenced by their location. The mangroves of this region grow in a narrow fringe between the intertidal zone and a steep bank leading to Shute Harbour Road. The ground in this area is relatively coarse, with large rocks, reducing the ability of mangroves to colonise the area, resulting in a lower overall cover than communities in the west and south of the bay (Section 5). Mangrove habitats in this area are relatively simple, lacking the direct connectivity with seagrass communities seen elsewhere in the bay. This connectivity between mangrove and seagrass communities is an important factor that has been shown to affect the structure and composition of fish assemblages, with seagrass-mangrove habitat mosaics generally supporting higher fish abundances than isolated habitats (Jelbart et al. 2006; Irlandi & Crawford 1997).

Little difference was observed in the relative value to fisheries of the seagrass communities in the north, west and south of Shute Bay. Each of these communities had a low number of species (2 – 3), low biomass, and low shoot height. Communities in the bight of the bay supported significantly higher whelk abundance than communities in the north and south. A full account of our assessment of the relative fish habitat values of the mangrove and seagrass communities of Shute Bay is presented in Appendix E.

11 Ecological Processes of Shute Bay

11.1 Foodwebs

Shute Bay contains numerous habitats of ecological importance, including mangroves, soft sediments, and small patches of seagrasses, saltmarsh, and coral communities. These habitats, individually and collectively, support a number of important ecological processes. Ecological processes are typically not habitat-exclusive; that is, few processes are reliant on only one particular habitat.

Shute Bay supports a diversity of foodwebs that varies both spatially and temporally. Foodwebs can be broadly delineated according to the varying habitats of the bay, although many foodwebs 'bridge' habitats. Marine plant communities, such as mangroves, saltmarshes and seagrasses, support highly productive detrital foodchains through leaf litter fall and microalgae production, which in turn supports invertebrates and juvenile fish, and consequently larger predators. The spit to the south of Shute Bay supports a complex matrix of habitats, including coral dominated communities, seagrass and macroalgae communities, and bare sand, which support a number of food webs and integrated trophic pathways, from micro-herbivory to higher order predation (Arias-Gonzalez et al. 1997).

11.2 Reproduction and Rearing

The mangroves and seagrasses of Shute Bay play an important role in the life history of a number of commercially and recreationally important species. Mangroves and seagrasses are widely recognised for their role as 'nurseries' for juvenile fish, crabs and prawns, and their subsequent contribution through recruitment to the productivity of offshore fisheries (Beck et al. 2001; Laegdsgaard & Johnson 1995). For example, adult mud crabs spawn off-shore, post-larvae move into coastal waters, where they settle in association with seagrass meadows and adjacent sand bars. Older juveniles typically move into narrow, mangrove-lined tidal waterways and adults move into larger channels and the open estuary (Hill et al. 1982) (Figure 11.1). A similar pattern of movement and utilisation of marine plant communities has been documented from a number of commercially important prawn species recorded from Shute Bay, including banana prawns (*Penaeus merguiensis*) and tiger prawns (*Penaeus esculentus*).

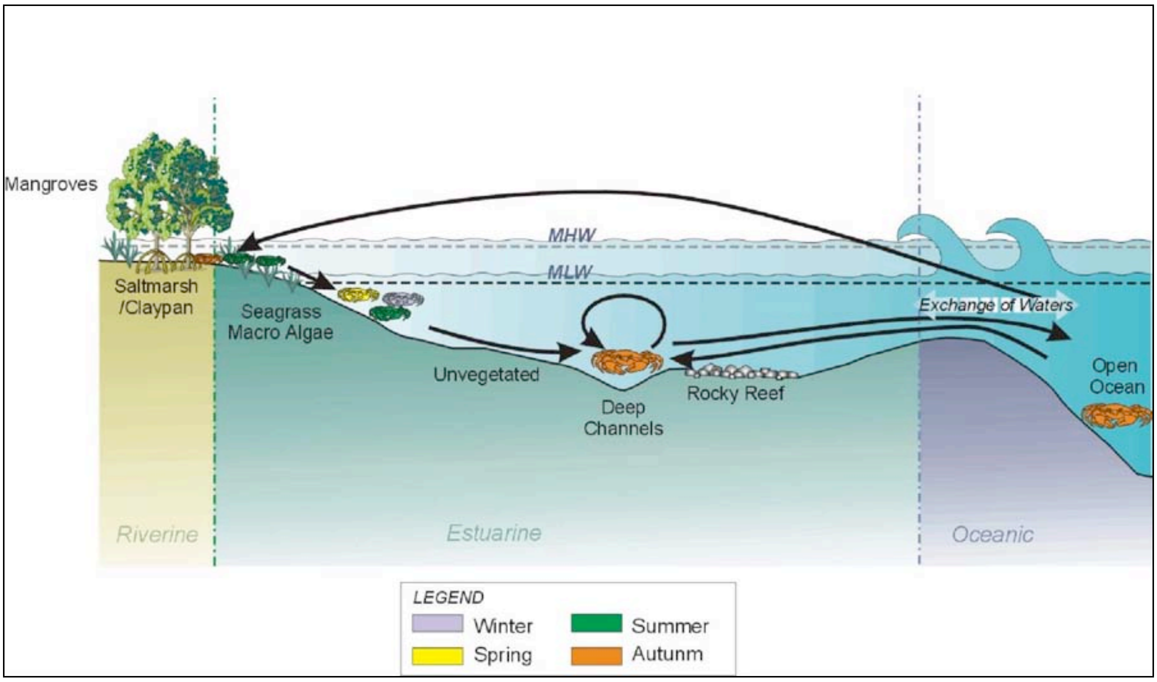


Figure 11.1 Life cycle and habitat associations for the mud crab (SKM / frc environmental 2001).

11.3 Ecological Attributes of the Habitats of Shute Bay

Mangroves

The term 'mangroves' refers to a vegetation type, which is essentially comprised of trees that are able to withstand regular inundation by both fresh and salt water. Typically, mangroves are restricted to sheltered shorelines occupying the intertidal shallows between the sea and land. The 'soil' or sediment upon which mangroves grow may be clean coarse sand, but is more commonly fine silt and mud, high in nutrients but essentially anaerobic (lacking in oxygen).

Mangroves are an important component of the estuarine habitat because they:

- input significant amounts of vegetable matter into the food chain. Leaves, fruits and bark fragments fall either directly into the water or to the ground where they are carried into the water on the next tide. As these components decompose, they provide both soluble nutrients and detrital fragments that are eaten by crustacea such as prawns and crabs and some fish. Bacteria and fungi also feed on the decomposing matter and in turn are eaten by larger organisms (West 1985);

- trap, accumulate and release nutrients (and in some cases pollutants) and particulate matter (silt) from surrounding land, thus acting as a buffer to the direct effects of runoff (West 1985);
- provide a habitat or shelter to a range of fauna and flora (e.g. Morton et al. 1987). Mangroves are recognised as important roosting sites for birds and macro-bats (e.g. Driscoll 1992), and the sediment in which they grow typically supports both a high diversity and abundance of fauna. Many species of algae and 'terrestrial' epiphytes are commonly found in association with mangrove communities. The creeks that wind through large mangrove forests are also important as fish and crustacean habitats (Blaber 2000; Robertson & Blaber 1992; Robertson & Duke 1990; Vance et al. 1990)
- protect the shoreline from erosion emanating either from the water (waves, boat wash) or the land (runoff) and contribute to the establishment of islands and the extension of shorelines (Blamey 1992)

Estuarine mangrove forests are important nursery grounds for many species of juvenile fishes (Blaber 1997; Halliday & Young 1996; Laegdsgaard & Johnson 1995; Robertson & Blaber 1992; Robertson & Duke 1990) and by comparison characteristically support greater abundances of fish than either seagrass areas or unvegetated tidal flats (Blaber et al. 1992; Laegdsgaard & Johnson 1995; Robertson & Duke 1987). Subtidal habitats characterised by mangrove-lined channels support a variety of fish species, which appear to have habitat-specific distributions according to individual species requirements for food and shelter from predation (Zeller 1998). For example, mangrove prop roots and fallen timber snags are influential in the distribution of estuarine snappers (such as *Lutjanus argentimaculatus*), rabbit fishes and bream, supporting a higher abundance of these species than unvegetated banks and mid-channel habitat. These latter habitats also support a smaller diversity of species, but are none the less positively correlated with the distribution of groupers and ariid catfishes (Sheaves 1996).

The branches, twigs and leaves of mangroves and other coastal plants, fallen into the sea and moved about by tidal action, also form temporary habitats for juvenile fishes (Conacher et al. 1996), often remote from the mangrove forests themselves (Daniel & Robertson 1990). Decaying organic matter of both plant and animal origins is consumed by both juvenile and adult greasy back prawn, and juvenile banana prawns – obligate residents of mud banks adjacent to mangroves (Staples et al. 1985). Adult banana prawns eat both small benthic invertebrates feeding on detritus in channels draining mangroves, and benthic algae on adjacent mud flats (Newell et al. 1995).

Saltmarsh / Claypan

Coastal saltmarshes are found in saline areas and are dominated by herbs, grasses or low shrubs (Adam 1990). Saltmarshes are frequently found in the upper intertidal, landward of the mangrove forests on areas that are infrequently inundated by tidal or fresh water, and that consequently have very high soil water salinities. Where soil salinity exceeds the ability of saltmarsh plants to grow, bare claypans may form. The mosaic of saltmarsh and claypan elements may result in a high quantity of eco-tonal habitat.

The ecological role of saltmarsh communities is perhaps the least well understood of the vegetated intertidal communities (i.e. saltmarsh, mangroves and seagrasses), particularly in Australia. However they are thought to have the following important roles:

- stabilisation of bare mud flats. Algae frequently colonise first forming mats over the bare mud. The mucilaginous nature of the algae stabilises the sediment surface, enabling colonisation by other (saltmarsh) plants. Sediment is then trapped by the leaves of these plants leading to a gradual build up of sediment. The binding of sediment by plant roots also probably confers some resistance to erosion (van Erdt 1985, cited in Adam 1990);
- provide habitat for fish and invertebrates;
- remineralisation of terrestrial and marine debris: saltmarshes contribute to nutrient cycling, and may buffer the water bodies from excess nutrients from the land (Adam 1990); and
- provide a direct food source for terrestrial, avian and marine fauna.

Understanding of the direct use of saltmarshes by finfish and nektonic crustaceans is comparatively poor. Early seasonal studies indicated that fish of importance to commercial and recreational fisheries rarely utilise upper littoral saltmarsh habitat (Connolly et al. 1997; Morton et al. 1988;) whilst more recent studies indicate that some Queensland saltmarsh / claypan areas are commonly frequented by fish species of significance to commercial and recreational fishers (Connolly 1999).

Saltmarshes may support dense mats of algae, which are important contributors to local fisheries productivity through providing an alternative source of food to detritus (Adam 1995). Further, the shallow pools topped up intermittently by rainfall support a variety of invertebrates (including crabs, other small crustaceans and insects) that are consumed by fishes following the rising tide. In particular, juvenile bream are known to enter tidal drains into saltmarsh habitat on the rising tide to feed, moving back into deeper water as the tide recedes (Morton et al. 1987).

Seagrass

As significant primary producers (Hillman et al, 1989), seagrasses have been recognised as playing a critical role in coastal marine ecosystems (Hyland et al. 1989; Poiner & Roberts 1986; Pollard 1984). They also provide shelter and refuge for resident and transient adult and juvenile finfish, crustacea and cephalopods, many of which are of commercial and recreational importance, others of which are the preferred foods of these species (Coles et al. 1993; Connolly 1997; Dredge et al. 1977; Edgar & Shaw 1995; Gray et al. 1996; Howard et al. 1989; Hutchings 1982; McNeill et al. 1992).

Seagrass meadows, like mangroves, provide important nursery habitat, particularly for a range of crustacean species (Coles & Lee Long 1985; Connolly 1994; Laegdsgaard & Johnson 1995; McNeill et al. 1992; West & King 1996; Young 1978). In Eastern Australia, seagrasses support both a greater diversity and abundance of fishes than bare substrate (Gray et al. 1996; Middleton et al. 1984; Ramm 1986). Seagrasses also provide a direct source of food for dugong, some turtle species (Lanyon et al. 1989), and some species of fish and crustacea.

The distribution of juvenile tiger prawns (*Penaeus semisulcatus* and *P. esculentus*), eastern king prawns and endeavour prawns is strongly correlated with inshore seagrass meadows (Staples et al. 1985). Each of the species in Queensland's east coast commercial prawn catch are dependent upon seagrass meadows as nurseries where juveniles may shelter and feed before recruiting to deepwater fishing grounds (Zeller 1998). Seagrass leaves provide physical cover for young prawns and provides a substrate for both epiphytic algae and minute grazing animals, which form a major component of the prawns' diet.

The distribution of juveniles of commercially important species such as bream, tarwhine, sea mullet, flat-tail mullet, luderick and sand whiting are also positively correlated with the occurrence of seagrass (West & King 1996).

Seagrasses trap, stabilise and hold bottom sediments (Fonseca & Kenworthy 1987; Poiner & Peterken 1995); slow and retard water movement promoting sedimentation of particulate matter and inhibiting resuspension of organic and inorganic matter (Philips & Menez 1988); supply and fix biogenic calcium carbonate (den Hartog 1970); produce and trap detritus and secrete dissolved organic matter that tends to internalise nutrient cycles within the system (Moriarty et al. 1984); and provide large amounts of substrate for encrusting animals and plants (Harlin 1975; Klumpp et al. 1989).

Macroalgae

Macroalgae are a commonly overlooked component of the marine environment, which may significantly contribute to the ability of a locality to support marine life, particularly fish and crustacea. The macroalgal component of estuarine floral communities may consist of several elements: loose lying or drift algae, rhizophytic or benthic macroalgae, and epiphytic algae on seagrass or other algae (den Hartog 1979).

The ecological significance of macroalgae and its role in nurturing and feeding fish and crustacea of importance to commercial and recreational fisheries has only recently been investigated. Macroalgal communities can play a role similar to other macrobenthic plants, providing oxygen, food and habitat for small fauna.

Macroalgae are likely to perform the following functions:

- provide shelter and refuge for resident and transient adult and juvenile animals, many of which are of commercial and recreational importance (Jenkins & Wheatley 1998; Zeller 1998);
- trap, stabilise and hold bottom sediments;
- slow and retard water movement, promoting sedimentation of particulate matter and inhibiting resuspension of organic and inorganic matter;
- supply and fix biogenic calcium carbonate;
- produce and trap detritus and secrete dissolved organic matter that tends to internalise nutrient cycles within the system; and
- provide food for many species including the green turtle (*Chelonia mydas*), an endangered species.

Algae and invertebrates attached to rocky shores and reefs are grazed by a variety of fishes, such as, drummer, rabbit fish and seabream.

Drifting macroalgae increases the habitat complexity of coastal waters and substrates, and may also serve to 'redistribute' small fish and invertebrates.

Unvegetated Soft Substrate

Unvegetated sandy and muddy sediments, whilst commonly considered to be not as productive as areas supporting seagrass, are also important to the ecosystem. 'Bare' substrate is rarely bare. Where sediments are stable, benthic microalgal communities become established within both the intertidal and shallow subtidal, predominantly in the top 3 cm of sediment. Benthic micro-algae are a major food source for benthic feeders such as prawns and other crustacea, bivalves, and polychaete and nematode worms, which in turn are an important source of food for fishes including juvenile mullet (Hollaway & Tibbetts 1995), bream and whiting (Weng 1983).

Productivity rates of benthic micro-algae are highest in shallow coastal regions, with biomass greatest at water depths of less than 5m. In these shallow regions, benthic micro-algae may form the basis of the coastal food web (Dennison & Abal 1999).

Mudflat habitats may be transitional zones between juvenile and adult habitats (Laegdsgaard & Johnson 1995). Bare substrates in shallow waters may also provide shelter from larger predators and the opportunity to employ camouflage: whiting, flathead and flounder are each examples of species positively associated with bare substrate habitat.

Intertidal and shallow subtidal sand flats support a variety of fish species. Fish such as whiting and flathead feed in sandy areas, whereas other such as bream and mullet prefer the fauna associated with muddy areas.

Bream and other important species, including juvenile sand whiting, feed over and along the edges of sand banks (Morton et al. 1987). Female sand crabs are associated with sand banks, whilst males are likely to be found in adjacent gutters (Smith & Sumpton 1987). Bait species important to both commercial and recreational fishers inhabit intertidal and shallow subtidal banks of sheltered bays (e.g. worms) and estuaries (e.g. yabbies) (Zeller 1998).

The fauna associated with soft sediment habitats is typically determined by the character of the sediment: its grain size and stability, and the presence or absence (Humphries et al. 1992; Poiner 1980), or proximity (Ferrell & Bell 1991) of seagrass. Grain size influences the ability of organisms to burrow, and the stability of 'permanent' burrows. Unstable sediments support less diverse benthic communities than those that are relatively stable. For example, bare sediments within 10 m of seagrass meadows were shown to support a similar total abundance of fishes, but a reduced diversity of species when compared with nearby *Zostera* meadows, whereas bare substrate 100 m distant from the seagrass meadows supported significantly fewer individuals and species (Ferrell & Bell 1991). In partial contrast, studies of bare substrate and nearby *Ruppia* meadows showed finfish diversity to be higher over bare substrate, but abundance and biomass highest in the seagrass meadows (Humphries et al. 1992).

Shallow water bare sediment communities are characterised by widely fluctuating abundances, species richness and diversity. These fluctuations are correlated with severe abiotic disturbances (such as wind and wave activity). During calmer months, shallow bare sand may develop similar communities to deepwater bare sand habitats (Poiner 1980).

Reefal Communities including Corals

Rocky substrates, such as emergent platform reefs and boulders, support a diversity of floral and faunal communities, such as hard and soft corals, sea urchins, sea stars, crustaceans, polychaetes and many other invertebrates, as well as fishes, reptiles, seagrasses and macroalgae. The high habitat diversity (including rock pools, gullies and ledges) found in these environments may support high species diversity. These habitat types are of importance to many species that require hard substrate for colonisation. Whilst the most diverse hard coral communities occur in clear, tropical offshore waters, extensive inshore coral communities are found along much of Australia's northern coastline, and within the Indo-Pacific region. The distribution of rocky reef flora and fauna is determined by physical characteristics, such as exposure to wave action and water quality (especially turbidity), and biological characteristics, such as competition, predation, recruitment and proximity to larval sources.

12 Recognised Conservation Value of the Site and Surrounds

12.1 Conservationally Significant Habitat

Marine Parks

Commonwealth Marine Parks

Shute Bay is part of the Great Barrier Reef Marine Park (GBRMP), which extends seaward from mean low water (MLW) to beyond the continental shelf in many areas. The GBRMP was established under the Commonwealth *Great Barrier Reef Marine Park Act 1975* to protect the values of the Reef and to manage activities within the marine park area. Shute Bay is within the Townsville / Whitsunday Management Area and the Whitsunday Planning Area, to which the *Whitsundays Plan of Management 1998* applies (under the provisions of Part VB of the *Great Barrier Reef Marine Park Act 1975*).

Shute Bay is designated as a Habitat Protection Zone within the GBRMP. Habitat Protection Zones are designed to provide protection of the natural integrity and values of the marine park; whilst providing opportunities for the preservation of the values of the relatively undisturbed areas of the marine park and the continuation of existing fishing use in the area. Within Habitat Protection Zones certain activities require permits and / or are limited, including:

- aquaculture
- harvest fishing
- collecting
- line fishing
- research other than limited impact research
- shipping other than in a designated shipping area
- tourism programs
- traditional use of marine resources, and
- trolling.

The waters adjacent to Repair, Tancred and Shute islands (in the mouth of Shute Bay) are zoned as Conservation Park (Figure 12.1). Conservation Park Zones are more restrictive than Habitat Protection Zones; they allow for increased protection and conservation, while providing opportunities for reasonable use and enjoyment, including limited extractive use.

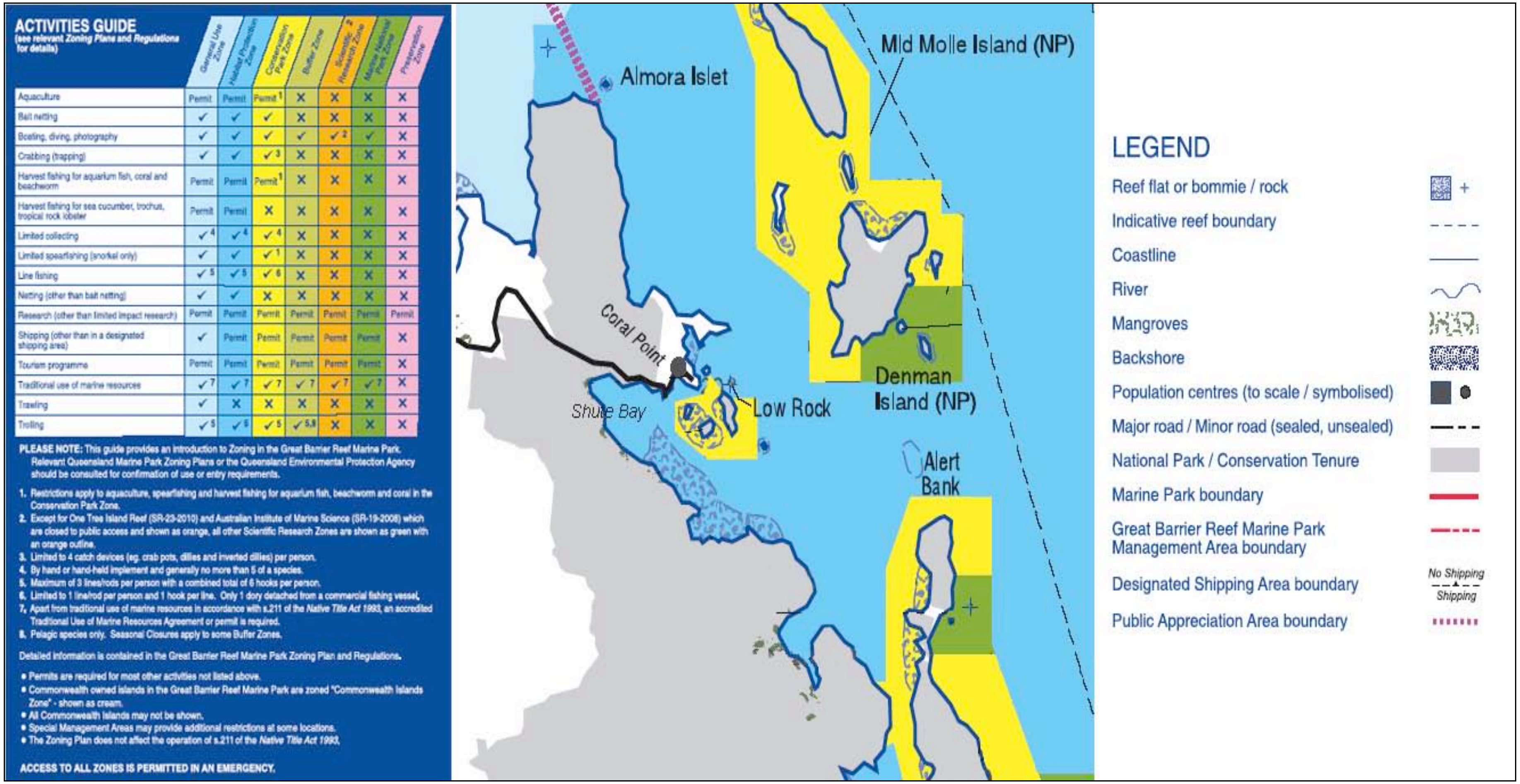


Figure 12.1 Great Barrier Reef Marine Park zonation in the vicinity of Shute Bay (GBRMPA 2007).

Queensland Marine Parks

The waters of Shute Bay are also part of the Great Barrier Reef (GBR) Coast Marine Park, protected under the Queensland *Marine Parks Act 2004*. The GBR Coast Marine Park extends seaward from highest astronomical tide (HAT) to 3 nm in most cases; hence areas between MLW and 3 nautical miles are concurrently managed by the GBRMP and the GBR Coast Marine Park (P. Koloi [GBRMPA] 2007, pers. comm.). The GBR Coast Marine Park runs the full length of the GBRMP and includes river, creek and mangrove areas.

The GBR Coast Marine Park complements the GBRMP by adopting similar zoning objectives, and entry and use provisions. Generally, activities that can be carried out within the GBR Coast MP and GBRMP are the same, however there are some Queensland-specific provisions in some areas.

In the Airlie Beach / Shute Harbour region, the GBR Coast Marine Park has replaced the former Townsville / Whitsunday Marine Park.

The Great Barrier Reef World Heritage Area

The Great Barrier Reef World Heritage Area (GBRWHA) extends from the low water mark seaward to the outer boundary of the Great Barrier Reef Marine Park beyond the continental shelf, between Cape York and Fraser Island – and thus includes the waters of Shute Bay.

The GBRWHA was inscribed in 1981 and is the largest World Heritage Area and marine protected area in the world. It is listed for all four World Heritage criteria for natural heritage as it:

- is an outstanding example representing the major stages in the earth's evolutionary history
- is an outstanding example representing significant ongoing ecological and biological processes
- is an example of superlative natural phenomena, and
- contains important and significant habitats for in situ conservation of biological diversity.

Properties that have been inscribed on the World Heritage list are automatically 'declared World Heritage Properties' and are therefore protected under the Commonwealth

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The GBRWHA is also protected under the *Great Barrier Reef Marine Park Act 1975*.

Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) commenced on the 16th July 2000. This Act provides that certain actions, in particular actions that are likely to have a significant impact on a matter of national environmental significance, are subject to a rigorous assessment and approval process. The Commonwealth may delegate to the States the responsibility for conducting assessments and, in limited circumstances, the responsibility for deciding whether to grant approval.

Matters of national environmental significance identified in the Act as triggers for the Commonwealth assessment and approval regime are:

- World Heritage properties
- Ramsar Wetlands
- nationally threatened species and ecological communities
- migratory species
- Commonwealth marine areas, and
- nuclear Actions (including uranium mining).

The project has the potential to impact on matters of national environmental significance, specifically the Great Barrier Reef World Heritage Area and nationally threatened species and migratory species, and has been referred to the Federal Environment Minister for approval under the EPBC Act.

Queensland *Nature Conservation Act 1992* and the Nature Conservation (Wildlife) Regulation 2006

Th *Queensland Nature Conservation Act 1992* and the subservient regulations are administered by the (Queensland) Environmental Protection Agency and provide generally for the protection and management of protected areas, native wildlife and wildlife habitats throughout Queensland. Wildlife is classified and listed in the Regulation as ‘presumed extinct’; ‘endangered’; ‘vulnerable’; ‘rare’; ‘near threatened’ or ‘least concern’. Under this Act, conservation plans may be prepared for any native wildlife, habitat or area that contains natural resources of significant nature conservation value.

Final conservation plans take effect as subordinate legislation, and local governments must not give approval to a proposal that is inconsistent with a conservation plan. 'Listed' species are referred to throughout this report where relevant.

Fisheries Legislation

As of 1st March 2005, a number of permit approvals previously administered by the Department of Primary Industries and Fisheries (DPI&F) under the *Fisheries Act 1994* (Fisheries Act) are now administered by the Department of Local Government, Planning, Sport and Recreation under the *Integrated Planning Act 1997* (IPA).

All waters of the state are protected against degradation by direct or indirect impact under section 125 of the Fisheries Act. If litter, soil, a noxious substance, refuse or other polluting matter is on land (including the foreshore, tidal and non-tidal land), in waters, on marine plants, or in a fish habitat, and it appears to the chief executive that the polluting matter is likely to adversely affect fisheries resources or a fish habitat, the chief executive may issue a notice requiring the person suspected of causing the pollution to take action to redress the situation.

A number of species are also protected under the Fisheries Act and Fisheries Regulation 1995 and cannot be taken. Protected species that may occur within the vicinity of the proposed development include female mud crabs, and female blue swimmer crabs.

Integrated Planning Act 1997, *Coastal Protection and Management Act 1995*, and Local Government Planning Schemes

The IPA establishes the land use planning system in Queensland to plan and regulate development. The IPA does not allow local governments to prohibit development, but each development application is assessed against desired environmental outcomes (DEO).

Applications for development within Queensland's coastal zone are assessed against specific coastal management criteria as outlined in the *Coastal Protection and Management Act 1995* (Coastal Act). This process includes consideration of coastal management policies such as the State Coastal Management Plan – Queensland's Coastal Policy and the Whitsundays Plan of Management. The State Coastal Management Plan details the coastal management outcomes, principles and policies to be considered when planning and assessing applications for environmental licences and permits. It has the effect of a State planning policy under the IPA and is a statutory instrument under s29 of the Coastal Act. Under these instruments, activities such as dredging, construction, and entering marine park areas require approvals.

Protection of Marine Plants

All marine plants, including mangroves, seagrass and saltmarsh plants that grow on intertidal and subtidal lands are protected under the Fisheries Act. It is an offence to unlawfully remove, damage or destroy a marine plant, being a plant that usually grows on, or adjacent to tidal lands. A permit is required to undertake any of these activities. Marine plants include:

- a plant that usually grows on or adjacent to tidal land, whether living, dead, standing or fallen
- material of a tidal plant, or other plant material on tidal land, and
- a plant, or material of a plant, prescribed under a regulation or management plan to be a marine plant (Couchman & Beumer 2002).

Plants of highest significance to fisheries include all mangroves, seagrass, marine algae, marine couch and samphires (Couchman & Beumer 2002). The occurrence of marine plants within and adjacent to the proposed development area is described in detail in Sections 0 and 5 of this report.

Fish Habitat Areas

Fish Habitat Areas (FHAs) are declared under the Fisheries Act to enhance existing and future fishing activities and to protect the habitat upon which fish and other fauna depend.

No FHA's have been declared within Shute Bay. The closest FHA to Shute Bay is located in Repulse Bay, approximately 40 km to the south of Shute Bay Figure 12.2.

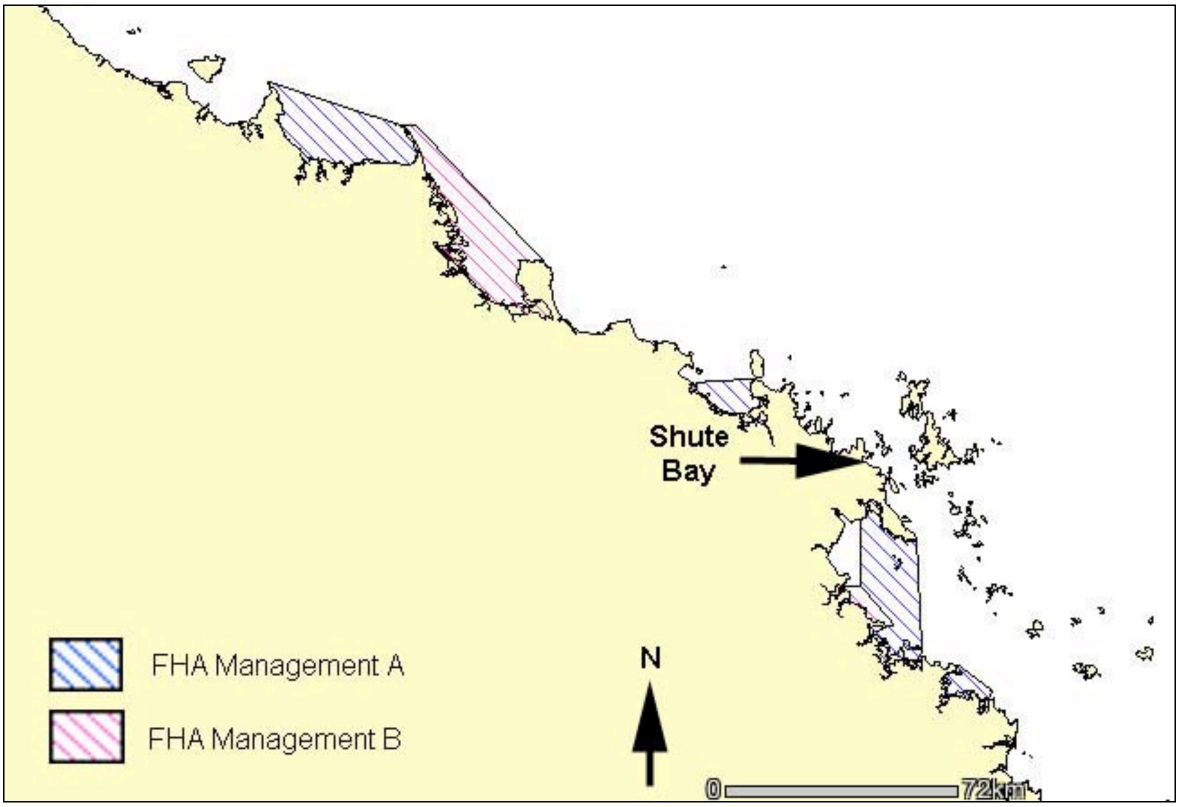


Figure 12.2 Fish Habitat Areas in the vicinity of Shute Bay (DPI 2007).

Wetlands of Significance

Wetlands of International Significance

The Ramsar convention promotes wetland conservation by nominating specific sites to the List of Wetlands of International Importance, based on importance to migratory wader bird species.

There are no Ramsar wetlands in the vicinity of Shute Bay. The closest Ramsar wetland is the Bowling Green Bay Area, approximately 180 km north of Shute Bay.

Wetlands of National Significance

All wetlands associated with the GBR, including those in Shute Bay, are listed in the Directory of Important Wetlands in Australia. A wetland is listed as being of national importance if it (Environment Australia 2001):

- is a good example of a wetland type occurring within a biogeographic region in Australia;
- is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex;
- is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail;
- supports 1% or more of the national populations of any native plant or animal taxa;
- supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level; or
- is of outstanding historical or cultural significance.

The GBR is listed as a wetland of national importance because it meets all six criteria.

Wetlands of State Significance

The majority of wetlands in Shute Bay are classified as being an 'Area of State Significance (natural resources) – Significant Coastal Wetland' in the Draft Mackay – Whitsunday Regional Coastal Management Plan (see below). These wetlands have been classified as being of state significance because of their ecological, economic and social values (EPA 2001).

Coastal Management Plan

The *State Coastal Management Plan – Queensland's Coastal Policy* (The State Plan; EPA 2001) describes how the coastal zone of Queensland is to be managed. Shute Bay lies within the Whitsunday Coast region; a Draft Regional Coastal Management Plan has been created for this region. The State Plan describes some of the important coastal management issues in this region, including: threats to water quality from agricultural, aquaculture, urban, tourism and vessel-based sources; loss and fragmentation of terrestrial and wetland habitat; expansion of residential development along the coastline; maintenance of coastal and island vegetation communities; and the impacts of acid sulfate soils.

12.2 Conservationally Significant Fauna

Shute Bay may provide habitat for a number of conservationally significant species, as recognised under various international lists, such as the International Union for Conservation of Nature and Natural Resources (IUCN) Red List; Commonwealth legislation such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and State legislation, such as the *Nature Conservation Act 1992* and Nature Conservation (Wildlife) Regulation 2006 (NCWR). Relevant species are discussed below.

Turtles, Crocodiles, Dugong and Dolphins

The distribution, abundance and ecology of these animals are discussed under a separate report (see Natural Solutions 2007).

Marine Fish

Whilst whale sharks (*Rhincodon typus*), grey nurse sharks (*Carcharius taurus*) and great white sharks (*Carcharodon carcharias)* have a range that includes the Whitsunday coast, and are listed as 'vulnerable' under the EPBC Act*,* Shute Bay does not provide significant habitat for these species. Whale sharks are highly migratory and only visit Australian waters seasonally, they are known to aggregate in waters off Ningaloo Reef and in the Coral Sea; aggregations are thought to follow pulses in food productivity. Grey nurse sharks Inhabit deep sandy-bottomed gutters and caves associated with inshore rocky reefs and islands, which are located in close proximity to areas of deeper water. Great white sharks are highly pelagic; they are typically found in temperate climes but can be found in tropical waters on occasion.

All fish from the families Syngnathidae (seahorses, seadragons and pipefish) and Solenostomidae (ghost pipefish) are listed marine species under the EPBC Act. Several species of Syngnathids and Solenostomids may occur in Shute Bay (EPA 2007), with the mangrove pipefish (*Hippichthys penicillus*) being recorded during seine net survey of the seagrass communities of the bay. Syngnathids and Solenostomids can live in a range of habitats, including: sandy bottom habitats; seagrass, sponge, algae or rubble beds; and coral reefs (Pogonoski et al. 2002; Kuiter 2000 and Vincent 1997, both cited in Horne 2001). Although there is no evidence of population declines in Australia, worldwide populations are under pressure from traditional medicine trades and aquarium trades (Pogonoski et al. 2002). Some members of these families are also caught as bycatch in the Queensland East Coast Trawl Fishery (Stokes et al. 2004).

13 Potential Impacts and Opportunities for Mitigation

13.1 Description of the Proposed Development

The Shute Harbour Marina Development (SHMD) is a proposed multi-use marina, commercial, tourism, and residential precinct.

The proposed marina will provide 669 vessel berths, a four-star tourist resort with 117 lots of high quality resort dwellings and a base for tourism activities.

The site will be established with the following precincts, as shown on the Masterplan in Figure 13.1: marina basin (with a combined total of 669 wet berths); marina accommodation; commercial; tourism industry; managed resort accommodation; parkland; and multi-level undercover car park. The proposed marina will cover an area of approximately 42.5 hectares that presently supports intertidal and subtidal marine habitat.

Major landform adjustments involve the dredging of the marina basin to -5 metres AHD, and the creation of an isthmus (of approximately 5.70 ha in area) on the western boundary of the site. Fill for the creation of the isthmus will be sourced from terrestrial quarries, in combination with extracted sediment from Shute Bay.

The southern and eastern breakwaters would be formed using steel pile and pre-cast concrete componenets that may have toes embedded to 1m below the sea bed. The original plan investigated the suitability of rubber tyre screens supported from horizontal plastic pipe clusters (understood to be 4 x 0.6m diameter. pipelines with draft of 0.6m). However, initial investigations demonstrated that that scheme would lead to unacceptable rates of siltation in the dredged marina basin. This siltation was caused by ebb tide currents flowing through the southern marina area where current speed reduced in the much deeper water, snd thereby reduced the sediment carrying capacity. Hence the proposed structures were changed to vertical walls that were impermeable to tidal flow.

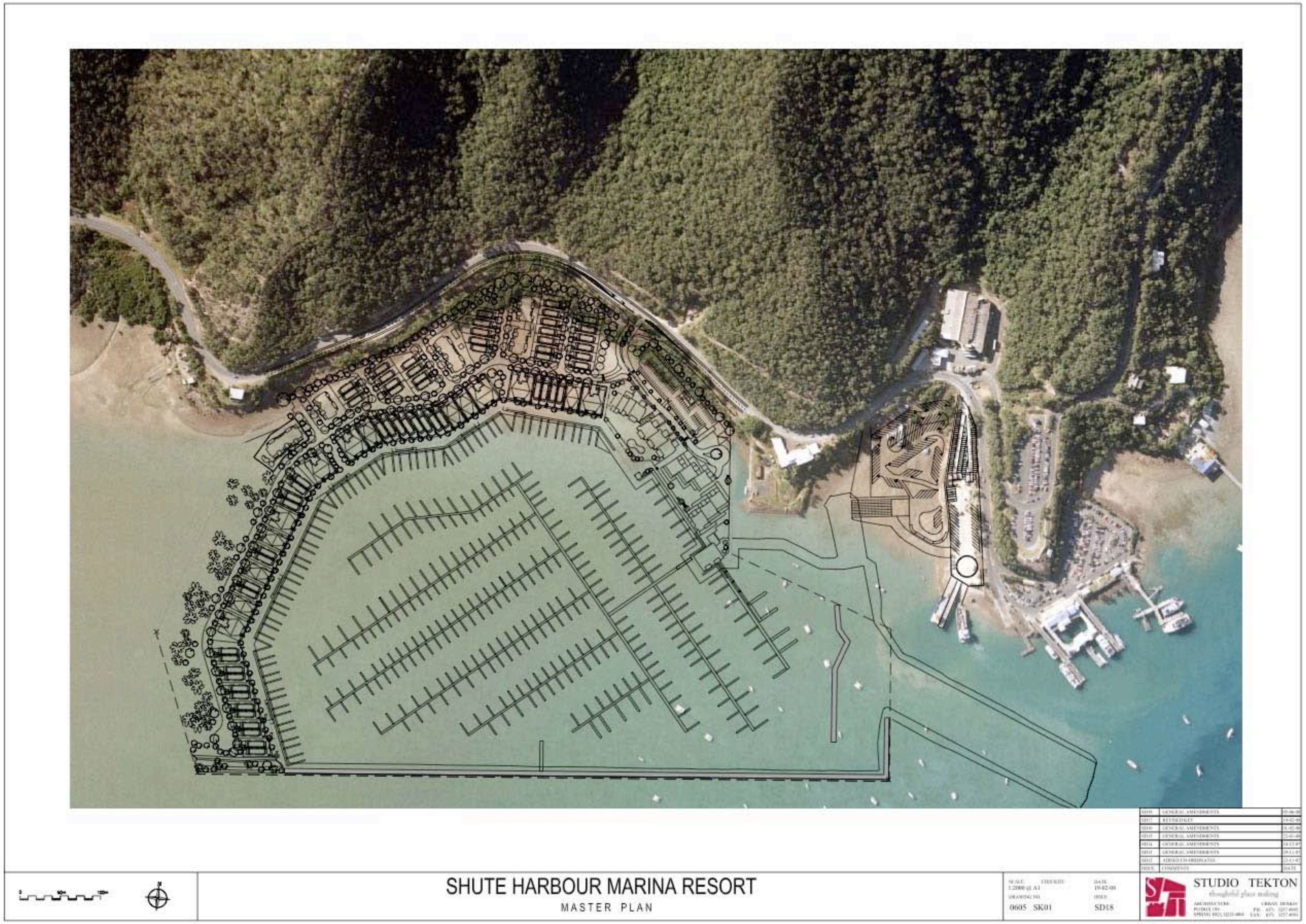


Figure 13.1 Masterplan – proposed Shute Bay Marina.

Dredging of a marine navigational channel to a depth of -5 metres AHD will allow boating access to the near-by Whitsunday islands. The design of the transit lane will be such that vessels are enabled safe passage whilst providing a safe area for aquatic fauna.

13.2 Scope of Potential Impacts

Potential impacts of the proposed development may be associated with the development of the site, or with the consequent use of the developed facilities. Impacts may be direct (e.g. removal of habitat) or indirect (e.g. through influences on water quality). Whilst some impacts will be permanent, others will be temporary and reversible.

The potential impacts of development are related to the sensitivities of floral and faunal communities within the area influenced by the proposed development. Appendix B provides a discussion of environmental factors influencing the distribution and abundance of the key floral and faunal communities of the region.

Whilst the proposed development will inevitably result in some detrimental ecological impacts, it will also result in some ecological benefits, with the provision of new habitat.

13.3 Construction Phase - Direct Impacts

Loss of Habitat

Seagrass

Construction of the marina (through excavation / dredging) will result in the direct loss of approximately 14.59 ha of relatively sparse seagrass that lies within the proposed development footprint.

Recent and historical surveys of seagrass in Shute Bay indicate that current seagrass distribution within the bay is close to the maximum recorded, and consequently the calculated loss is likely to over-estimate the loss averaged over time.

Mangroves

Development of the proposed marina complex will result in the direct loss of approximately 1.84 ha of fringing mangrove forest.

Macroalgae

Development of the proposed marina will result in the direct loss of approximately 35 ha of sparse macroalgal beds from the development footprint.

Corals

Development will result in the loss of approximately 10 small coral colonies within the footprint of the proposed marina complex.

Gain of Habitat

Atificial Structures as Habitat

The proposed marina will add a significant degree of physical complexity to the intertidal and shallow subtidal habitat in the north of Shute Bay, and to the local diversity of habitat and productivity of associated flora and fauna. Habitats that provide structural and topographical relief, such as woody debris, rock and oyster reefs and rubble, play an important role in the recruitment and survival of many commercially important species (Skilleter & Loneragan 2003 and references therein). Each habitat provides a characteristic combination of hard surfaces, voids and shading, and may alter both the water quality and sediment characteristics in its immediate vicinity.

Construction of the proposed marina will result in a mosaic of habitats associated with pontoons, piles and other intertidal and subtidal structures (and of course boats). The hard surfaces of these structures may provide substrate for many species of algae, hard and soft corals, sponges, ascidians and a variety of other invertebrate fauna. In turn, this hard-substrate benthic community may provide shelter and food for a variety of fishes and other fauna (vis. the Shute Harbour Ferry Terminal and nearby Abel Point Marina, pers. obs.). The structures associated with the proposed development will also provide a high degree of shade, important in attracting many fish species (de la Moriniere et al. 2004; Verweij et al. 2006).

Studies of natural and artificial habitat have shown that each may support a fish fauna of similar species richness – yet of different (but often overlapping) assemblages (Clark & Edwards 1999; Fujita et al. 1996). The total abundance of fishes has been shown to increase with an increase in rugosity (structural complexity) and degree of fouling (Rooker et al. 1997). Whilst larger artificial structures are likely to attract both a greater abundance and diversity of organisms; small structures support a disproportionately high diversity of biota (Bohnsack et al. 1991).

Existing structures at Shute Harbour, in the ferry terminal and rent-a-yatcht marina, support diverse communities of flora and fauna (See Appendix F). The pilings and rock groyne support a rich fish assemblage, with 15 finfish families recorded in association with these artificial habitats. The existing marina pilings and sheltered rock groyne support abundant soft coral and macroalgae communities, approaching 100% cover on available substrate. It is expected that the hard sheltered structures of the proposed marina expansion will exhibit a similar cover and diversity.

Investigations of zooplankton in the Raby Bay canal estate (adjoining Moreton Bay) showed that the canal system supported higher densities of zooplankton taxa than the adjoining bay. These aggregations could provide relatively rich foraging patches for zoo-planktivorous larval and juvenile fishes (King & Williamson 1995). The man-made foreshores of Raby Bay support a similar fish fauna to the remaining mangrove lined shores (Williamson et al, 1994).

Little attention has been given to the habitat value provided by moored vessels, although the concept of floating, moored fish-attracting devices (FADs) is well appreciated by fishers and fisheries managers world-wide. Pontoons and moored boats are a common feature in the Airlie Beach / Shute Harbour region, and are capable of supporting communities similar to those associated with rocky reefs, pylons and concrete revetments (Holloway & Connell 2002).

In the current design, a rip-rap wall of approximately 400 m in length will be used to protect the western marina body. This structure will provide a variety of interstitial spaces to accommodate different species and life history stages (United States Army Corps of Engineers 1995, cited in Derbyshire 2006). The concrete faces of the southern and eastern breakwaters will provide habitat for a variety of benthic organisms. The existing rock groynes of the Shute Harbour ferry terminal support a diverse assemblage of flora and fauna. As observed at Able Point Marina, the exposed faces of the proposed concrete breakwaters are expected to support a greater diversity than the sheltered structures (See Appendix F).

The waters of the marina basin are likely to have a relatively lesser ecological value: water depths are likely to be too great to support significant communities of seagrasses and macroalgae. Habitat, and consequently ecological value, could be enhanced through these waters with the addition of fish-friendly structures. The Queensland Department of Primary Industries and Fisheries (QDPI&F) *Fisheries Guidelines for Fish-Friendly Structures* described a number of artifical 'fish-friendly' structures that may enhance the fish habitat provided by aquatic infrastructure, these include: the Fish Hab; Aqua Crib; Reef Ball; Plastic Mesh Structures; Mushroom Hats; Stake Beds; Log Cribs; Wooden Cross-pieces Structures; Wooden Pallets; and Spawning Structures (see Derbyshire 2006 for a comprehensive review). The primary value of these artifical habitats arrises from the provision of complex structural habitat, which may serve as: substrate for epibiota; nursery habitat for juvenile fish; general habitats and spawning areas for adult fish habitat. Several of these modules, or other similarly complex engineered structures, could be incorporated into the current marina design to provide additional habitat for fish and other fauna.

Natural and artificial habitat can provide a synergistic benefit to fishes. For example, in Botany Bay (NSW) a seagrass meadow within a small, constructed harbour supported abundances of post-larval and juvenile bream, tarwhine and blackfish up to 73 times that of other nearby seagrass meadows (McNeill et al. 1992).

The DPI&F outlines several general and specific fish-friendly design features intended for developments that require aquatic infrastructure (Derbyshire 2006). Specific design guidelines are included for several features included in the proposed Shute Harbour marina development, including guidelines for general small boat harbours and marinas, jetties and pontoons, boat ramps, stabilisation structures, dredge spoil, and mooring buoys (see Derbyshire 2006 for a complete review). Opportunities to enhance the habitat value of the proposed marina will be fully considered at the detailed design stage.

'Gain' of Seagrass

Development of the proposed marina and access channel will necessitate that a number of swing-moorings be relocated. These moorings currently impact on the seabed through chronic physical disturbance as the moored vessel responds to changing winds and tides. These moorings will be converted to the more environmentally friendly 'ezyride' moorings. This is expected to enable seagrass to re-establish (at those mooring beyond the footprint) and a more stable and productive benthic community to develop. Passive recolonisation of seagrass, macroalgae and a more stable benthic invertebrate fauna is expected to follow mooring relocation.

The converstion of 57 moorings is expected to result in a 'gain' of approximately 950 m^2 of seagrass and macroalgal habitat.

Gain of Mangroves

There is likely to be a gain of mangroves in the lee of the western breakwater (see altered hydrodynamics).

13.4 Indirect Impact of Construction

Construction activities including: exacavation, dredging, spoil consolidation, and pile driving have the potential to result in:

- increased suspended sediment levels and consequent sediment deposition within the bay and adjoining waters
- a release of nutrients from the disturbed sediments
- spills of hydrocarbons and other contaminants
- disturbance of acid sulfate or potential acid sulfate sediments (ASS / PASS)
- increased human activity, including changes in light and noise levels, and
- altered hydrodynamics and consequently altered patterns of sediment deosition and erosion.

The extent of impact on sedimentation or turbidity of adjoining waters during excavation will be directly related to both the techniques used and the season.

The principal indirect impacts of construction activities are summarised below.

Increased Suspended Solids Concentration and Sediment Deposition

The effects of increased suspended solids and sedimentation resulting from excavation and spoil handling are highly variable. The likelihood of increases in suspended sediments and of smothering are closely related to the characteristics of the sediment. Coarse sediments settle from the water column quickly and are unlikely to move away from the excavation site. Fine sediments remain suspended longer; may be carried further before settling, and consequently are more likely to smother marine organisms.

Plume modelling (Cardno Lawson & Trealoar 2007) shows the likely dredge plume to be generally confined to the area between the marina and the boat ramp (Figure 13.2), with a peak concentration of approximately 150 mg/L. The plume is greatest close to the bed, although suspended solids concentrations are less near the bed than near the surface. This modelling represents a conservative assessment based on 100 % dredge works. The majority of excavation activities will be undertaken in a dry environment, with sheet piling used to confine excavation works in suitable depths. Given this consideration, peak suspended solid concentrations may be lower, and persist for a shorter duration, than those modelled on 100 % dredge works.

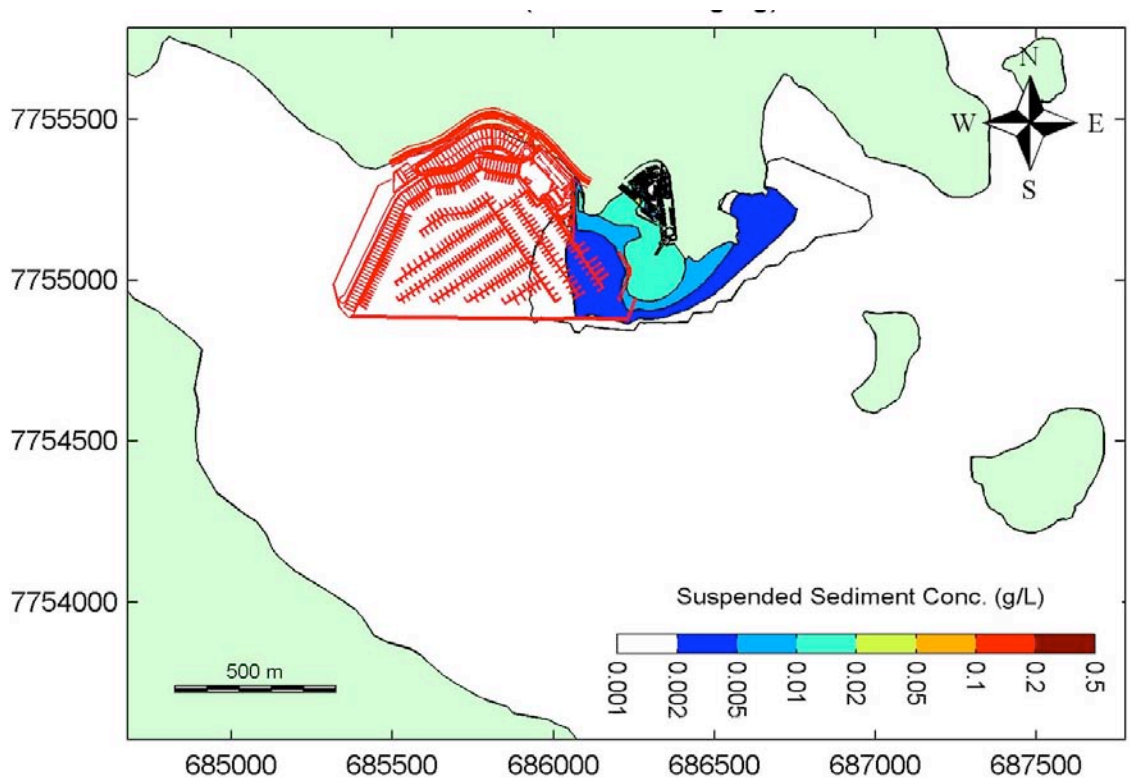


Figure 13.2 End of dredging (18:00) plume prediction (bed layer) (adapted from Cardno Lawson Treloar 2007).

Effects on Seagrass and Macroalgae Communities

The temporary increase in turbidity associated with excavation and spoil handling will reduce the penetration of light through the water column. Light availability, or specifically the duration of light intensity exceeding the photosynthetic light saturation point controls the depth distribution of seagrasses (Dennison & Alberte 1985; Dennison 1987; Abal & Dennison 1996). For example, on average 30% of surface light; a light attenuation coefficient of less than $1.4m^{-1}$ and total suspended solids of less than 10 mg/L are required for the survival of *Zostera capricorni* (Longstaff et al. 1998; Abal & Dennison 1996). *Halophila ovalis* another common species in the area, has a particularly low tolerance to light deprivation caused by pulsed turbidity such as floods and dredging (Longstaff et al. 1998). However, *Halophila ovalis* can quickly recolonise areas due to its high growth rate and high seed production.

Availability of light also affects the productivity of seagrasses. Seagrass exposed to higher light intensity is more productive than seagrass in less intense light (Grice et al. 1996). Consequently, impacts associated with dredging may result in at least a temporary decrease in seagrasses productivity. Light also controls the population dynamics of macroalgae (Lukatelich & McComb 1986a; cited in Lavery & McComb 1991).

Small patches of sparse and moderately dense *Halodule uninervis* communities (3.12 and 1.06 ha, respectively) and 12.47 ha of macroalgae communities, typically of less than 20 % total cover, lie within the predicted dredge plume and are likely to be impacted to varying degree. This figure represents a conservative aseessment based on modelled data from 100 % dredge works. Given that the majority of excavation will be conducted in a dry environment, this figure may be lower.

Effects on Corals

The effects on coral reefs of increased sedimentation and light attenuation from sediment plumes can range from mild coral stress to subtle changes in community structure, to outright coral mortality and ecological collapse of the community.

The impacts of increases in sediment deposition on coral communities can include: reduced algal and coral diversity and reductions in epifaunal densities (Hatcher *et al*. 1989). The varied biota found associated with coral communities, living or feeding in the crevices and crannies within and around corals are likely to suffer as these spaces are filled with deposited sediment (Johannes 1975). Coral communities are generally better developed, are more diverse, and with greater coral cover and rates of coral growth the lower the sediment load is in overlying waters (Rogers 1990). There is little quantitative information on the sub-lethal effects of chronic elevated turbidity and sedimentation.

Coral communities of the Whitsunday coast (including those of Shute Bay) are influenced at a broad-scale by the discharges of the Proserpine and O'Connell Rivers. The coral communities of the spit in the south of Shute Bay area are dominated by *Goniopora*, *Porites,* and *Turbinaria* species and massive corals in the family Faviidae, and are typical of inshore river dominated communities. As such, they are highly influenced by both elevated suspended solids and nutrients. Corals found in coastal habitats are also generally more efficient at sediment clearance than those species typically found on offshore reefs (Salvat 1987), and can consequently withstand deposition of sediment better than offshore species.

Patchy coral communities exist in the small, unnamed bay to the west of the Shute Harbour ferry terminal, in the path of the predicted dredge plume. Coral communities in this area are dominated by *Acropora* and *Goniopora*, which are hardy genera that are highly efficient at sediment clearing (Salvat 1987) and typically inhabit waters with limited light penetration. However, prolonged periods of elevated suspended sediment levels are likely to detrimentally impact this community.

The coral communities of the Shute Harbour ferry terminal and rent-a-yacht marina are likely to be largely unaffected by increased suspended solid concentration and sediment deposition. These corals grow in mid water, and consequently are likely to escape the majority of sediment deposition. It is unlikely that these corals will be affected by temporary reduction in light intensity, given that they currently inhabit relatively turbid waters with highly variable light penetration.

Effects on Soft Sediment Benthos

The fauna associated with soft sediment habitats is typically determined by the character of the sediment: its grain size and stability and with the presence or absence of seagrass. Grain size influences the ability of organisms to burrow, and the stability of ‘permanent’ burrows. Unstable sediments support less diverse benthic communities than those that are relatively stable. Resuspension of fine sediments can interfere with the feeding and respiration of benthic fauna.

Increases in the concentration of suspended solids may impact the respiration and feeding of a variety of taxa reducing abundance, species diversity and productivity. The deposition of fine sediment over existing substrate is likely to influence the community structure in favour of those species most able to cope with fine sediment substrate to the disadvantage of those less able. Filter feeding and gilled fauna are most likely to be affected. Whilst the proposed dredging may impact the soft sediment invertebrate communities within the dredge plume, any impact will be temporary and reversible.

Effects on Fishes

The effect of increased suspended solids concentration and sediment deposition on fish communities of the likely dredge plume dispersal area is likely to be minimal. The sparse nature of the seagrass in the area makes it unlikely habitat for conservationally significant species, such as Syngnathids or Solenostomids.

Although some marine vertebrates may avoid areas of high turbidity, areas of high turbidity may also be attractive to a range of fishes, particularly juveniles, as it confers a greater degree of protection from predators (Blaber & Blaber 1980). The predcted plume is highly unlikely to significantly influence the onshore migration of juveniles, or the offshore recruitment of adults.

Nutrient Enrichment

Nutrients released from disturbed sediments may alter the community composition of floral and consequently faunal communities. Increased nutrient loads may to lead to an increase in phytoplankton densities, and consequently a reduction in water clarity and seagrass depth distribution (Dennison et al. 1993).

Moderate amounts of additional nutrients in the water column can also increase seagrass growth (McRoy & Helfferich 1980). However, as macroalgae are more efficient at absorbing nutrients from the water column than seagrasses or coral, higher levels of nutrient enrichment can lead to an increase in macroalgae growth at the expense of seagrass and coral (Wheeler & Weidner 1983; Zimmerman & Kremer 1986; Koop et al 2001; Lapointe 1997; McCook 1999). Consequently, benthic macroalgae may overgrow and displace seagrass, whilst drift and epiphytic algae may physically shade seagrass and coral, reducing their growth and distribution (Twilley et al. 1985; Silberstein et al. 1986; Maier & Pregnall 1990; Tomasko & Lapointe 1991). Epiphytic algae may also reduce diffusive exchange of dissolved nutrients and gases at leaf surfaces (Twilley et al. 1985; Neckles et al. 1993). Acute nutrient enrichment may also stimulate the growth of mangrove and saltmarsh (Adam 1990; Adam 1995).

The trophic structure of benthic invertebrate communities often changes with increased nutrient levels, becoming dominated by small opportunistic deposit feeders. In eutrophic estuaries deposit feeding spionid and capetellid polychaete worms often tend to dominate benthic communities.

The impact of any dredging-related acute elevation of nutrient concentrations may have a moderate and temporary impact on the flora and fauna of Shute Bay. However, as the majority of excavation works will be conducted in a dry environment, these effects may be reduced.

Spills of Hydrocarbons and other Contaminants

Different organisms and different life-stages of particular organisms react to petroleum hydrocarbon pollution in different ways. The damage to marine biota by petroleum hydrocarbons is determined more by the degree of persistence of the oil than its absolute toxicity when fresh (van Gelder-Ottway 1976). As such contamination arguably poses a greater risk during operation of the proposed development than during the construction phase, the potential impacts of hydrocarbon contamination are discussed in the section discussing the impacts of operation.

Disturbance of Acid Sulfate or Potential Acid Sulfate Sediments

Disturbance of intertidal and marine sediments may expose acid sulfate potential sediments to oxidising (acidifying) conditions. Ullman & Nolan (2004) consider the sediments of Shute Bay as likely to have a potential for acid generation, but also a relatively high acid neutralising capacity. Acidification of both the sediment and adjacent waters may severely impact aquatic flora and fauna within the effected area.

Potential acid sulfate soils were formed under restricted conditions between about 3,000 and 6,000 years ago. The conditions required the presence of riverine iron-rich sediments, sulfate from seawater, the presence of sulfate reducing bacteria, and plentiful supplies of organic matter (usually mangroves).

Actual acid sulfate materials are formed when pyrite in sediments is exposed to oxidation. Pyrite (FeS_2) is unstable in the presence of specialised bacteria and atmospheric oxygen, decomposing to form ferrous iron and sulfuric acid. A common cause for the oxidation of pyrite is the excavation of pyritic material.

A direct effect of the oxidation of pyrite is the lowering of pH. The consequences of short-term and localised acidification may be profound. Chronic low level acidity may result in decreased vigour and increased incidence of disease. Historical fluctuations in commercial finfish and prawn catches may be in part attributable to periods of enhanced acidity in estuarine waters (Leadbitter 1993). The effects of acidification on Australian estuarine biota, including fishes, is poorly understood, however the relatively sudden reduction of pH has been shown to be responsible for fish-kills, disease and other disturbances (Sammut et al. 1993).

Other environmental effects of oxidation of pyrite include: the dissolution of clay minerals and the release of soluble aluminium, which is highly toxic to gilled animals (including fish, molluscs and crustacea) and aquatic plants; the release of soluble iron, also toxic to aquatic life in high concentration; and the oxidation of ferrous iron causing large decreases in dissolved oxygen.

An acid sulfate soils management plan will be developed in accordance with QASSIT Guidelines and in consultation with QASSIT (Ullman & Nolan 2004).

Human Activity

The construction of the proposed marina is likely to result in increased noise and activity. This may temporarily disturb some fauna, and they may move away. However, this is likely to be a short-term response, and they are likely to return once this increased activity ceases. Increased noise and activity with the contruction of the proposed marine is most likely to affect marine megafauna (i.e. dolphins, dugong and turtles); this is addressed in a separate report on marine megafauna (Natural Solutions 2007).

Construction activities themselves may also directly impact fauna. For example, in 1999, two marine turtles were killed in Queensland ports during dredging (Haines et al. 2000).

Altered Hydrodynamics

Modelling by Cardno Lawson & Treloar (2007a) show that the marina is likely to be well flushed: water quality within the marina will be similar to that elsewhere in Shute Bay.

Some accretion of sediment is predicted immediately in the lee of the western breakwater, though annual accretion rates are low. Scouring along the southern bay is also predicted, again at a low annual rate (refer CLT's Figure 4.21). Accretion in the lee of the western breakwater is likely to raise bed levels such that moderate and sparse *Halodule uninervis* communities are replaced by sparse mixed and sparse *Zostera muelleri*-dominated communities; whilst scouring along the central southern shore of Shute Bay may favour *Halodule uninervis* over existing *Zostera muelleri* and *Halophila ovalis* dominated communities (Figure 13.3). That is, accretion on one side of Shute Bay and scouring on the other are likely to have impacts that in essence off-set each other.

Accretion in the lee of the marina may increase the recruitment success of mangroves here; whilst scouring may reduce the recruirtment success of mangroves to the central southern shore of the bay.

The predicted changes in the distribution and abundance of mangrove and seagraess are likely to be very subtle (though measurable). No ecologically significant net loss or gain of seagrass or mangrove habitat within Shute Bay is predicted as a consequnce of altered hydrodynamics and related sediment deposition and scouring.

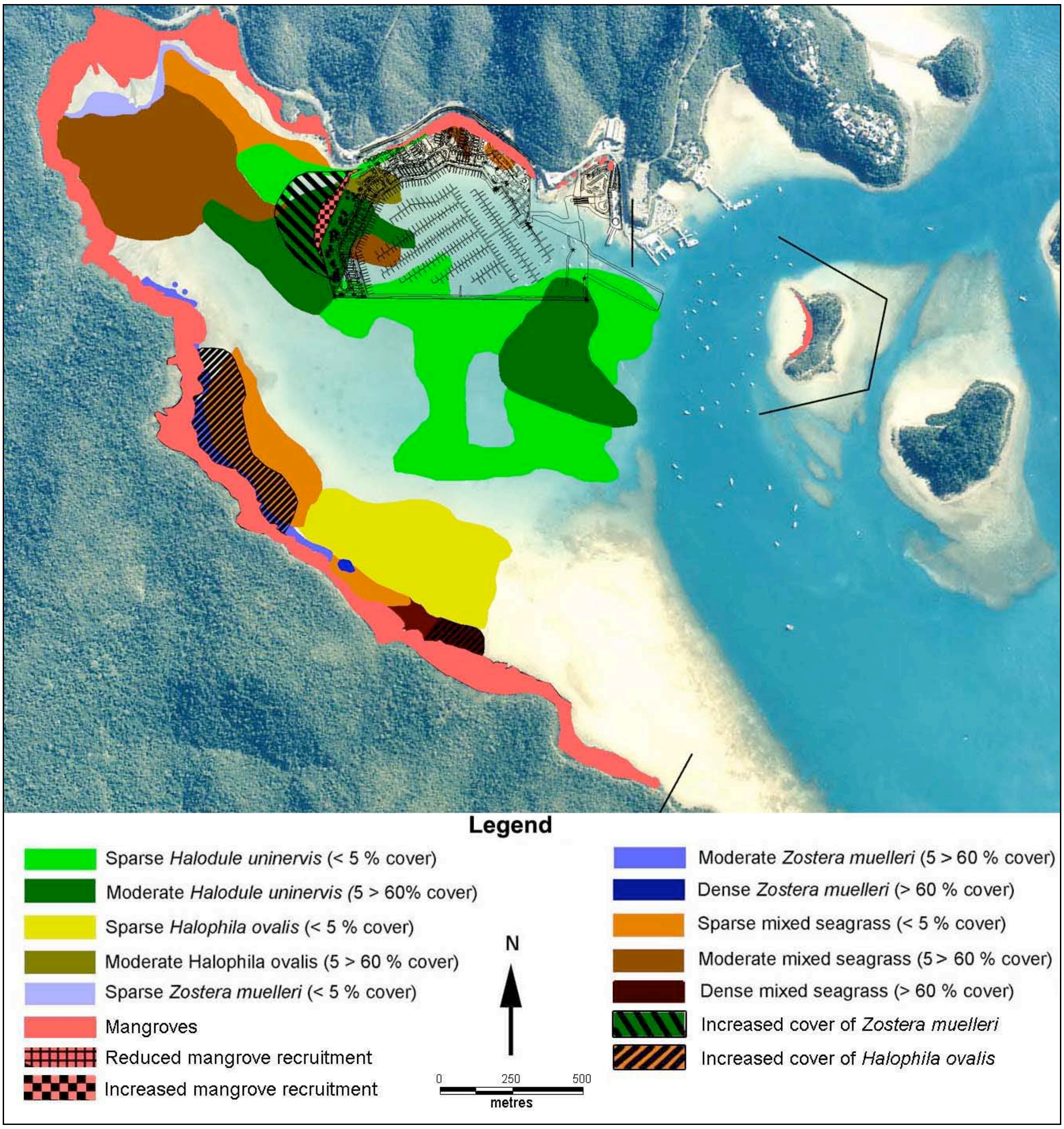


Figure 13.3 Likely changes to seagrass and mangrove communities with altered hydrodynamics, with a styalised representation of the proposed marina and resort.

Other Impacts, including the Disturbance of Contaminated Sediments

Excavation activities may alter other aspects of water quality. For example, disturbance of sediments in a reducing environment can lead to a significant elevation of biological and chemical oxygen demand, depleting enclosed waters of dissolved oxygen. Increases in bacterial concentration are typically associated with turbid waters surrounding dredging operations (Salvat 1987). Bacteria are known to adhere to suspended solids. Toxicants may also be released from the sediment. Depending upon the nature and extent of this release, impacts could range from morbidity and the reduction of reproductive capacity of some species, through to outright mortality of plants and animals.

Boat users have historically used a nearby embayment as an ad hoc hardstand area. It is likely that the stripping and application of antifouls containing copper and tributyl tin has been a regular occurrence and consequently the sediments in this area may be contaminated.

13.5 Impacts of Marina Operation

Potential impacts associated with the operation of the marina and associated infrastructure are likely to be principally linked to human activity. Use of the marina will result in an increase in human activity, specifically an increase in boat traffic within Shute Bay, and an increase in, for example, refuelling operations. There is likely to be an increase in recreational fishing in the bay, and any ‘charismatic megafauna’ (e.g. turtles and dugong) are likely to attract increased attention. There will be an increased opportunity for litter to find its way into the bay. The characteristics of these potential impacts are discussed in detail in the following sections.

Hydrocarbon Contamination

Chronic hydrocarbon pollution can result from the synergistic effects of small, frequent spills. Such a pattern of spillage may be commonly associated with the refuelling of smaller crafts at marinas, other purpose built and ad hoc refuelling facilities and boat ramps (refer Cullen Grummitt and Roe 2000; GBRMPA 1998). Marinas that support considerable activity, including pleasure boat marinas, boat repair facilities and commercial fishing operations have significantly higher levels of both aromatic and aliphatic hydrocarbons than estuaries seldom used by boats (Voudrias & Smith 1986). The small-scale spills commonly associated with small-scale refuelling operations are rarely reported or treated: the petrol, diesel or oils are left to disperse under essentially natural conditions.

In contrast to the comprehensive consideration given to the effects of large scale or ‘industrial’ fuel and oil spills, the effects of small-scale fuel spills have been very poorly documented.

However, it is clear that the chronic presence of hydrocarbons has the potential to cause locally significant impacts. Low levels of petroleum hydrocarbons in the aquatic environment are adsorbed onto, or incorporated into, the sediments, where they may persist for years (Pelletier et al. 1991; Voudrias & Smith 1986). A large number of small-scale oil spills may lead to a significant increase in hydrocarbons over time, in effect resulting in a ‘permanent’ impact. Mangrove sediments in particular may serve as long-term reservoirs for chronic contamination holding hydrocarbons for periods in excess of 5 years (Burns et al. 1994). Clearly, in determining the potential for chronic contamination at a particular site, characteristics of flushing and sediment stability need to be considered.

Whilst acute (or at least a ‘one off’) contamination may result in severe ecological consequences, communities generally recover over time. In contrast, chronic contamination can result in the ‘permanent’ (or at least for the duration of contamination) morbidity or localised extinction of flora and fauna. Floral communities and sessile faunal communities (such as the many groups of invertebrates that develop attached to the substrate) are clearly most at risk from chronic hydrocarbon pollution. As these communities often form a critical component of ‘habitat’ (providing structural complexity, shelter and often food), a ‘permanent’ impact to these communities may have a consequentially widespread impact on the mobile components of the original faunal community, including the fishes and crustacea.

Whilst ‘one off’ spills of great volume have the potential to severely impact a large area, recovery is likely; chronic small spills, though probably influencing a lesser area, effectively prevent recovery and lead to cumulative impacts. Frequent spills from a diffuse number of locations within a waterway can in concert, resulting in an enduring impact over a very wide area.

Where fuel storage and handling activities are undertaken in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids - encompassing spill containment and response protocols), the risk of acute spills is considered minor.

Maintenance Dredging

Maintenance dredging will have the same suite of impacts associated with capital dredging (discussed above).

Introduction of Marine Pests

The introduction of exotic species can threaten the integrity of natural communities, the existence of rare and endangered species, the viability of living resource-based industries and pose risks to human health (CSIRO 2005, Hutchings et al. 2002). Of the 338 exotic marine species that have been recorded in Australian waters, only 15 species are regarded as pests; a further 32 are considered as potential pests (CRC Reef 2004; CSIRO 2005).

Introductions of marine species in ballast water and via hull fouling have been identified in virtually all regions of the world. Introductions causing substantial deleterious impacts appear to occur more extensively in temperate (Hewitt 2002) than tropical regions (Hilliard & Raaymakers 1997). A survey of 12 tropical ports in eastern Australia revealed far fewer exotic marine species than in temperate ports of Australia (Hilliard & Raaymakers 1997). However, the lack of baseline surveys and the poor taxonomic status of many tropical groups may have hindered detection (Hewitt 2002). The recent incursion of the black striped mussel (*Mytilopsis sallei*) in northern Australia was due to hull fouling on a recreational vessel (CRC Reef 2004). However, many of the species that are translocated with hull fouling have minimal effects on receiving environments, which are often limited to the nuisance fouling of hard structures (CSIRO 2005).

To reduce the risk of introducing marine pests in ballast water, the International Convention for the Control and Management of Ships Ballast Water & Sediments (refer IMO 2008) requires that international ships undertake ballast water exchange at sea, or apply an alternative (IMO approved) ballast water management measure. To minimise the potential for shipping to introduce fouling marine organisms, the Australian Quarantine Inspection Service (AQIS) has developed strict new biofouling laws to protect Australia (AQIS 2006); these involve an assessement of risk and the mandatory inspection (of hull and ancillary gear) of high-risk vessels. These preventative measures are employed at major shipping ports around Australia.

The proposed marina will not serve as a point of entry to Australia and will not service international commercial shipping: consequently there will be no substantive risk of introductions via ballast water. The risk of fouling-based introductions is also very low as international vessels will be required to clear quarantine, and potentially be subject to inspection, at their port of entry. However, as a further precaution monitoring plates will be installed and inspected on a monthly basis by the marina manager.

13.6 Impacts to the World Heritage Area and State Marine Park

The marina footprint and access channel lies within the GBRWHA and the Great Barrier Reef (GBR) Coast Marine Park. Constructed and managed in accordance with current best practice, the marina is not likely to significantly impact on any of the key features of the GBRWHA or GBR Coast Marine Park. With specific reference to the world heritage values of Shute Bay, the proposed development:

- will not impact on any features of geological or geomorphological significance. Possible indirect effects from sedimentation during dredging will be managed by a dredge management program.
- The project will result in a direct maximum loss of approximately 14.59 ha of seagrass from the footprint of the proposed development. This represents approximately 10 % and 0.00028 % of that recorded in Shute Bay and the GBRWHA respectively. Approximately 14.7 ha of seagrass will be impacted by altered hydrodynamics within Shute Bay, although there is likely to be little net loss / gain. A further 4.18 ha of seagrass is likely to be temporarily impacted by elevated suspended solids and sediment deposition associated with dredging.
- The project will result in a loss of 1.84 ha of mangroves from Shute Bay. This represents approximately 1.34 % and 0.00001 % of that recorded in Shute Bay and the GBRWHA, respectively. While most of the mangroves affected occur outside of the WHA boundary, they are included in the GBR Coast Marine Park. The mangroves to be lost are of lower value to fisheries than mangroves in the western and southern shore of the bay. In addition, altered hydrodynamics is likely to reduce recruitment to approximately 9.88 ha of mangroves along the southern shore of the bay, whilst simultaneously increasing mangrove recruitment to an area of deposition of approximately 0.93 ha in the lee of the marina. In the broader setting of Shute Harbour, this impact is not likely to be ecologically significant.
- The project will result in a direct loss of approximately 35 ha of macroalgae from the footprint of the proposed development. A further 12.47 ha is likely to be impacted by dredge-related elevated suspensed solids and subsequent sediment deposition.
- The project will result in the removal of less than 10 small coral colonies within the development footprint.

- intertidal habitat will be reduced by approximately 7.4 ha, which equates to approximately 30% of the intertidal habitat in Shute Bay. None of the intertidal habitat to be lost is within the WHA but is within the GBR Coast Marine Park.
- No other habitats or species of conservation significance is expected to be affected by this project.

13.7 Summary of Impacts

Construction of the marina (through excavation / dredging) will result in the direct loss of approximately 14.59 ha of relatively sparse seagrass; 1.84 ha of fringing mangrove; 35 ha of sparse macroalgal beds; and a small number of small coral colonies. The predicted seagrass loss equates to approximately 10% of the seagrass of Shute Bay and represents the most significant habitat loss.

The constructed marina will provide approx. 1.8 km of breakwater habitat, associated pylons and pontoons. Relocation and conversion of a number of swing moorings will reduce the impact of proposed development on seagrass and macrophyte communities.

Construction activities including dredging, spoil consolidation, and pile driving may result in:

- increased suspended sediment levels and consequent sediment deposition within the bay and adjoining waters
- a release of nutrients from the disturbed sediments
- spills of hydrocarbons and other contaminants
- disturbance of acid sulfate or potential acid sulfate sediments (ASS / PASS)
- increased human activity, including changes in light and noise levels, and
- altered hydrodynamics and consequently altered patterns of sediment deposition and erosion.

Plume modelling predicts that the extent of waters likely to experience elevated turbidity, and rates of sediment deposition are relatively small, and will be primarily confined to the northern, developed shore of the bay. Impacts to seagrass, macroalgae, coral and benthic infauna are likely to be acute and reversible. Impacts on onshore – offshore migration os fishes is likely to be ecologically insignificant.

Should disturbed sediments release nutrients, tidal flushing is likely to effect dispersion and dilution: any impact is likely to be minor and reversible.

A construction management plan will be developed to effectively manage the contingency of both construction–related oil spillage and acid sulfate sediments.

Increased human activity in an area already supporting a busy tourist terminal is unlikely to have any significant further impact[4].

Altered hydrodynamics are predicted to result in sediment deposition in the lee of the marina, and scouring of the southern shore of the bay. Whilst these physical impacts are likely to influence the community structure of seagrass meadows, there is likely to be no significant net effect.

Impacts associated with marina operation include maintenance dredging and chronic, low level, localised hydrocarbon contamination. The impact of maintenance dredging will be similar to that of capital dredging: localised and reversible. Chronic hydrocarbon contamination is likely to prevent the colonisation of fauna and flora that are highly sensitive, whilst still enabling a diverse and healthy floral and faunal community to develop.

Construction and operation of the proposed marina will not significantly impact on the values of the Great Barrier Reef World Heritage Area or on the region's fisheries.

Potential impacts associated with both construction and operational phases are summarised in Figure 13.4.

[4] The impact of development and operation on dugong, turtles and dolphins is considered by others.

• Mangrove Loss / Gain • Coral Loss • Seagrass Gain due to Revoked Swing-moorings • Smothering of In-benthos in Dredge Plume • Smothering of Coral in Dredge Plume • Smothering of Seagrass in Dredge Plume Smothering of Macroalgae in Dredge Plume • Increased Human Activity • Increased Nutrients • Fish Disturbance by Dredge Plume • Chronic Hydrocarbon Exposure • Impact of Altered Hydrodynamics on Fauna	• Seagrass Loss • Macroalgae Loss • Habitat Gained as Artificial Structures	
	• Disturbance of Contaminated Sediment	
	• Acidification due to ASS Disturbance	• Major Hydrocarbon Spills • Introduction of Marine Pests

Likelihood

Severity

Figure 13.4 Risk matrix for potential impacts of marina construction and operation.

13.8 Opportunities for Impact Mitigation

Current 'best practice' assessment and engineering practices offer significant opportunities to minimise the impacts associated with both construction and operation of the proposed development.

Loss of natural habitat has been minimised through the refinement of the marina design and orientation following coastal process studies (see Cardno Lawson & Trealoar 2007a). Unavoidble loss of habitat can be mitigated through the creation of habitat that serves a similar ecological function, or through the enhancement of similar habitat elsewhere. The contribution of funding (in cash or kind) to habitat-related research has also been recently recognised as an appropriate form of mitigation for habitat loss (Dixon & Beumer 2002). A habitat loss compensation strategy will be developed in support of the Proponent's marine plant permit application.

An Acid Sulfate Soil Management Plan and Oil Spill Management Plans will be prepared in accordance with State Planning Policy requirements and to the satisfaction of EPA and DNRM.

The effective 'isolation' of the development footprint, using bunding, silt curtains, oil spill booms and/or similar technologies can significantly reduce the escape of waters carrying contaminants such as spilt oil, elevated suspended solids concentrations and litter. Use of appropriate dredging and spoil handling methods can minimise the release of sediments and associated contaminants to the surrounding waters.

Monitoring and the use of 'trigger levels' can also contribute to effectively controlling suspended solids concentrations in adjoining waters.

14 Ecological Monitoring

An ecological monitoring program will be developed and undertaken by the Proponent to assess the veracity of predicted impacts, and to inform the project's Construction and Operation Environmental Management Plans so that timely remedial action can be taken.

Monitoring will focus of the distribution and health of seagrasses and macroalgae in the vicinity of the construction footprint (including the access channel), and in areas where altered hydrodynamics are likely to impact on the community structure of seagrass and mangrove communites.

Monitoring would be based on the acquisition of pre-construction base-line data followed by seasonal re-surveys. Indicators likely to be employed include: distribution mapping and community description, seagrass depth distribution, and physiological indicators.

A detailed monitoring program will be developed to support the Proponent's marine plant application. Guidelines are currently being developed for the establishment / re-establishment of mangroves in the lee of the marina.

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Appendix A Assessment of the Distribution of Seagrass and Macroalgae Communities

June 2004

In June 2004, the distribution of seagrass and macroalgae within and in the vicinity of the proposed marina and access channel was determined referring to DPI's 1999 & 2000 mapping of the region's seagrasses (Campbell et al. 2002), and using aerial photographs and traverses of the area. Depending on water depth, traverses involved the use of a long handled rake and / or diver tows. Traverses were conducted approximately 50 m apart to cover the proposed development site and surrounds. Raking and spot point diver surveys were used to characterise the seagrasses of the bay's south-eastern shore, distant from the proposed development footprint.

The biomass of seagrasses within the study area was determined at five broadly representative sites (Figure A.1). At each site, all seagrasses within five replicate 0.1 m^2 quadrats were collected, dried, and weighed to determine above- and below-ground dry weights. By comparing these biomass measurements to estimates of cover (a modification of the methodology of Mellors (1991) estimates of the biomass for seagrass throughout the bay were derived.

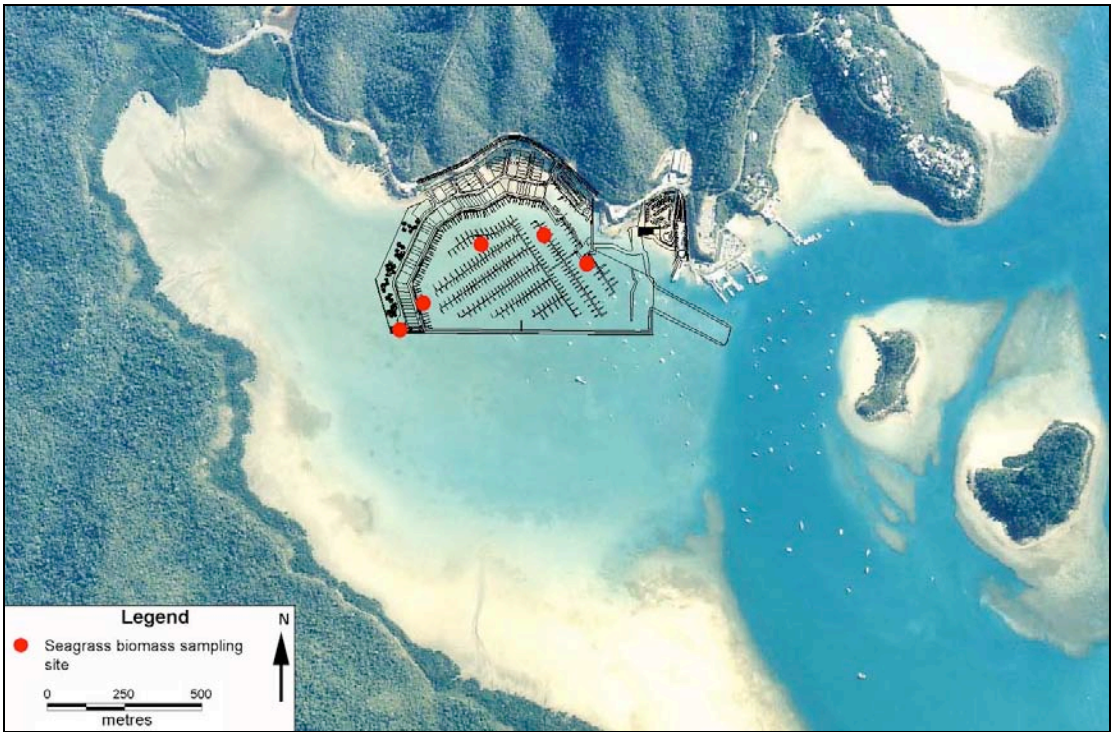

Figure A.1. Seagrass biomass sampling sites June 2004, with a stylised representation of the proposed marina and resort.

April 2007

In April 2007 the seagrass and macroalgae communities in Shute Bay were comprehensively surveyed using a series of SCUBA dive, snorkel and on-foot line transects (Figure A.2). Subtidal areas of the bay were surveyed via SCUBA dive and snorkel transects. Visibility at the time of survey was typically < 2 m. The boat was driven along in a south-east – north west direction (to accommodate prevailing winds), pausing at approximately 10 m intervals, or whenever a change in community structure was observed, to record the floral and faunal communities present at each point.

Intertidal sections of the bay were surveyed on foot at low tide. Members of the survey team walked in a zig-zag fashion along the intertidal zone (Figure A.2), and recorded the floral and faunal communities present in 10 m intervals, or whenever a change in community structure was observed.

At each position, we recorded substrate type, the species composition of floral and faunal communities and the abundance and percent cover of benthic communities. Survey coordinates were input into MAPINFO and mapped over digitally rectified aerial photos.

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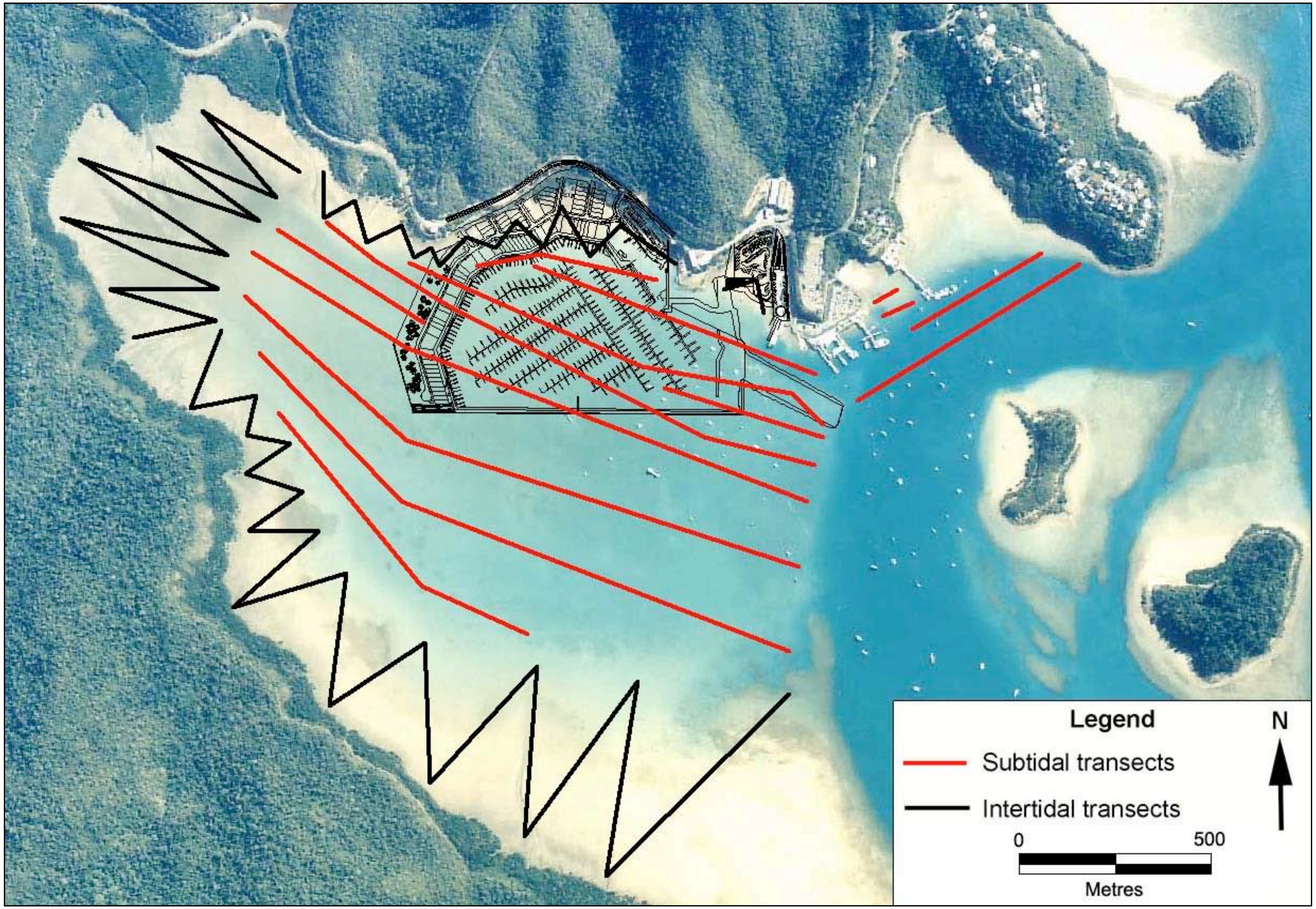


Figure A.2 Location of survey transects for seagrass and macroalgae communities within Shute Bay, April 2007, with a stylised representation of the proposed marina and resort.

Appendix B Assessment of the Distribution and Characteristics of Coral Communities

Methods

The location of coral communities in Shute Bay were identified using aerial photographs, ground truthing and diver tows. Diver tows took place in the small bay to the east of the existing ferry terminal, and on the spit oriented approximately north-south on the south-western side of Shute Bay. These coral communities were surveyed using a modification of a method established by Devantier et al. (1998) using diver swims. Six diver swims were conducted in this area, stratified into two reef zones (depths) and divided into three swims at each depth, one each on the embayment and seaward sides of the spit, and one on the point of the spit. The three 'deep' swims were conducted on the reef slope at approximately 1.5 m to 5.5 m below LAT (the reef ended at approximately 5.5 m below LAT, where it became sandy seabed), and the three 'shallow' swims were conducted on the reef crest and shallow slope, at approximately 0 m to 1.5 m below LAT. The start and end points of the swims were recorded using GPS, and on each swim the diver made visual estimates of percent cover of key substrate types, and compiled a taxonomic inventory of hard and soft corals, macroalgae and other sessile benthos. The abundance of each of these categories was ranked at the end of each swim.

Results

A total of 46 coral taxa were recorded from the spit on the south-western side of Shute Bay (Table B.1). The cover of major benthic flora and fauna recorded on each swim, and cover of the major substrata categories, from this area, are expressed in Figures B.1 & B.2.

References

DeVantier, L. M., De'Ath, G., Done, T. J., & Turak, E., 1998, 'Ecological assessment of a complex natural system: a case study from the Great Barrier Reef', *Ecological Applications*, 8: 480-496.

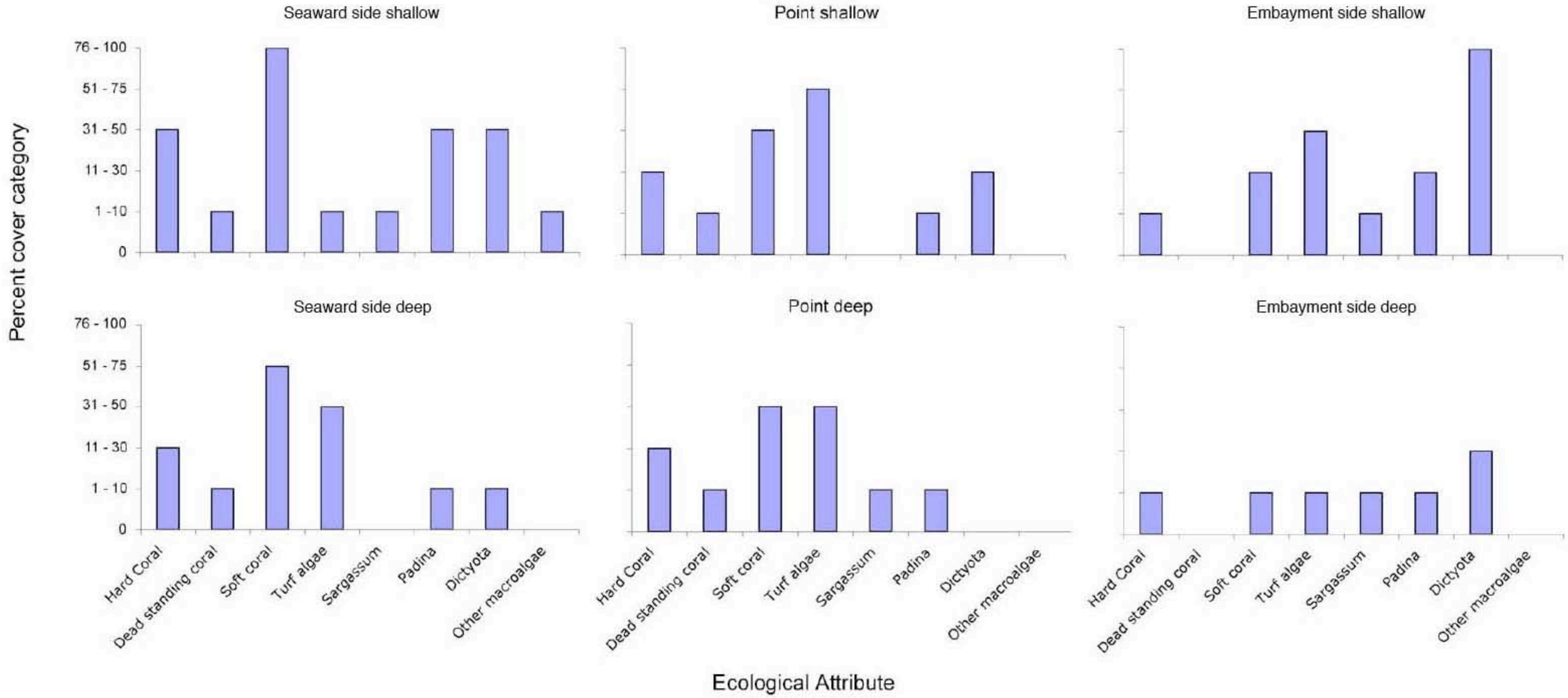


Figure B.1 Cover of major benthic flora and fauna recorded on each swim survey of the coral community on the spit in Shute Bay.

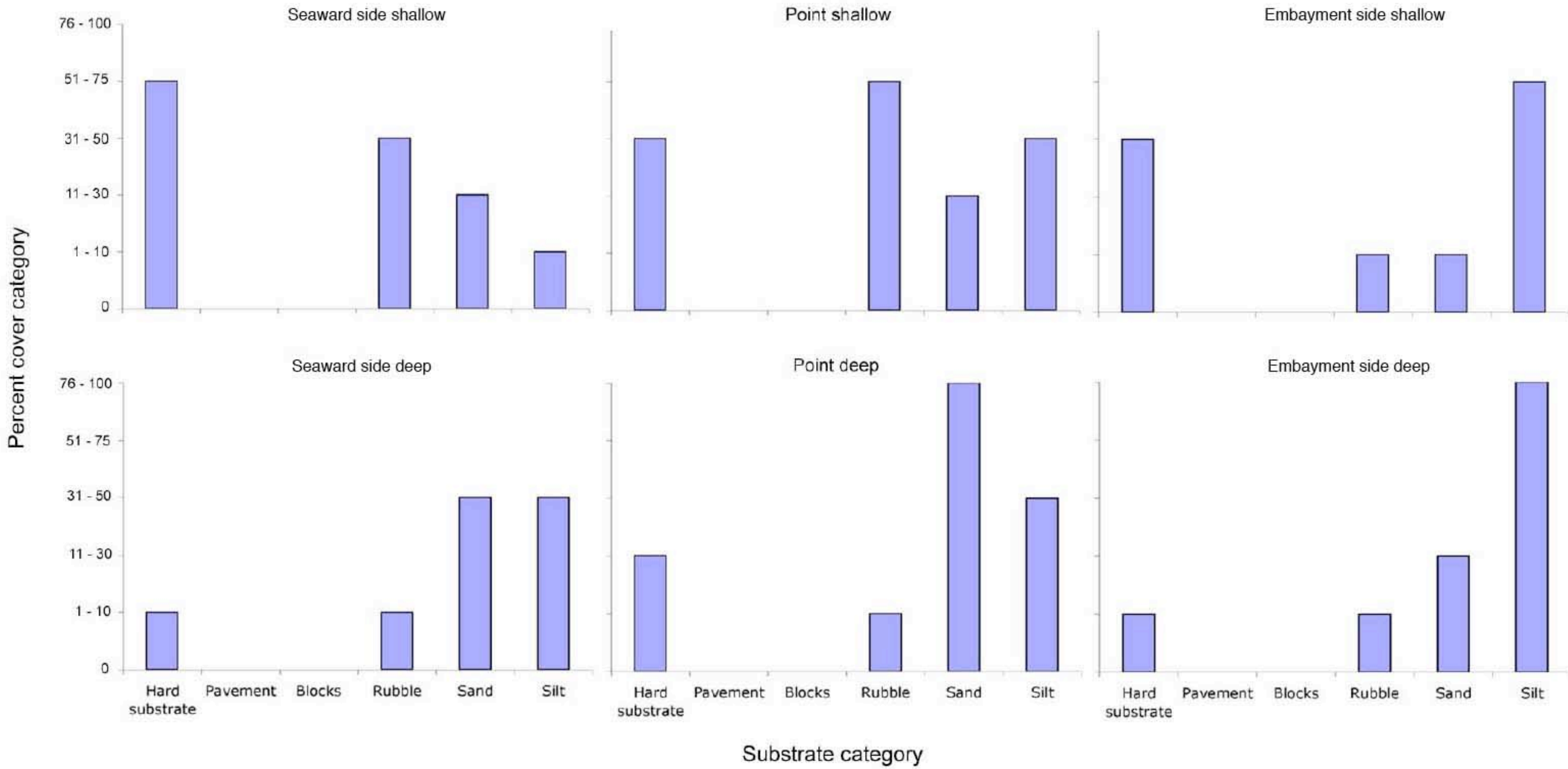


Figure B.2 Cover of major substrata category recorded on each swim survey of the coral community on the spit in Shute Bay.

Table B.1 Abundance of benthic invertebrates, macroalgae and seagrasses recorded on the spit on the southern side of Shute Bay, June 2004.

Group / Family	Genus	Offshore shallow	Offshore deep	Point shallow	Point deep	Inshore shallow	Inshore deep
Scleractinia (hard corals)							
Acroporidae	*Acropora* bottlebrush	3	1	2	0	0	0
Acroporidae	*Acropora* branching	3	3	2	3	2	0
Acroporidae	*Acropora* tabular	3	3	2	3	2	1
Acroporidae	*Astreopora*	1	1	2	0	1	1
Acroporidae	*Acropora (Isopora)*	1	0	0	0	0	0
Acroporidae	*Montipora enc*	1	2	2	3	2	2
Agariciidae	*Leptoseris*	2	1	0	0	0	0
Agariciidae	*Pachyseris*	1	1	1	2	1	0
Agariciidae	*Pavona*	0	0	2	1	0	0
Dendrophylliidae	*Tubastrea*	1	0	0	0	0	0
Dendrophylliidae	*Turbinaria*	3	3	0	1	1	1
Euphyllidae	*Euphyllia*	1	1	0	0	1	0
Faviidae	*Barabattoia*	0	0	1	0	0	0
Faviidae	*Caulastrea*	2	2	0	0	1	1
Faviidae	*Cyphastrea*	2	2	2	0	1	0
Faviidae	*Diploastrea*	0	0	0	0	1	0
Faviidae	*Echinopora*	2	0	0	1	0	0
Faviidae	*Favia*	3	3	3	3	2	2
Faviidae	*Favites*	2	2	2	2	0	0
Faviidae	*Goniastrea*	2	0	2	2	0	2
Faviidae	*Leptastrea*	0	2	1	2	1	0
Faviidae	*Moseleya*	0	1	1	1	1	0
Faviidae	*Oulophyllia*	1	1	2	0	0	1
Faviidae	*Platygyra*	0	2	2	2	1	1
Fungiidae	*Ctenactis*	1	1	1	0	0	0

Group / Family	Genus	Offshore shallow	Offshore deep	Point shallow	Point deep	Inshore shallow	Inshore deep
Fungiidae	*Cycloseris*	1	1	1	0	0	0
Fungiidae	*Fungia*	2	2	0	0	1	0
Fungiidae	*Heliofungia*	3	1	0	0	0	0
Fungiidae	*Podabacia*	1	0	0	1	0	0
Merulinidae	*Hydnophora*	1	1	0	0	0	0
Merulinidae	*Merulina*	2	1	0	1	1	0
Mussidae	*Lobophyllia*	2	2	1	2	2	0
Mussidae	*Scolymia*	0	1	1	0	1	0
Mussidae	*Symphyllia*	0	2	2	0	2	0
Oculinidae	*Galaxea*	2	2	0	0	1	0
Pectiniidae	*Echinophyllia*	2	1	0	0	0	0
Pectiniidae	*Mycedium*	2	1	0	1	1	0
Pectiniidae	*Oxypora*	1	0	0	0	0	0
Pectiniidae	*Pectinia*	1	1	1	0	1	0
Pocilloporidae	*Pocillopora*	0	1	0	0	0	0
Pocilloporidae	*Seriatopora*	0	1	1	2	0	0
Poritidae	*Goniopora*	5	4	3	3	2	2
Poritidae	*Porites* branching	2	0	3	0	2	0
Poritidae	*Porites* encrusting	2	1	3	2	0	2
Poritidae	*Porites* massive	2	1	3	3	2	2
Siderastreidae	*Coscinaraea*	0	0	1	0	0	0
Alcyonacea (soft corals)							
Ellisellidae	*Junceella*	1	3	0	3	0	0
Xeniidae	*Anthelia*	0	2	0	0	1	0
Xeniidae		2	0	0	0	0	0
Alcyoniidae	*Klyxum*	5	5	3	4	3	2
Clavulariidae		2	3	0	0	0	0

Group / Family	Genus	Offshore shallow	Offshore deep	Point shallow	Point deep	Inshore shallow	Inshore deep
Nephtheidae	*Capnella*	0	2	0	0	0	0
Nephtheidae	Other	0	2	1	0	0	0
Alcyoniidae	*Sinularia*	4	2	4	0	3	2
Alcyoniidae	*Lobophyton*	4	3	3	2	2	0
Alcyoniidae	*Sarcophyton*	4	4	3	0	0	0
Alcyoniidae	*Cladiella*	0	0	1	2	2	1
Other benthic invertebrates							
Echinoidea	*Diadema*	0	2	2	2	2	0
Sponge massive / vase / blade		2	2	1	1	1	0
Sponge encrusting		0	2	0	0	0	1
Sponge foliaceous / whorl		0	0	1	0	0	0
Ascidiacea		1	1	0	1	1	0
Coralliomorpharia		0	1	0	0	0	0
Foraminifera		0	0	0	0	0	5
Macroalgae							
	Padina	5	3	0	0	3	3
	Dictyota dichotoma	4	4	3	0	5	3
	Sargassum	2	0	0	1	2	2
	Turbinaria ornata	2	0	0l	0	0	0
	Halimeda macroloba	0	0	0	0	1	1
Seagrasses							
	Halophila ovalis	0	1	0	2	1	1
	Cymodocea serrulata	0	0	0	0	2	2
	Halodule uninervis	0	0	0	0	3	3

*Abundance rankings: 0 absent; 1 rare; 2 uncommon; 3 common; 4 abundant; 5 dominant

Appendix C Assessment of Benthic Invertebrate Communities

The benthic infauna within the proposed development site was characterised by sampling five replicates within each of three broadly representative locations (Figure C.1). Benthic fauna was collected using hand-dug 2 L samples, as the substrate in many places within Shute Bay had a coarse component, preventing the use of hand-driven cores. Benthic fauna collected was identified to family level where possible, and estimates of density were derived.

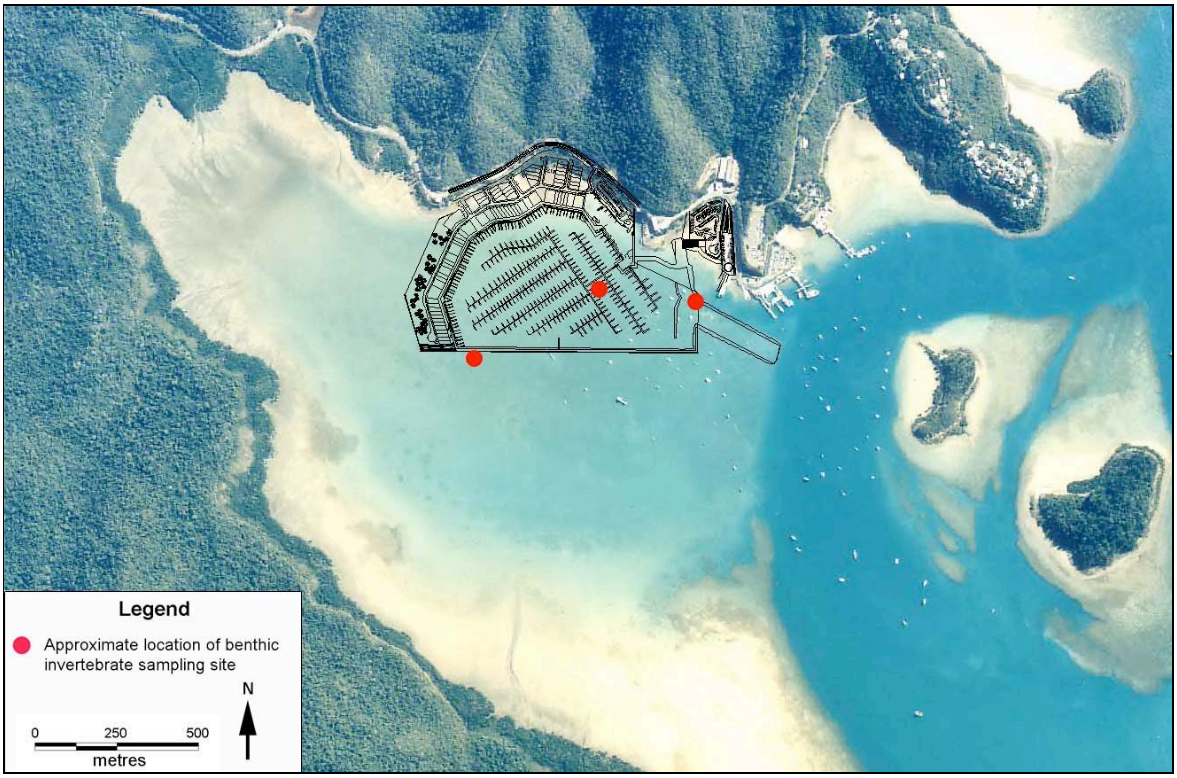


Figure C.1. Benthic invertebrate sampling sites, with a stylised representation of the proposed marina and resort.

Table C.1 Mean number of benthic macro-invertebrates per sample from families recorded in subtidal sediments in Shute Bay (refer to Appendix C for site locations).

Class / Family	Common Name	Marina Inshore	Marina Offshore	Access Channel / Area of Dredge Plume Dispersal
Bivalvia				
Lucinidae		1.8	1.0	1.6
Mactridae	mactra clams	0.6	0.0	0.8
Nuculidae	nuculid clams	0.0	0.0	0.2
Pharidae	fingernail clams	0.0	0.0	0.6
Ungulinidae		0.2	0.0	0.0
Gastropoda				
Littorinidae	winkles	0.0	0.0	0.2
Naticidae	moon snails	0.0	0.0	0.2
Holothuroidea				
Holothuroidea	sea cucumbers	0.0	1.0	0.0
Malacostraca				
Alphaeidae	snapping shrimp	0.0	0.2	0.0
Caprellidaea	skeleton shrimp	0.4	0.0	0.0
Ocypodidae	sentinel crabs	0.2	0.0	0.4
Tanaidacea	tanaids	0.0	0.6	1.0
Ophiuroidea				
Ophiuroidea	brittle stars	0.4	0.2	1.0
Polychaetea				
Alciopidae	pelagic worms	0.0	0.6	0.0
Ampharetidae	spaghetti worms	1.8	0.0	0.0
Capitellidae	lug worms	2.4	0.4	1.0
Cirratulidae	hairy worms	2.2	0.0	0.4
Cossuridae		0.2	0.0	0.0
Dorviellidae	fire worms	0.0	0.0	0.2
Eunicidae	fire worms	1.2	0.8	1.0
Glyceridae	blood worms	1.4	1.2	2.2
Lumbrineridae	fire worms	1.8	2.4	4.4
Magelonidae		0.2	0.0	0.2
Maldanidae	bamboo worms	1.6	1.8	2.6
Nephtyidae	sand worms	0.4	0.2	0.0
Nereidae	rag worms	2.4	1.0	1.2
Oenonidae		0.0	0.0	0.4
Onuphidae	beach worms	1.0	0.0	1.4
Opheliidae	grub worms	0.4	0.0	0.2

Class / Family	Common Name	Marina Inshore	Marina Offshore	Access Channel / Area of Dredge Plume Dispersal
Paraonidae		0.0	0.8	0.4
Phyllodocidae	paddle worms	0.8	0.0	0.0
Sabellaridae		0.8	0.4	1.8
Sabellidae	feather-duster worms	0.6	0.0	0.0
Scalibregmatidae	grub worms	0.0	0.2	0.0
Sternaspidade	peanut worms	0.4	0.2	0.6
Syllidae	hairy worms	0.4	1.0	0.2
Terebellidae	spaghetti worms	4.2	1.0	3.4
Sipuncula				
Sipuncula	peanut worms	0.4	1.4	0.2
Mean Number of Invertebrate Families		13.4	10.6	14.2

Table C.2 Macro-invertebrates recorded from mangroves forests in the bight of Shute Bay.

Species	Common Name	Abundance
Grapsidae		
Sesarma spp.	mangrove crabs	+++
Metopograpsus frontalis	broad-fronted mangrove crabs	+++
Littorinidae		
Littoraria scabra	scabra periwinkles	+++
Ocypodidae		
Austraplax tridentata	furry-clawed crabs	+++
Portunidae		
Scylla serrata	mud crab	++
Thalamita crenata	-	+++
Potamididae		
Pyrazus ebeninus	Hercules clubs	+
Telescopium telescopium	telescope mud creepers	+++
Terebralia sulcatus	striate mud creepers	+++
Cerithidea anticipata	mangrove mud creepers	++++
Thalassinidae		
Thalassina sp.	mangrove lobsters	++

+ not common
++ common
+++ abundant
++++ very abundant

Table C.3 Macro-invertebrates recorded from the mangrove forest and associated rocky outcrops within the marina footprint in Shute Bay.

Species	Common Name	Abundance
Balanomorpha		
Balanus spp.	barnacles	++++
Grapsidae		
Metopograpsus frontalis	broad-fronted mangrove crabs	+++
Littorinidae		
Bembicium spp.	conniwinks	++
Littoraria scabra	scabra periwinkles	+++
Nodolittorina pyramidalis	pyramid nodiwinks	++
Neritidae		
Nerita balteata	lineate nerites	++
Nerita undata	waved nerites	++
Ocypodidae		
Macropthalamus sp.	sentinel crabs	++
Austraplax tridentata	furry-clawed crabs	++
Ostreidae		
Saccostrea cucculata	hooded rock oysters	++++
Potamididae		
Pyrazus ebeninus	Hercules clubs	+
Cerithidea anticipata	mangrove mud creepers	++++
Thaidinae		
Morula marginalba	carnivorous whelks	+

+ not common
++ common
+++ abundant
++++ very abundant

Appendix D Assessment of the Fish Assemblages of Coral, Mangrove and Seagrass Habitats

The fish assemblages of various habitats within Shute Bay were surveyed by netting, trapping and Underwater Visual Census (UVC), via SCUBA and free dives. During the surveys, fish species were identified to the highest possible taxonomic group, and their abundance determined. An assessment was then made of the likely productivity and fish habitat value of the area to be impacted.

Methods

Coral Habitats

Coral UVCs were conducted in June 2004. Underwater Visual Census was conducted using a modified version of the AIMS Long-term Monitoring Program, Standard Operational Procedure Three: Visual Census Surveys of Reef Fish (Halford & Thompson 1994).

Surveys were conducted between 10:00 and 16:00 hours. Surveys were conducted along three 50 m permanent transects. Two passes of each transect were completed, with the more mobile, larger fish recorded in a 5 m belt during the first swim, and the less mobile fish (e.g. Pomacentridae) recorded from a 1 m belt during the second swim.

Only fish in the 1+ year age class were counted (due to temporal variability in the 0+ age class) (Halford & Thompson 1994).

Mangrove Habitats

The fish communities of mangrove communities of Shute Bay were surveyed at six sites (Figure D.3) by constructed fyke net, cast net, and baited traps.

Fyke nets were comprised of a 5 m wing length x 2 m drop panel and 10 mm mesh. Fykes were set across mangrove creeks and drainage lines running into Shute Bay (Figure D.1). Fykes were baited with whole mullet. Fykes were placed on a high tide, left overnight for a minimum of 15 hours, and removed the following day.

Six baited traps of 1.5 mm mesh were set at each site. Traps were baited with small dog biscuits. Traps were set during the day on an outgoing tide, left to soak overnight, and removed the following morning.

Species were identified and counted in the field, and representative samples were returned to frc environmental's Brisbane laboratory frozen, to enable field identifications to be confirmed.

Figure D.1

Fyke net set at high tide.

Seagrass Habitats

The fish communities of seagrass habitats were initially conducted in via UVC in June 2004.

In April 2007, fish communities were surveyed at three sites (Figure D.3) by seine netting (Figure D.2). The net was comprised of a 5 m long x 1.5 m drop panel with 2 mm mesh size. The net was hauled for 25 m over the seagrass bed, with a constant mouth width of 4 metres, thus sampling a total area of 100 m^2 for each trawl. Three replicate seines were collected at each site. Replicate seines were positioned at linear series and separated by a distance of 10 m.

All seine netting was conducted on an outgoing tide. Water depth was relatively constant (between 0.75 and 1.00 m) throughout the study. Matter obtained in the net was placed into zip-lock bags, frozen and returned to frc environmental's Brisbane laboratory for identification.

Figure D.2

Seine net sampling in Shute Bay.

frc environmental also liaised with the Queensland Fisheries Service, Sunfish and the Queensland Seafood Industry Association (the latter two are peak bodies representing the state's recreational and commercial fishers) and with local recreational fishers and hire boat operators.

The sampling of all fishes in the April 2007 surveys was conducted under General Fisheries Permit No. PRM37573J; Animal Ethics Approval No. CA 2006/03/106.

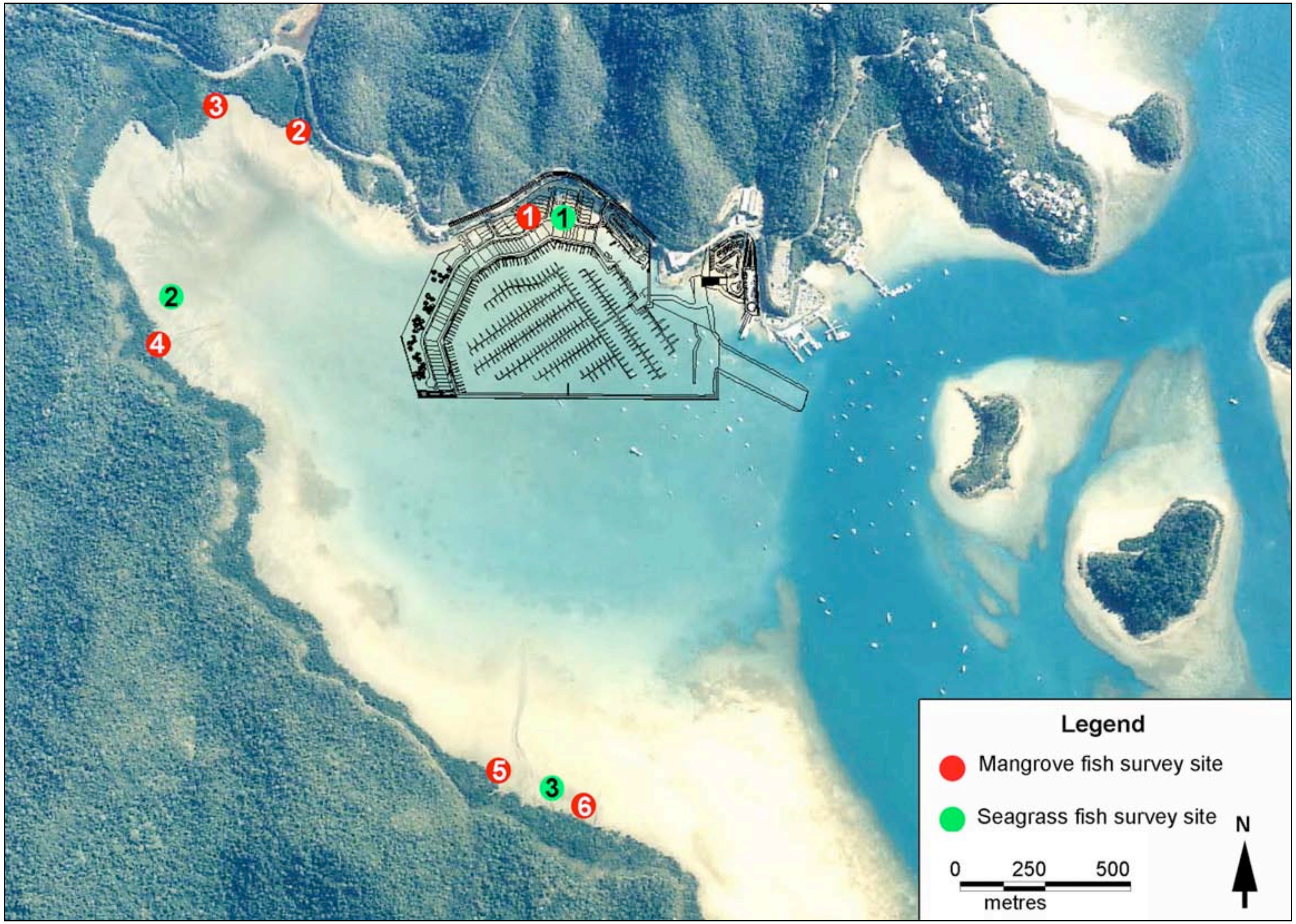


Figure D.3 Mangrove and seagrass fish survey sites in Shute Bay, with a stylised representation of the proposed marina and resort.

Results

Coral Habitats

Fish species observed during Underwater Visual Census (UVC) over the coral community included angelfish, damselfish, emperor, wrasse, butterfly fish, seaperch, cod, rabbitfish and surgeonfish. Their abundances are listed in Table D.1.

Table D.1 Fish species observed over coral outcrops in Shute Bay during underwater visual censuses.

Species	Common Name	Abundance
Acanthuridae		
Acanthurus nigricauda	blackstreak surgeonfish	++
Blennidae		
Meiacanthus lineatus	lined fangblenny	+
Caesionidae		
Caesio cuning	red-bellied fusilier	++++
Chaetodontidae		
Chaetodon lunula	racoon butterflyfish	+
Chaetodon rainfordi	rainford's butterflyfish	+
Chelmon rostratus	beaked coralfish	++
Gobidae		
Gobidae spp.	gobies	++
Haemulidae		
Diagramma pictum	painted sweetlip	+++
Labridae		
Choerodon cephalotes	grass tuskfish	+
Choerodon cyanodus	blue tuskfish	+++
Choerodon graphicus	graphic tuskfish	+
Halichoeres sp.	wrasse	+
Labroides dimidiatus	cleaner wrasse	++
Epibulus insidiator	sling-jaw wrasse	+
Thalasoma lunae	moon wrasse	++
Lethrinidae		
Lethrinus laticaudis	grass emperor	++
Lethrinus nebulosus	spangled emperor	++
Gymnocranius spp.	sea bream	+
Lutjanidae		
Lutjanus carponotatus	spanish flag	+
Lutjanus russelli	moses perch	+++
Mullidae		
Parupeneus barberinus	dash-dot goatfish	+

Species	Common Name	Abundance
Pomacanthidae		
Chaetodontoplus duboulayi	scribbled angel	++
Pomacantus sexstriatus	six-banded angel	+
Pomacentridae		
Abudefduf bangelensis	bangal sergeant	++
Chromis nitidia	barrier reef chromis	+++
Pomacentrus moluccensis	lemon damsel	++
Neopomacentrus cyanomus	regal damoiselle	+++
Pomacentrus coelestus	neon damsel	+
Chromis margaritifer	bicolor damsel	+++
Ostracidae		
Ostracion cubicus	yellow boxfish	+
Scaridae		
Scarus ghobban	bluebarred parrotfish	+
Serranidae		
Plectropomus leopardus	coral trout	++
Epinephalus fasciatus	black-tipped rockcod	+
Diploprion bifasciatum	barred soapfish	+
Siganidae		
Siganus lineatus	goldlined rabbitfish	+++
Siganus fuscescens	dusky rabbitfish	+++
Sparidae		
Acanthopagrus australis	yellowfin bream	+
Trichonotidae		
Parapercis cylindrica	sharpnose sandperch	++

+ not common
++ common
+++ abundant
++++ very abundant

Seagrass Habitats

Gobies were the only fish recorded during the underwater visual survey over the seagrass and soft sediment areas of Shute Bay conducted in June 2004. Visibility was limited (always < 2m) during the June 2004 survey, which no doubt resulted in an underestimation of fish abundance and species richness. Previous surveys have found fanbellied leatherjacket (*Monacanthus chinensis*), gobies (cf. *Amblyeleotris* spp.), monocle bream (*Pentapodus* sp.), northern fortescue (*Centropogon marmoratus*), seahorse (Syngnathidae), tongue sole (*Paraplaguisa unicolor*), trevally (Carangidae), trumpeter (*Pelates quadnlineatus*), and dusky rabbitfish (*Siganus fuscescens*) within

Shute Bay (frc environmental 1999). Dusky rabbitfish are algal grazers and are likely to be transient within the bay.

Surveys of the fish assemblages of the seagrass communities in Shute Bay were re-conducted in April 2007, using seine nets. A total of 12 families of finfish and 1 family of commercially important crustacean were recorded from the seagrass communities of Shute Bay (Table D.2). Finfish communities were typically comprised by mobile, transient species including hardyheads (*Atherinomorus* sp.), queenfish (*Scomberoides commersonianus*), anchovies (*Tyryssa hamiltoni*) and ponyfish (*Secutor ruconius*). Gobies (*Istiogobius* sp.) were also common.

Table D.2 Fish species recorded from seagrass communities in Shute Bay during seine net surveys, April 2007.

Species	Common Name	Abundance
Finfish		
Atherinidae		
Atherinomorus sp.	hardyheads	+++
Belonidae		
Tylosurus crocodilus	crocodilian longtom	+
Blenniidae		
Petroscirtes lupus	fang blenny	+
Carangidae		
Carangoides sp.	-	+
Scomberoides commersonianus	Talang queenfish	+++
Dasyatidae		
Himantura toshi	black spotted stingray	+
Engraulidae		
Tyryssa hamiltonii	Hamilton's anchovy	++++
Gerreidae		
Gerres subfasciatus	silverbiddy	++
Gobiidae		
Glossogobius sp.	goby	+
Istigoboius sp.	goby	++++
Leiognathidae		
Secutor ruconius	pugnose ponyfish	++++
Platycephalidae		
Platycephalus fuscus	dusky flathead	+
Psettodidae		
Pseudorhombus arsius	large-toothed flounder	+
Syngnathidae		
Hippichthys penicillus	mangrove pipefish	+

Species	Common Name	Abundance
Crustacea		
Hippolytidae		
Hippolyte sp.	-	+
Majidae		
Paranaxia sp.	-	+
Mysidacea		++++
Ocypodidae		
Enigmaplax sp.	-	+
Macrophthalmus sp.	sentinel crab	++
Penaeidae		
Metapenaeus esculentus	brown tiger prawn	+++

+ not common
++ common
+++ abundant
++++ very abundant

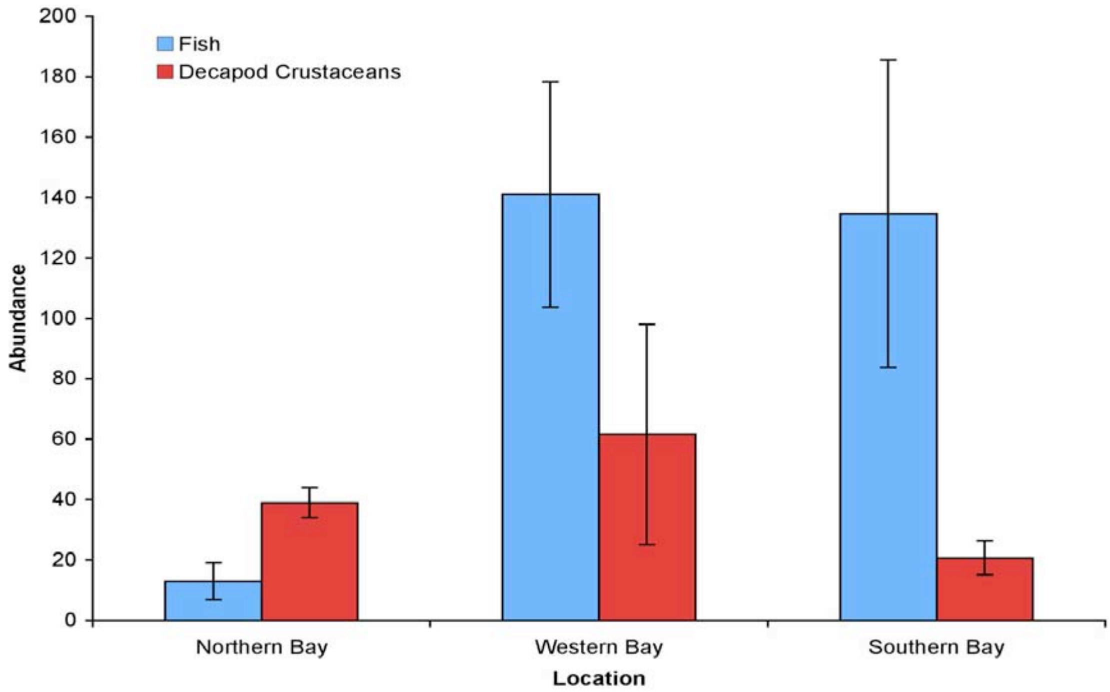


Figure D.4 Total abundance of fish in seagrass habitats in Shute Bay, April 2007.

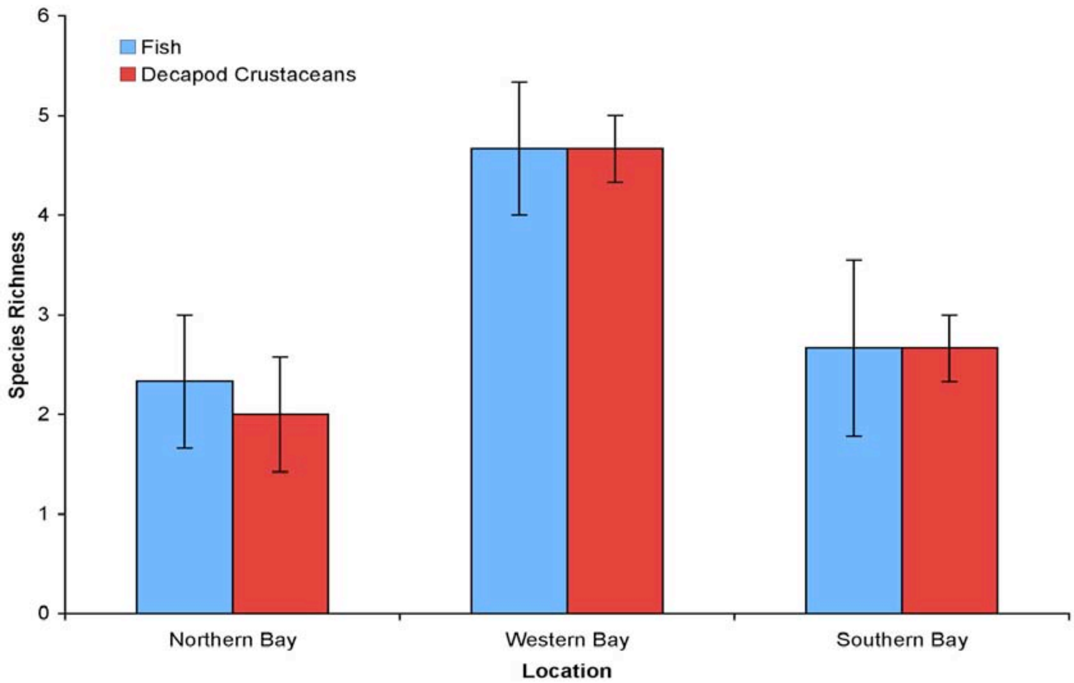


Figure D.5 Species richness of fish and decapod crustaceans in seagrass habitats in Shute Bay, April 2007.

Mangrove Habitats

The mangrove communities of Shute Bay support abundant and diverse fish assemblages. In total 15 families of finfish and 2 families of commercially important crustacea were recorded from the bay. A full list of the species recorded during the mangrove survey is found in Table D.3.

Table D.3 Fish species recorded from mangrove communities in Shute Bay during fyke net surveys, April 2007.

Species	Common Name	Abundance
Finfish		
Ambassidae		
Ambassis marianus	estuary perchlet	++++
Atherinidae		
Atherinidae spp.	hardyheads	+++
Belonidae		
Tylosurus crocodilus	crocodilian longtom	+
Carangidae		
Caranx sp.	trevelly	+
Scomberoides commersonianus	giant leaherskin / queenfish	+
Clupeidae		
Nematalosa come	hairback herring	+
Dasyatidae		
Himantura toshi	black spotted stingray	+
Engraulidae		
Engraulidae spp.	anchovy	+
Gerreidae		
Gerres subfasciatus	silverbiddy	+++
Gobiidae		
Periophthalmus argentilineatus	mudskipper	++
Hemiramphidae		
Arramphus sclerolepis	snub-nosed gar	+
Hemiramphidae spp.	gar	+
Leiognathidae		
Leiognathus leuciscus	whipfin ponyfish	+
Secutor ruconius	pugnose ponyfish	++++
Lutjanidae		
Lutjanus fulviflamma	black spot seaperch	+
Mugilidae		
Mugil cephalus	sea mullet	+++
Siganidae		
Siganus lineatus	golden-lined spinefoot	++
Sillaginidae		
Sillago analis	golden-lined whiting	+

Species	Common Name	Abundance
Crustacea		
Penaeidae		
Metapenaeus esculentus	brown tiger prawn	++
Portunidae		
Scylla serrata	mud crab	++
Thalamita crenata	-	+++

+ not common
++ common
+++ abundant
++++ very abundant

Mangrove habitats in the footprint of the proposed marina expansion (Site 1) supported both the lowest abundance, and richness of fish species recorded from the six sites surveyed across Shute Bay (Figure D.6; Figure D.7).

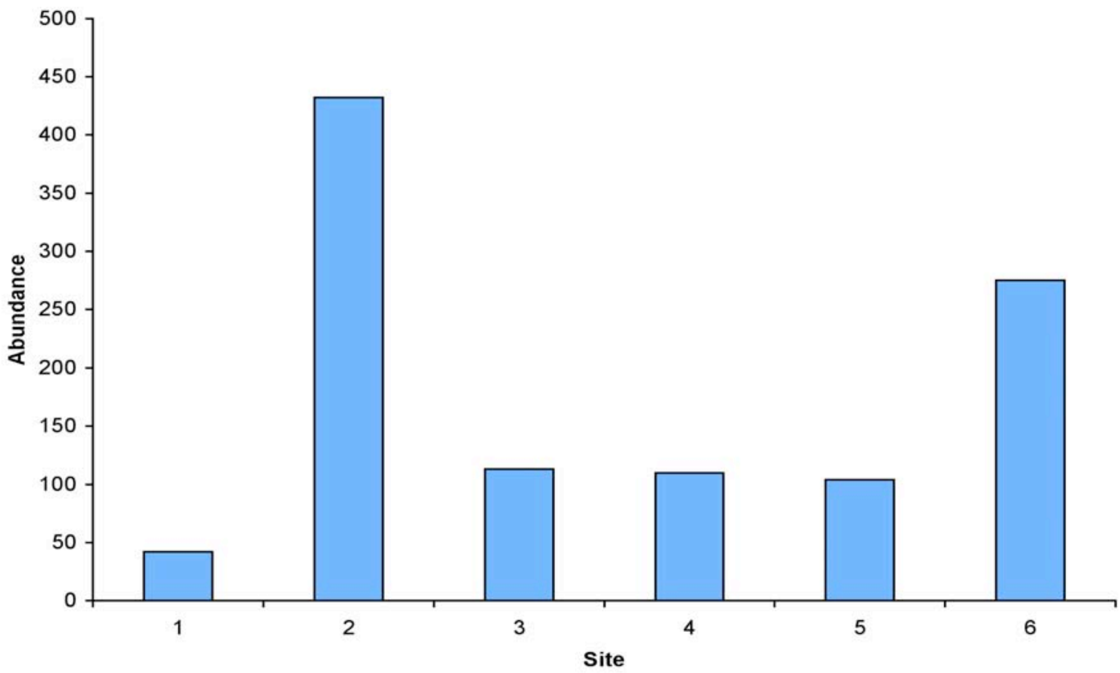


Figure D.6 Total abundance of fish in mangrove habitats in Shute Bay, April 2007.

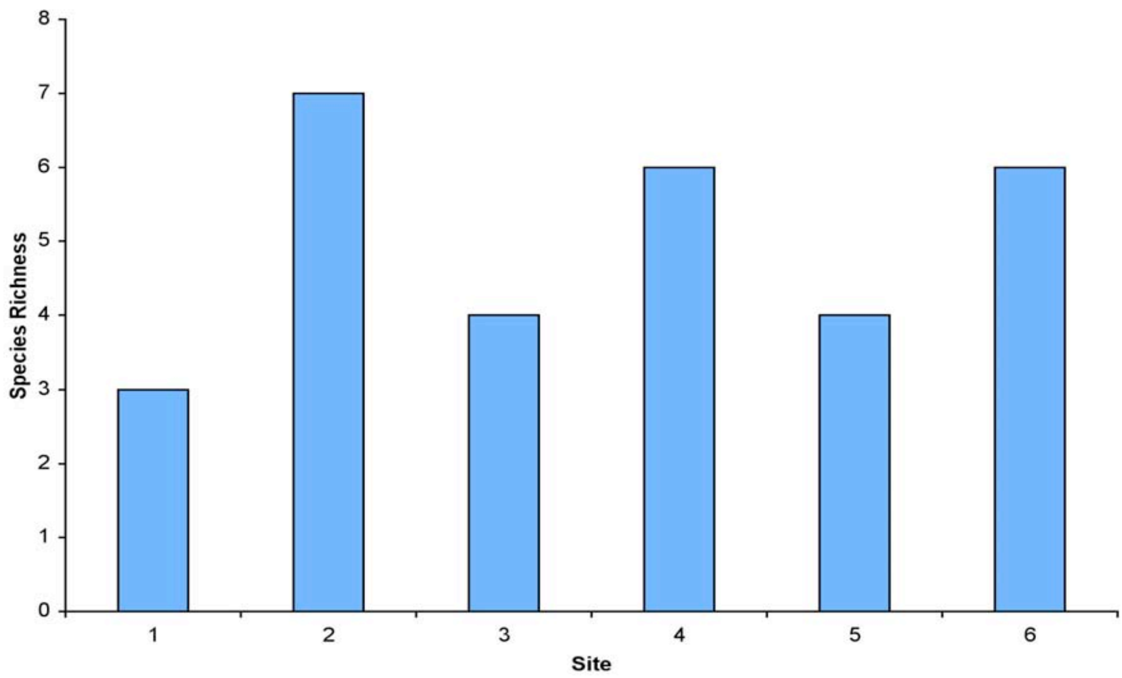


Figure D.7 Species richness of fish communities in mangrove habitats in Shute Bay, April 2007.

Variation in Community Structure of Mangrove and Seagrass Habitat Mosaics

Mangroves and seagrass habitats of Shute Bay support different fish assemblages (note the delineation between the habitats in Figure D.8). Variation within habitats (and sites) was high, as evidenced by the relatively large spread between replicates from each habitat in the MDS analysis (Figure D.8).

The fish assemblages of the northern mangrove communities were significantly different to that of the western and southern mangrove communites (ANOSIM Pairwise tests, R = 1.00, p >5%). Differences between the northern and southern mangroves were largely attributed to greater abundances of pugnose ponyfish (*Secutor ruconis*), estuary perchlet (*Ambassis marianus*), silverbiddies (*Gerres subfasciatus*), and lower abundances of hardyheads (*Atherinomorus* sp.) in the southern mangrove communities. Differences between the northern and western mangroves were largely attributed to greater abundances of *S. ruconis*, *A. marianus* and sea mullet (*Mugil cephalus*), and lower abundances of hardyheads (*Atherinomorus* sp.) in the western mangroves. No differences in overall community structure were observed between the fish assemblages of the western and southern mangrove communities of Shute Bay.

The fish assemblages inhabiting the seagrass communities in the north of Shute Bay were significantly different to those inhabiting the seagrasses in the west of the bay (ANOSIM Pairwise tests, R = 0.852, p>5%), but showed no difference to those inhabiting seagrasses in the south of the bay (ANOSIM Pairwise tests, R = 0.185, p>5%). Differences between the fish assemblages of the seagrass communities in the north and west of Shute Bay were largely attributed to higher abundances of *Metapeneaus ensis*, *S. ruconis*, Hamilton's anchovy (*Thryssa hamiltoni*) and gobies (*Istigobius* sp.), and a lower abundance of mysids in the western seagrasses.

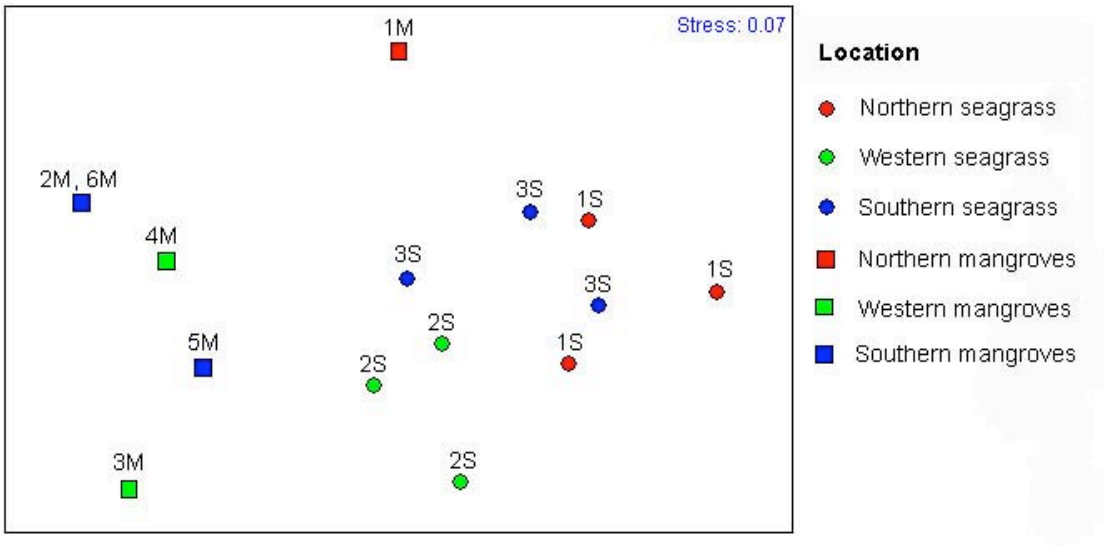


Figure D.8 MDS ordination of fish communities from mangrove and seagrass habitats in Shute Bay, based on a dissimilarity matrix of abundance. Numbers in the figure reflect sites as per Figure E.3. 'M' = mangrove habitats, S = seagrass habitats.

Differences were observed between fish assemblages caught from mangroves and seagrasses within close proximity to each other. Northern mangroves supported a significantly different fish community structure to their nearby seagrass beds ((ANOSIM Pairwise tests, r=1.00, p>5%), as did western (ANOSIM Pairwise tests, r=0.852, p>5%) and southern (ANOSIM Pairwise tests, r=0.917, p>5%) mangrove-seagrass mosaics.

References

Halford, A. R. & Thompson, A. A., 1994, Visual Census Surveys of Reef Fish, Long-term monitoring of the Great Barrier Reef – Standard Operational Procedure Number Seven, Australian Institute of Marine Science, Townsville.

FRC Environmental, 1999, *Proposed Shute Bay Dredging and Spoil Deposition: Seagrass and Fisheries Studies*, Report prepared for Whitsunday Shire Council.

Appendix E Assessment of the Fisheries Value of the Mangrove and Seagrass Habitats

In April 2007 frc environmental conducted an assessment of the fisheries values of mangrove and seagrass habitats within Shute Bay.

Methods

Mangrove Habitats

The relative value of mangrove communities as estuarine fisheries habitat was assessed at seven locations in Shute Bay (Figure E.1). Mangrove fisheries values were surveyed at the sites of the fish assemblage survey, with the inclusion of an additional site in the western side of the bay (Site 7 in Figure E.1). At each site, we assessed community composition and fisheries value in three large (10 x 10 m) quadrats. In each quadrat, we recorded species composition, canopy height, canopy cover, the number of live and dead trees, and distance from LAT. To assist in assessing fisheries value, we recorded the number of aerial roots, visible crab and mollusc species present, number of crab burrows and the cover of leaf litter and large woody debris in three randomly placed small (1.0 x 1.0 m) quadrats in each of the larger quadrats. Cover of mangrove algae (*Catenella nipae*) was given a score of 0-5, with 0 reflecting no *C. nipae* present, and 5 reflecting very high mangrove algae cover.

Seagrass Habitats

Seagrass community composition and value to fisheries was quantified at three sites in Shute Bay (Figure E.1). Seagrass fisheries value survey sites were situated where the fish assemblage surveys where conducted. At each site, we recorded the number of species, species composition, percent overall cover, compaction of sediment, and sediment grain size (percent sediment > 2 mm) within three large (10 m x 10 m) quadrats. In three randomly placed small (1.0 x 1.0 m) quadrats in each of the large quadrats, we quantitatively assessed percent cover, shoot height, biomass, and the number of visible invertebrate species present.

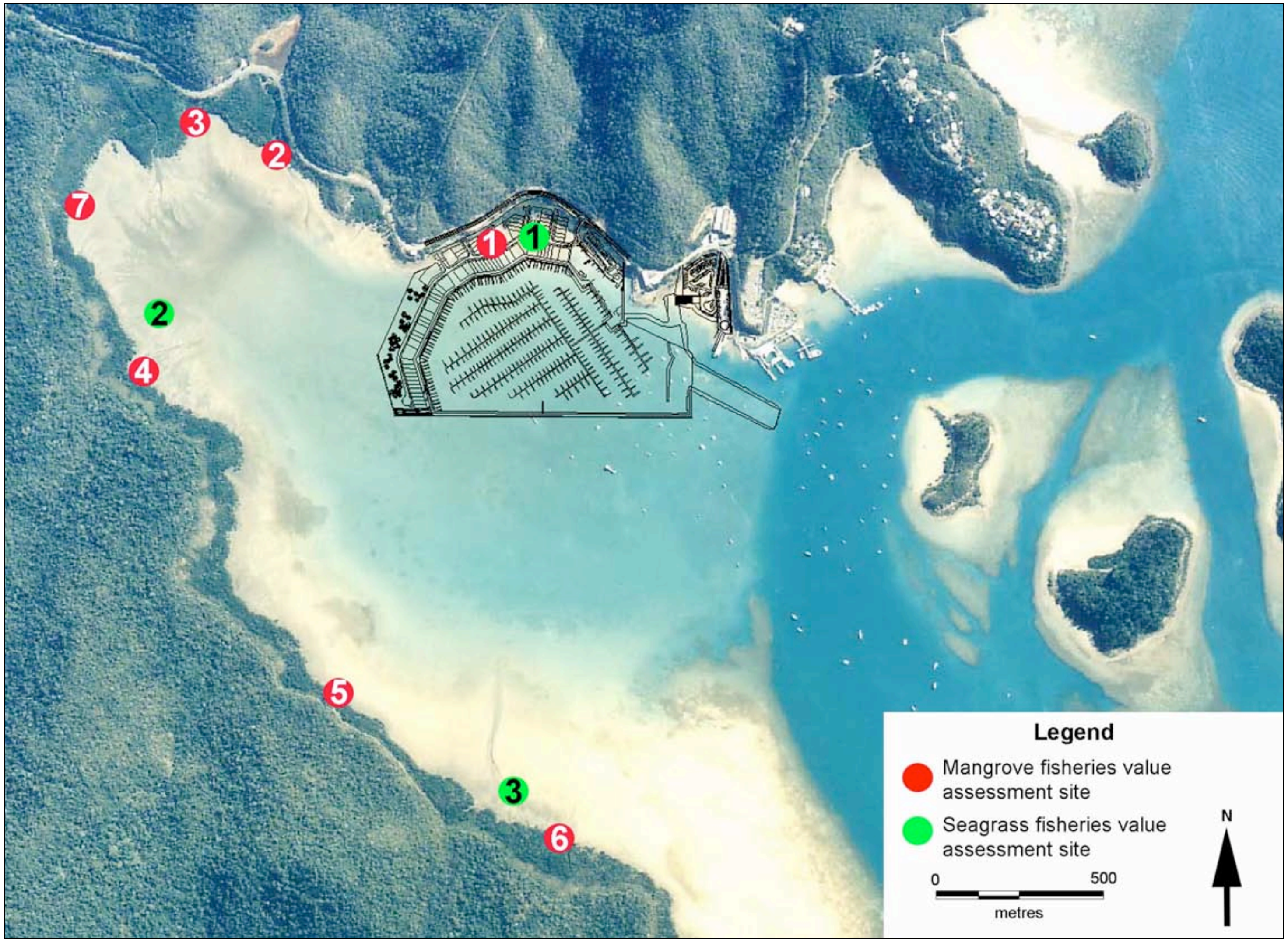


Figure E.1 Mangrove and seagrass fisheries value assessment sites in Shute Bay, with a stylised representation of the proposed marina and resort.

Results

Mangrove Habitats

Species Composition

Species diversity within the survey sites was low (Figure E.2). Two species of mangrove were recorded at each site: the grey mangrove (*Avicennia marina*) and the red mangrove (*Rhizophora stylosa*). A third species (the mangrove apple, *Sonneratia* sp.) was recorded from Site 1 on the northern bank of Shute Bay.

Canopy Height

Canopy height was similar throughout the Bay. Mangroves in the study site at the north of Shute Bay (in the footprint of the proposed marina) were smaller (Figure E.3), however this difference was not statistically significant.

Canopy Cover

Canopy cover of mangroves survey in the footprint of the proposed development was significantly lower than that of the mangroves communities at the southern side of Shute Bay (Figure E.4), and Site 3 on the western side of the bay.

Number of Trees

No significant difference was observed between the number of trees per quadrat between the survey site in the footprint of the proposed development and from the sites and the west and south of Shute Bay (Figure E.5).

No dead trees were observed at any of the survey sites.

Number of Aerial Roots

The number of aerial roots per 1 m^2 was relatively uniform across the western and southern survey sites (Figure E.6). The number of aerial roots in the northern survey site was significantly lower than that observed at all sites on the western side of the bay, and Site 6 on the southern side of the bay.

Cover of Litter / Debris

Cover of litter was similar between the survey site in the footprint of the proposed development and the survey sites on the southern side of the bay and sites 2 & 4 on the western side of the bay (Figure E.7). Sites 3 & 7 on the western side of the bay had significantly higher amounts of litter than the other sites of the bay.

Number of Seedlings

Number of seedlings was low across all sites. No significant difference was observed between the survey site in the footprint of the proposed development and the other survey sites of the bay (Figure E.8).

Cover of Catenella

Cover of *Catenella* sp. varied significantly across the survey sites. No *Catenella* was observed at Site 1, in the footprint of the proposed development (Figure E.9). Cover of *Catenella* was significantly higher at sites in the south of Shute Bay than the north and west (Figure E.9).

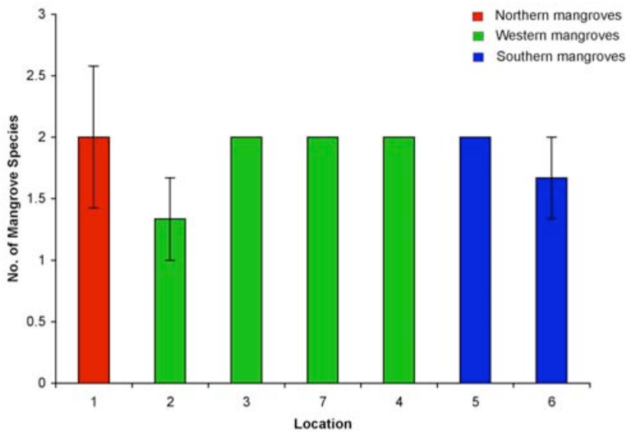


Figure E.2 Mean number of mangrove species at survey sites in Shute Bay (+/- 1 S.E.).

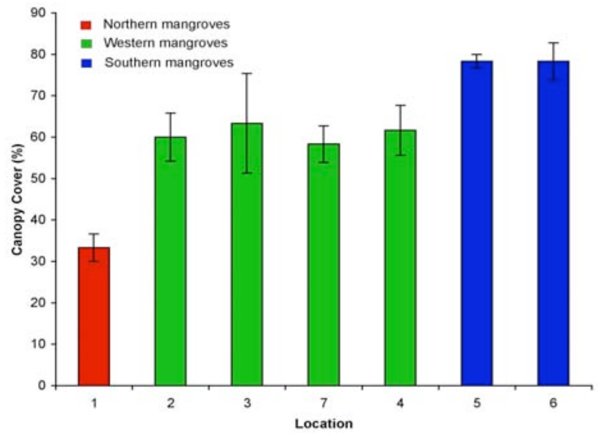


Figure E.4 Mean canopy cover of mangroves at survey sites in Shute Bay (+/- 1 S.E.).

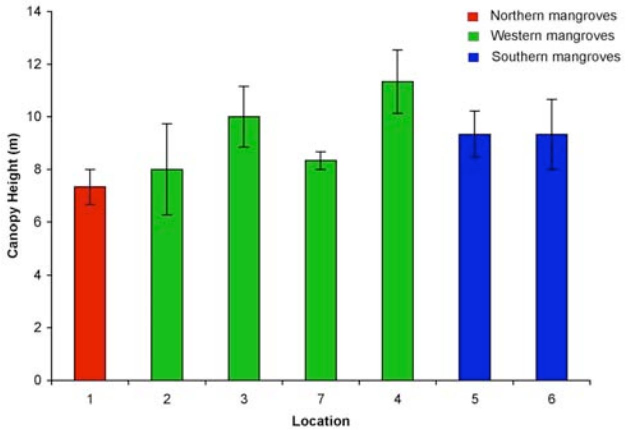


Figure E.3 Mean canopy height (m) of mangroves at survey sites in Shute Bay (+/- 1 S.E.).

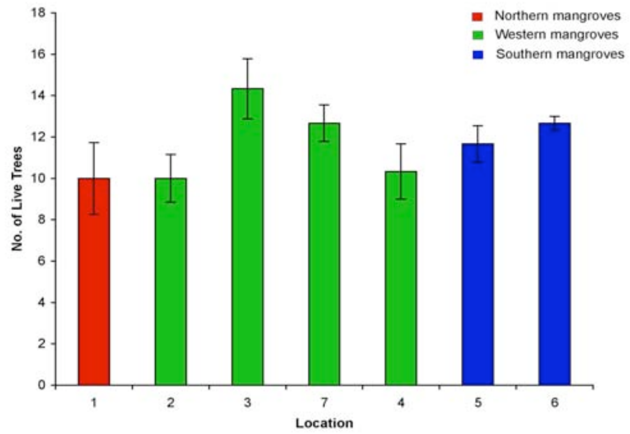


Figure E.5 Mean number of live trees per 100m^2 in mangrove communities in Shute Bay (+/- 1 S.E.).

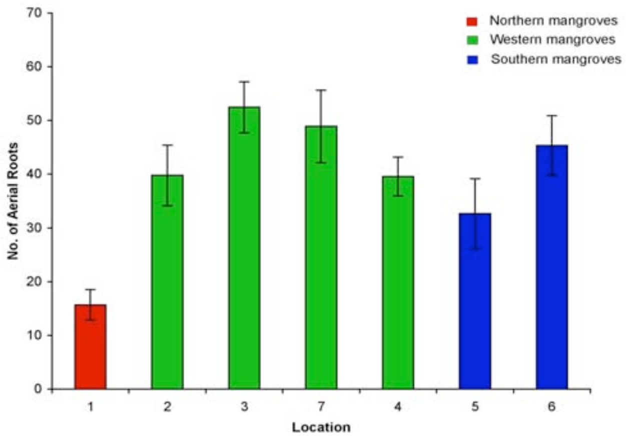


Figure E.6 Mean number of aerial roots per m^2 in mangrove communities at survey sites in Shute Bay (+/- 1 S.E.).

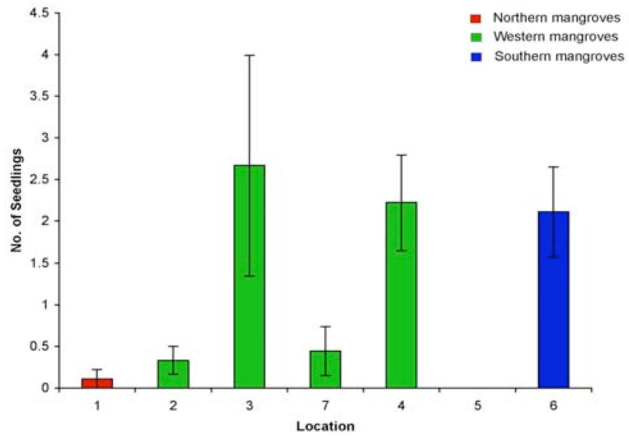


Figure E.8 Mean number of seedlings per m^2 in mangrove communities in Shute Bay (+/- 1 S.E.).

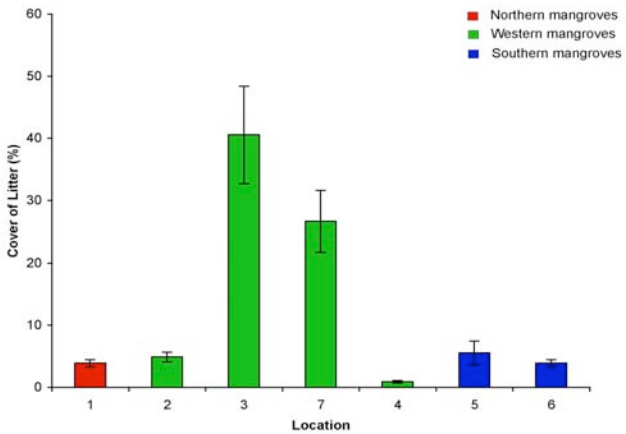


Figure E.7 Mean percent cover of litter in mangrove communities in Shute Bay (+/- 1 S.E.).

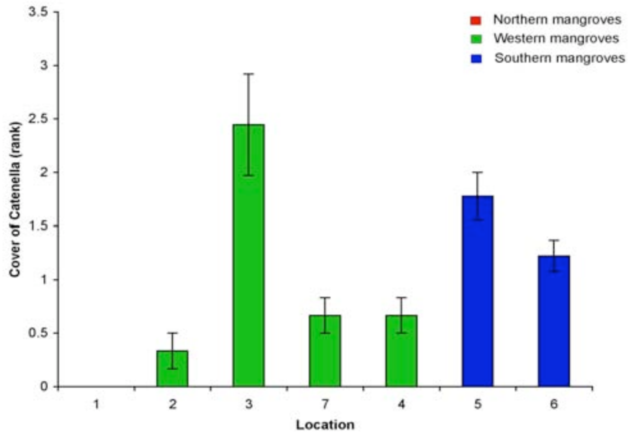


Figure E.9 Mean cover of mangrove algae, *Catenella* sp. in mangrove communities in Shute Bay (+/- 1S.E.).

Abundance of Infauna

The predominant macroinvertebrate infauna on the forest floor of the survey sites were crabs, including swimming crabs (*Thalamita crenata*) (Figure E.10), fiddler crabs (*Uca* spp.) sentinel crabs (*Macropthalamus* spp), furry-clawed crabs (*Australoplax tridentata*) and red-fingered marsh crabs (*Parasesarma erythrodactyla*).

Whelks (*Terebralia sulcata* and *Telescopium telescopium)* were commonly observed on the forest floor at all sites.

Figure E.10

Swimming crab (*Thalamita crenata*) observed at Site 3.

There were no differences in the density of crab burrows between the survey sites at the north, west and south of Shute Bay (Figure E.11). No difference occurred between location (northern, western or southern sites) or site in terms of numbers of large or small burrows (Figure E.12 & Figure E.14). No difference occurred between overall location and number of medium burrows. Site 1 (in the footprint of the proposed development) supported significantly lower numbers of medium burrows than Site 6 on the south side of the bay (Figure E.15).

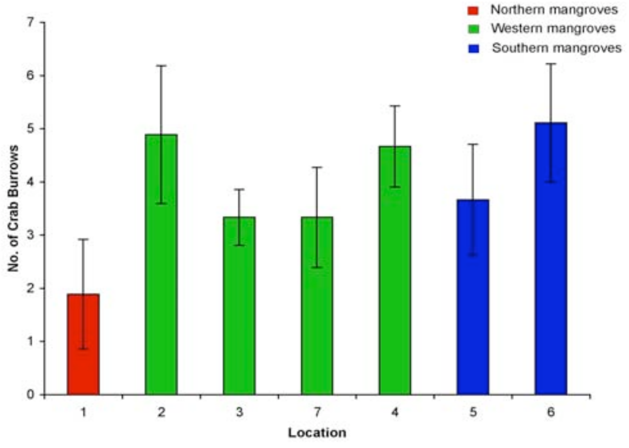


Figure E.11 Mean number of crab burrows per m^2 in mangrove communities in Shute Bay (+/- 1 S.E.).

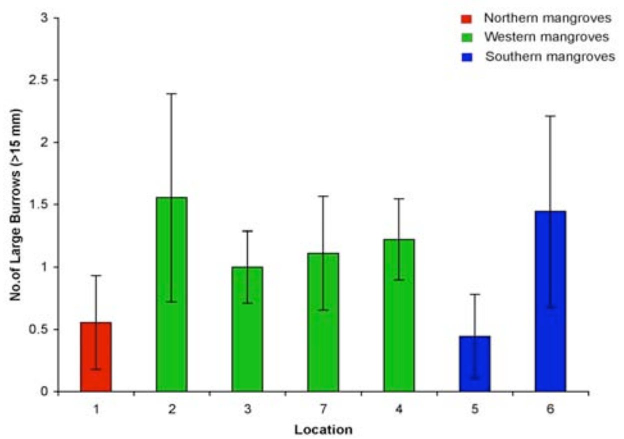


Figure E.12 Mean number of large burrows per m^2 in mangrove communities in Shute Bay (+/- 1 S.E.).

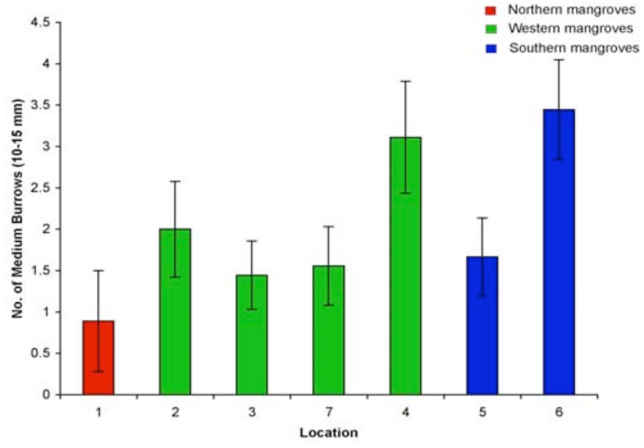


Figure E.13 Mean number of medium burrows per m^2 in mangrove communities in Shute Bay (+/- 1 S.E.).

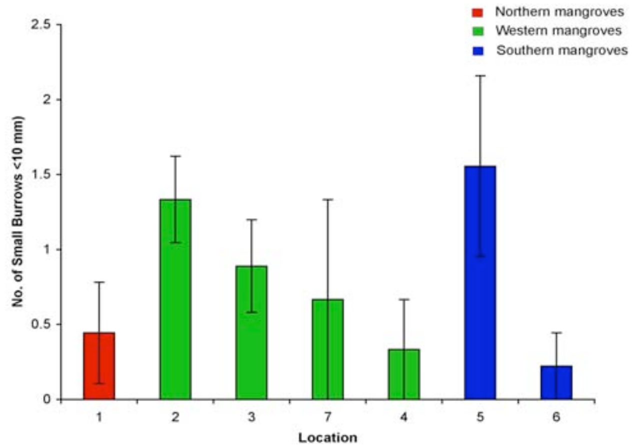


Figure E.14 Mean number of small burrows per m^2 in mangrove communities in Shute Bay (+/- 1 S.E.).

Variation in Vegetative Characteristics and Faunal Abundance

A high amount of variation existed between mangrove communities from the northern (Site 1), western (Sites 2, 3, 7 & 4) and southern (Sites 5 & 6) sides of Shute Bay (as evidenced by the large spaces between locations and sites in the Principle Components Analysis (PCA) (Figure E.15).

The mangrove community surveyed in the north of Shute Bay (in the footprint of the proposed development) generally appeared different to that of the communities in the western and southern sides of the bay (which generally overlapped in their characteristics). This was primarily due to these mangrove communities having lower canopy height, canopy cover, and abundances of aerial roots, seedlings and cover of *Catenella* in this location.

The two displayed axes of the PCA account for 44.5% of the variation observed between mangrove communities. PC1 primarily reflects variation in number of aerial roots, canopy cover, number of live tress and cover of *Catenella* sp.; PC2 reflects variation in cover of litter, cover of *Catenella* sp., number of species present and number of crab burrows.

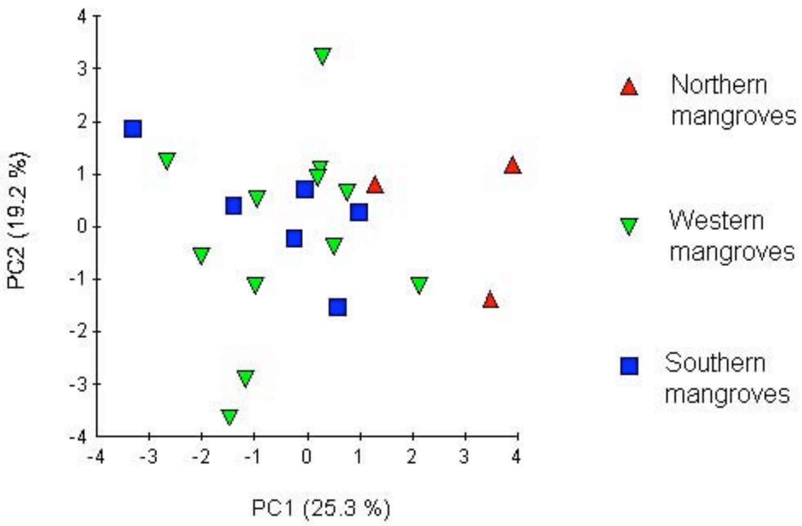


Figure E.15 Principle Components Analysis (PCA) of the habitat characteristics and faunal abundance of the mangroves communities of Shute Bay.

Seagrass Habitats

Species Composition

Seagrass species diversity within the survey sites was low (Figure E.16). Two species of seagrass were recorded at each site: *Z. muelleri* and *H. ovalis*. A third species (*H. uninervis*) was recorded from the survey site on the northern bank of Shute Bay.

Percent Cover

Percent cover of seagrass at the northern site (in the footprint of the proposed development) was lower than that observed at the western and southern sites of Shute Bay (Figure E.17).

Significant differences occurred between all three sites in terms of seagrass cover in the 1 m^2 quadrats (Figure E.18). Differences in overall percent cover and cover of the 1 m^2 quadrats reflect the patchy distribution of the seagrass at the survey sites.

Sediment Characteristics

Sediment compaction was significantly lower at the southern site compared to the northern and western seagrass survey sites (Figure E.19). No difference was observed between the northern and western sites.

No difference was observed in sediment grain size between the three sites (Figure E.20).

Shoot Height

No difference was observed in shoot height between the northern and southern seagrass communities of Shute Bay. Seagrass communities of the western side of Shute Bay were significantly smaller in terms of shoot height than these communities (Figure E.21).

Biomass

Seagrass biomass was significantly lower at Site 1 (within the proposed development footprint) than Sites 2 & 3 (western and southern Shute Bay, respectively) (Figure E.22)

Abundance of Infauna

Whelk abundance was significantly higher in the western site of Shute Bay compared to the northern and southern sites (Figure E.23).

No crabs were observed within the seagrass quadrats at any site.

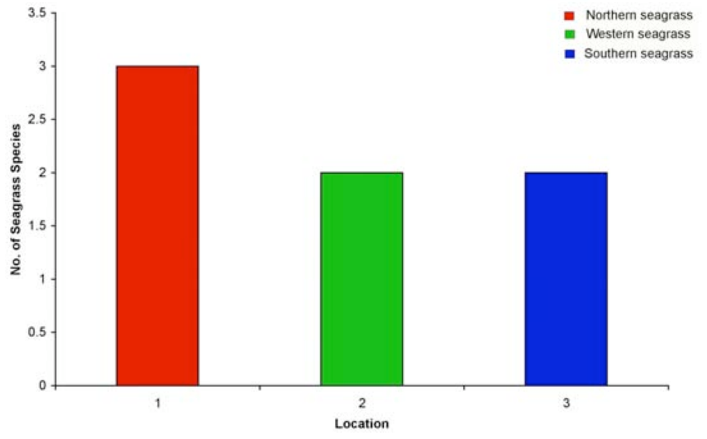


Figure E.16 Mean number of seagrass species at survey sites in Shute Bay.

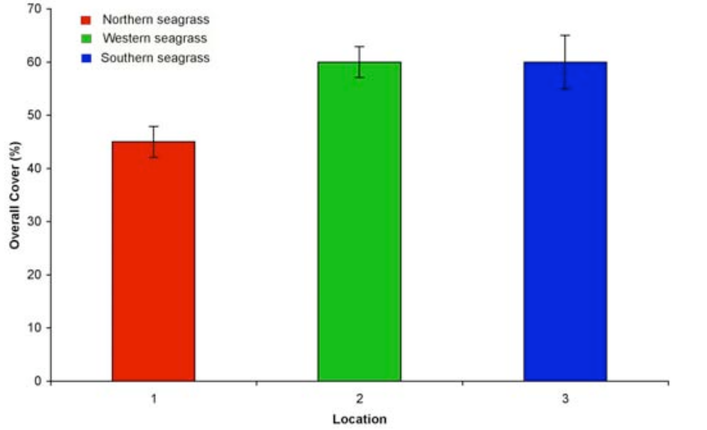


Figure E.17 Mean% cover of seagrass at survey sites in Shute Bay (+/- 1 S.E.).

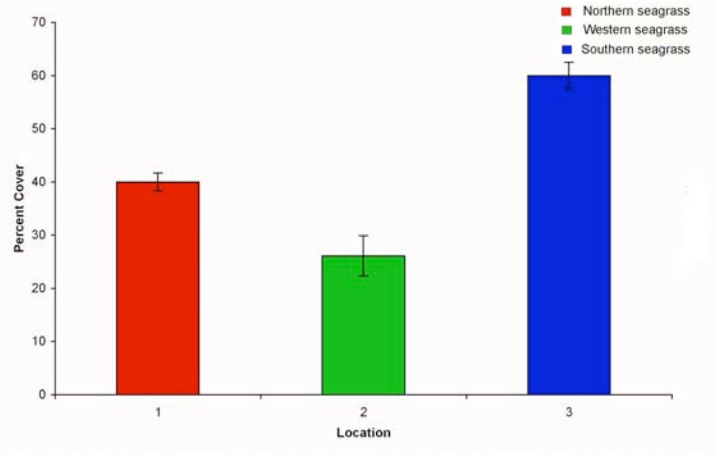


Figure E.18 Mean percent cover of seagrass in $1m^2$ quadrats at survey sites in Shute Bay (+/- 1 S.E.).

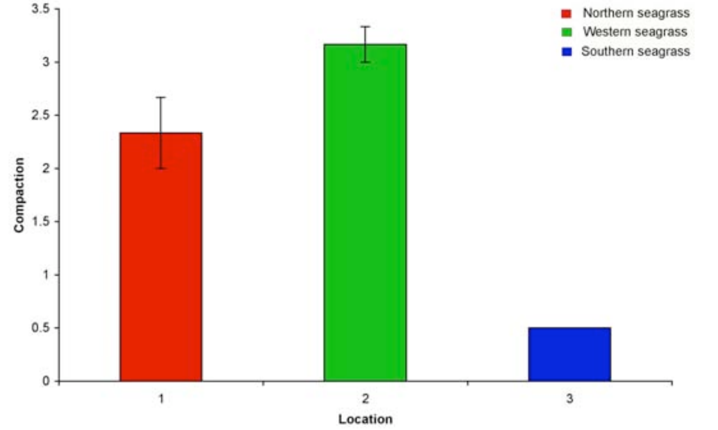


Figure E.19 Mean compaction of sediments at seagrass survey sites in Shute Bay (+/- 1 S.E.).

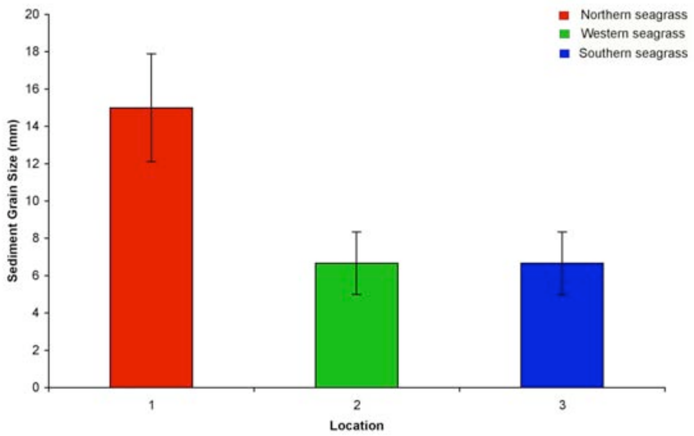


Figure E.20 Mean sediment grain size at seagrass survey sites in Shute Bay (+/- 1 S.E.).

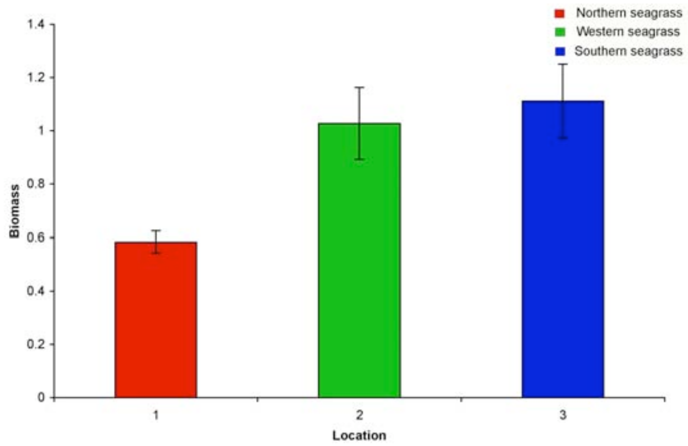


Figure E.22 Mean biomass of seagrass at survey sites in Shute Bay (+/- 1 S.E.).

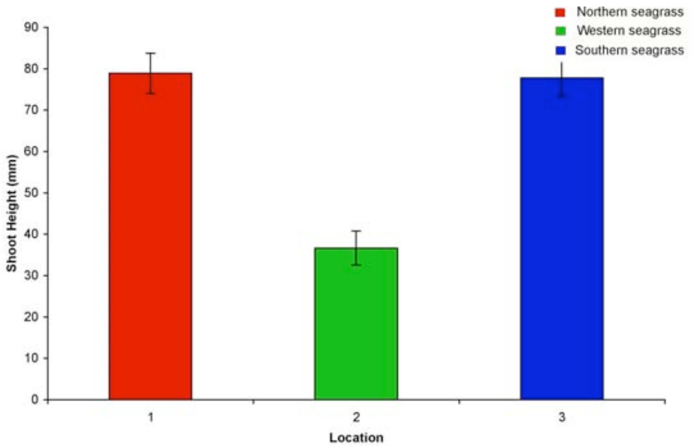


Figure E.21 Mean shoot height of seagrass at survey sites in Shute Bay (+/- 1 S.E>).

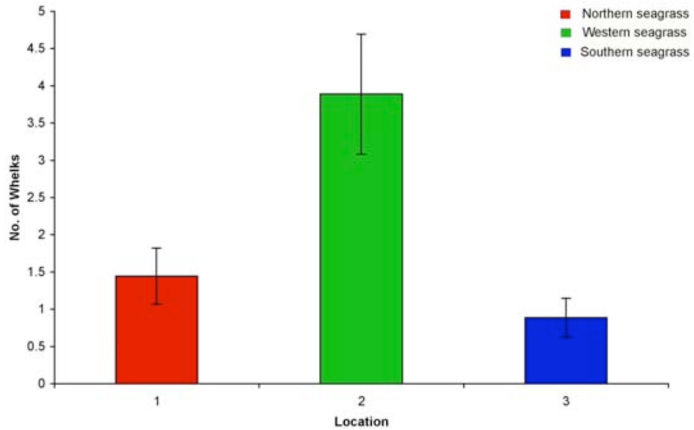


Figure E.23 Mean number of whelks in seagrass communities at survey sites in Shute Bay (+/- 1 S.E.).

Variation in Vegetative Characteristics and Faunal Abundance

The seagrass communities surveyed from the northern, western and southern sides of the Shute Bay were highly distinct, with each location forming a distinct cluster in the PCA (Figure E.24).

The seagrass community surveyed in the north of Shute Bay (in the footprint of the proposed development) generally appeared different to that of the communities in the western and southern sides of the bay. This was primarily due to this seagrass community having a higher number of species present and a lower biomass.

The two displayed axes of the PCA account for 44.5% of the variation observed between seagrass communities. PC1 primarily reflects variation in overall percent cover, compaction of sediment, percent cover, shoot height and biomass; PC2 reflects variation in number of species and sediment grain size.

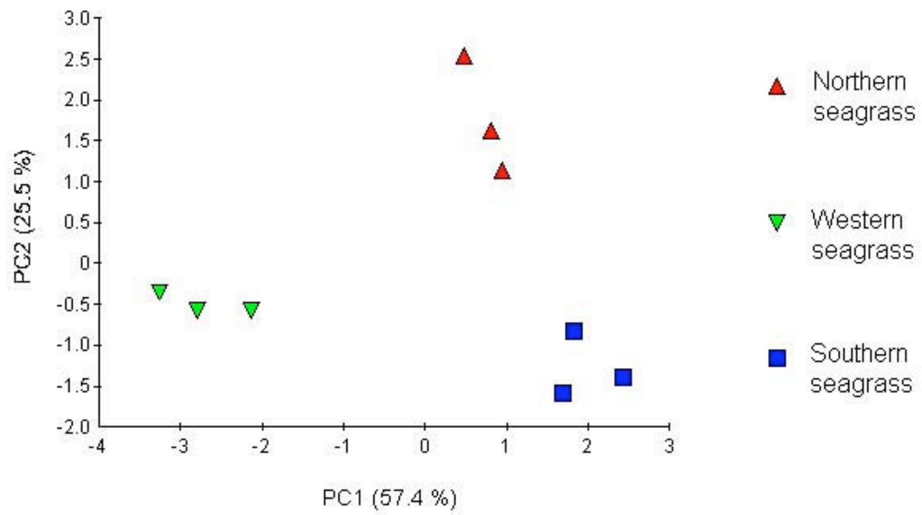


Figure E.24 Principle Components Analysis (PCA) of the habitat characteristics and faunal abundance of the seagrass communities of Shute Bay.

Appendix F Assessment of the Ecology of the Existing Marina Structures

To help determine the potential species that may colonise the proposed marina development, we undertook surveys of flora, sessile invertebrate fauna and fish assemblages associated with existing structures at the Shute Harbour ferry terminal.

Surveys of the Floral and Sessile Invertebrate Communities

Methods

The floral and sessile invertebrate communities inhabiting the existing pilings and rock groyne of the ferry terminal were surveyed by photograph-based quadrats.

Surveys were conducted along three 25 m transects. Two transects were based around the existing pilings, whereas one transect was based on the existing rock groyne. To allow further extrapolation of the communities that might inhabit the structures of the proposed expansion, we surveyed the floral and sessile invertebrate faunas of the rock groyne on the outside of Abel Point Marina via one 25 m snorkel transect.

Transects were surveyed using a modified version of the procedure employed by the University of Queensland for conducting photo transects to monitor coral cover (Roelfsema et al. 2006). For the piling surveys, photographs were taken at two depths (approx 2.0 and 4.0 LAT) from each piling along the transect line. To survey the rock groyne, photographs were taken every metre along the 25 m transect lines. For all transects the camera lens was kept parallel to the reef substrate, at a distance of 40 to 50 cm from the substrate. This distance is similar to that used by the University of Queensland (Roelfsema et al. 2006), the Hawaii Coral Reef Monitoring Program and the Florida Keys National Marine Sanctuary Coral Reef Monitoring Program (Hill & Wilkinson 2004), but is greater than the 15 – 20 cm used by the Australian Institute of Marine Science (AIMS) in their benthic video surveys (Page et al. 2001). This greater distance allowed us to include a lager, more representative area in each photo, without any loss of clarity.

Results

Soft corals from the families Alcyoniidae and Xeniidae dominated the community on the existing pilings of the ferry terminal (Figure F.1; Figure F.5). Coralline algae, the brown algae *Padina* sp. and filamentous algae are less common (Figure F.5). A small cover of hard coral from the family Faviidae was recorded during both transects (Figure F.2; Figure F.5).

Figure F.1

Sarcophyton sp. (left) and *Xenia* sp. are common at on the existing pilings of Shute Marina.

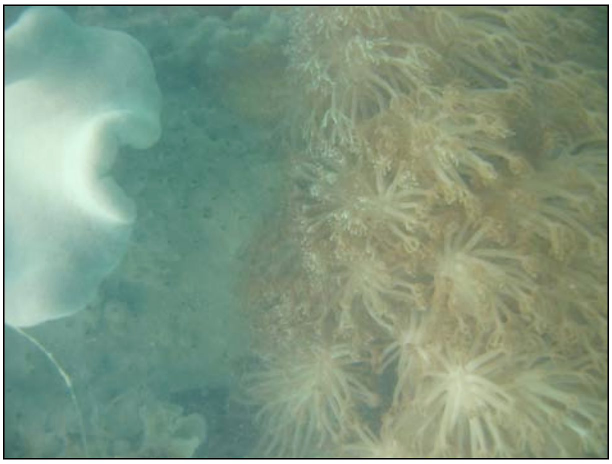
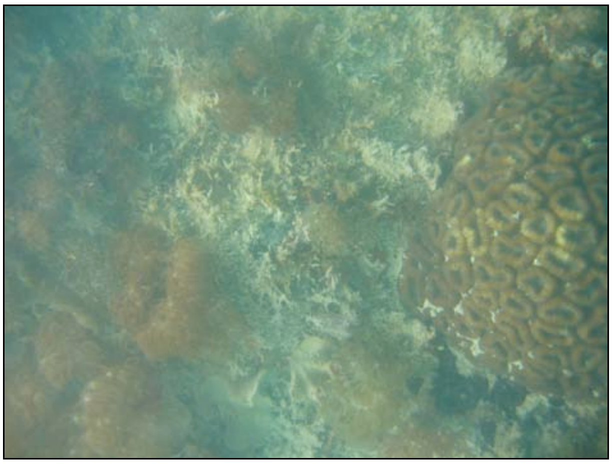


Figure F.2

Favia sp. (right) on the existing pilings of Shute Marina.



Soft corals and macroalgae dominated communities on the existing rock groyne of the Shute Harbour ferry terminal. Soft corals were represented by the families Alcyoniidae (namely the genera *Sarcophyton* sp and *Sinularia* sp.) (Figure F.3; Figure F.5). Filamentous algae was the most commonly recorded algae assemblage.

Diversity along the groyne was observed to be lower than that of the outside rock groyne of Abel Point Marina (Figure F.5). Hard and soft corals, the brown algae *Sargassum* sp., oyster shells and barnacles dominated communities in this more exposed location. Hard corals observed along the groyne include *Turbanaria* sp. (Figure F.4), *Acropora* sp., *Goniopora* sp., and *Lobophyllia* sp.. Soft corals recorded along the groyne include species of *Sarcophyton* and *Sinularia*. As these species have all been recorded from

Shute Bay (see Appendix B), it is expected that many of these species will occur on the hard structures of the proposed marina.

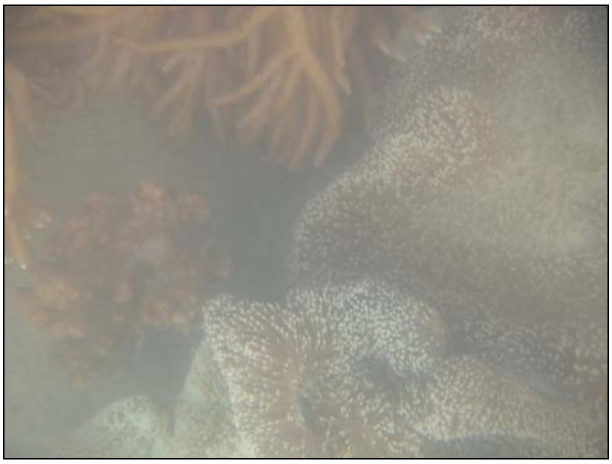


Figure F.3

Sarcophyton sp. (right) and *Sinularia* sp. are common at on the inside rock groyne of Shute Marina.

Figure F.4

Turbinaria sp. and *Sarcophyton* sp. on the outside rock groyne of Abel Point Marina.

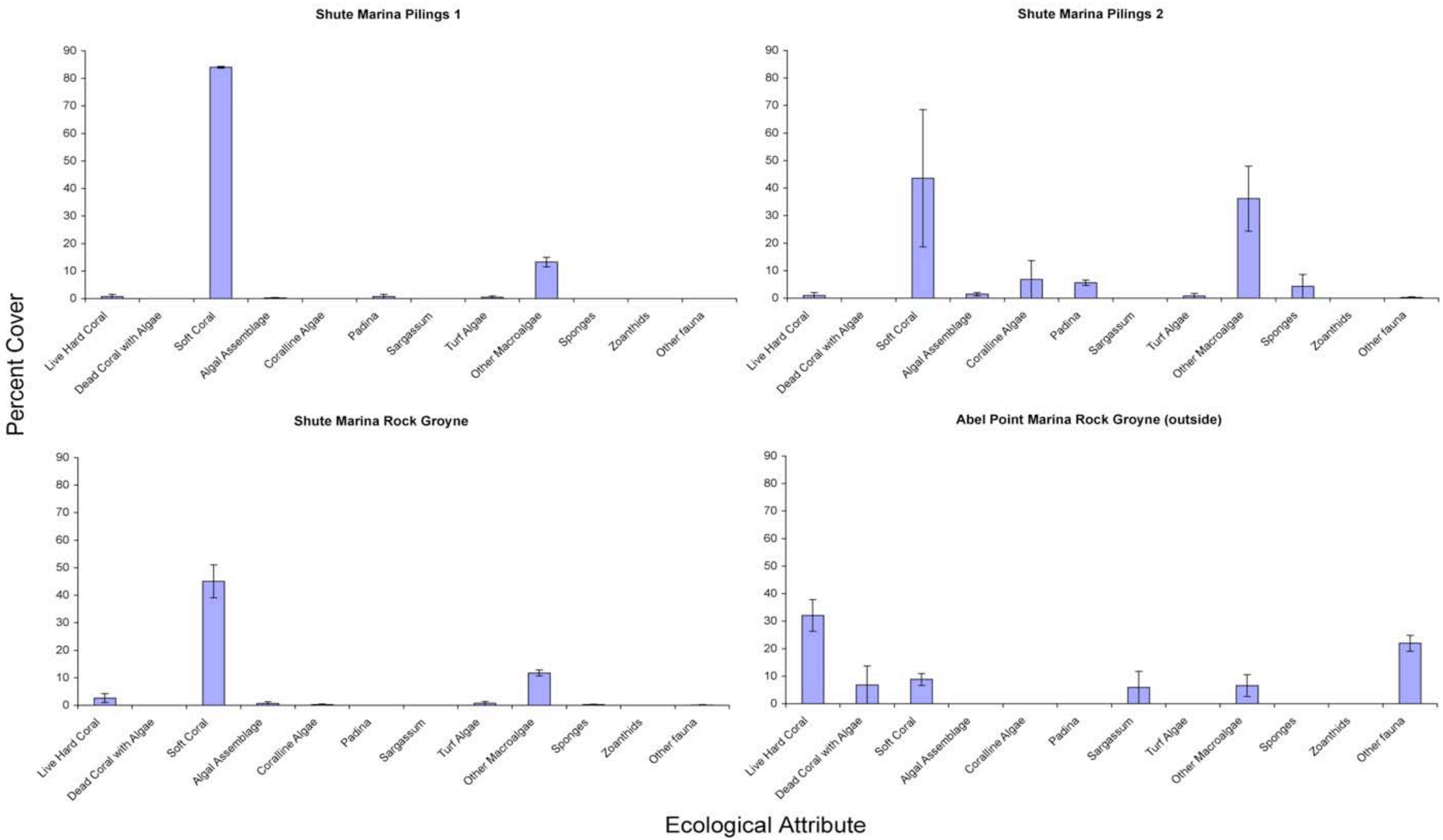


Figure F.5 Cover of the major benthic flora and fauna recorded from the existing ferry terminal and marina structures (Shute Habour and Abel Point).

Fish Surveys

Methods

Surveys of the fish species associated with the ferry terminal pilings and rock groyne were conducted by UVC on SCUBA in April 2007. To allow further extrapolation of the fish assemblages that might utilise the proposed development, we also conducted surveys along the outside rock groyne of Abel Point Marina via two 20 m snorkel UVCs.

Underwater Visual Censuses were conducted using a modified version of the AIMS Long-term Monitoring Program, Standard Operational Procedure Three: Visual Census Surveys of Reef Fish (Halford & Thompson 1994).

Surveys were conducted between 09:00 and 16:00 hours. Surveys at the Shute Harbour ferry terminal were conducted along three 20 m transects. Two transects were based around the existing pilings, whereas one transect was based on the existing rock groyne. Two passes of each transect were completed, with the more mobile, larger fish recorded in a 2 m belt (due to poor visibility at the time of survey) during the first swim, and the less mobile fish recorded from a 1 m belt during the second swim.

Only fish in the 1+ year age class were counted (due to temporal variability in the 0+ age class) (Halford & Thompson 1994).

Results

The marine structures of the Shute Harbour ferry terminal support a diverse fish assemblage. A total of 17 species from 13 families were recorded in association with the pilings and related structures, whereas the rock groyne supported no less than 12 species from 11 families (Table F.1; Table F.2). Many species, including hardyheads (Atherinidae), golden trevally (*Gnathodon speciosus*), dusky beaked coralfish (*Chelmon muelleri*), slatey bream (*Diogramma labiosum*), sergent majors (*Abudefduf* spp.) and bicolour chromis (*Chromis margaritifer*) were sighted around both the pilings and along the rock groyne.

Fish species recorded from the structures of the Shute Habour ferry terminal included cardinalfish (Apogonidae), hardyheads (Atherinindae), blennies (Blenniidae), trevallies (Carangidae), butterflyfish (Chaetodontidae), batfish (Ephippidae), gobies (Gobidae), sweetlips (Haemulidae), garfish (Hemiramphidae), wrasses (Labridae), mangrove jack (Lutjanidae), stripeys (Microcanthidae), angelfish (Pomacanthidae), and damselfish (Pomacentridae).

Table F.1 Fish species recorded from the Shute Harbour ferry terminal pilings during underwater visual censuses, April 2007.

Species	Common Name	Abundance
Atherinidae		
Atherinidae spp.	hardyheads	++++
Blenniidae		
Blenniidae spp.	blennies	+
Petroscirtes fallax	yellow sabretooth blenny	+
Carangidae		
Caranx sexfasciatus	bigeye trevally	++
Gnathodon speciosus	golden trevally	+
Chaetodontidae		
Chelmon muelleri	dusky beaked coralfish	+
Ephippididae		
Platax pinnatus	long-beaked batfish	+
Gobidae		
Gobidae spp.	gobies	+
Haemulidae		
Diogramma labiosum	slatey bream	+
Plectorhinchus gibbosus	brown sweetlip	+
Hemiramphidae		
Hemiramphus robustus	three-by-two garfish	+
Labridae		
Thalasomma spp.	wrasses	+
Lutjanidae		
Lutjanus argentimaculatus	mangrove jack	+
Microcanthidae		
Microcanthus strigatus	stripey	+
Pomacanthidae		
Chaetodontoplus duboulayi	scribbled angelfish	+
Pomacentridae		
Abudefduf spp.	sergent majors	++
Chromis margaritifer	bicolour chromis	+++

+ not common
++ common
+++ abundant
++++ very abundant

Table F.2 Fish species recorded from the Shute Harbour ferry terminal rock groyne during underwater visual censuses, April 2007.

Species	Common Name	Abundance
Apogonidae		
Apogon flavus	yellow cardinalfish	++
Atherinidae		
Atherinidae spp.	hardyheads	++++
Blenniidae		
Blenniidae spp.	blennies	++
Carangidae		
Gnathodon speciosus	golden trevally	+
Chaetodontidae		
Chelmon muelleri	duskybeaked coralfish	+
Gobidae		
Gobidae spp.	gobies	+
Haemulidae		
Diogramma labiosum	slatey bream	+
Holocentridae		
Myripristis sp.	soldierfishes	++
Labridae		
Thalassoma sp.	wrasses	+
Microcanthidae		
Microcanthus strigatus	stripey	++
Pomacentridae		
Abudefduf spp.	sergent majors	+++
Chromis margaritifer	bicolour chromis	+++

\+ not common
++ common
+++ abundant
++++ very abundant

The rock groyne outside of Abel Point Marina supported a comparable fish assemblage to that of the Shute Harbour ferry terminal. A total of 10 families were represented, with no less than 15 species sighted. Visibility was limited (always < 2m) during the survey, which no doubt resulted in an underestimation of fish abundance and species richness, particularly of larger, more mobile species. No species of commercial significance were recorded from the rock groyne. A full list of the species recorded can be found in Table F.3.

Table F.3 Fish species recorded from the rock groyne outside of Abel Point Marina during underwater visual censuses, April 2007.

Species	Common Name	Abundance
Acanthuridae		
Acanthurus grammoptilus	ring-tailed surgeonfish	++
Ctenochaetus striatus	lined bristletooth	+
Apogonidae		
Apogon flavus	yellow cardinalfish	++
Atherinidae		
Atherinidae spp.	hardyheads	++++
Blenniidae		
Blenniidae spp.	blennies	++
Chaetodontidae		
Chaetodon lineolatus	lined butterflyfish	+
Parachaetodon ocellatus	ocellate coralfish	+
Gobidae		
Gobidae spp.	gobies	+
Holocentridae		
Myripristis sp.	soldierfishes	++
Labridae		
Thalassoma sp.	wrasses	+
Microcanthidae		
Microcanthus strigatus	stripey	++
Pomacentridae		
Abudefduf spp.	sergent majors	+++
Chromis viridis	blue green chromis	+++
Chromis margaritifer	bicolour chromis	+++
Dischistodus chrysopoecilus	whitepatch damsel	++

\+ not common
++ common
+++ abundant
++++ very abundant

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Appendix G Conservationally Significant Fauna

Table G.1 Conservationally significant marine mammals, reptiles and fishes that may occur in the Whitsundays region (DE&WR 2007; EPA 2007; IUCN 2007).

Family	Species	Common Name	NCWR[1]	EPBC Act[2]	IUCN Red List[3]
MAMMALS					
Balaenopteridae	*Megaptera novaeangliae*	humpback whale	V	V, M. C	VU
Balaenidae	*Balaenoptera musculus*	blue whale	LC	true blue: E, M, C pygmy blue: insufficient data	EN
Balaenidae	*Balaenoptera edeni*	Bryde's whale	LC	M, C	DD
Delphinidae	*Orcinus orca*	killer whale	LC	M, C	LR
Delphinidae	*Delphinus delphis*	common dolphin	LC	C	LR
Delphinidae	*Grampus griseus*	Risso's dolphin	LC	C	DD
Delphinidae	*Orcaella brevirostris*	Irrawaddy dolphin	R	M, C	DD
Delphinidae	*Orcaella heinsohni*	Australian snubfin dolphin	NL	NL	DD
Delphinidae	*Sousa chinensis*	Indo-Pacific humpback dolphin	R	M, C	DD
Delphinidae	*Stenella attenuata*	spotted dolphin	LC	C	LR
Delphinidae	*Tursiops aduncus*	spotted (inshore) bottlenose dolphin	LC	C	DD
Delphinidae	*Tursiops truncatus*	bottlenose dolphin	LC	C	DD
Dugongidae	*Dugong dugon*	dugong	V	M, O	VU

Family	Species	Common Name	NCWR[1]	EPBC Act[2]	IUCN Red List[3]
REPTILES					
Crocodylidae	*Crocodylus porosus*	estuarine / salt-water crocodile	V	M, O	LR
Cheloniidae	*Caretta caretta*	loggerhead turtle	E	E, M. O	EN
Cheloniidae	*Chelonia mydas*	green turtle	V	V, M. O	EN
Cheloniidae	*Eretmochelys imbricata*	hawksbill turtle	V	V, M. O	CR
Cheloniidae	*Lepidochelys olivaceae*	olive ridley turtle	E	E, M, O	EN
Cheloniidae	*Natator depressus*	flatback turtle	V	V, M. O	DD
Dermochelyidae	*Dermochelys coriacea*	leathery turtle	E	V, M, O	CR
Hydrophiidae	*Acalyptophis peronii*	horned seasnake	LC	O	NL
Hydrophiidae	*Aipysurus duboisii*	Dubois' seasnake	LC	O	NL
Hydrophiidae	*Aipysurus eydouxii*	spine-tailed seasnake	LC	O	NL
Hydrophiidae	*Aipysurus laevis*	olive seasnake	LC	O	NL
Hydrophiidae	*Astrotia stokesii*	Stokes' seasnake	LC	O	NL
Hydrophiidae	*Disteira kingii*	spectacled seasnake	LC	O	NL
Hydrophiidae	*Disteira major*	olive-headed seasnake	LC	O	NL
Hydrophiidae	*Enhydrina schistosa*	beaked seasnake	LC	O	NL
Hydrophiidae	*Hydrophis macdowelli*	small-headed seasnake	LC	O	NL
Hydrophiidae	*Hydrophis ornatus*	seasnake	LC	O	NL
Hydrophiidae	*Lapemis hardwickii*	spine-bellied seasnake	LC	O	NL
Hydrophiidae	*Pelamis platurus*	yellow-bellied seasnake	LC	O	NL
Laticaudidae	*Laticauda colubrina*	sea krait	LC	O	NL
Laticaudidae	*Laticauda laticaudata*	sea krait	LC	O	NL

Family	Species	Common Name	NCWR[1]	EPBC Act[2]	IUCN Red List[3]
ELASMOBRANCHS					
Chondrichthyes	*Carcharodon carcharias*	great white shark	-	M, O	VU
Chondrichthyes	*Rhincodon typus*	whale shark	LC	V, M	VU
Chondrichthyes	*Carcharius taurus*	grey nurse shark	E	CE	VU
FISH					
Solenostomidae		Several species of Solenostomidae (ghost pipefishes) (see Table)	LC	O	NL
Syngnathidae		Several species of sygnathid (pipefishes, seadragons and seahorses (see Table)	LC	O	NL

1 The status of species under the Queensland Nature Conservation (Wildlife) Regulation 1994 (NCWR): LC – Least concern, CE – Critically endangered, E – Endangered, R – Rare, V – Vulnerable.

2 The status of species under the *Environmental Protection & Biodiversity Conservation Act 1999* (EPBC Act): E – Endangered, C – Cetacean, M – Migratory, O – Marine, V – Vulnerable.

3 The status of species under the *IUCN Red List:* CR – Critically endangered, EN – Endangered, VU - Vulnerable, LR – Lower risk, DD – Data deficient, NL – Not listed.

Table G.2 Sygnathids and Solenostomids that may occur in Shute Bay (DE&WR 2007; EPA 2007; IUCN 2007).

Species	Common Name	NCWR[1]	EPBC Act[2]	IUCN Red List[3]
Acentronura tentaculata	hairy pygmy pipehorse	LC	O	NL
Campichthys tyroni	Tyron's pipefish	LC	O	NL
Choeroichthys brachysoma	Short-bodied pipefish	LC	O	NL
Choeroichthys suillus	Pig-snouted pipefish	LC	O	NL
Corythoichthys amplexus	Fijian banded pipefish	LC	O	NL
Corythoichthys flavofasciatus	Yellow-banded pipefish	LC	O	NL
Corythoichthys intestinalis	Banded pipefish	LC	O	NL
Corythoichthys ocellatus	orange-spotted pipefish	LC	O	NL
Corythoichthys paxtoni	Paxton's pipefish	LC	O	NL
Corythoichthys schultzi	Schultz's pipefish	LC	O	NL
Cosmocampus darrosanus	D'Arros pipefish	LC	O	NL
Doryrhamphus excisus	Blue-stripe pipefish	LC	O	NL
Festucalex cinctus	girdled pipefish	LC	O	NL
Halicampus dunckeri	Duncker's pipefish	LC	O	NL
Halicampus grayi	mud pipefish	LC	O	NL
Halicampus nitidus	Glittering pipefish	LC	O	NL
Halicampus spinirostris	Spiny-snout pipefish	LC	O	NL
Hippichthys cyanospilos	blue-speckled pipefish	LC	O	NL
Hippichthys heptagonus	madura pipefish	LC	O	NL
Hippichthys penicillus	mangrove pipefish	LC	O	NL
Hippocampus bargibanti	Pygmy seahorse	LC	O	NL
Hippocampus kuda	spotted seahorse	LC	O	NL
Hippocampus planifrons	flat-face seahorse	LC	O	NL
Hippocampus zebra	Zebra seahorse	LC	O	NL
Micrognathus andersonii	Anderson's pipefish	LC	O	NL

Species	Common Name	NCWR[1]	EPBC Act[2]	IUCN Red List[3]
Micrognathus brevirostris	thorn-tailed pipefish	LC	O	NL
Nannocampus pictus	Painted pipefish	LC	O	NL
Solegnathus hardwickii	pipehorse	LC	O	NL
Solenostomus cyanopterus	blue-finned ghost pipefish	LC	O	NL
Solenostomus paradoxus	harlequin ghost pipefish	LC	O	NL
Stigmatopora nigra	wide-bodied pipefish	LC	O	NL
Syngnathoides biaculeatus	double-ended pipehorse	LC	O	NL
Trachyrhamphus bicoarctatus	bend stick pipefish	LC	O	NL
Trachyrhamphus longirostris	Long-nosed pipefish	LC	O	NL

[1] The status of species under the Queensland Nature Conservation (Wildlife) Regulation 1994 (NCWR): LC – Least concern, CE – Critically endangered, E – Endangered, R – Rare, V – Vulnerable.

[2] The status of species under the *Environmental Protection & Biodiversity Conservation Act 1999* (EPBC Act): E – Endangered, C – Cetacean, M – Migratory, O – Marine, V – Vulnerable.

[3] The status of species under the *IUCN Red List:* CR – Critically endangered, EN – Endangered, VU - Vulnerable, LR – Lower risk, DD – Data deficient, NL – Not listed.

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