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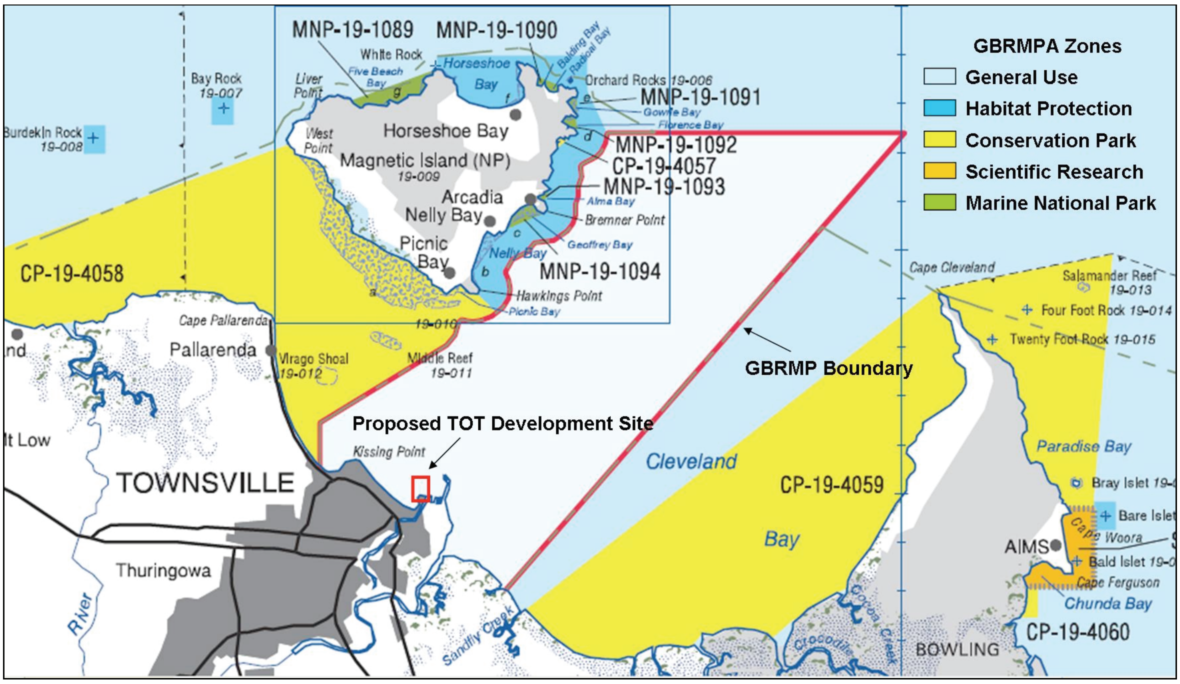
TOWNSVILLE OCEAN TERMINAL

REPORT ON POTENTIAL IMPACTS ON MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE (EPBC ACT)



REPORT FOR: CITY PACIFIC LIMITED

C&R CONSULTING PTY LTD

OCTOBER 2007

"IMPORTANT NOTE"

Signed on behalf of
C&R CONSULTING PTY LTD

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Director/s

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Date

1 EXECUTIVE SUMMARY

Background Setting of the TOT Development Site

The proposed development is sited within an area of complex interactions between Local, State and Federal jurisdictions, each with their own specific, and often inconsistent, environmental assessment criteria. The most contentious points of conflict result from the existence of a relatively large coastal city with an active export and import Port within zones of Marine National Parks and World Heritage Areas. The anthropogenic settlement and associated activities imply a degree of impact, whereas National Parks and World Heritage Areas imply relatively pristine conditions. This contradiction means that the Development may be assessed against the stringent conditions relating to developments in protected areas, but that these conditions themselves have to be assessed against a background of impacted conditions. In these circumstances it is believed that a criteria of "no significant proportional increase over existing ambient conditions in the Cleveland Bay environment" should be used as an assessment criterion.

Description of TOT Development, Location and Background.

This separate, stand-alone report addressing matters of National Environmental Significance (NES) under the *Environment Protection and Conservation Act 1999* (EPBC Act) has been undertaken to assess and advise on all relevant matters under Section 1.7 of the Terms of Reference (ToR) for the Townsville Ocean Terminal (TOT) Development.

The TOT site is located on and adjacent to the existing Townsville foreshore and incorporates the existing Port Western and Northern breakwaters, the existing perimeter of the land around the Townsville Casino and the Townsville Convention Centre and Mariners Drive Peninsula.

The Development site is located adjoining the developed Centre of Townsville, directly adjacent to the Port of Townsville facilities and has been previously disturbed with construction of the existing breakwaters and adjoining reclamation works.

The TOT Development was declared a controlled action under the EPBC Act on 16 October 2006, to investigate whether the TOT Development was, or was likely to have, significant impacts on *at least* the following matters of National Environmental Significance (NES):

- Sections 12 and 15A: Great Barrier Reef World Heritage Area
- Sections 16 and 17B: Bowling Green Bay Ramsar Site
- Sections 18 and 18A: Listed Threatened Species and Communities, for
  - Humpback whale (Megaptera novaeangliae)
  - Flatback turtle (*Natator depressus*)
- Sections 20 and 20A: Listed Migratory Species, for:
  - Dugong (Dugong dugon)
  - Humpback whale (Megaptera novaeangliae)
  - Flatback turtle (*Natator depressus*)

World Heritage Values

The Development site is not within the boundaries of the Great Barrier Reef Marine Park (GBRMP), but is located within the greater Cleveland Bay area, which lies within the Boundaries of the Great Barrier Reef World Heritage Area (GBRWHA). Cleveland Bay represents a small portion of the overall GBRWHA (~0.07%), but harbours a number of important inshore marine species and communities. Of the specific criteria for which the GBRWHA was listed, the following elements are represented in the wider Cleveland Bay area:

- coral reefs (especially inshore coral reefs in good condition, potentially more resilient to climate change than reefs further offshore),
- inter-reefal and lagoonal benthos,
- seagrass meadows and mangrove ecosystems,
- habitats for species of conservation significance,
- coastal / continental islands (Magnetic Island) of exceptional natural beauty,
- many species of coral (including colonies > 200 years old), macroalgae, crustaceans, polychaetes, molluscs, phytoplankton, fish, seabirds, mammals and reptiles.

Ramsar Wetlands

The Ramsar-listed Bowling Green Bay Wetlands are located upstream of the Development site and are therefore are considered at minimal risk of impacts from the TOT Development, and are therefore not described or considered in detail. The earlier inclusion of this matter of NES in its referral to the Department of the Environment and Water Resources (DEW) was due to a proposal to dredge sand material from a river mouth closer to the Ramsar site. This has now been discounted through the new construction methodology adopted.

Listed Threatened and Migratory Species

Nineteen species listed by the EPBC Act as threatened or migratory have been recorded in Cleveland Bay, and some have been observed or recorded either within or directly outside the TOT Development site. This includes the three species specified by the ToR (Humpback whale *Megaptera novaeangliae*, Dugong *Dugong dugon* and Flatback turtle *Natator depressus*). Cleveland Bay is a core aggregation site for the Australian east coast population of Dugongs, and lies in the annual migration path of the Humpback whale. Flatback turtles forage in Cleveland Bay and nest on Townsville's mainland beaches. Some nesting sites on the Strand have the potential to bring individual Flatback turtles into proximity with the Development site.

The other relevant species listed in the EPBC Act as threatened or migratory include:

- Australian snubfin dolphin (*Orcaella heinsohni*)
- Indo-Pacific humpbacked dolphin (*Sousa chinensis*)
- Bryde's whale (Balaenoptera edeni)
- Blue Whale (Balaenoptera musculus)
- Loggerhead turtle (*Caretta caretta*)
- Green turtle (*Chelonia mydas*)
- Leatherback turtle (*Dermochelys coriacea*)
- Hawksbill turtle (Eretmochelys imbricata)
- Olive Ridley turtle (*Lepidochelys olivacea*)
- Estuarine crocodile (*Crocodylus porosus*)
- Red goshawk (Erythrotriorchis radiatus)
- White-bellied sea-eagle (*Haliaeetus leucogaster*)
- White-throated needletail (*Hirundapus caudacutus*)
- Barn swallow (*Hirundo rustica*)
- Black-faced monarch (*Monarcha melanopsis*)
- Australian painted snipe (*Rostratula australis*)

For these listed threatened and migratory species, this report provides information on, where available:

- the species' current distribution;
- relevant information about the ecology of the species (habitat, feeding and breeding behaviour etc);
- information about any populations of the species or habitat for the species in the area affected by the proposed action;
- current pressures on the species, especially those in the area to be affected by the proposal; and
- relevant controls or planning regimes already in place.

Impacts and Potential Impacts

While many activities associated with the TOT Development will be contained within the Development site, their effects will almost certainly extend beyond the site's limits. The potential impacts described below should therefore be taken to apply to the Development site itself and the surrounding marine habitats of Cleveland Bay. The potential impacts include:

- increased noise pollution through construction activities and the increase in large and small vessel traffic during operation;
- the increased potential for boat strikes;
- adverse affects on water quality through increased turbidity, causing light attenuation and sediment deposition onto seagrasses and corals, with corresponding impacts on listed species dependant on such ecosystems for food source;
- contamination of seagrasses, corals, benthic communities and water quality from oil, chemical or sewerage spills;
- fishes in Cleveland Bay may be subject to increased recreational exploitation, as a result of the increased visitation caused by the Development;
- elevated nutrient contents, endangering seagrasses and corals through the increased growth and shading by macroalgae, and through an increase in contaminants in the water and sediments;
- damage to seagrasses and benthic communities through contaminated sediments;
- the potential burial of benthic organisms through sediment deposition; and
- the potential reduction in predator populations of benthic invertebrates (e.g. fishes, birds).

The construction and operation of the TOT Development have the potential to adversely affect the World Heritage Value of the GBRWHA as represented by Cleveland Bay coral reefs, seagrass beds, benthic communities and rare, threatened and migratory species that rely on these habitats. Cleveland Bay is a small area of the GBRWHA (~0.07%), but contains important inshore coral reefs and seagrass beds that offer a core habitat to Dugong, Indo-Pacific humpbacked dolphins and Australian snubfin dolphins. Potential impacts, described in more detail in the main body of this report, have the potential to:

- modify or inhibit ecological processes in a World Heritage property, by interfering with the health of coral reefs, seagrass beds and benthic communities through water and sediment quality reduction;
- reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property, by causing mortality to the more vulnerable species of seagrasses, corals and benthic invertebrates;
- fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage property, by reducing seagrasses and therefore removing an important food resource for Dugongs;
- cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property;
- fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage property.

It is possible to mitigate some of these impacts through the maintenance of water and sediment quality within stringent limits, and other recommended actions for noise, marine debris and increased vessel traffic.

The construction and operation of the TOT Development have the potential to adversely affect populations of EPBC-listed threatened and migratory species for which Cleveland Bay represents a key habitat. Potential impacts vary, depending on the range and habitat requirements of the listed species. The most relevant impacts on threatened or migratory species, described in more detail below, have the potential to:

- lead to long term decrease in the size of a population (Dugongs, Australian snubfin dolphins);
- reduce the area of occupancy of the species (Indo-Pacific humpbacked dolphins, Australian snubfin dolphins, Dugongs, Green turtles, Flatback turtles);
- adversely affect habitat critical to the survival of the species (Dugongs, Australian snubfin dolphins);
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline (Dugongs, Australian snubfin dolphins);
- result in invasive species that are harmful to the species becoming established (introduced birds and mammals, introduced marine pests);
- introduce disease that may cause the species to decline (Green turtles, algal blooms); or
- interfere with the recovery of the species (Dugongs).
- The TOT Development is unlikely to:
- fragment an existing population into two or more populations; or
- disrupt the breeding cycle of a population.

For listed migratory species in particular, the TOT Development has the potential to:

- substantially modify, within the TOT Development site, an area of important habitat for migratory species (Dugong, Humpback whale, Australian snubfin dolphins);
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species (Green turtle); and
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species (Dugong, Australian snubfin dolphins).

EPBC-listed species potentially affected by the TOT Development, and the primary potential impacts, include:

- Dugong (*Dugong dugon*) – contamination and reduction of feeding areas and key habitat, noise pollution, increased boat strike
- Humpback whale (*Megaptera novaeangliae*) – disruption of migration pathway, noise pollution, increased boat strike
- Australian snubfin dolphins (*Orcaella heinsohni*) – disturbance of feeding habitat, contamination or mortality of prey species, noise pollution, increased boat strike
- Indo-Pacific humpbacked dolphin (*Sousa chinensis*) – disturbance of feeding habitat, contamination or mortality of prey species, noise pollution, increased boat strike
- Flatback turtle (*Natator depressus*) – noise and light pollution, increased boat strike, ingestion of or entanglement in marine garbage and debris
- Green turtle (*Chelonia mydas*) – contamination or reduction of feeding areas, noise and light pollution, increased boat strike, ingestion of or entanglement in marine garbage and debris
- White-bellied sea-eagle (*Haliaeetus leucogaster*) – contamination or reduction in prey species, increased competition from introduced birds

EPBC-listed species unlikely to be significantly affected by the TOT Development at the population level include:

- Bryde's whale (Balaenoptera edeni)
- Blue whale (Balaenoptera musculus)
- Estuarine crocodile (*Crocodylus porosus*)
- Loggerhead turtle (*Caretta caretta*)
- Leatherback turtle (*Dermochelys coriacea*)
- Hawksbill turtle (Eretmochelys imbricata)
- Olive Ridley turtle (*Lepidochelys olivacea*)
- Red goshawk (Erythrotriorchis radiatus)
- White-throated needletail (*Hirundapus caudacutus*)
- Barn swallow (*Hirundo rustica*)
- Black-faced monarch (*Monarcha melanopsis*)
- Australian painted snipe (*Rostratula australis*)

Recommendations

For each matter of NES, recommendations are made for the prevention, monitoring and remediation of all potential impacts. Many impacts can be prevented through the maintenance of water and sediment quality, the education of construction and operation staff, residents and visitors, the early preparation of contingency plans, the avoidance of dredging during adverse tidal, current and weather conditions, the establishment of, and adherence to, a strong monitoring programme and the adherence to strict measures to mitigate the impacts of noise, marine debris and vessel traffic.

If water and sediment quality are maintained at current conditions, then it is concluded that the project is sustainable. However, it is stressed that given the high environmental values of the corals, seagrass beds, and other flora and fauna of the Bay (e.g. the Snubfin Dolphin), maintenance of this water and sediment quality is vital to the sustainability of these ecosystems and the viability of the project. To this end, a stringent monitoring programme involving:

- continuous water quality monitoring for the operational phase,
- quarterly, annual and event monitoring at designated locations, of corals, seagrasses, dolphins and other listed fauna, and their associated ecosystems, during the construction period and continuing for a period of 5 to 10 years after the Development has been completed.
- Quarterly, annual and event monitoring at the same designated locations, of sediments and waters for a comprehensive range of chemical species including heavy metals and nutrients, during the construction period and continuing for a period of 5 to 10 years after the Development has been completed.

Except for the continuous water quality monitoring, the above mentioned recommendations are proposed on the basis of the precautionary principle. Should an event be experienced then reference should be made to the continuous water quality monitoring to determine the probability of the impact originating specifically from this Development.

Conclusions

The marine environment in Cleveland Bay harbours a host of valuable and protected ecological communities and species that are easily accessible to residents and visitors of Townsville and Magnetic Island, and susceptible to anthropogenic impacts. Thus, in keeping with the concept of Ecological Sustainability, and the expressed wishes of the Developers, consideration was given to the appropriateness of the proposed extent of the Development. Further, the Developers acknowledge that an intact marine environment is not only ecologically vital, it will add significantly to the economic value of residential and tourist areas in the vicinity. Hence, a full range of environmental options was considered, ranging between the two extremes of “no further action required” to the ‘no development’ option. However, it is considered that adequate mitigation measures and a clearly defined monitoring regime will significantly minimise most impacts from this Development.

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2 BACKGROUND INFORMATION

2.1 INTRODUCTION

This report describes the occurrence and extent of Matters of National Environmental Significance (NES) protected by the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* in Cleveland Bay, particularly in areas potentially affected by the proposed Townsville Ocean Terminal (TOT) Development. The requirement to identify and protect these matters has been outlined in Section 1.7 of the Terms of Reference (ToR) issued by The Coordinator General, Queensland Government, under Part (4) of the *Queensland State Development and Public Works Organisation Act 1971 (SDPWOA)*.

Subsequent to the referral by the Proponent of the proposed TOT Development to the Department of the Environment and Water Resources (DEW), stating the Proponent's belief that the matter was a controlled action, The TOT Development was declared a controlled action under the EPBC Act on 16 October 2006.

In accordance with the Queensland Bilateral Agreement process, the Environmental Impact Assessment (EIA) process under the SDPWOA is an accredited process for the assessment of whether the TOT Development was, or was likely to have, significant impacts on the following matters of NES declared for the TOT Development:

- Sections 12 and 15A: Great Barrier Reef World Heritage Area
- Sections 16 and 17B: Bowling Green Bay Ramsar Site
- Sections 18 and 18A: Listed Threatened Species and Communities, for
  - Humpback whale (Megaptera novaeangliae)
  - Flatback turtle (Natator depressus)
- Sections 20 and 20A: Listed Migratory Species, for:
  - Dugong (Dugong dugon)
  - Humpback whale (Megaptera novaeangliae)
  - Flatback turtle (Natator depressus))

The ToR does not provide for the consideration of species listed under the EPBC Act as 'marine' or 'cetacean'.

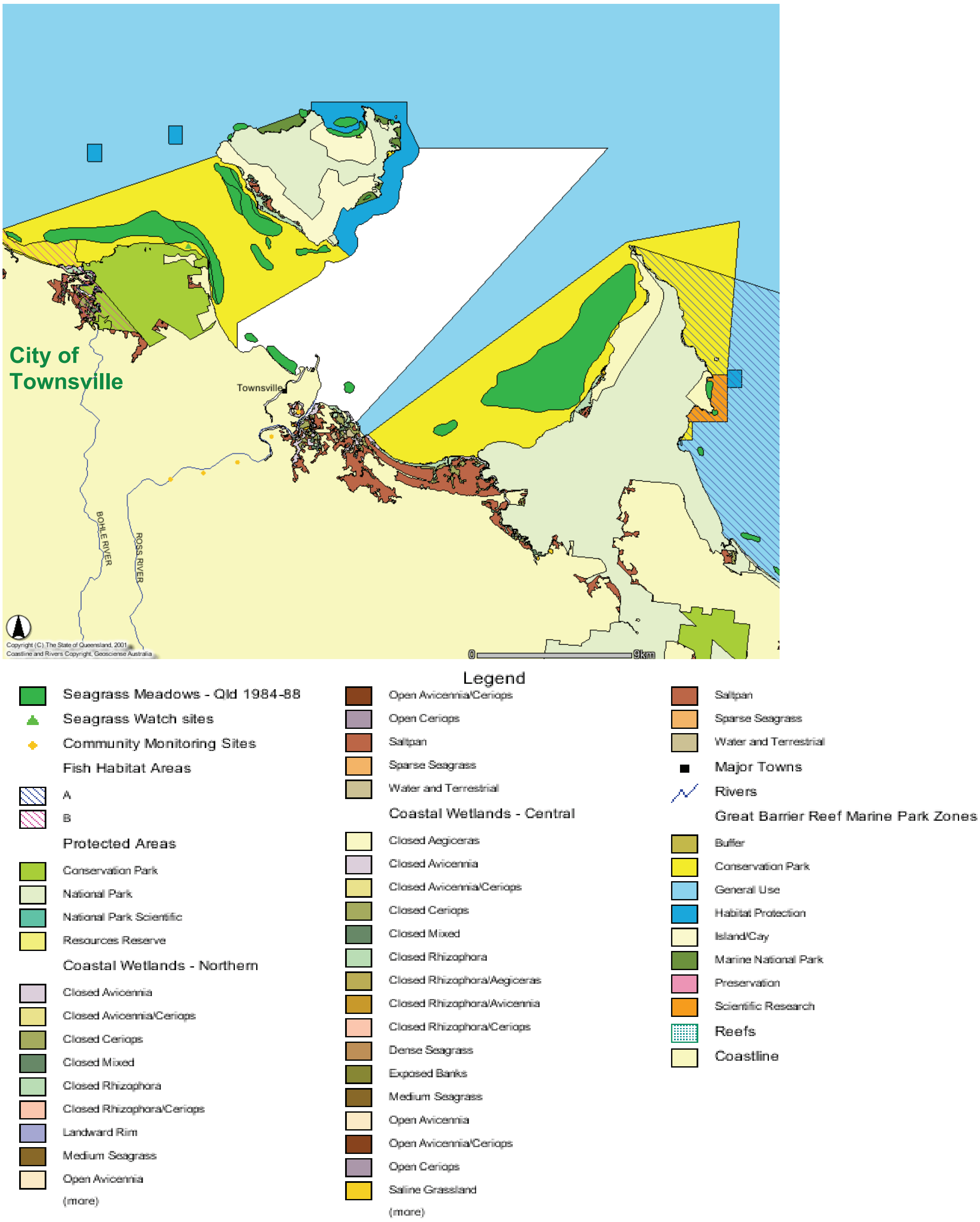
This report satisfies the further requirements of the State EIS process by the provision of a separate 'Stand-Alone' report (for annexure to the EIS) dealing only with matters of NES.

2.2 DESCRIPTION OF THE DEVELOPMENT

2.2.1 Background Setting of the TOT Development Site

The proposed development is sited within an area of complex interactions between Local, State and Federal jurisdictions, each with their own specific, and often inconsistent, environmental assessment criteria. The most contentious points of conflict result from the existence of a relatively large coastal city with an active export and import Port within zones of Marine National Parks and World Heritage Areas. (refer Figures 4, 5 and 6) The anthropogenic settlement and associated activities imply a degree of impact, whereas National Parks and World Heritage Areas imply relatively pristine conditions. This contradiction means that the Development may be assessed against the stringent conditions relating to developments in protected areas, but that these conditions themselves have to be assessed against a background of impacted conditions. In these circumstances it is believed that a criteria of “no significant proportional increase over existing ambient conditions in the Cleveland Bay environment” should be used as an assessment criterion.

Figure 1. Cleveland Bay Protected Areas. **Please note that World Heritage Areas extend across the whole area.**



2.2.2 TOT Development Site

The TOT site is located on, and adjacent to, the existing Townsville foreshore and incorporates the existing Port western and northern breakwaters, the existing perimeter of the land around the Townsville Casino and the Townsville Convention Centre and Mariners Drive Peninsula (Figure 2). The TOT site is located within a complex mix of terrestrial and marine environments. Along the coastline the relatively large coastal city of Townsville supports an active industrial, mining and grazing hinterland that exports and imports through the Port of Townsville (sited immediately adjacent to the TOT Development). However, the TOT site is also within the coastal waters of Cleveland Bay with zones of Marine National Parks and World Heritage Areas supporting a complex array of protected species and habitats.

Figure 2. Location of Development site

The TOT Development site is disturbed, with the previous construction of

- the Port western and northern breakwaters;
- surrounding reclamation for the Entertainment Centre and Casino Complex;
- the reconstruction of the Strand by the Townville City Council in 1999; and
- the active Townsville Port facilities adjacent.

The existing western breakwater forms the western side of the navigation channel known as the “Platypus Channel”, the main access channel for the Townsville Port. This channel forms an extension to Ross Creek and is currently dredged to a level of 11.7m below Lowest Astronomical Tide (LAT).

As is identified below, the TOT Development site is located with the wider Cleveland Bay coastal area but is directly adjacent to the existing Townsville CBD, residential and Port centres.

The Development site is located outside the Great Barrier Reef Marine Park (GBRMP) boundaries and is within the exclusion area for the Port of Townsville. However, the site is adjacent to the GBRMP and is located in the wider Great Barrier Reef World Heritage Area (GBRWHA).

Downstream from the Development Site, the closest GBRMPA Zone is classified as 'Conservation Park' ('yellow zone'), where trawling, netting other than bait netting, and collecting of some invertebrates is prohibited (Figure 3). The key habitats in the GBRWHA are soft-sediment benthic communities, seagrass beds and coral reefs (see Section 5.1). The habitats of highest environmental sensitivity in Cleveland Bay are the seagrass beds and the coral reefs. Both habitats have been identified by this and previous studies to be extensive, currently in good condition, and potentially affected by the TOT Development.

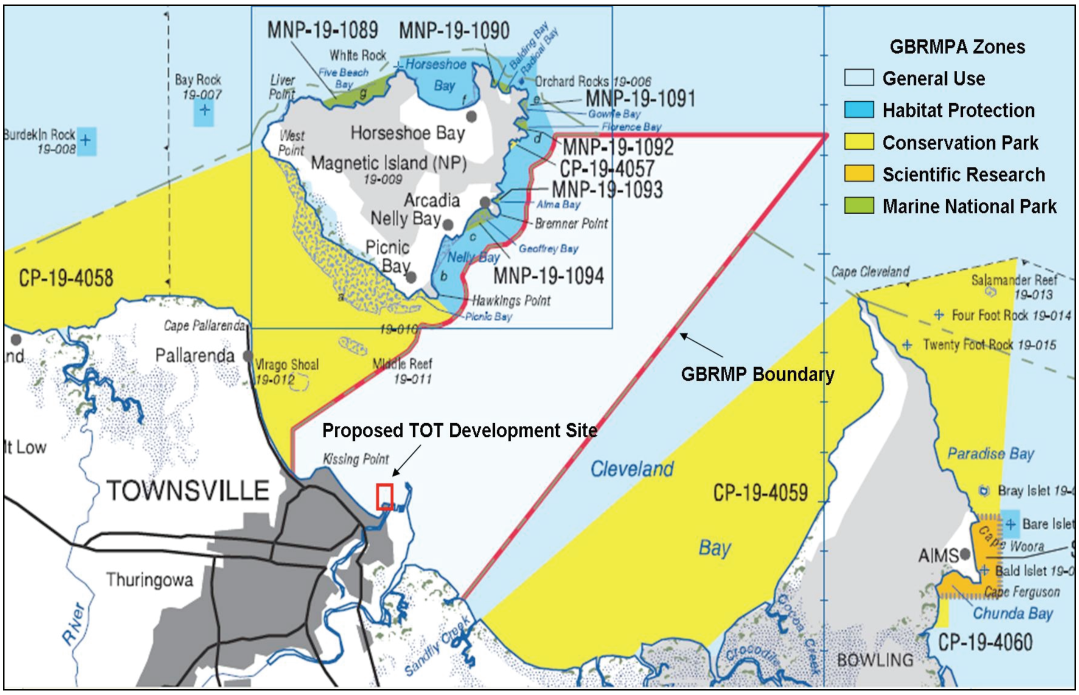


Figure 3. GBRMPA zoning map for Cleveland Bay. Adapted from GBRMPA (2006).

The intent of the TOT Development is to provide:

- A dedicated Ocean Terminal and ancillary facilities for use by cruise ships and naval vessels; and
- a residential waterfront community known as Breakwater Cove comprising a mixed range of dwelling types, including detached dwellings, attached dwellings and apartment buildings between two and nine storeys in height.

The main proposed elements of the TOT Development will be:

- The augmentation of the existing northern breakwater wall to the seaward side of the Development site;

- Open space adjacent to portions of the Port western breakwater wall and the northern breakwater wall;
- 200 detached dwellings and 500 medium density attached and/or detached dwellings / apartments;
- Approx 1500m^2 of commercial space;
- Large car parking facility;
- Private recreational vessel berthing moorings, jetties and pontoons, moorings for super yachts, and boardwalks to waterways (Figure 4).

Figure 4. Artist's impression of the proposed TOT Development. Obtained from City Pacific website

2.3 DESCRIPTION OF THE ENVIRONMENT: REVIEW OF PREVIOUS RESEARCH

The physical characteristics and ecology of Cleveland Bay have been subject to a large number of studies in the past, particularly in relation to dredging activities around the Townsville Port (Benson et al. 1994). However, most studies have been of short duration, limited to differing components of different communities, driven by the acquisition of data for a specific purpose, and isolated in both time and space. Hence, while a large, but fragmented, data base exists, the majority of the data exists as sporadic pieces of information, predominantly in unpublished reports or theses. Studies conducted before 2001 were reviewed by Kettle et al (2002) and Anderson et al (2002), and some aspects of Cleveland Bay were included in the assessment of the conditions of marine, coastal and estuarine resources in the Burdekin Dry Tropics region (Scheltinga and Heydon 2005). Few published studies exist from after 2002, although the habitats (seagrass beds, coral reefs) and species (dolphins, dugongs, turtles) most susceptible to disturbance have been subject to some form of monitoring. Baseline studies for the TOT will take previous research into account, but will also focus on areas that were poorly studied in the past, such as soft-sediment benthic communities.

The proposed development is sited within an area of complex interactions between Local, State and Federal jurisdictions, each with their own specific, and often inconsistent, environmental assment criteria. The most contentious points of conflict possibly result from the existence of a relatively large coastal city with an active export and import Port within zones of Marine National Parks and World Heritage Areas. The anthropogenic settlement and associated activities imply a degree of impact, whereas National Parks and World Heritage Areas imply relatively pristine conditions. This contradiction means that while the Development itself has to be assessed against the stringent conditions relating to developments in protected areas, these conditions themselves have to be assessed against the background impacted conditions. Thus, in these circumstances, it is believed that a criteria of “no significant proportional increase over existing ambient conditions in Cleveland Bay” should be used as an assessment criteria.

Townsville’s coastal zone is already subject to extensive urban development (Scheltinga and Heydon 2005). This makes it difficult to distinguish the impacts of individual Developments from the large number of anthropogenic influences already present (e.g. recreational fishing and collecting, dredging, shipping noise, urban and industrial runoff). The current TOT baseline studies will need to establish links with previous datasets to provide a temporal framework. Any changes in the environment can then be measured against existing temporal and seasonal patterns, making the monitoring programme more effective. Current sampling designs will aim to replicate sites and methodologies already used for previous studies or ongoing monitoring programmes as much as possible within the framework of currently accepted ‘best practice’ methodologies. Where available, species lists have been gathered and compiled to guide baseline study research and to suggest areas / species in need of most attention from the point of view of both conservation and the need for baseline data.

2.4 BENTHIC COMMUNITIES

Kettle et al. (2002) reported that soft-sediment communities make up 85% of the seabed area in Cleveland Bay and should be the first place to search for impacts of dredging activities. However, this is perhaps the most neglected area of the Bay, presumably due to sampling difficulties. The one study published since 2001 on Cleveland Bay seabed communities was conducted to measure impacts on seabed benthic communities from the dumping of dredge spoil (Cruz-Motta and Collins 2004). One of the sites surveyed by the Seabed Biodiversity Project (SBP, CRC Reef) lies between Geoffrey Bay and Cape Cleveland, but communities closer to the Port and directly seaward of the Strand, Pallarenda and south of the Ross River remain unknown. Information on the SBP surveys indicates that the seabed community at their survey site is dominated by starfish, sea cucumbers and urchins, followed by molluscs and worms, and containing smaller proportions of crustaceans, ascidians and worms (CRC Reef 2006).

Due to their large extent within Cleveland Bay, and the fact that they provide a significant food resource for the Bay’s fish populations, soft-sediment communities have been included in the TOT baseline surveys. Study sites have been selected to be representative of areas likely to be affected by the Development, with areas unlikely to be affected acting as Control sites.

2.5 SEAGRASS BEDS

The seagrass beds in Cleveland Bay support a significant Dugong population (Scheltinga and Heydon 2005) and act as nursery grounds for a large number of commercially important species. Seagrasses are susceptible to a variety of environmental stress factors, especially when they occur intertidally or close to the coast, where the physical environment (e.g. temperature, wave action, salinity, turbidity) is highly variable (Carruthers et al. 2002).

The primary locations of subtidal seagrass beds in Cleveland Bay occur in areas shallower than 4m, between the mainland (The Strand, Rowes Bay and Pallarenda) and Magnetic Island (Cockle Bay, Picnic Bay), and adjacent to Cape Cleveland in the vicinity of Alligator Creek and Crocodile Creek (Table 1). Although most attention has been directed to intertidal seagrass beds (McKenzie et al. 2006), subtidal seagrass beds have previously been surveyed and mapped (Lee Long et al. 1993, Lee Long et al. 1996, SciMar 2005b).

Aerial surveys targeting Dugongs have found that the largest Dugong populations in Cleveland Bay frequent the seagrass beds adjacent to Cape Cleveland (Dr. I. Lawler, TESAG, JCU, pers. comm.). The existence of large patches of seagrass throughout the Bay, however, has contributed to the establishment of the Dugong Protection Area which encompasses the entire Bay, including Magnetic Island. It is widely accepted that Cleveland Bay is highly significant to Dugongs along the Australian East Coast (Dr. I. Lawler, TESAG, JCU, pers. comm.).

Agriculture, urban expansion, coastal Development and industrial activities may lead to increased sediments, nutrients, and other contaminants (such as heavy metals, organochlorine compounds, and polycyclic aromatic hydrocarbons), all of which are potentially threatening to seagrass beds (Schaffelke et al. 2005). Inshore seagrass communities in Cleveland Bay are already subject to a number of pressures, particularly those associated with light attenuation through high turbidity and contaminants associated with Port activities (e.g. dredging and shipping).

Table 1. Seagrass species found in intertidal areas of Cleveland Bay (McKenzie et al. 2006), with information about characteristics and threats (Carruthers et al. 2002, Scheltinga and Heydon 2005). Available information is source dependent.

Seagrass species	Areas found	Limiting Factors
Halodule uninervis	Bushland Beach, Shelley Beach, Rowes Bay, Picnic Bay, Cockle Bay	Physical disturbance, low nutrients
Halodule pinifolia	Cleveland Bay, Magnetic Island	
Halophila decipiens	Cleveland Bay, Magnetic Island	
Halophila ovalis	Bushland Beach, Shelley Beach, Rowes Bay, Picnic Bay, Cockle Bay	Terrigenous runoff, physical disturbance, low light, low nutrients
Halophila ovata	Cleveland Bay, Magnetic Island	
Halophila tricostata	Magnetic Island	
Zostera capricorni	Shelley Beach, Sandfly Creek, Picnic Bay	Terrigenous runoff, physical disturbance
Halophila spinulosa	Shelley Beach	Physical disturbance, low light, low nutrients
Cymodocea serrulata	Picnic Bay, Cockle Bay	Terrigenous runoff, physical disturbance, low light, low nutrients

Cymodocea rotundata	Magnetic Island	
Thalassia hemprichii	Picnic Bay, Cockle Bay	Low nutrients
Syringodium isoetofolium	Picnic Bay, Cockle Bay	Physical disturbance

2.6 INTERTIDAL COMMUNITIES

Intertidal flora and fauna can be found in a number of habitats in Cleveland Bay, including sand and mud flats, rocky shores and mangroves. The most extensive intertidal areas occur in Rowes Bay (mud flats), Pallarenda (sand flats), Cockle Bay (mud flat and mangroves), Picnic Bay (coral reef flat) and Cape Pallarenda (rocky shore; Table 2). Past studies in these habitats have tended to focus on populations of single species or select groups of species (Kettle et al. 2002). Only a few studies have explored the composition of entire communities. Community-level assessments exist of flora and fauna on rocky shores and outcrops, both natural and artificial (Neil 2000), sandy shore benthos (Muffley 1981) and algal communities (Price 1989).

Table 2. Location of intertidal habitats in Cleveland Bay (Kettle et al. 2002, Scheltinga and Heydon 2005)

Intertidal Habitat	Location in Cleveland Bay
Mangroves	Cockle Bay, Magnetic Island
	Ross River
	Ross Creek
	Stuart Creek
	Alligator Creek
	Crocodile Creek
	Rowes Bay
	Three Mile Creek
Mud flats	Rowes Bay
	Cockle Bay
	Shelley Beach
	Coast between Ross River and Cocoa Creek
Rocky shores	Cape Pallarenda
	Cape Cleveland
	Magnetic Island headlands
	Kissing Point
Sand flats	Pallarenda
	Shelley Beach

No recent published data (post-2001) exists for intertidal communities in Cleveland Bay, although species lists are available from recent unpublished datasets. Studies of rocky shore communities suggested that biodiversity and community structure change significantly as a result of disturbances (Neil 2000). Many organisms living in the intertidal zone already exist near the limits of their tolerance levels to their physical environment (e.g. temperature, exposure, salinity), and are therefore likely to respond quickly to additional stress associated with anthropogenic impacts (e.g. additional turbidity or habitat contamination).

2.7 CORAL REEFS

Corals reefs in Cleveland Bay (Middle Reef, Virago Shoal) and surrounding Magnetic Island are perhaps the best studied habitats and communities in Cleveland Bay. They were extensively surveyed and documented in 1992 for the Environmental Monitoring Programme of the Townsville Port Authority's Capital Dredging Programme (Kaly et al. 1994, Stafford-Smith et al. 1994), and have been regularly monitored since by AIMS and GBRMPA (e.g. Ayling and Ayling 2005), in response to various projects. They therefore provide an excellent opportunity for assessing the impacts from construction and operation of the proposed TOT Development.

Along with seagrass beds, coral communities are the most susceptible to declines in water quality, as they already exist in a turbid, relatively nutrient-rich and highly variable physical environment. Eighty-seven species of hard corals have been identified on the reefs of Magnetic Island by the Museum of Tropical Queensland (Appendix 1), and numerous species of soft corals are also present.

2.8 FISH AND FISHERIES

The main species targeted by commercial and recreational fisheries include sharks, barramundi, grey mackerel, mullet, blue and king threadfin, queenfish and garfish (DPI&F 2004). A number of projects, primarily by JCU students, have studied different components of the fish communities in Cleveland Bay (Anderson et al. 2002); (Table 3). Very little recent data exist, and most remains unpublished. This may be due to the difficulty in surveying the fish communities of this shallow, turbid bay without using destructive sampling techniques. Cleveland Bay is under review as a potential Fish Habitat Area, due to its importance to many fish species as a nursery area (Kettle et al. 2002, Scheltinga and Heydon 2005).

Table 3. Studies conducted on the pelagic and demersal fish communities in Cleveland Bay (Anderson et al. 2002, Kettle et al. 2002).

Study conducted by	Year	Taxa
Cabanban	1991	Leiognathidae
Fogg	1993	Carangidae
McCormick	1992	Mullidae
Molony	1993	Chandidae
Mosse	1991	Clupeoid fishes
Gunn	1978	Sillaginidae
Gunn & Milward	1985	Sillaginidae
Hoedt	1984, 1994	Engraulidae
Yap	1993	Scianidae
Sondita	1997	Community structure
Sheaves	1995	Lutjanidae and Serranidae
Nursall	1981	Mudskippers
Simpferdorfer	1986, 1992, 1993, 1998	Carcharhinidae and Sphyrnidae
Simpferdorfer & Milward	1993	Carcharhinidae and Sphyrnidae
Wilson	1999	Estuarine fish

It is considered that sampling demersal and pelagic fishes in Cleveland Bay would require destructive techniques that are unsuitable for a baseline survey. The sampling of fishes is likely to be more destructive than the TOT Development impacts, and is not recommended.

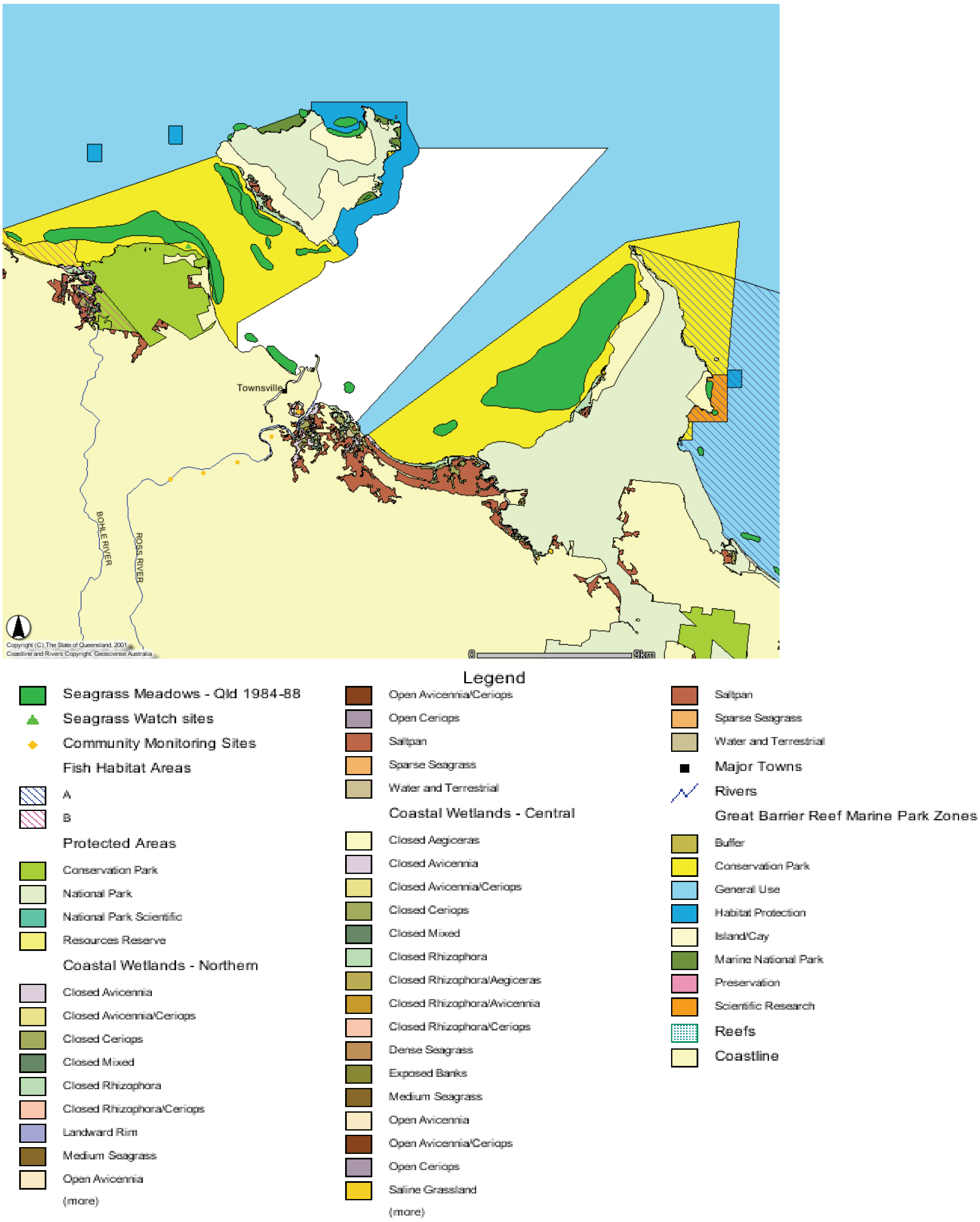


Figure 5. Cleveland Bay Protected Areas. Please note that World Heritage Areas extend across the whole area.

2.9 ENVIRONMENTALLY SENSITIVE FLORA AND FAUNA OF CLEVELAND BAY

Although much of Cleveland Bay is significantly impacted by anthropogenic activities, the Bay does support a number of environmentally sensitive habitats, communities and species. The Cleveland Bay seagrass beds are at least of Regional significance, if not of

National and International significance, as they support the 3rd largest Dugong population on the East Coast of Australia. Benthic communities are diverse and support a large fish community, which includes many species of high commercial and conservation significance. Many of the commercially important species (e.g. Barramundi, Trevallies and Mackerels) are either dependent on the connectivity between marine habitats and the surrounding estuaries, or use the shallow areas of the Bay as nursery grounds. Furthermore, the Bay is frequented by a large number of rare and vulnerable species that are subject to State, National and International legislation (Appendix 2).

2.9.1 Sensitive Habitats

The habitats of highest environmental sensitivity in Cleveland Bay are the seagrass beds and the coral reefs and both currently exist in an area potentiall already subject to significant anthropogenic impacts. Both habitats have been identified by this and previous studies to be extensive and potentially affected by the Development.

Seagrasses are a highly valuable component of Cleveland Bay's ecology, both as food resources for vulnerable species (Dugongs, Green turtles) and as nursery habitats for commercially important species (prawns, fish). Seagrasses are susceptible to light attenuation, both directly from increased turbidity and indirectly from increased macroalgal and epiphytic growth through increased nutrient loading. Additionally, seagrass beds can suffer from changes in sediment composition and scouring that can occur during storm events or as a result of human modifications to sediment transport regimes.

Cleveland Bay is already a highly turbid, relatively nutrient rich environment with sediment transport mechanisms modified by dredging and by alterations to river and creek systems. The suggestion by recent data that turbidity in Cleveland Bay may approach and sometimes exceed the tolerance thresholds of seagrasses necessitates the application of the precautionary principle. In spite of these provisos, investigations to date indicate that with some exceptions the marine water quality of Cleveland Bay is high (approximately satisfying 95% Species Protection Levels of ANZECC 2000 levels for most analytes). Similarly, the groundwaters just beneath the surface of the Bay are well within the range of similar waters found elsewhere in the Townsville region in relatively unimpacted systems (Three Bay Study 1976; Townsville City Council, Horseshoe Bay Drainage Management Plan 2007.

Coral reefs around Magnetic Island support a high coral cover relative to midshelf and outer shelf reefs, despite the high levels of turbidity and the seasonal blooming of macroalgae common to all coastal reefs. In the last two decades, these reefs have shown remarkable resilience in the face of disturbance events, particularly bleaching events and cyclones. Recovery rates of coral cover and community structure was rapid after each disturbance event, despite the concerns of declining water quality in coastal environments. However, these recoveries were documented along the southeast-facing reefs of Magnetic Island, from Nelly Bay to Florence Bay, and it is likely that reefs such as Picnic Bay, Cockle Bay and Middle Reef will be at greater risk from turbidity arising from the Development. Furthermore, it is likely that further declines in water quality may affect the ability of coastal reefs to recover from disturbance (Hughes et al. 2005).

2.9.2 Sensitive Species

One of the key values of the GBRWHA is habitat for species of conservation significance. The list compiled by the DEW website's ERIN search engine for the Cleveland Bay area included 95 species identified as requiring some level of protection, consisting of 22 seabirds, 12 marine mammals, 22 marine reptiles and 39 ray-finned fish species (Appendix

2). Further species were added from the Queensland Environmental Protection Agency (EPA)'s list of environmentally sensitive species. It is recognised that there are limitations to a species list compiled electronically, and that some of these species may frequent habitats similar to those found in Cleveland Bay or adjacent to Cleveland Bay. However, the high level of connectivity in the marine ecosystem means that it is highly likely that Cleveland Bay is of some significance to all or most of these species.

The species listed as requiring the highest levels of protection (at national and international level) are the leatherback turtle (*Dermochelys coriacea*), the blue whale (*Balaenoptera musculus*), the loggerhead turtle (*Caretta caretta*), the green turtle (*Chelonia mydas*) and the olive Ridley turtle (*Lepidochelys olivacea*), followed by the red goshawk (*Erythrotriorchis radiatus)*, the Dugong (*Dugong dugon*), the humpback whale (*Megaptera novaeangliae*), the hawksbill turtle (*Eretmochelys imbricata*), the Flatback turtle (*Natator depressus*) and the yellow seahorse (*Hippocampus kuda*). Most of these species are threatened by the decreasing extent of their habitat, and the contamination and exploitation occurring within their range. A number of these pressures, associated with the large human population, industrial activities and the Port, are already occurring in Cleveland Bay. Key issues to be mitigated and monitored during both the construction and operation phases of the Development will include increasing noise pollution, which affects marine mammals, fishes and reptiles (DoIR 2002), and the risk of increased boat strikes through increased visitation (DEH 2006).

The sensitive species most commonly reported from Cleveland Bay are dugongs, turtles, snubfin dolphins, Indo-Pacific humpback dolphins, humpback whales and various species of sharks. The entire area of Cleveland Bay was declared a Dugong Protection Area in 1998. Dugong populations are monitored by aerial survey every five years (Marsh and Lawler 2001), and were last surveyed in 2005 (I. Lawler, pers. comm.). In the past, there was some concern over levels of dioxins, particularly the octa-substituted PCDDs, as well as mercury, lead and nickel measured during autopsies of Dugong carcasses found on beaches on Magnetic Island and Halifax Bay (Anderson et al. 2002). Dugongs are listed as vulnerable in both State and International legislation. They are dependent on seagrass beds, and Cleveland Bay is identified as one of two core areas for the Dugong populations of the Great Barrier Reef Region (Scheltinga and Heydon 2005). It is therefore vital that the integrity of the Bay be maintained to a standard that sustains healthy seagrass and Dugong populations.

The rare inshore Australian snubfin dolphins (*Orcaella heinsohni*) and Indo-Pacific humpback dolphins (*Sousa chinensis*), as well as the more common Bottlenose dolphins (*Tursiops truncatus*), are found regularly in Cleveland Bay; the former two species being subject to ongoing studies (Parra 2006, Parra et al. 2006). Population sizes are small, making these species vulnerable to local extinction (Parra et al. 2006). Indo-Pacific humpback dolphins in particular appear to be attracted to dredged channels (Parra 2006), increasing their vulnerability to boat strikes (Scheltinga and Heydon 2005). Marine turtles are also highly vulnerable to boat strikes, and a recent analysis shows an area of concentrated risk near the Port of Townsville (Hazel and Gyuris 2006).

A large variety of birds feeds in the waters of Cleveland Bay and use the beaches and headlands of the mainland and Magnetic Island as nesting and breeding sites. A number of the birds using Cleveland Bay are listed as marine, migratory, endangered, vulnerable or rare. For instance, Little terns have been observed feeding in the TOT Development site, and their habitat requirements will need to be addressed.

The other listed species (Appendix 2) are recorded from the GBRMP, and are known to feed, nest, migrate through or reside in turbid nearshore waters such as those found in

Cleveland Bay. All the species listed are vulnerable to pollution and habitat destruction, and have varying tolerance to water quality. Dugongs and turtles are arguably the most sensitive species, because of their abundance in Cleveland Bay, their dependence on sensitive food resources (seagrass beds, pelagic organisms), and their vulnerability to boat strikes in shallow water. The survival of green turtles was recently put into question in the context of global warming, highlighting the need to protect key habitats and food resources (Mangnall 2006).

For the purposes of this report, only species listed as threatened and/or migratory under the EPBC Act will be considered in detail.

3 OBJECTIVES AND SCOPE

The objectives of this report are to determine the presence and extent of matters of NES in and adjacent to the TOT Development site and to identify the potential impacts of the Development on these Matters. Specific objectives, as specified by Section 1.7 of the ToR, are addressed in sections below.

3.1 A Description of the Affected Environment Relevant to the Matters Protected

The World Heritage Area is already subject to impacts from co-existing anthropogenic activities and the overall mantra of this specific project is that the Development should entail no significant proportional increases over existing ambient conditions in the Cleveland Bay environment. This report, therefore, aims to set out the World Heritage values that are potentially affected by the proposal within the wider context of the values of the property as a whole.

For wetlands of international importance, this report aims to set out the relevant ecological characteristics of the Ramsar wetland that are potentially affected by the proposal within the wider context of the values of the wetland as a whole.

For listed threatened and migratory species, the description of the environment includes:

- The species' current distribution;
- Relevant information about the ecology of the species (habitat, feeding and breeding behaviour etc);
- Information about any populations of the species or habitat for the species in the area affected by the proposed action;
- Current pressures on the species, especially those in the area to be affected by the proposal; and
- Relevant controls or planning regimes already in place.

3.2 Assessment of Relevant Impacts and Mitigation Measures

For each section below, the impacts and potential impacts on the matters of NES and the possible mitigation measures for each impact are described.

If alternative ways of taking the action have been identified, the relative impacts of these alternatives are also considered.

When effective mitigation measures are not available, the discussion is broadened to include compensatory measures to offset unavoidable impacts.

The discussion of impacts to the relevant matters of NES addresses all relevant impacts, and provides sufficient justification for all conclusions reached on specific impacts.

Where impacts are relevant to more than one matter protected, the impacts are addressed together, clearly stating the relevance of the impact to the different matters of NES.

3.3 POTENTIAL SIGNIFICANT IMPACTS ON MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE (NES)

3.3.1 Impact on the World Heritage values:

- Modify or inhibit ecological processes in a World Heritage property;
- Reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property;
- Fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage property;
- Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property; and
- Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage property.

3.3.2 Impact on the values of wetlands of international importance:

- Areas of the wetland being destroyed or substantially modified;
- A substantial and measurable change in the hydrological regime of the wetland for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland;
- The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected;
- A substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or
- An invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.

3.3.3 Impact on a listed threatened species:

Potential impacts vary depending on whether the species is extinct in the wild, endangered or vulnerable but are generally as follows:

- Lead to long term decrease in the size of a population;
- Reduce the area of occupancy of the species;
- Fragment an existing population into two or more populations;
- Adversely affect habitat critical to the survival of the species;
- Disrupt the breeding cycle of a population;
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- Result in invasive species that are harmful to the species becoming established;
- Introduce disease that may cause the species to decline; or
- Interfere with the recovery of the species.

3.3.4 Impact on a listed migratory species:

- Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), within the Development site and greater Cleveland Bay area, destroy or isolate an area of important habitat for a migratory species;

- Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

4 METHODS

4.1 *STUDY AREA*

The area targeted for the baseline study includes the nearshore coastal habitats of Cleveland Bay and the coral reefs around Magnetic Island (Figure 6). Cleveland Bay is a shallow bay defined by Cape Pallarenda to the North, Cape Cleveland to the south and Magnetic Island to the east. It lies within the seasonally dry tropics, with a summer rainfall maximum (more than 80% of rainfall occurs between October and March) associated with the Australian summer monsoon. The rainfall regime of Cleveland Bay is characterised by very high inter-annual variability (between 80mm in 1901-1902 and 2,646mm in 1939-1940), and tropical cyclones occur at a rate of approximately six per decade. A number of watercourses drain into Cleveland Bay, including Alligator Creek, Crocodile Creek, Cocoa Creek, Sandfly Creek, Ross Creek, Ross River, and Three Mile Creek, as well as Gustav Creek and a number of other ephemeral creeks on Magnetic Island.

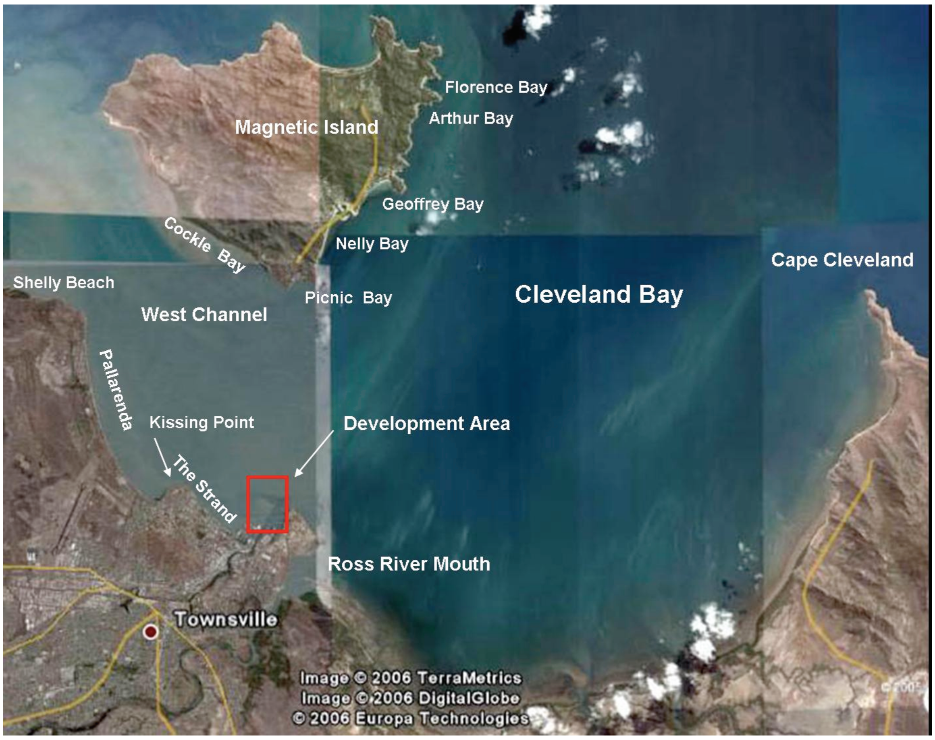


Figure 6. Map of Cleveland Bay, showing the Development Site.

Currents in Cleveland Bay are driven both by tides and by the prevailing south-easterly trade winds. Flood tide currents enter the bay between Cape Cleveland and Magnetic Island and flow southwest, while ebb tides generally move in the opposite direction. In West Passage there are zones of very little water movement, but flood tides are directed southeast close to Pallarenda, and in a westerly direction close to Townsville. Maximum tidal currents tend to be no stronger than 50 cm/s. The trade winds generate a northwestward longshore current entering the Bay at Cape Cleveland and exiting through West Passage. During average conditions of 15 knot winds, wind-driven currents are approximately 5 m/s and flush the entire Bay in 5 days (see also Coastal Engineering Solutions Pty Ltd 2007).

4.2 SAMPLING DESIGN

This baseline study was designed with a view to being a lead-in for a regular monitoring programme, and is therefore structured like a full Environmental Impact Assessment. The sampling design followed a Before-After-Control-Impact (BACI) design, with modifications relevant to the specific environments found in Cleveland Bay. The BACI design proposes that sampling is undertaken at a number of times before and after construction of the TOT begins, and ideally also during the construction phase. Furthermore, it is proposed that samples are taken from locations expected to be affected by the TOT ('Impact' sites) and from equivalent locations that are expected to remain unaffected by any activities associated with the TOT ('Control' sites). This is particularly important at this site where the complexity of existing and external impacts may need to be clearly differentiated from impacts perceived to be the responsibility of the Development.

Sampling design for the TOT was developed specifically to target the recommended locations. Due to the nature of the Development (which presents a single Impact site) and the potential impact (plumes of sediment or contaminants), the sampling design included one Impact and three Control locations. The locations were stratified according to the three target habitats: seagrass beds, soft-bottom benthos and coral reefs. Seagrass beds and soft-bottom benthos were prevalent throughout the Bay and could be sampled at the Impact location itself, and at eight further sites established with increasing distance from the Development site on a logarithmic distance scale (Figure 7).

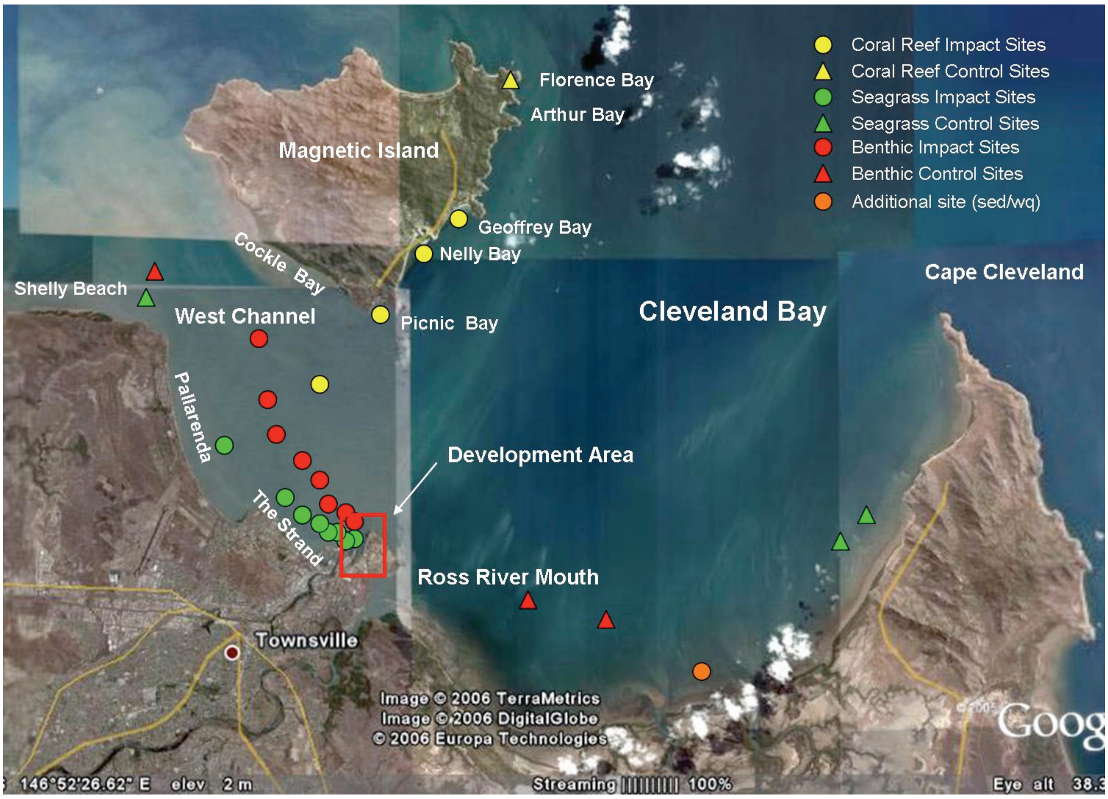


Figure 7. Map of sampling sites. Distances between points represent approximate locations.

4.3 GBR WORLD HERITAGE VALUES

The sections below describe the methods used to directly sample the habitats that represent key values of the GBRWHA.

4.3.1 Benthic Communities

Soft-sediment communities make up 85% of the seabed area in Cleveland Bay (Kettle et.al 2002). Previous research suggested that these communities provide an early warning system of environmental change associated with the impacts of dredging activities. While these communities are seldom used as an indicator of environmental response, their location adjacent to the Development site, the potential for environmental degradation from the dredging of the access channel, the value of these communities as a food source for commercial and recreational fishes, and the Developers expressed concern not to cause unnecessary environmental damage, dictated that these communities should be included in the sampling process for indications of adverse environmental impact. This concern is directly incorporated into the proportionality mantra cited earlier.

Soft sediment community sampling sites were spaced in a similar way to seagrass sites, but outside seagrass beds, to ensure the sites were representative of soft-sediment habitats rather than seagrass bed habitats. At each sampling site, three grab samples were taken using a 1 kg stainless steel Van Veen grab. The volume of each sample was measured, and macrobenthic samples were washed onto a 1 mm sieve and transported to the laboratory for processing. Samples to be sorted later were preserved in 10% formalin. All macroinvertebrates were identified to the lowest practical taxonomic level (usually to Family or morphospecies) and counted using compound and stereo microscopy. The number of invertebrates in each sample was standardised to individuals per litre. Total macrobenthic abundance and species richness were compared among Impact and Control sites and analysed using a univariate analysis of variance (ANOVA), and differences in species composition were analysed using multivariate ANOVA (MANOVA). Prior to analysis, raw data was tested for homogeneity of variances and normality, and $\log_{10}$ or In-transformations of the raw data were used to meet the assumptions of ANOVA.

4.3.2 Seagrass Beds

Sampling sites were selected to encompass the areas of most extensive subtidal seagrass density (Lee Long et al. 1993, Lee Long et al. 1996). Nine Impact sites were surveyed (established with increasing distance from the Development site on a logarithmic distance scale) and nine Control sites (in areas not expected to be affected by the Development), as described in Section 4.2 and shown in Figure 7.

At each site, ten randomly distributed quadrats (0.5m x 0.5m) were examined by two divers to determine seagrass species composition. All seagrass species were identified according to Waycott et al. (2004), and the divers also made notes on substratum composition and recorded the percent cover of macroalgal species present. Seagrass abundance data for each quadrat was multiplied by four to convert the 0.25m^2 samples to an estimate of shoot density per m^2. Means and standard errors (S.E.) were calculated and represented graphically for each seagrass species at each site. Total seagrass abundance was compared among Impact and Control sites and analysed using ANOVA, and differences in species composition were analysed using MANOVA. Prior to analysis, raw data was tested for homogeneity of variances and normality, and $\log_{10}$ transformations of the raw data were used to meet the assumptions of ANOVA. Macroalgal cover was also analysed to determine whether significant differences existed in percent cover and taxonomic composition between Control and Impact sites. As the data did not conform to the assumptions of ANOVA, non-parametric tests (Kolmogorov-Smirnov, Mann-Whitley U-Test) were conducted.

4.3.3 Coral Reefs

Line intersect transects were used to survey the coral reef benthic cover in Cleveland Bay and on reefs around Magnetic Island (Middle Reef, Picnic Bay, Nelly Bay, Geoffrey Bay, Arthur Bay and Florence Bay). Wherever possible, the sites surveyed were those used for previous surveys (Ayling and Ayling 2005). On Middle Reef and in Picnic Bay, the sites established in 1988 and 1989 were no longer marked, and new sites were established. At each site, four permanent 20 m transects were marked with stakes, stretching out from a central star picket. A fibreglass measuring tape was stretched tightly along the transect markers, as close to the substratum as possible, and the length of intersection of all benthic organisms was recorded in cm. A total of 24 sites were surveyed, spread over six reefs.

For the purposes of analyses, sites were classified in groups of three. In previous studies, eastern and western parts of Nelly Bay, and to some extent also Geoffrey Bay, were found to differ markedly in terms of their coral composition (Ayling and Ayling 2005), and were therefore treated separately in these analyses. This sampling occasion allowed for the inclusion of only two Impact reefs (Middle Reef and Picnic Bay), and four Control reefs (Nelly Bay, Geoffrey Bay, Arthur Bay and Florence Bay). Means and standard errors (S.E.) were calculated for all benthic taxa and for selected groups (e.g. total algae, total hard corals, etc.), and represented graphically. Total coral and algal percent cover was compared among sites and analysed using ANOVA, and differences in taxonomic composition were analysed using MANOVA. Prior to analysis, raw data was tested for homogeneity of variances and normality, and $\log_{10}$ transformations of the raw data were used to meet the assumptions of ANOVA.

4.3.4 Fish and fisheries

Fish species lists were obtained from unpublished theses on the benthic and pelagic fishes of Cleveland Bay, and from current datasets compiled by Dr. Marcus Sheaves and Mr. Ross Johnston, JCU. The resulting species list was extended to indicate the fisheries (commercial and recreational), aquaculture and aquarium values of each species, and conservation values for species listed on the IUCN Red List.

Literature searches were conducted to determine the primary dietary items selected by fish species of commercial or conservation significance. The data obtained was used to link the benthic communities to the fish fauna of Cleveland Bay, and is presented as part of the benthic community results. This allowed us to assess the importance of benthic groups not only in terms of their density and biodiversity, but also in terms of their contribution to sustaining the fish community. The Department of Primary Industries and Fisheries was consulted to provide data on the value of commercial fisheries in Cleveland Bay.

4.4 RAMSAR WETLANDS

The Ramsar listed Bowling Green Bay wetlands were not considered at risk from the proposed TOT Development. Once it was determined that no sand extraction from Ross Creek was to occur. This area was therefore not sampled or described.

4.5 THREATENED AND MIGRATORY SPECIES

The list compiled by the DEW website's ERIN search engine for the Cleveland Bay area included 95 species listed under the EPBC Act, consisting of 22 seabirds, 12 marine mammals, 22 marine reptiles and 39 ray-finned fish species (Appendix 2). Of these, six species of seabird, six species of marine mammal and seven species of marine reptile are listed by the EPBC Act as threatened (i.e., endangered or vulnerable) or migratory. These species were subjected to a brief desktop study for the purposes of this investigation.

4.6 RISK ASSESSMENT

This risk assessment was compiled using tables commonly used and accepted by the Department of the Environment and Water Resources (DEW) for Marine Reserve assessments (Appendix 3,

Table 7).

5 A DESCRIPTION OF THE ENVIRONMENT OF CONCERN RELEVANT TO THE MATTERS PROTECTED

5.1 GREAT BARRIER REEF WORLD HERITAGE AREA (GBRWHA)

The TOT Development is within the GBRWHA. The GBRWHA makes direct contact with the coastline at the low water mark. The GBRWHA is listed as a Matter of NES (Figure 8).

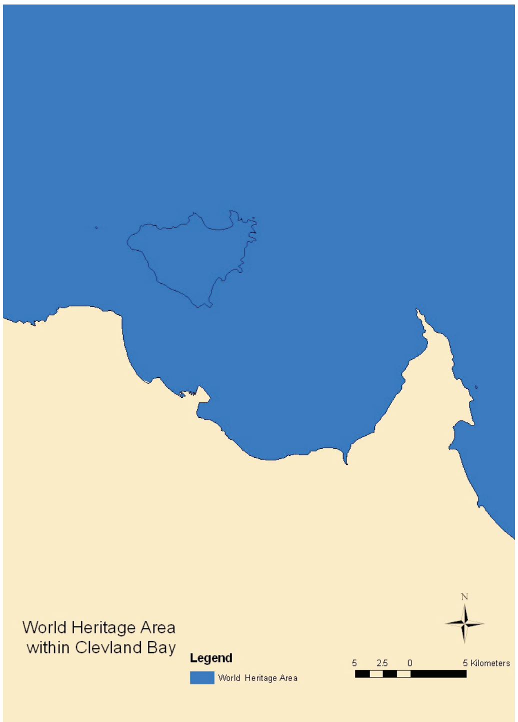


Figure 8. GBRWHA (blue area) as identified by Geoscience Australia.

The World Heritage values of the Great Barrier Reef are extensive, and not all apply to the Development site and the wider Cleveland Bay area (Table 4). The key habitats of the GBRWHA that are represented in or near the Development site can be summarized as soft-sediment benthic communities, seagrass beds, coral reefs and threatened and migratory species (the latter are described in Section 5.3). The habitats of highest environmental sensitivity in Cleveland Bay are the seagrass beds and the coral reefs. Both habitats have been identified by this and previous studies to be extensive, currently in good condition in spite of the anthropogenic activities in the area, but both are potentially affected by the TOT Development.

Table 4. World Heritage values of the Great Barrier Reef. Those values relevant to Cleveland Bay and the proposed Development are highlighted in bold.

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981.	Examples of World Heritage values of the Great Barrier Reef for which the property was inscribed on the World Heritage List in 1981.
Criterion (i) an outstanding example representing a major stage of the earth's evolutionary history.	The Great Barrier Reef is by far the largest single collection of coral reefs in the world. The World Heritage values of the property include: • 2904 **coral reefs** covering approximately 20 055km^2; • 300 coral cays and 600 continental islands; • reef morphologies reflecting historical and on-going geomorphic and oceanographic processes; • processes of geological evolution linking islands, cays, reefs and changing sea levels, together with sand barriers, deltaic and associated sand dunes; • record of sea level changes and the complete history of the reef's evolution are recorded in the reef structure; • record of climate history, environmental conditions and processes extending back over several hundred years within old massive corals; • formations such as serpentine rocks of South Percy island, intact and active dune systems, undisturbed tidal sediments and "blue holes"; and • record of sea level changes reflected in distribution of continental island flora and fauna.
Criterion (ii) an outstanding example representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment.	Biologically the Great Barrier Reef supports the most diverse ecosystem known to man and its enormous diversity is thought to reflect the maturity of an ecosystem, which has evolved over millions of years on the northeast Continental Shelf of Australia. The World Heritage values include: • the heterogeneity and interconnectivity of the reef assemblage; • size and morphological diversity (elevation ranging from the sea bed to 1142m at Mt. Bowen and a large cross-shelf extent encompass the fullest possible representation of marine environmental processes); • on going processes of accretion and erosion of coral reefs, sand banks and coral cays, erosion and deposition processes along the coastline, river deltas and estuaries and continental islands; • extensive *Halimeda* beds representing active calcification and sediment accretion for over 10 000 years; • evidence of the dispersion and evolution of hard corals and associated flora and fauna from the "Indo-West Pacific centre of diversity" along the north-south extent of the reef; • inter-connections with the Wet Tropics via the coastal interface and Lord Howe Island via the East Australia current;

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981.	Examples of World Heritage values of the Great Barrier Reef for which the property was inscribed on the World Heritage List in 1981.
	• indigenous temperate species derived from tropical species; • living **coral colonies** (including some of the world's oldest); • inshore coral communities of southern reefs; • five floristic regions identified for continental islands and two for coral cays; • the diversity of flora and fauna, including: - **Macroalgae** (estimated 400-500 species); - Porifera (estimated 1500 species, some endemic, mostly undescribed); • **Cnidaria: Corals** - part of the global centre of coral diversity and including: - hexacorals (70 genera and 350 species, including 10 endemic species); - octocorals (80 genera, number of species not yet estimated); - Tunicata: Ascidians (at least 330 species); - Bryozoa (an estimated 300-500 species, many undescribed); • **Crustacea** (at least 1330 species from 3 subclasses); • Worms: • **Polychaetes** (estimated 500 species); • Platyhelminthes: include free-living Turbellaria (number of species not yet estimated), polyclad Turbellaria (up to 300 species) and parasitic helminthes (estimated 1000's of species, most undescribed); • **Phytoplankton** (a diverse group existing in two broad communities); • **Mollusca** (between 5000-8000 species); • Echinodermata (estimated 800 extant species, including many rare taxa and type specimens); • **fishes** (between 1200 and 2000 species from 130 families, with high species diversity and heterogeneity; includes the Whale Shark *Rhynchodon typus*); • **seabirds** (between 1.4 and 1.7 million seabirds breeding on islands); • **marine reptiles** (including 6 sea turtle species, 17 sea snake species, and 1 species of crocodile); • **marine mammals** (including 1 species of Dugong (*Dugong dugon*), and 26 species of whales and dolphins); • terrestrial flora: see "Habitats: Islands" and; • terrestrial fauna, including: • invertebrates (pseudoscorpions, mites, ticks, spiders, centipedes, isopods, phalangids, millipedes, collembolans and 109 families of insects from 20 orders,

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981.	Examples of World Heritage values of the Great Barrier Reef for which the property was inscribed on the World Heritage List in 1981.
	and large over-wintering aggregations of butterflies); and • vertebrates (including seabirds (see above), reptiles: **crocodiles and turtles**, 9 snakes and 31 lizards, mammals); • the integrity of the inter-connections between reef and island networks in terms of dispersion, recruitment, and the subsequent gene flow of many taxa; • processes of dispersal, colonisation and establishment of plant communities within the context of island biogeography (e.g. dispersal of seeds by air, sea and vectors such as birds are examples of dispersion, colonisation and succession); • the isolation of certain island populations (e.g. recent speciation evident in two subspecies of the butterfly *Tirumala hamata* and the evolution of distinct races of the bird *Zosterops spp);* • remnant vegetation types (hoop pines) and relic species (sponges) on islands. • evidence of morphological and genetic changes in **mangrove and seagrass flora** across regional scales; and • feeding and/or breeding grounds for international migratory seabirds, cetaceans and sea turtles.
Criterion (iii) contain unique, rare and superlative natural phenomena, formations and features and areas of exceptional natural beauty.	The Great Barrier Reef provides some of the most spectacular scenery on earth and is of exceptional natural beauty. The World Heritage values include: • the vast extent of the reef and island systems which produces an unparalleled **aerial vista**; • islands ranging from towering forested continental islands complete with freshwater streams, to small coral cays with rainforest and unvegetated sand cays; • **coastal and adjacent islands** with mangrove systems of exceptional beauty; • the rich variety of landscapes and seascapes including rugged mountains with dense and diverse vegetation and adjacent fringing reefs; • the abundance and diversity of shape, size and colour of marine fauna and flora in the coral reefs; • spectacular breeding colonies of seabirds and great aggregations of over-wintering butterflies; and • migrating whales, dolphins, dugong, whale sharks, sea turtles, seabirds and concentrations of large fish.
Criterion (iv) provide habitats where populations of rare and endangered species of plants and animals still survive.	The Great Barrier Reef contains many outstanding examples of important and significant natural habitats for *in situ* conservation of species of conservation significance, particularly resulting from the latitudinal and cross-shelf

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981.	Examples of World Heritage values of the Great Barrier Reef for which the property was inscribed on the World Heritage List in 1981.
	completeness of the region. The World Heritage values include: • **habitats for species of conservation significance** within the 77 broadscale bioregional associations that have been identified for the property and which include: - over 2900 **coral reefs** (covering 20 055km^2) which are structurally and ecologically complex; - large numbers of islands, including: ∗ 600 **continental islands** supporting 2195 plant species in 5 distinct floristic regions; ∗ 300 coral cays and sand cays; ∗ seabird and sea turtle rookeries, including breeding populations of green sea turtles and Hawksbill turtles; and ∗ coral cays with 300-350 plant species in 2 distinct floristic regions; • **seagrass beds** (over 5000km^2) comprising 15 species, 2 endemic; • mangroves (over 2070km^2) including 37 species; • *Halimeda* banks in the northern region and the unique deep water bed in the central region; and • large areas of ecologically complex **inter-reefal and lagoonal benthos**; and • species of plants and animals of conservation significance.

5.1.1 Benthic Communities

Benthic Communities: Key Findings

Benthic grab sampling resulted in the collection and identification of 100 invertebrate species, with greater density and species richness found at the Impact sites (Development site, Strand, Pallarenda) than at the Control sites (Shelly Beach and Cape Cleveland). The large number of polychaetes and microcrustaceans found in the samples make up a significant portion of the diets of many fishes of commercial and conservation significance. Benthic communities may be affected by dredging, sediment and water quality contamination, and smothering by waste and debris. Careful management of these impacts can prevent losses of benthic invertebrates that may affect fish communities.

A total of 703 individual organisms, representing 100 species, were collected during benthic grab sampling. Benthic fauna occurred in greater densities at the Impact sites than at the Control sites (Figure 9) with 553 individuals collected from Impact sites and 150 sampled at the Control sites. It should be noted that the use of the term “control” site should not imply that these sites are pristine and have not anthropogenic impacts.

Species richness was also significantly higher at the combined Impact sites than at combined Control sites (Figure 10). However, there was also more variation at the Impact sites than the Control sites, both for density (Figure 11) and species richness (Figure 12). Impact sites closest to the Development site had lower density and species richness than those further away, possibly due to the gradient of increasing disturbance towards the Port area.

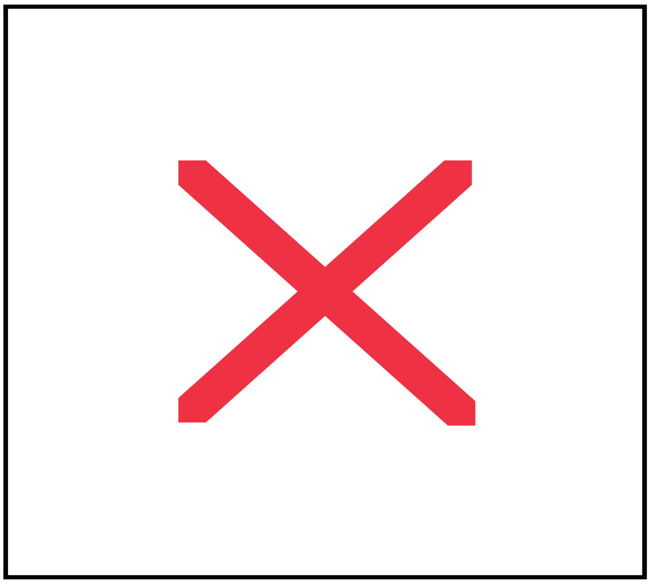


Figure 9. Overall mean densities per litre of benthic macroinvertebrates found at pooled Impact and Control sites (+/- 1 S.E.). ANOVA, $F_{1,52} = 12.516$, $p < 0.01$.

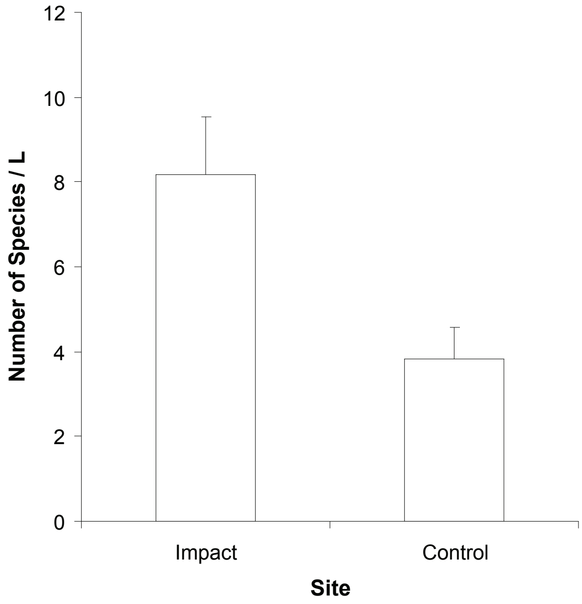


Figure 10. Overall mean species richness of benthic macroinvertebrates per litre at pooled Impact and Control sites (+/- 1 S.E.). ANOVA, $F_{1,52} = 10.699$, $p < 0.01$.

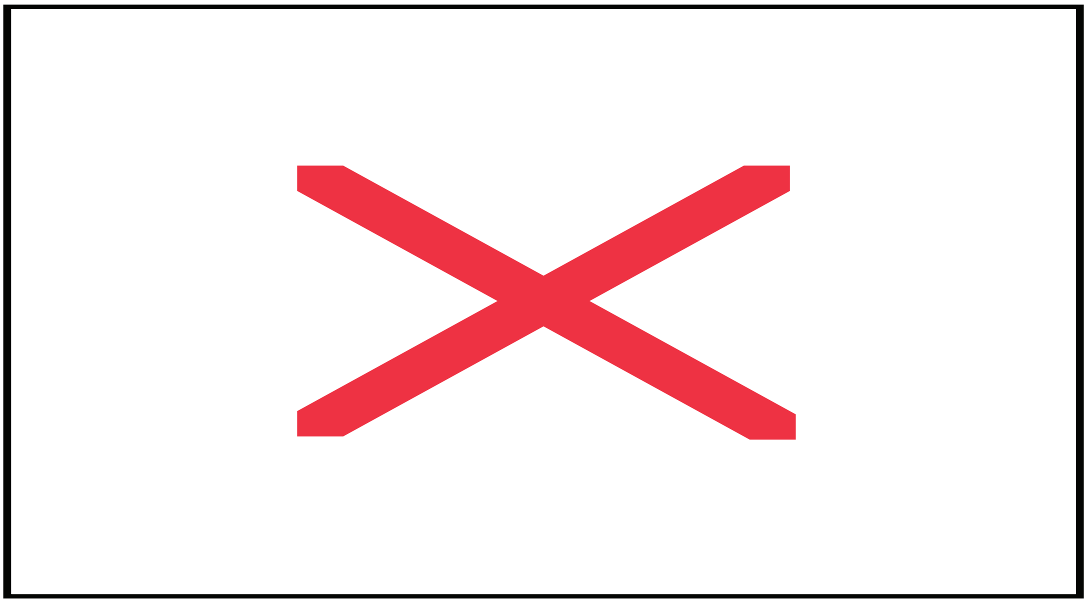


Figure 11. Variability in the mean density of total macroinvertebrates at Impact (I1-I9) and Control (CS1-CS3, CC4-CC9) sites (+/- 1 S.E.). I: Impact; CS: Shelly Beach Control; CC: Cape Cleveland Control.

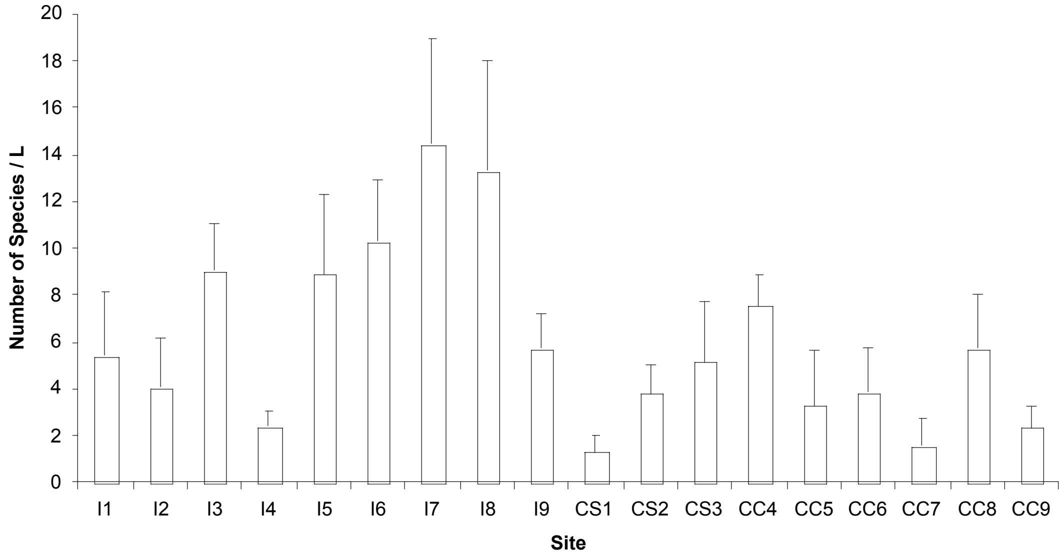


Figure 12. Variability in the mean species richness of total macroinvertebrates at Impact (I1-I9) and Control (CS1-CS3, CC4-CC9) sites (+/- 1 S.E.). I: Impact; CS: Shelly Beach Control; CC: Cape Cleveland Control.

Invertebrate fauna in the samples was dominated by polychaete worms (5.17ind. / L +/- 1.16 S.E.), which were over four times as abundant as amphipods (1.5 ind. / L +/- 0.73 S.E.). All other categories ranged between approximately 0.2 and 0.9 individuals / L (Figure 13).

Different groups of organisms were found between Control and Impact sites, both at the level of broad categories (Figure 14) and at the level of the most abundant families, genera or species. Polychaete worms, amphipods, bivalves and isopods occurred at more than double the densities at the Impact sites when compared to the Control sites, and ascidians were only found at the Impact sites.

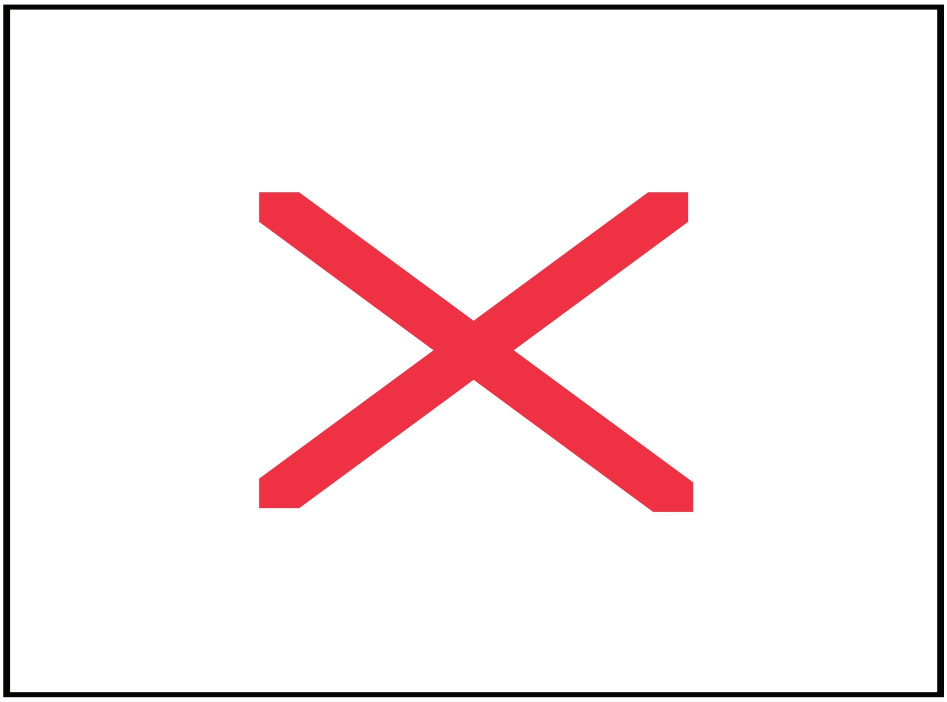


Figure 13. Mean densities of broad taxonomic groups found in benthic grab samples in Cleveland Bay (+/- 1 S.E.).

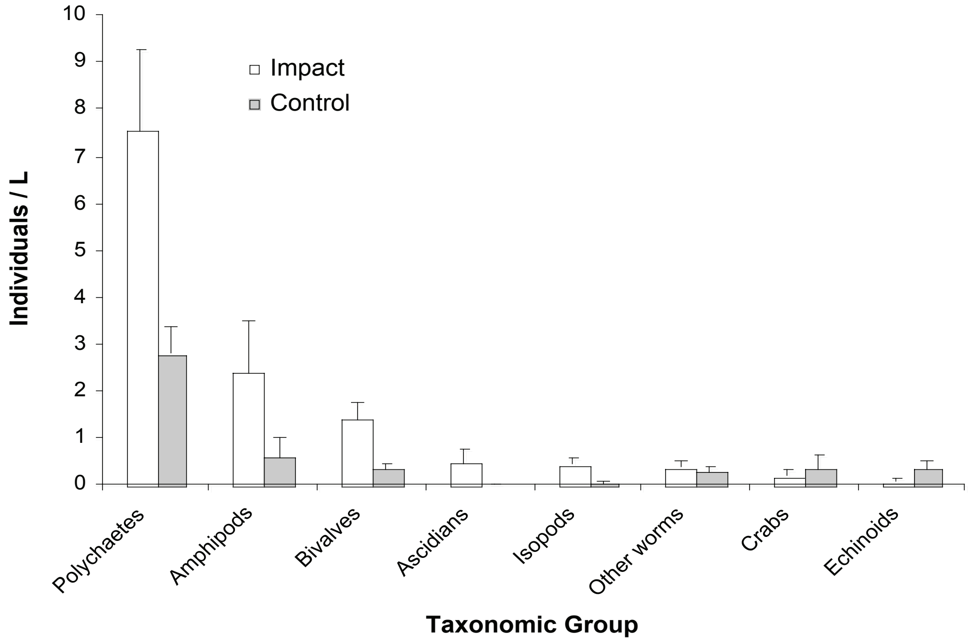


Figure 14. Distribution of mean densities of broad taxonomic groups between Impact and Control sites (+/- 1 S.E.). Broad category differences: MANOVA Pillai's Trace $F_{8,36} = 2.415$, $p < 0.05$. Most abundant taxa differences: MANOVA Pillai's Trace $F_{9,35} = 16.889$, $p < 0.001$.

Different groups of species were also found between the individual Impact and Control sites. Sites around Kissing Point had the highest densities of the most common groups, and the greatest species richness (15 species found in one standardised sample). There was a general increase in species richness and individual group density with increasing distance from the Development site (Figure 15). The lowest representation of groups was found at the sites on the Cleveland Bay side of the Port, with only one group represented at some sites (usually polychaetes) and a maximum of three represented at others.

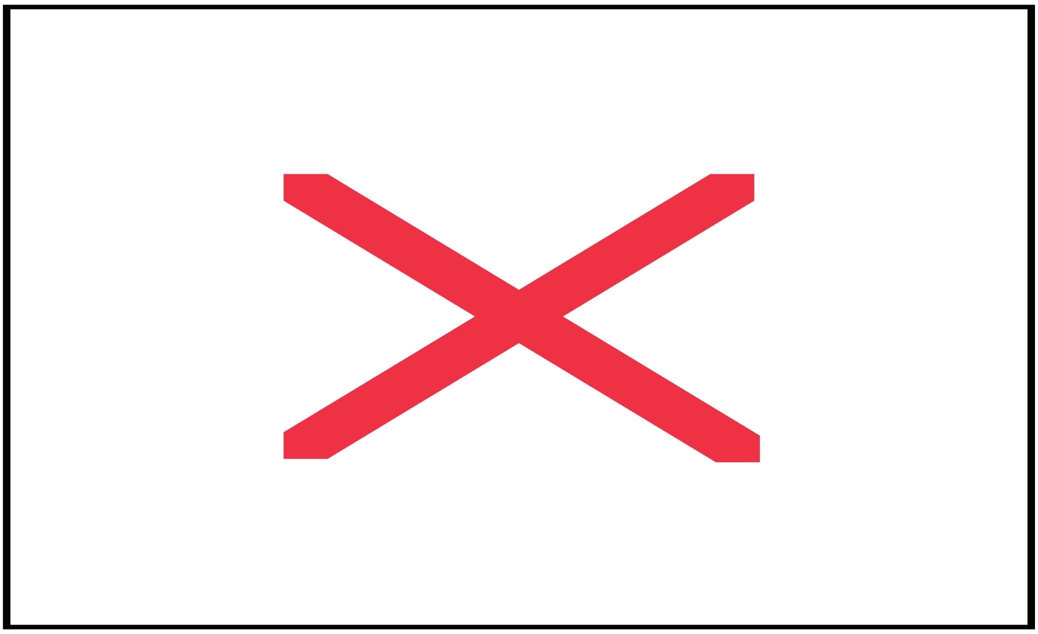


Figure 15. Densities and taxonomic composition of broad invertebrate groups at Impact and Control sites (+/- 1 S.E.). I: Impact; CS: Shelly Beach Control; CC: Cape Cleveland Control. Broad category differences: MANOVA Pillai's Trace $F_{72,344} = 1.581$, $p < 0.01$. Most abundant taxa differences: MANOVA Pillai's Trace $F_{81,387} = 2.504$, $p < 0.001$.

The assessment of the Cleveland Bay benthic communities in terms of their dietary contribution to the fish community revealed that all groups found during the benthic survey, except corals, were targeted by one or more fish species of commercial and/or conservation significance. This includes 85 species that frequent Cleveland Bay and the Ross River mouth (see Appendix 4). Crustaceans and microcrustaceans (crabs, amphipods and isopods) were most often found as part of the diets of these fish species (15-25% of fish diets, Figure 16). Bivalves and polychaetes formed a part of the diet of 9.4 and 8.2% of fish species, respectively. Gastropods, other worms, foraminiferans, ascidians and echinoids were each represented in the diets of less than 6% of fish species.

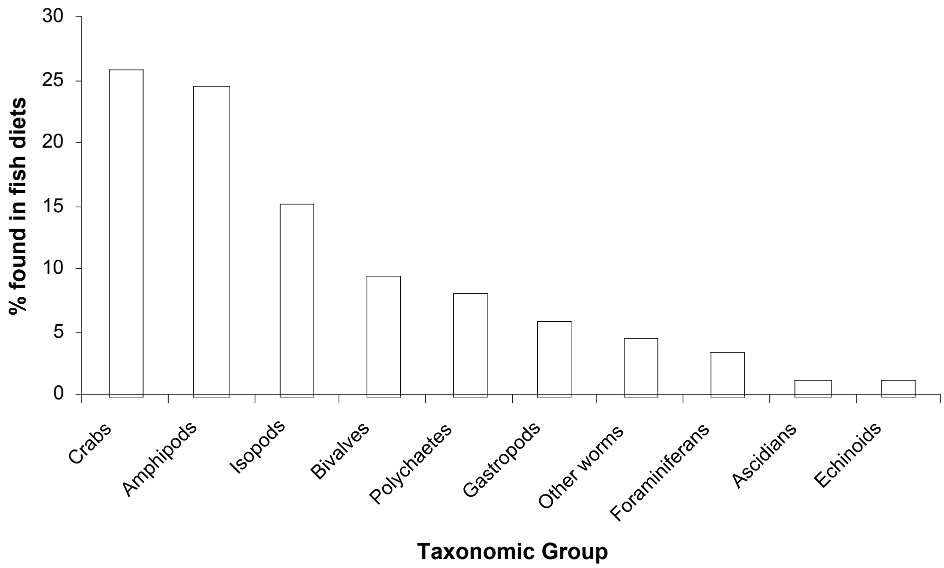


Figure 16. Taxonomic groups of benthic fauna found in the diets of fishes of commercial and/or conservation significance. The y - axis represents the % of important fish species consuming each group as part of their diet.

5.1.2 Seagrass Beds

Seagrass Beds: Key Findings:

Large seagrass beds occur in Cleveland Bay, providing a nationally significant feeding ground for dugongs and justifying the status of the Bay as a Dugong Protection Area. The greatest density of seagrasses was found at the sites near Kissing Point and Pallarenda. High densities and species richness also occurred at the Cape Cleveland sites. Seagrasses also occur inside the Development site, although it is an artificially constructed environment. It is highly likely that seagrasses in Cleveland Bay already exist at the lower limit of their tolerance to light attenuation, and small increases in turbidity are expected to cause substantial mortality. During construction and operation, careful management of TOT activities (especially water and sediment quality) can prevent damage to Cleveland Bay's seagrass beds.

The density of seagrasses in the sampled areas was significantly higher at the Control sites than at the Impact site (Figure 17), but variability was also higher between the individual Impact sites (Figure 18). Along the impact gradient, the highest seagrass densities were found around the Kissing Point and Pallarenda Beach areas, where there was also the highest substratum complexity (i.e. coarser sediments). Areas closer to the Development site were patchier and had lower overall densities. Inside the Development site, high-density *Halophila spinulosa* patches alternated with the green alga *Caulerpa taxifolia*, whereby the individual shoots of *H. spinulosa* were larger than any other specimens observed in Cleveland Bay. This is potentially due to the protected, and therefore relatively stable, physical conditions in the Development site.

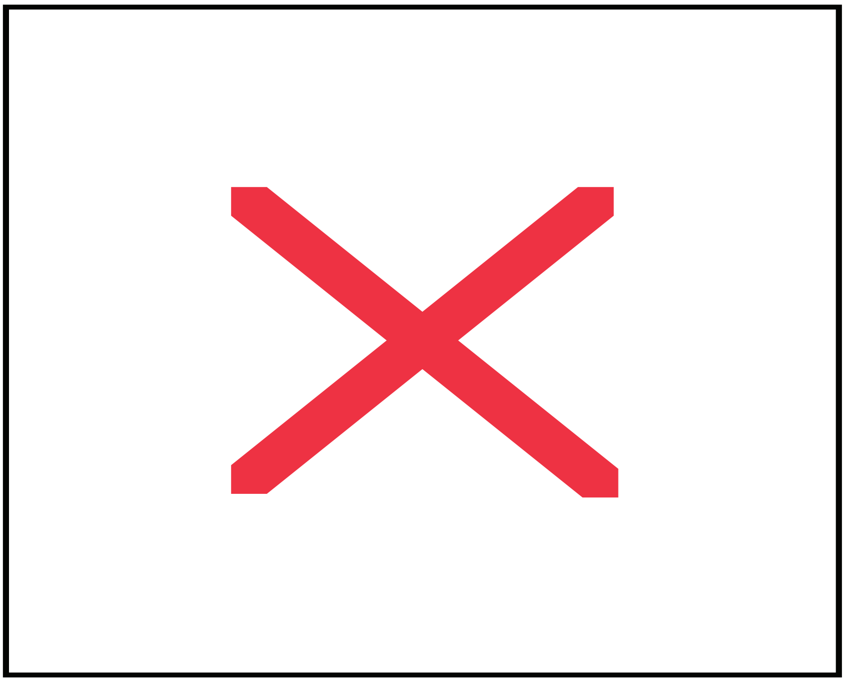


Figure 17**.** Total density of seagrasses at combined Impact and Control sites in Cleveland Bay (+/- 1 S.E.). ANOVA $F_{1,178} = 17.89$, $p < 0.001$.

Seagrass densities at the Control sites were approximately three times higher than at the Impact sites, although a five-fold variability also existed within the Control sites. The primary differences in seagrass density between Control sites were between the Shelly Beach site (where densities were relatively low) and the two high-density Cape Cleveland sites (Figure 18).

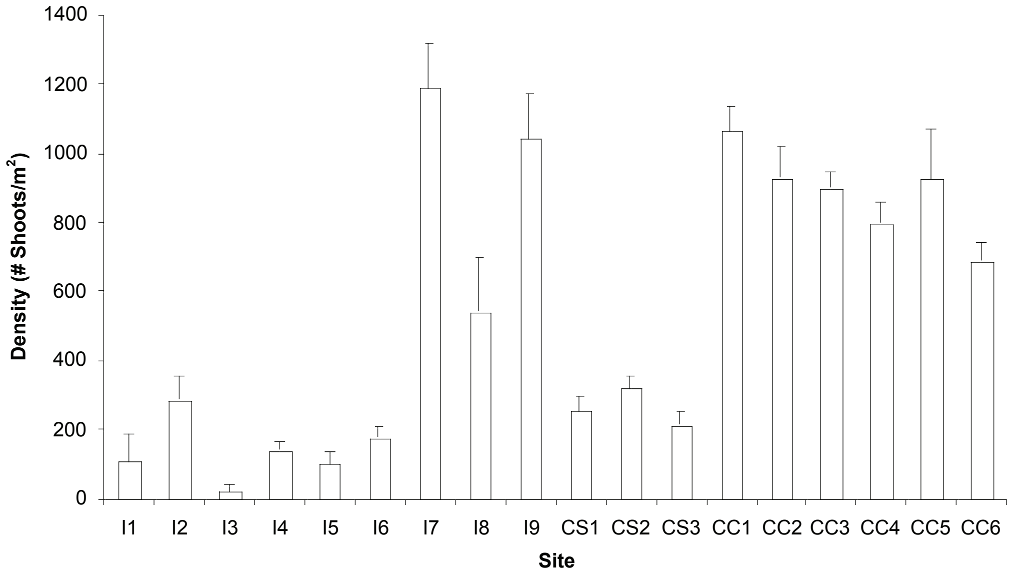


Figure 18. Total density of seagrasses at each Impact and Control site. I = Impact site, CS = Shelly Beach Control site, CC = Cape Cleveland Control site (+/- 1 S.E.).

Species composition varied significantly between sites, and between combined Control and Impact sites. The very fine sediments inside and directly outside the Development site (I1 and I2) were dominated by *H. spinulosa*, while sites I3 to I6, in coarser sediments offshore from the Strand, were characterised by sparse *H. ovalis* and *H. decipiens* (Figure 19). Closer inshore, dense stands of *Cymodocea* spp. were observed (but not at designated sampling sites). Sites adjacent to Kissing Point and Rowes Bay had varied benthic communities, including hard corals, soft corals, sponges, ascidians, bryozoans and *Sargassum* sp. These sites, and site I9 (Pallarenda), had the highest density of seagrasses and were dominated by *Halodule uninervis*[1], *Halophila ovalis* and *H. spinulosa*.

All Control sites were dominated by *H. spinulosa*, but the Cape Cleveland sites had higher species richness and density than the Shelly Beach site. All four abundant species were found in almost all quadrats at the Cape Cleveland sites, while the Shelly Beach site had almost only *H. spinulosa* and *H. ovalis*.

[1] *Halodule uninervis* and *H. pinifolia* are treated together here, as suggested in: Waycott M, McMahon K, Mellors JE, Calladine A, Kleine D (2004) A guide to tropical seagrasses of the Indo-West Pacific. James Cook University, Townsville.

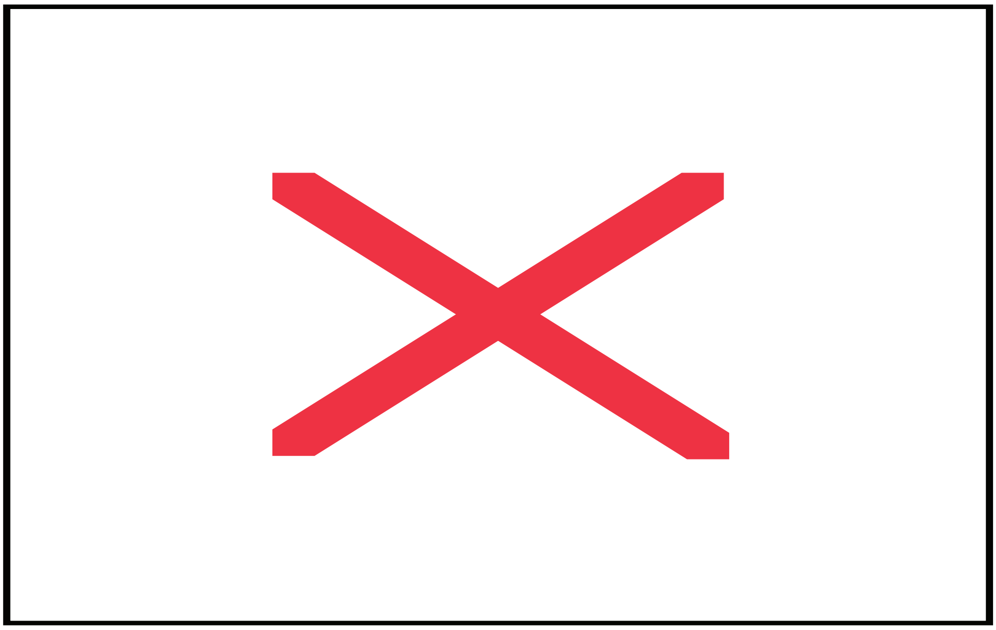


Figure 19. Density of each seagrass species found at sampling sites in Cleveland Bay. I = Impact site, CS = Shelly Beach Control site, CC = Cape Cleveland Control site (+/- 1 S.E.). Individual site analysis: MANOVA $F_{80} = 14.007$, $p < 0.001$. Combined Impact vs. Control analysis: MANOVA $F_{5} = 151.416$, $p < 0.001$.

Macroalgae associated with seagrass beds reached a maximum of 50.5% cover (+/-6.03 S.E.), and were primarily red algae (*Laurencia* spp. and *Hypnea* spp.) and erect calcified algae (*Halimeda* spp. and *Jania* spp.). The green alga *Caulerpa taxifolia* was also present at many of the Impact sites. Unlike seagrass distribution patterns, the cover of combined macroalgae was significantly higher at Impact sites than at Control sites (Figure 20). However, regression analysis showed that there was no clear causal relationship between the cover of macroalgae and the density of seagrasses. This suggests that at the sampled scale, macroalgal cover did not influence seagrass density ($F_{(1,178)} = 1.795$, $p = 0.182$). Should an impact of the Townsville Ocean Terminal be an increase in nutrients in the water column, this increase in macroalgal cover could cause a decline in seagrasses, and this relationship may become significant.

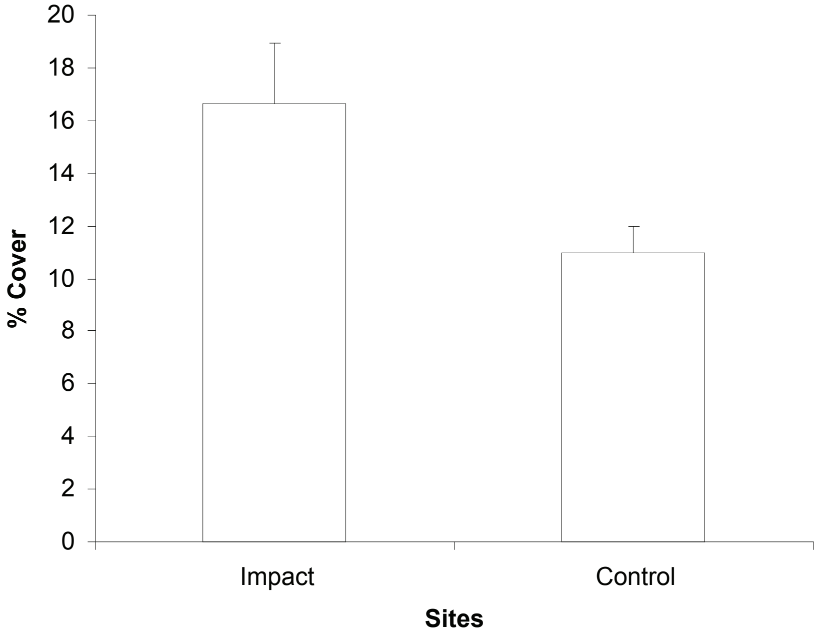


Figure 20. Percent cover of combined macroalgae at Impact and Control sites (+/- 1 S.E.). Kolmogorov-Smirnov Z = 2.087, $p < 0.001$.

Distinct patterns occurred in the distribution of different macroalgal groups across the sampling sites in Cleveland Bay. *Caulerpa taxifolia* was found in patches only at the Impact sites, often closely associated with patches of seagrass and, inside and directly outside the Development site, overgrown by blue-green algae (Figure 21). Red and brown algae were present at sites west of the Strand (Kissing Point, Pallarenda and Shelly Beach), while the calcified algae *Jania* spp. and *Halimeda* spp. were abundant at the Cape Cleveland sites (Figure 21). The most diverse algal communities occurred at Kissing Point and Shelly Beach.

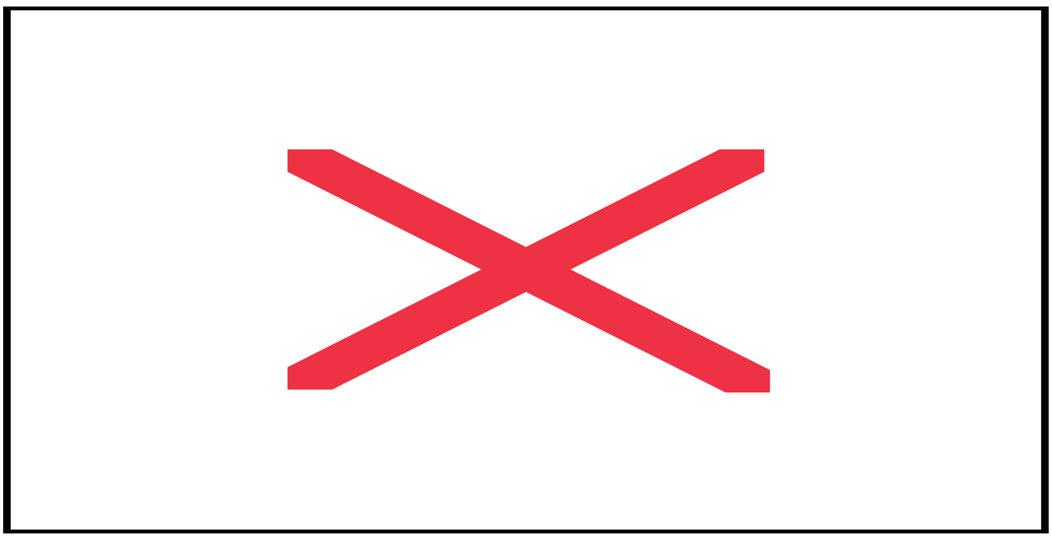


Figure 21. Composition of macroalgae across the sampling sites in Cleveland Bay. Abundance is shown as % Cover (+/- 1 S.E.)

These findings corroborate results from previous surveys about seagrass distribution in Cleveland Bay (Lanyon and Marsh 1995, Lee Long et al. 1996, SciMar 2005a), despite the dynamic nature of Cleveland Bay's seagrass beds (Dr. M. Waycott, pers. comm.). This suggests that, despite fluctuations in seagrass density, distribution and taxonomic composition, regrowth of seagrass beds tends to take place in similar areas of the Bay, and that in this sense subtidal seagrass beds are temporally somewhat more stable than intertidal seagrass beds. This increases the ecological and economic importance of subtidal seagrass beds, as they provide a refuge during events that change or damage intertidal seagrasses (Lee Long et al. 1996). Presently, seagrasses in Cleveland Bay are in near 'peak' condition, due to a four to five year period of relatively stable climatic conditions (Dr. M. Waycott, JCU, pers. comm.).

It is likely that these seagrasses are primarily limited by depth, due to diminished light intensity below 4m (Lee Long et al. 1996, Schaffelke et al. 2005). Seagrass distribution is generally also controlled by shelter, turbidity and tidal exposure (Lee Long et al. 1996). The most dense and diverse seagrass beds in Cleveland Bay currently occur in the coarser sediments around Kissing Point and Pallarenda, and adjacent to Cape Cleveland.

Despite the evidence that seagrasses in the GBR region are generally nutrient limited (Waycott et al. 2005), a possible adverse effect of nutrients on seagrass beds is through the stimulation of macroalgal growth, leading to shading and epiphytic overgrowth of seagrasses. It is unlikely that this is occurring at the sampled sites in Cleveland Bay, as there was no indication of an inverse correlation between macroalgal cover and seagrass density. Epiphytic overgrowth of seagrasses was scarce, and canopy-forming macroalgae such as *Sargassum* spp. were relatively rare.

Cleveland Bay is a highly turbid environment, due to its shallow water depth, predominance of very fine terrigenous sediments that are easily resuspended and its exposure to the south easterly trade winds (Larcombe and Woolfe 1999). Suspended Sediment Concentrations (SSC) near the seabed in Cleveland Bay have been measured at a maximum of approximately 300 mg/L, with an SSC of 100 mg/L occurring on around 20 days each year (Anderson et al. 2002). Under moderate to rough sea conditions, the entire Bay is subject to SSCs of between 5 and 20 mg/L.

Furthermore, its location in the 'dry tropics' means that nutrient, sediment and contaminant input from estuarine catchments is delivered to the Bay in periodic pulses (Brodie et al. 2001). This turbidity limits seagrass growth to the shallower and calmer portions of the Bay, whereby seagrass beds are uncommon below approximately 4m, except in the somewhat sheltered areas near Cape Cleveland (Lee Long et al. 1996). Given that the exposure of the Bay to the south easterly trade winds often generates high levels of water movement, the negative effects of high turbidity on seagrasses are likely to be caused both by light attenuation and sediment scouring (Dr. M. Waycott, JCU, pers. comm.), while smothering through sediment deposition may be less problematic.

There are differences in how adaptable the different seagrass species are to light reduction stress; *Halophila ovalis* and *Halodule* species, for example, are highly resilient to freshwater inputs, sediment deposition and variable light conditions (Longstaff and Dennison 1999). Both these species are abundant in Cleveland Bay, and are usually the first to recover after disturbance events (Dr. J. Mellors, DPI&F, pers. comm.). In general, increasing turbidity-related light-stress is expected to have a negative impact on seagrasses in Cleveland Bay, although the exact thresholds and tolerance levels for different species are not yet known (Waycott et al. 2005). Recent unpublished research indicates that seagrasses in Cleveland Bay already exist at the lower limit of their tolerance to light attenuation, and small increases in turbidity are likely to cause substantial mortality (Dr. M. Waycott, JCU, pers. comm.).

5.1.3 Coral Reefs

Coral Reefs: Key Findings

Despite high turbidity and seasonal macroalgal blooms, the reefs in Cleveland Bay support high coral cover which continues to increase since the damage incurred in past cyclones and bleaching events. Middle Reef, the most likely reef to suffer impacts of the Development, supports the highest coral cover at 77.1 % +/- 5.74 S.E.). Reefs with high overall coral cover tended to be dominated by corals of the family Acroporidae, except in Arthur Bay, where there was a high cover of Fungiidae or mushroom corals, and ‘deep water corals’. These results suggest that current conditions are favourable for coral reef recovery, but with increasing sea levels and water temperatures, additional impacts must be avoided to ensure the resilience of these inshore coral reefs. Dredging, marine pests and garbage from the TOT Development and associated increasing vessel traffic must be strictly controlled to prevent damage to Cleveland Bay’s coral reefs.

The cover of live hard coral was significantly different between the surveyed reeds (Figure 22). Comparisons of live hard coral cover and total algal cover (*Sargassum* spp. and turf algae) made it possible to separate the survey sites into three groups:

Middle Reef, Nelly Bay West and Arthur Bay with very high live coral cover and low algal cover;

Nelly Bay East and Florence Bay with lower live coral cover and relatively low algal cover; and

Picnic Bay, Geoffrey West and Geoffrey East, where live coral cover was relatively low and similar to algal cover at the surveyed sites.

The percent cover of hard corals was highest on Middle Reef, with an average of 77.1 % (+/- 5.74 S.E.) and some transects resulting in 100% live coral cover. Nelly Bay (west and east) and Arthur Bay also had over 50% live coral cover, with Middle Reef, Nelly Bay West and Arthur Bay sites containing less than 10% algal cover (Figure 22).

The live, hard coral cover, on Middle Reef found in this survey appears similar to that found in 1992/93 (Kaly et al. 1994). This suggests that this reef has suffered little damage in the last 14 years, or that recovery from bleaching or cyclone damage has been rapid. Rapid recovery is likely, as this has been found for Magnetic Island reefs (Ayling and Ayling 2005). Middle Reef has the added advantage of low *Sargassum* abundance, reducing the likelihood that coral mortality will result in a rapid *Sargassum* bloom, and also reducing the seasonal *Sargassum* blooms found on Magnetic Island reefs.

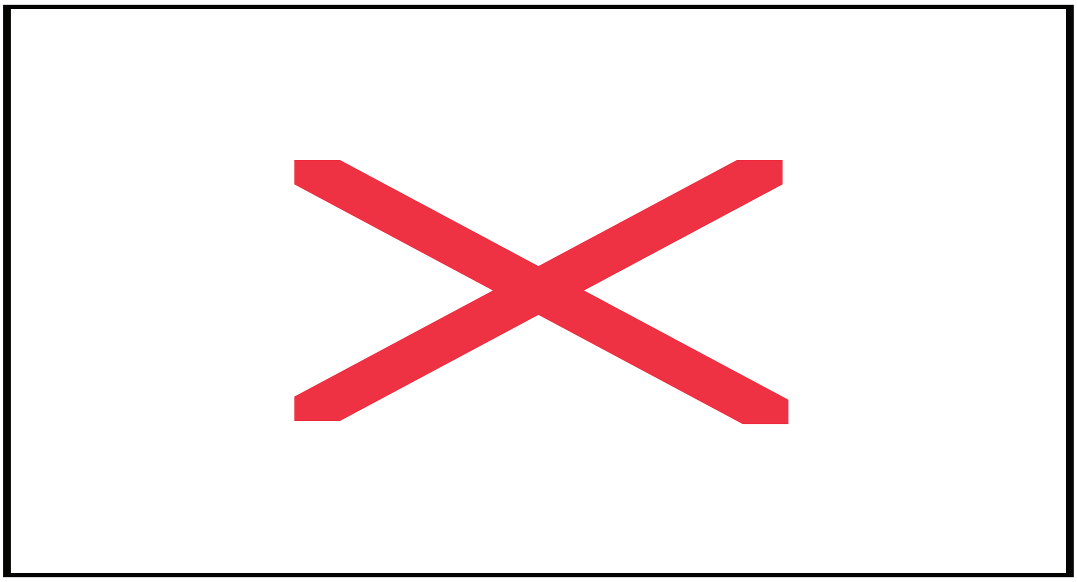


Figure 22. Total percent cover of live hard coral and algae (including *Sargassum* and turf algae) on all surveyed reefs. (ANOVA of live hard coral cover: $F_{7,88} = 14.932$, $p < 0.001$).

Treating Middle Reef and Picnic Bay as ‘Impact Sites’ and all other reefs as ‘Control Sites’ results in the assessment that algal cover is similar between Impact and Control sites (Figure 23). Live hard coral cover is statistically not significantly higher at Impact sites, but a trend exists of higher coral cover at Impact than Control sites. However, it is possible that the statistical interpretation is biased by the low live hard coral values recorded at Picnic Bay in comparison to Middle Reef, and the much higher algal cover of Picnic Bay Reef in comparison to all other reefs. This would indicate that while both Picnic Bay Reef and Middle Reef may be the sites most likely to be impacted by occurrences associated with the Development, the two sites are very different from each other and account will need to be taken of this factor in future advent sampling programmes.

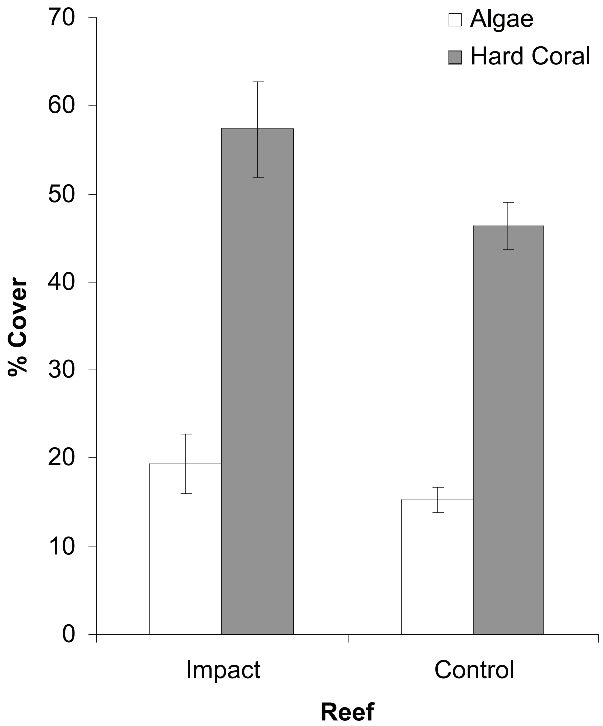


Figure 23. Algal and hard coral cover at combined Impact and Control sites, where Middle Reef and Picnic Bay are the Impact reefs and all other reefs are used as Control reefs. (ANOVA of live hard coral cover: $F_{1,94}$ = 3.886, p=0.052).

Benthic taxonomic composition was different between reefs, and reefs with high overall coral cover tended to be dominated by corals of the family Acroporidae (Figure 24). This was true of all reefs except Arthur Bay, which had high cover of Fungiidae or mushroom corals, and 'deep water corals' (those families and genera usually expected to occur in deeper water). Geoffrey Bay (both east and west) was characterized by a relatively even abundance of the most common taxa, while Picnic Bay was found to have the highest cover of algal turf.

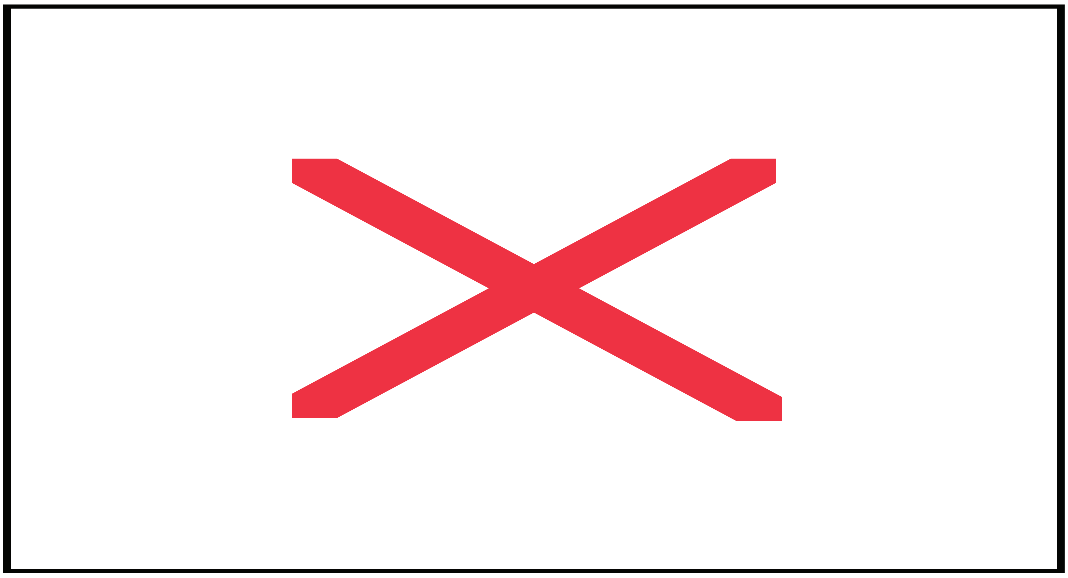


Figure 24. Hard coral and algal taxonomic composition across all surveyed reefs. Deep water coral families: siderastrids, fungiids, *Galaxea*, pectiniids, merulinids, euphylliids, mussids and agaricids usually more abundant in deeper water. The most abundant of these are *Pachyseris speciosa* and *Merulina ampliata*. MANOVA Pillai's Trace Value = 2.711, $F_{70,595}$ = 5.374, $p < 0.001$.

The three most abundant genera of hard coral, *Acropora*, *Montipora* and *Turbinaria* also occurred in different abundances across the surveyed reefs (Figure 25). Corals of the genus *Acropora* dominated Middle Reef, while a most even distribution of the three genera occurred on most other reefs. The cover of *Montipora* was highest at the Middle Reef, Nelly Bay East and Florence Bay sites, while *Turbinaria* was most abundant at the Nelly Bay West sites.

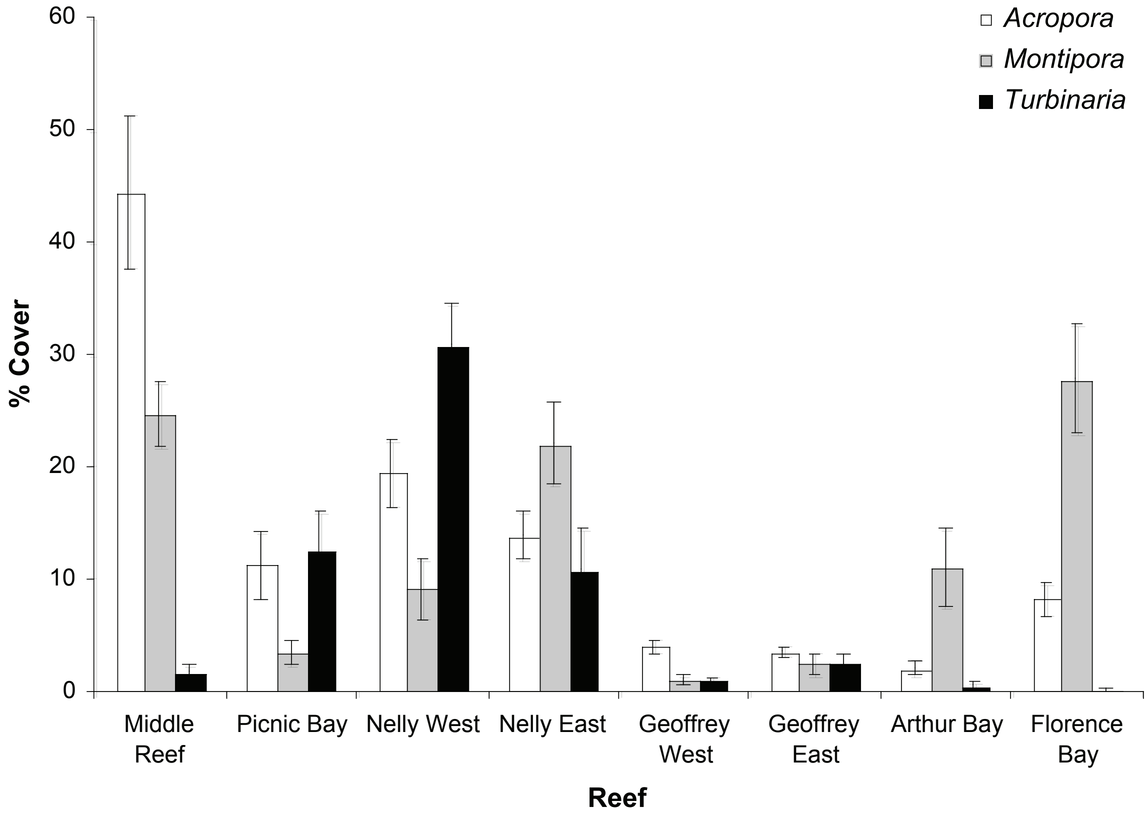


Figure 25. Distribution and % cover of the three most abundant genera across all surveyed reefs.

It appears that since the last survey conducted by Ayling and Ayling (2005), there has been an overall increase in *Sargassum* cover from 4.2% to 5.4% in Nelly, Geoffrey, Arthur and Florence Bays combined. However, the cover of combined live hard corals has also slightly increased, from 42% in 2005 to 46.4% in 2006. The taxonomic composition of the reefs in 2005 and 2006 has remained similar. Future monitoring must take into account both corals and macroalgae, as increasing macroalgal cover can inhibit coral recruitment and recovery (Kuffner et al. 2006).

The increase in hard coral cover suggests that after the disturbances of the last decade (bleaching in 1998, cyclone Tessi in 2000 and bleaching in 2002), coral cover is still recovering. Since the last bout of coral mortality from bleaching in 2002, conditions have been stable enough for a steady increase in coral cover to occur. To detect an impact to coral cover on these reefs, these longer-term trends must be taken into account.

5.1.4 Fish communities

Fish: Key Findings

Current and past datasets identify an estimated 253 fish species from 136 Genera and 65 Families in Cleveland Bay and in the lower reaches of the Ross River and the Ross Creek. Many of these are of value to commercial and recreational fisheries, the aquarium trade and the aquaculture industry. The commercial fishing industry revenue from Cleveland Bay is approximately 1 million dollars, and recreational fisheries, although much more difficult to quantify, are probably worth many times more. Damage to fish habitats must be avoided to ensure the continued viability of both industries.

Current and past datasets identify an estimated 253 species from 136 Genera and 65 Families in Cleveland Bay and in the lower reaches of the Ross River and the Ross Creek (Appendix 1). These datasets do not include species found specifically on the coral reefs of Cleveland Bay and Magnetic Island, but concentrate on the benthic and pelagic fishes that rely on soft-bottom benthic communities or on other pelagic organisms for their primary food sources. The most speciose family represented in fish data is the Carangidae, or trevallies (Figure 26), of which most species are of commercial and recreational fishing value. There were more than twice as many species of Carangidae than the next most speciose family, the Clupeidae (sardines and herring). Leiognathidae, or ponyfishes, were the third most speciose but have been found to be numerically the most abundant (Cabanban 1991, Sondita 1997). The shallow portions of Cleveland Bay act as nursery grounds for trevally and other fish families (Fogg 1993), most notably a number of shark species (Simpendorfer 1993).

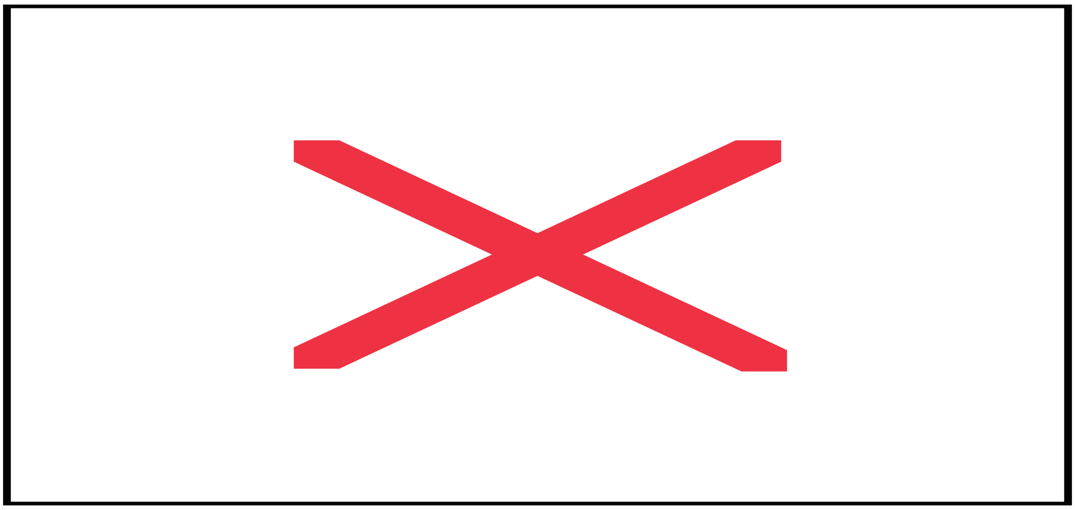


Figure 26. Fish families represented by more than one species found in Cleveland Bay, Ross River and Ross Creek, in order of decreasing species richness.

Fish species richness was higher in Cleveland Bay than Ross River and Ross Creeks, but this comparison lacks a standardising variable such as area or distance, and is therefore to be interpreted with caution. Similar numbers of species were found only in the Ross River / Creek and in both habitats (Figure 27). This suggests that species found in the Ross River / Creek areas represent not only a subsample of those found in Cleveland Bay, but a distinct fish fauna exists in the lower reaches of the Ross River and Ross Creek.

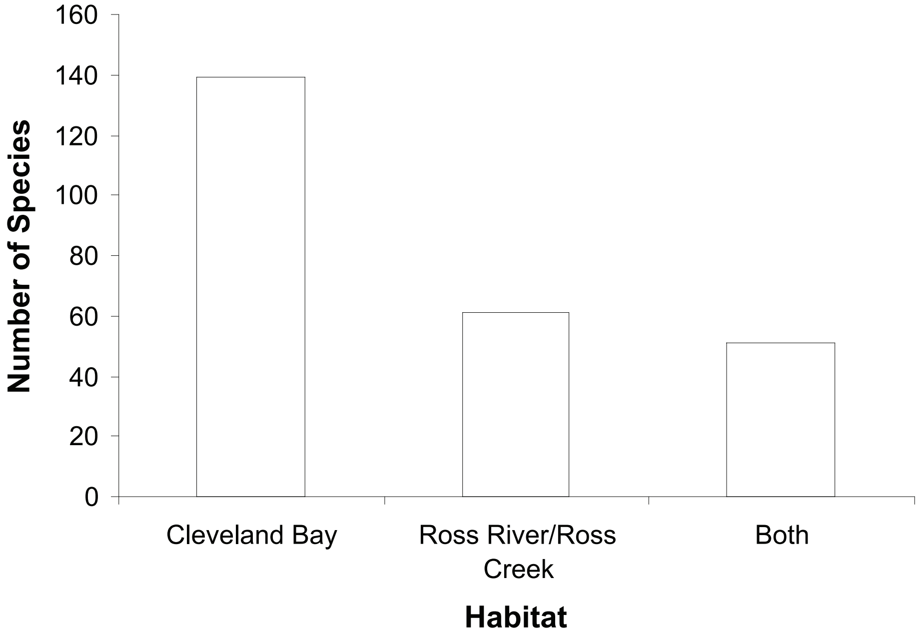


Figure 27. Species richness of fishes found only in Cleveland Bay, only in the lower reaches of the Ross River and Ross Creek, and in both habitats.

Of the 253 fish species, approximately one-third (81 species) undertake some form of migration during their life cycle (Figure 28). Over 40 species migrate between freshwater and marine habitats for purposes other than breeding and spawning (amphidromous), consistent with the finding that a substantial number of species are found both in Cleveland Bay and in the Ross River and Ross Creek (Figure 27). Oceanodromous fishes (migrating within the marine environment) and potadromous fishes (migrating within freshwater) were represented by 23 and two species, respectively. The most vulnerable species are those that migrate between freshwater and marine habitats for breeding and spawning purposes, because they rely on adequate access between these habitats. Seven anadromous species (migrate from marine to freshwater habitats to breed) and five catadromous species (migrate from freshwater to marine habitats to breed) were recorded in the species lists (Figure 28). Many of the anadromous and catadromous species (e.g. anchovy and herring) are considered of fisheries value. Also migrating between freshwater and marine habitats for spawning purposes is *Lates calcarifer*, the Barramundi, perhaps the most important species for Queensland fisheries (CRC Reef 2005). The presence of *L. calcarifer* in Cleveland Bay, the Ross River and the Ross Creek indicates that the connectivity may still be taking place (possibly through Gordon, Stuart and Sandfly Creeks) even though access to the fresh waters of Ross River has been severed. However, it may simply be the downstream result of the Barramundi stocking programme of the Upper Ross River. These inconsistencies will need to be considered for future sampling programmes.

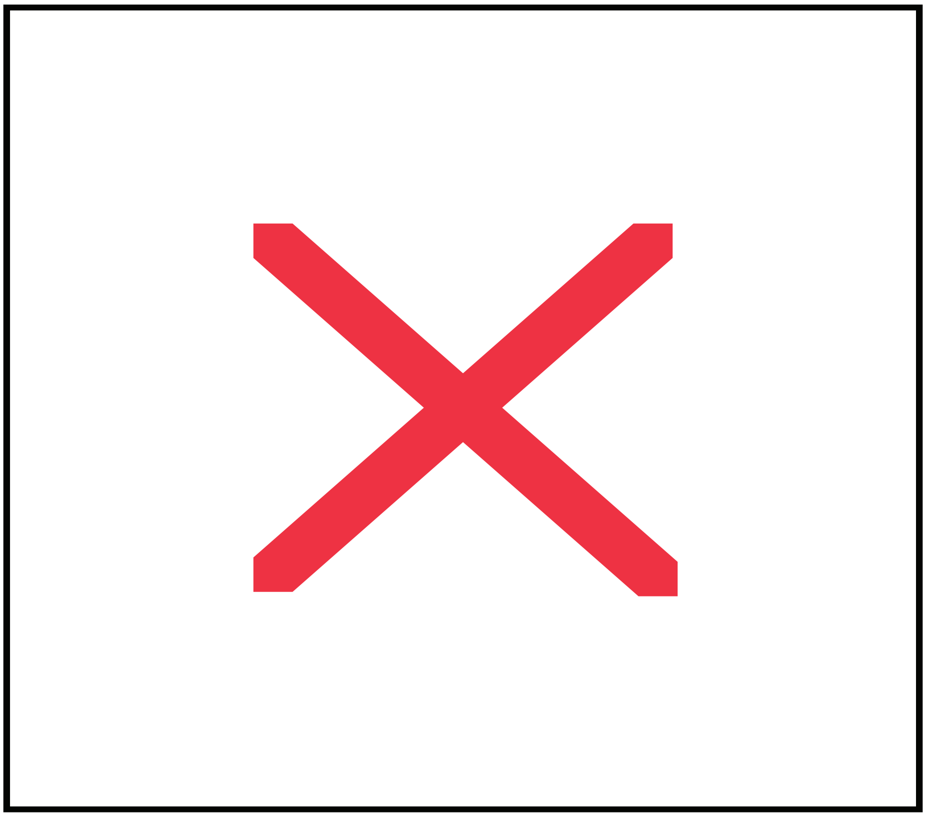


Figure 28. Migratory patterns of fishes found in Cleveland Bay, the Ross River and Ross Creek. Am: Amphidromous (migrate between freshwater and marine habitats, but not for breeding); Oc: Oceanodromous (migrate within marine environment); An: Anadromous (migrate from marine to freshwater habitats for breeding); Cat: Catadromous (migrate from freshwater to marine environment for breeding); Pot: Potadromous (migrate within freshwater environment).

5.1.5 Aesthetic values

The GBRWHA is listed as containing ‘superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance’. The aesthetic qualities of the GBRWHA are closely related to its natural assets and amenity values. Recent research suggests that the aesthetic qualities most valued by the general community, as they apply to the TOT Development, are:

- Unspoiled views across the water (in spite of the settlement on Magnetic Island);
- Views of Magnetic Island;
- The opportunity to pursue leisure activities beside an area of open water;

5.2 BOWLING GREEN BAY RAMSAR WETLANDS

A small portion of the Ramsar-listed Bowling Green Bay Wetlands adjoins the southern portion of Cleveland Bay (Figure 29). Because the wetlands are located upstream of the Development site, they are considered at minimal risk of impacts from the TOT Development, and are therefore not described or considered in detail.

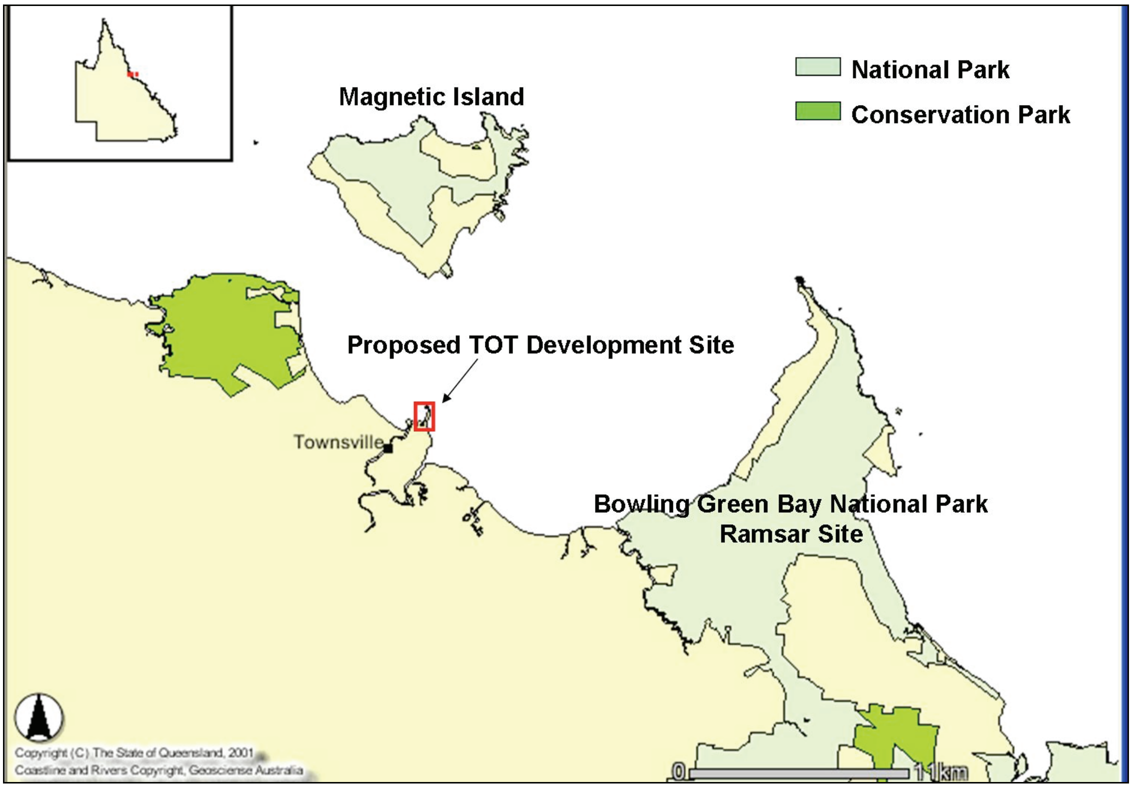


Figure 29. National and Conservation Parks in relation to the TOT Development site, including the Ramsar-listed Bowling Green Bay wetlands. From DPI&F (2007).

5.3 LISTED AND MIGRATORY SPECIES

The three EPBC-listed species in the ToR (Humpback whale, Flatback turtle and Dugong) were investigated, and an additional sixteen species, including marine mammals, reptiles and birds, were found to frequent Cleveland Bay and, in some cases, the Development site itself (

Table 5). This list excludes species that are listed as ‘marine’ or ‘cetacean’ by the EPBC Act; a more complete list of protected species can be found in Appendix 2.

Table 5. List of threatened and migratory species (EPBC Act) compiled by ERIN for the Cleveland Bay area. Included are, where appropriate, listing under other legislation.

	Species	Common Name	Qld[1]	EPBC[2]	J/C[3]	CMS[4]	CITES[5]	IUCN[6]
Birds	Erythrotriorchis radiatus	Red goshawk	E	V				VU
	Haliaeetus leucogaster	White-bellied sea-eagle		M	C			LC
	Hirundapus caudacutus	White-throated needletail`		M	C			LC
	Hirundo rustica	Barn swallow		M	C,J			LC
	Monarcha melanopsis	Black-faced monarch		M				LC
	Rostratula australis	Australian painted snipe		V				
Mammals	*Balaenoptera edeni*	Bryde's whale		M		App II	App I	DD
	Balaenoptera musculus	Blue whale		E,M		App I	App I	EN
	Dugong dugon	Dugong	V	M		App II	App I	VU
	Megaptera novaeangliae	Humpback whale	V	V,M		App I	App I	VU
	Orcaella heinsohni	Australian snubfin dolphin	R	M				DD
	Sousa chinensis	Indo-Pacific humpbacked dolphin	R	M		App II	App II	DD
Reptiles	*Caretta caretta*	Loggerhead turtle	E	E,M		App I		EN
	Chelonia mydas	Green turtle	V	V,M		App I	App I	EN
	Crocodylus porosus	Estuarine crocodile	V	M		App II	App II	LR/lc
	Dermochelys coriacea	Leatherback turtle	E	V,M		App I	App I	CR
	Eretmochelys imbricata	Hawksbill turtle	V	V,M		App I		
	Lepidochelys olivacea	Olive Ridley turtle	E	E,M		App I		
	Natator depressus	Flatback turtle	V	V,M				

[1] **Qld** (Queensland): E: Endangered; V: Vulnerable; NT: Near Threatened; R: Rare
[2] **EPBC** Act species: M: Migratory; V: Vulnerable; E: Endangered.
[3] **J/C**: JAMBA/CAMBA: Japan (or China) – Australia Migratory Bird Agreement.
[4] **CMS** (Convention on Migratory Species): Appendix I: Threatened with extinction; Appendix II: Under protection of legislation and agreements.
[5] **CITES** (Convention on the International Trade of Endangered Species): Appendix I: Species threatened with extinction, trade usually prohibited; Appendix II: trade must be strictly controlled.
[6] **IUCN** (International Union for the Conservation of Nature): LR/lc or LC: Least Concern; VU: Vulnerable; LR/nt: Low Risk/near threatened; DD: Data Deficient; EN: Endangered; LR/cd: Conservation dependent; CR: Critically Endangered.

5.4 MARINE MAMMALS

5.4.1 Dugong (Dugong dugon)

5.4.1.1 DISTRIBUTION

The Dugong (*Dugong dugon*) is the only strictly herbivorous marine mammal and is the only extant species in the Family Dugongidae. Its current distribution spans shallow waters of the Indian Ocean, Red Sea, Persian Gulf, Indo-Pacific region and northern Australia. In Australia, it is found primarily in coastal tropical waters (Figure 30) from the Queensland/New South Wales border in the east to Shark Bay on the Western Australian coast, and the Australian population is believed to include most of the world's Dugongs (Marsh and Lawler 2000). Cleveland Bay (in spite of proximity to and probability of potential anthropogenic impacts) has been noted as a regionally important area for Dugongs, due to its extensive seagrass beds.

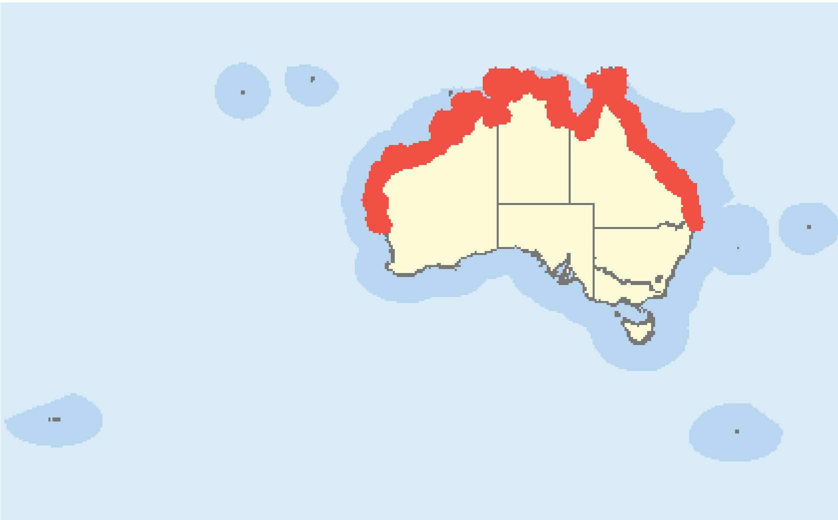


Figure 30. Current distribution of Dugongs in Australia. (from DEW 2007).

5.4.1.2 ECOLOGY

The Dugong depends almost entirely on seagrasses for subsistence, and therefore exists only in the coastal habitats where seagrass meadows occur. The largest populations of Dugongs are typically found in wide, shallow, protected areas such as bays, mangrove channels and the lee sides of large inshore islands. Their primary feeding mechanism is uprooting sea-grass by digging furrows in the sea-floor with their snouts.

Dugongs can undertake lengthy migrations, both within and between countries in their range. Their life history makes them highly vulnerable to population decline and the species is endangered throughout its range. They have long life spans (~ 70 years), late maturation (~ 17 years), long gestation and lactation periods (~ 15 and 18 months, respectively), infrequent calving (3-7 year intervals) and few offspring (single calf per litter). Dugong populations are unlikely to increase at rates of more than approximately 5% per year, and even a slight decline in adult survivorship can cause a chronic decline (Marsh et al. 2002).

5.4.1.3 POPULATION POTENTIALLY AFFECTED

Eastern Cleveland Bay (near Cape Cleveland) is recognized as a core Dugong habitat on the north Queensland coast (Preen 2000, Scheltinga and Heydon 2005). Dugongs along this coast are highly mobile, as discovered by tracking experiments, but the core areas (e.g. Cleveland Bay) provide key habitat and food resources where Dugongs tend to aggregate. Although Cleveland Bay has relatively high boat traffic, the eastern Cleveland Bay core area for Dugongs has been identified as one of relatively low boat traffic. Additionally, in the eastern section of the Bay there is an aggregation of dugongs on the seagrass beds in the area. This area is also favoured due to the distance from the main Cleveland Bay shiping channel and enables the dugong to avoid areas of high boat traffice, However, the frequent migrations of dugongs between the eastern side of Cleveland Bay and areas further north brings them into proximity of the heaviest areas of shipping traffic in Cleveland Bay.

5.4.1.4 CURRENT PRESSURES

Dugong populations everywhere in the world are under intense pressure from human activities. Accidental entanglement in nets, traps and marine debris and deaths resulting from vessel strike are relatively minor causes of mortality, but the critically low rate of population increase means that all accidental deaths of individual Dugongs must be avoided at all costs. Boat traffic, which can easily injure, displace or disturb marine mammals (Richardson et al. 1995, Hodgson and Marsh 2007), is likely to increase as a result of the Development.

The most serious source of Dugong population decline is the vulnerability of the seagrass ecosystems on which they depend (Marsh et al. 2002). Seagrass beds may be destroyed directly by mining and trawling, or lost through the effects of disturbances such as dredging, land clearing and land reclamation, which cause increases in sedimentation and turbidity which, in turn, lead to degradation of seagrass extent, density and productivity through smothering and lack of light. Extreme weather events (e.g. cyclones) may also cause periodic, but extensive, destruction of seagrass meadows, and may be slower to recover in areas subject to high levels of human disturbance (Marsh et al. 2002). In addition to the threat of Dugong starvation as a result of seagrass loss, times of low food abundance lead to a delay in breeding, accelerating population decline.

The proposed TOT Development has the potential to negatively affect the Dugong population in Cleveland Bay through the increase in noise levels during the construction phase, the highly probable increase in boat traffic. There is also a potential threat to seagrass beds to the north-west of the Development site.

5.4.1.5 EXISTING CONTROLS AND PLANNING REGIMES

Dugongs are listed as Migratory under the EPBC Act and as Vulnerable under the Nature Conservation Act in Queensland. Due to its importance to Dugong populations along the north Queensland coastline, Cleveland Bay has been declared a Dugong Protection Area (Zone A; Figure 31), where there are restrictions to the use of certain netting practices. It is believed that the benefits of Dugong Protection Areas were significantly enhanced under the *Great Barrier Reef Marine Park Zoning Plan 2003*, which increased the proportion of strictly protected zones in the Park to over 33%. It is now estimated that 57% of Dugongs in the GBRWHA are highly protected from incidental drowning in mesh nets, and 83% of Dugongs occur in areas where trawling is banned (GBRMPA 2007).

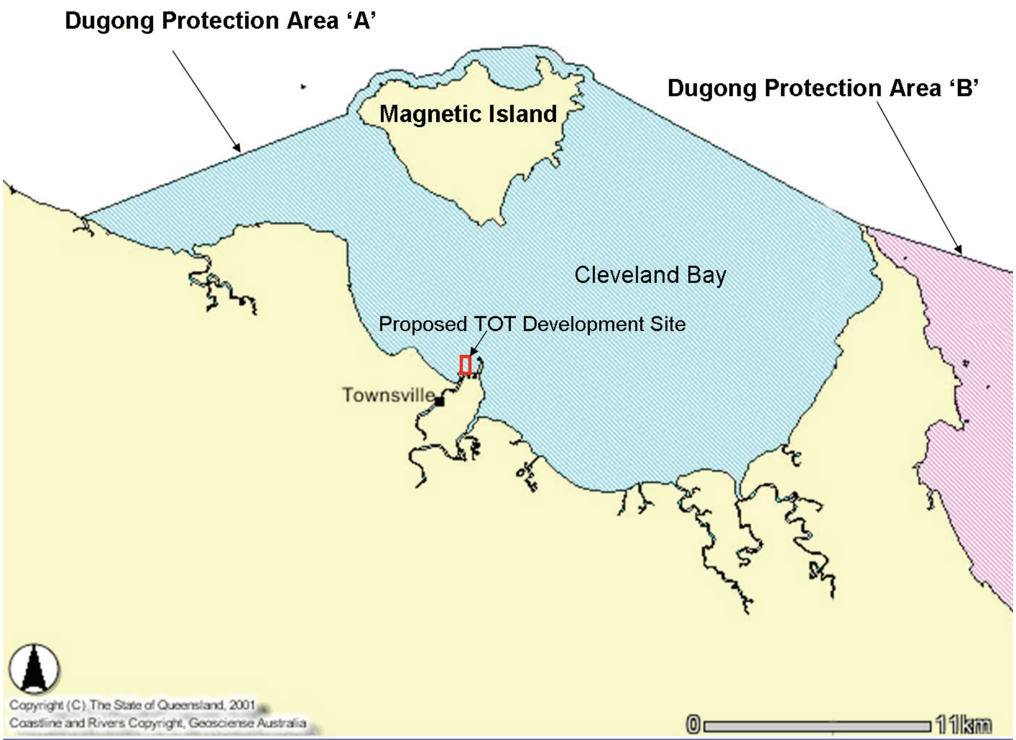


Figure 31. Dugong Protection Area in Cleveland Bay. From DPI&F (2007). Dugong Protection Area 'A' refers to significant Dugong habitat where certain netting practices are restricted or prohibited, see http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/natural_values/dugongs/dugong_protection_areas

5.4.2 Humpback Whale (Megaptera novaeangliae)

5.4.2.1 DISTRIBUTION

The Humpback whale is distributed globally and undertakes extensive migration between high-latitude summer feeding grounds and low-latitude winter calving grounds. There is believed to be little mixing between geographically separated stocks, but more recently it has been established that there is connectivity between breeding groups in each ocean basin.

In Australian waters, Humpback whales occur throughout Australian Antarctic waters, Commonwealth offshore waters, and all State waters (Bannister et al. 1996). Humpback whales have been sighted in the northern waters of the Great Barrier Reef (GBR) between October and January (DEW 2007), and in Cleveland Bay between July and September (Figure 32). With an increasing number of Humpback whales, there is the potential for expansion of their current habitat range.

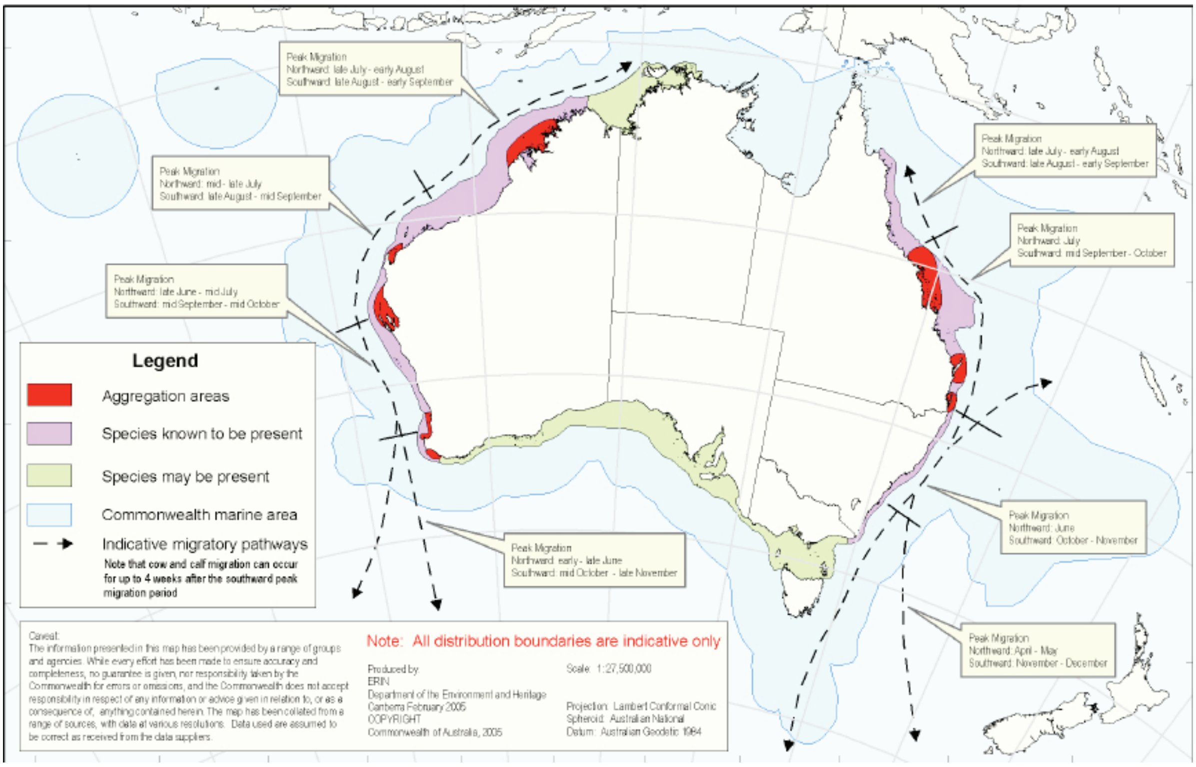


Figure 32. Distribution and migration pathways for Humpback Whales in Australian waters (from DEW 2007).

5.4.2.2 ECOLOGY

The ecology of Humpback whales is driven by their migrations between polar habitats, where abundant krill populations form their main food source, and equatorial waters, where warmer temperatures allow the successful birthing and rearing of calves. There is some evidence of feeding on fish and plankton swarms in warmer waters (DEW 2007). The peak feeding season in the southern hemisphere is mid-January to February, with dispersal as the season progresses. Humpback whales give birth to a single calf every two to three years, with occasional reports of annual calving. Mating and calving seasons in Australian waters are June - October, and gestation lasts between 11 and 11.5 months.

Humpback whales reach sexual maturity between 4-10 years of age, and tend to live approximately 50 years. Population estimates suggest that Humpback whale abundance is increasing, and that the east Australian population was approximately 8,000 in 2006.

5.4.2.3 POPULATION POTENTIALLY AFFECTED

Cleveland Bay is an important part of the annual migration of Humpback whales north and south along the Australian east coast. Whales are sighted every year from Magnetic Island, the Strand and the ferry service between Townsville and Magnetic Island (pers. obs.). A number of individual Humpback whales are therefore likely to pass within 7km and downstream of the area potentially affected by the Development site, and across the Platypus Channel, where there will be an increase in large vessel traffic during operation of the TOT. The proportion of the population traveling through Cleveland Bay, rather than east of Magnetic Island, is unknown, as is the proportional increase in large vessel traffic.

5.4.2.4 CURRENT PRESSURES

Current threats to Humpback whale populations in Australia are primarily those that cause the degradation or destruction of habitat, particularly along migration routes. Human activities that may interfere with or disrupt whale migration routes include noise pollution, entanglement in marine debris, physical injury or death from boat strikes, built structures, changing water quality and pollution, and changes to water flow regimes causing extensive sedimentation or erosion or altered currents in near shore habitat (e.g. canals and dredging) (NHT 2005a). Migration routes are almost entirely along shallow coastal areas, which makes the population susceptible to all or any of these activities, and the disruption to migration routes may cause lower reproductive success or even mortality. Declines at the population level would be more likely in areas where activities that cause habitat degradation occurred intensively and/or cumulatively (NHT 2005a).

Current pressures on Humpback whales in Cleveland Bay (high boat traffic, susceptibility to pollution and water quality changes, noise pollution) may be exacerbated during both the construction phase (higher noise levels) and operation phase (higher shipping traffic) of the TOT Development.

5.4.2.5 EXISTING CONTROLS AND PLANNING REGIMES

In Australia, Humpback whales are listed as vulnerable and migratory under the EPBC Act, which has established the Australian Whale Sanctuary and gives high levels of protection to cetaceans in Commonwealth waters. Within the Australian Whale Sanctuary it is an offence to kill, injure, take, trade, keep, move or interfere with any cetacean (whale or dolphin). Humpback whales are protected in all States and Territories under general native species and/or threatened species protection and management legislation (NHT 2005a).

A number of measures currently exist to manage interactions with all species of whales. Both Commonwealth and State regulations exist to manage whale watching activities. Within the Great Barrier Reef Marine Park, activities that will interfere with cetaceans are regulated through the *Great Barrier Reef Marine Park Zoning Plan 2003* (NHT 2005a).

5.4.3 Australian Snubfin Dolphin (*Orcaella heinsohni*)

5.4.3.1 DISTRIBUTION

The Australian snubfin dolphin is found only in the coastal waters of northern Australia, with a possible range expansion into Papua New Guinea. It is the only species of dolphin thought to be endemic to Australia. It is found in small groups, and the best studied population occurs in Cleveland Bay, where they are seen year-round (Dr. G. Parra, University of Queensland, pers. comm.).

5.4.3.2 ECOLOGY

The Australian snubfin dolphin was only recently discovered to be a separate species, having been identified as the Irrawaddy dolphin until 2005. It closely resembles the Irrawaddy dolphin in appearance, and is expected to have similar biological and ecological traits. Its reproductive biology is not well understood, but calving appears to take place in winter months. Australian snubfin dolphins are rare, with less than 100 individuals inhabiting Cleveland Bay (Dr. G. Parra, University of Queensland, pers. comm.). It feeds on fish and crustaceans, with a significant proportion of cephalopods in the diet (Parra 2006). Cleveland Bay is an important feeding and nursing area for this species, especially near the mouth of the Ross River (Dr. G. Parra, University of Queensland, pers. comm.).

5.4.3.3 POPULATION POTENTIALLY AFFECTED

The TOT Development site and areas immediately surrounding it form part of the key habitat for the Australian snubfin dolphin. It appears that this is related to their diet, as there is a high proportion of cephalopods (squid) in their diet, and coastal squid species often aggregate near natural and constructed rocky habitats (Parra 2006).

5.4.3.4 CURRENT PRESSURES

Australian snubfin dolphins are considered of high conservation priority, due to their perceived rarity (their population status is unknown) and their coastal habitat requirements, which bring them into close proximity with human impacts. They are susceptible to accidental catch in shark control and commercial fishing nets, habitat loss, overfishing of prey, noise pollution and vessel strike. The TOT Development is likely to result in the alteration of key feeding habitat, and cause an increase in some of the existing pressures on this species, such as noise pollution, habitat loss and vessel strike. It is not known whether the TOT Development in its operational stage will provide suitable habitat for the Australian snubfin dolphin. Emerging research suggests that there may not be a high level of connectivity between Australian snubfin dolphin populations in different locations, putting them at higher risk of local extinction (Dr. G. Parra, University of Queensland, pers. comm.).

5.4.3.5 CONTROLS AND PLANNING REGIMES

The Australian snubfin dolphin is listed as migratory under the EPBC Act. Apart from the automatic protection afforded to all cetaceans within the Australian Whale Sanctuary, no specific measures exist yet to protect this species.

5.4.4 Indo-Pacific humpbacked dolphin (*Sousa chinensis*)

5.4.4.1 DISTRIBUTION

The Indo-Pacific humpbacked dolphin is found from southern China through the Indo–Malay Archipelago to northern Australia. Most occur along north of 24°S, with occasional strandings reported in New South Wales (mostly north of 29°S) (Figure 33). It is not considered to be migratory. Key habitats along the Queensland coast appear to be Moreton Bay and adjacent offshore waters and Tin Can Inlet, Great Sandy Strait (Bannister et al. 1996). These dolphins are seen year-round in Cleveland Bay (Dr. G. Parra, University of Queensland, pers. comm.).

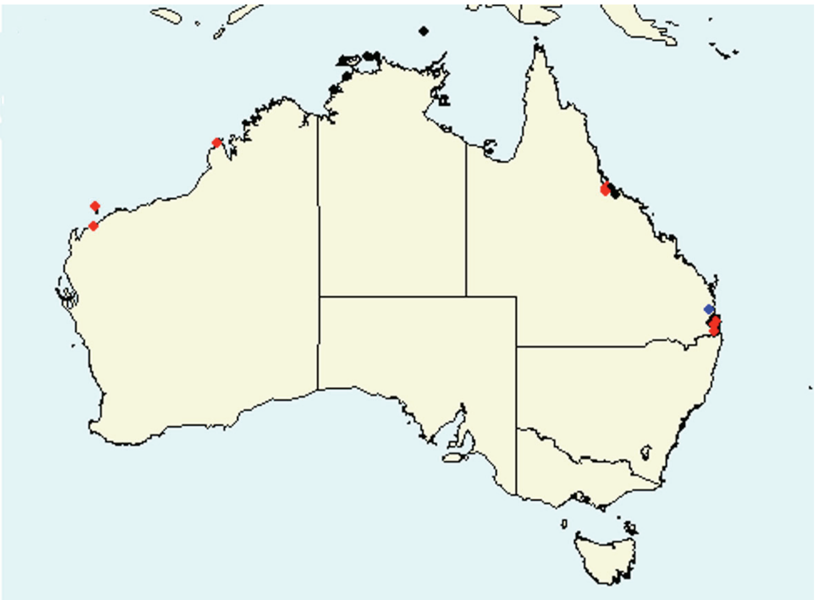


Figure 33. Western Australian Museum records of Indo-Pacific humpbacked dolphin sightings (coloured dots).

5.4.4.2 ECOLOGY

Indo-Pacific humpbacked dolphins are generally distributed in coastal, estuarine and occasionally riverine habitats less than 20m in depth, where they feed primarily on fish. Cephalopods and crustaceans can also form part of their diet. Little is known of their biology and there are no definitive population estimates, although the dolphins are often counted during aerial surveys targeting Dugongs. Recent research on their habitat requirements is centred around Cleveland Bay (e.g. Parra et al. 2004, Parra 2006, Parra et al. 2006). Cleveland Bay is an important feeding and nursing area for this species, especially near the mouth of the Ross River (Dr. G. Parra, University of Queensland, pers. comm.).

5.4.4.3 POPULATION POTENTIALLY AFFECTED

Aerial surveys often record dolphin numbers in Cleveland Bay, around 35% of which are thought to be Indo-Pacific humpbacked dolphins (Preen 2000). Research suggests that Cleveland Bay does not provide permanent habitat for the dolphins, but that they are often present in the Bay, with individuals residing there for days or months at a time. Approximately 200 Indo-Pacific humpbacked dolphins inhabit the greater Cleveland Bay region (Parra et al. 2004). Their relatively small population sizes and movement patterns make them vulnerable to local extinction (Parra et al. 2006). Core areas of use for Indo-Pacific humpbacked dolphins in Cleveland Bay are centred around the Townsville Port and associated breakwalls and dredged channels (Parra 2006). This pattern brings them in close proximity with the proposed Development site.

5.4.4.4 CURRENT PRESSURES

Pressures affecting Indo-Pacific humpbacked dolphins include habitat degradation through pollution and debris, noise pollution, harassment, boat strike, incidental capture in fishing or shark control nets, and declines in populations of their prey species. As coastal cetaceans, these dolphins are more vulnerable in areas close to larger cities (Bannister et al. 1996). It is likely that pressures such as habitat degradation, boat strike, the effects of marine debris and noise pollution will increase as a result of TOT construction and operation activities. It is not known whether the TOT Development in its operational stage will provide suitable habitat for the Indo-Pacific humpbacked dolphin.

5.4.4.5 EXISTING CONTROLS AND PLANNING REGIMES

In Australia, Indo-Pacific humpbacked dolphins are listed as migratory under the EPBC Act, and is protected country-wide by the Australian Whale Sanctuary. Within the Australian Whale Sanctuary it is an offence to kill, injure, take, trade, keep, move or interfere with any cetacean (whale or dolphin). This dolphin is also protected in all States and Territories under general native species and/or threatened species protection and management legislation (NHT 2005a).

5.4.5 Bryde's whale (Balaenoptera edeni)

5.4.5.1 DISTRIBUTION

Bryde's whales occur circumglobally in tropical and subtropical waters of at least 20º C. Three separate forms have been recognized, including a coastal form, an offshore form and a 'dwarf' form that occurs primarily throughout the Solomon Islands.

5.4.5.2 ECOLOGY

The ecology of Bryde's whales is not well known. Their diet is composed almost entirely of small fish and krill (Murase et al. 2007), and their primary habitat appears to be coastal. Sexual maturity is reached at approximately 10 years, and breeding occurs year-round, with a gestation period of approximately 12 months. They are generally not found in large groups, but can congregate around dense concentrations of food (Bannister et al. 1996).

5.4.5.3 POPULATION POTENTIALLY AFFECTED

There are almost no records of Bryde's whales in the Cleveland Bay area, although it lies well within their range (TCC 2007). A high-profile stranding of a Bryde's whale occurred in Cairns in 2000, and the large amounts (~6m^2) of plastic found in the whale's stomach has been used to publicise the susceptibility of marine fauna to floating plastic debris (Haines and Limpus 2000, Mortison 2001). Cleveland Bay is not currently considered a key habitat for this species.

5.4.5.4 CURRENT PRESSURES

Little specific information exists on threats particularly affecting Bryde's whales, but it can be assumed that they are similar to threats affecting other cetaceans. This includes habitat degradation through pollution and debris, noise pollution, harassment, boat strike, incidental capture in fishing or shark control nets, and declines in populations of their prey species. Generally, coastal areas present a higher concentration of these risks than offshore areas, and existing pressures increase with increasing development.

5.4.5.5 EXISTING CONTROLS AND PLANNING REGIMES

Bryde's whales are listed as Data Deficient by the International Union for the Conservation of Nature and Natural Resources (IUCN). It is listed as a migratory species by the EPBC Act and is protected by the Australian Whale Sanctuary. More specific control and management measures for this species can only be developed in conjunction with further research.

5.4.6 Blue Whale (Balaenoptera musculus)

5.4.6.1 *Distribution*

Blue whales are globally distributed, with three more or less separate populations: one in the North Pacific, another in the North Atlantic and a third in the southern hemisphere, especially in the cold waters above Antarctica. Blue Whales migrate between polar feeding grounds and tropical breeding and calving grounds, much like Humpback Whales. Aggregations can occur in areas of ocean upwelling, where food is abundant. Two such aggregations are found in Australian waters; one in the south-east off the South Australian and Victorian continental shelf, and one in the south-west, west of Rottnest Island. Individual sightings have been recorded from around Australia (DEW 2007).

5.4.6.2 *Ecology*

Blue whales were hunted nearly to extinction in the past, and it is still unclear whether a significant recovery has occurred. Their highly migratory nature and circumglobal distribution makes it difficult to obtain a reliable estimate of overall population size.

During summer and autumn, Blue whales in the southern hemisphere feed on krill in Antarctic Waters, and also aggregate to feed in areas of upwelling in temperate waters (e.g. Bonney Upwelling area in south-eastern Australian waters) (Butler et al. 2002). During winter, they migrate to tropical waters to mate and give birth, often without feeding throughout the whole winter – spring breeding period. While breeding is expected to occur in productive tropical habitats, where some feeding is also possible, no breeding areas have been identified in the southern hemisphere (DEW 2007).

5.4.6.3 *Population Potentially Affected*

Cleveland Bay is part of the expected range of Blue whales, especially along the southern hemisphere migration route from Antarctic waters to tropical breeding habitats. There are currently no records of Blue whales in Cleveland Bay, and it is possible that they may not to enter into Cleveland Bay. It is unlikely that the construction phase of the TOT Development will affect Blue whale populations, although increased large vessel traffic to and from Cleveland Bay may interfere with migration routes.

5.4.6.4 *Current Pressures*

Blue whales are possibly the most endangered of the large baleen whales, and all the pressures that affect other cetaceans also apply to this species. This includes habitat degradation through pollution and debris, noise pollution, harassment, boat strike, incidental entanglement in nets and other debris, and declines in populations of their prey species. The TOT Development is not expected to contribute a significant increase in most existing pressures, although there is a potential for the increased localized risk of vessel strike through an increase in large vessel traffic once the TOT is operational.

5.4.6.5 *Existing Controls and Planning Regimes*

Blue whales are protected under international, Commonwealth and state legislation, and by the Australian Whale Sanctuary in Australian waters. They are listed as endangered and migratory under the EPBC act, and a recovery plan exists for this species (NHT 2005c).

5.5 *Marine Reptiles*

Flatback turtles, Green turtles and Estuarine crocodiles are the only marine reptiles that have been officially recorded in Cleveland Bay and in the vicinity of the TOT Development site. Nevertheless, the Bay can provide foraging, nesting or migration habitat to a number of other EPBC-listed marine turtles, and has been included in their habitat range. They are briefly discussed below.

5.5.1 Flatback Turtle (*Natator depressus*)

5.5.1.1 DISTRIBUTION

The Flatback turtle is endemic to the waters over the Australian continental shelf, and is one of only two marine turtle species without a global distribution (NHT 2005b). Although they can feed as far north as Papua New Guinea and Indonesia, the only recorded nesting sites are in Australia (Figure 34). Flatback turtles forage in soft-bottomed habitats, primarily for benthic soft-bodied invertebrates (soft corals, sea pens, holothurians) and jellyfish, and their hatchlings lack an oceanic pelagic phase. Six major nesting aggregations are known in Australia: the southern GBR, north eastern Gulf of Carpentaria, southern Gulf of Carpentaria, western Arnhem Land and the Kimberley region of WA, and the NW shelf, WA around Barrow Island (DEW 2007). Lower density nesting occurs on many mainland beaches and offshore islands north of Gladstone, with the highest density overall occurring on Crab Island in western Torres Strait.

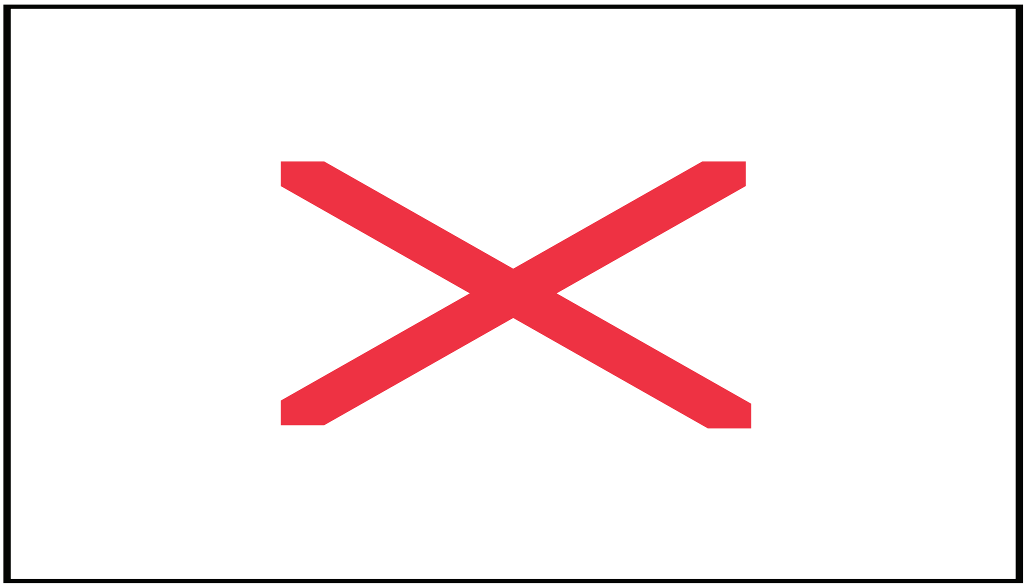


Figure 34. Recorded distribution of Flatback turtles in Australia (NHT 2005b).

5.5.1.2 ECOLOGY

The Flatback turtle is strictly carnivorous, feeding on soft-bodied prey such as sea cucumbers, soft corals and jellyfish. Its primary habitat is the subtidal, soft-bottomed inshore seabed from Hervey Bay to Torres Strait, Gulf of Carpentaria, North West Shelf, Arafura Sea and the Gulf of Papua (NHT 2005b).

Flatback turtle hatchlings are unique among turtle species in that they lack a dispersive oceanic phase, remaining instead within the habitat range preferred by the adults. This species make long reproductive migrations (recorded at between 216 and 1300 km from their nesting beach) similar to other species of sea turtles, but these movements are restricted to the continental shelf (DEW 2007).The full extent of their distribution, and other aspects of their ecology, have yet to be studied in detail.

5.5.1.3 POPULATION POTENTIALLY AFFECTED

Cleveland Bay forms part of the range of the Flatback turtle, and provides favourable soft-bottom foraging habitat. Although not identified as a key nesting area, Flatback turtles have been recorded to nest at Pallarenda Beach and on the Strand, near the marina (IPSTCG 2002). This indicates that individual nesting Flatback turtles may occasionally come into the vicinity and into areas downstream of the Development Site.

5.5.1.4 CURRENT PRESSURES

Like other species of sea turtles, Flatback turtles are threatened by boat strikes (40% of stranded turtles in Cleveland Bay between 1996-2006 bore evidence of boat strike), feral pigs and other introduced egg predators, vehicle and light disturbance on nesting beaches, pollution and declining water quality, and entanglement in marine debris (especially fishing nets). Flatback turtles are also in danger of ingesting plastic debris that is mistaken for jellyfish, which can often result in mortality (NHT 2005b). Noise pollution can also affect turtles, which can react to noise through behavioural modification, including mild disturbance, disruption or impairment of activities, and displacement from key habitats, to injury, disorientation, capillary damage, loss of motor control and even to death in severe cases (NHT 2005b). These threats are currently present in Cleveland Bay. Some of these pressures, including the risk of boat strike, marine debris and light and noise pollution, are likely to increase as a result of the Development, although the comparative risk is considered to be small.

5.5.1.5 EXISTING CONTROLS AND PLANNING REGIMES

Flatback turtles are protected by Commonwealth and State legislation, and the Commonwealth provides funding for the monitoring of nesting sea turtles throughout their key habitats. Protection from entanglement in trawler nets is being implemented through the compulsory use of TEDs (Turtle Exclusion Devices). Most significant rookeries in eastern Queensland have been declared as protected under the *Queensland Conservation Act 1992*; Cleveland Bay is not included under this category (DEW 2007). Overall, a recovery plan exists for all marine turtles found in Australia (Environment Australia 2003).

5.5.2 Green turtle (*Chelonia mydas*)

5.5.2.1 DISTRIBUTION

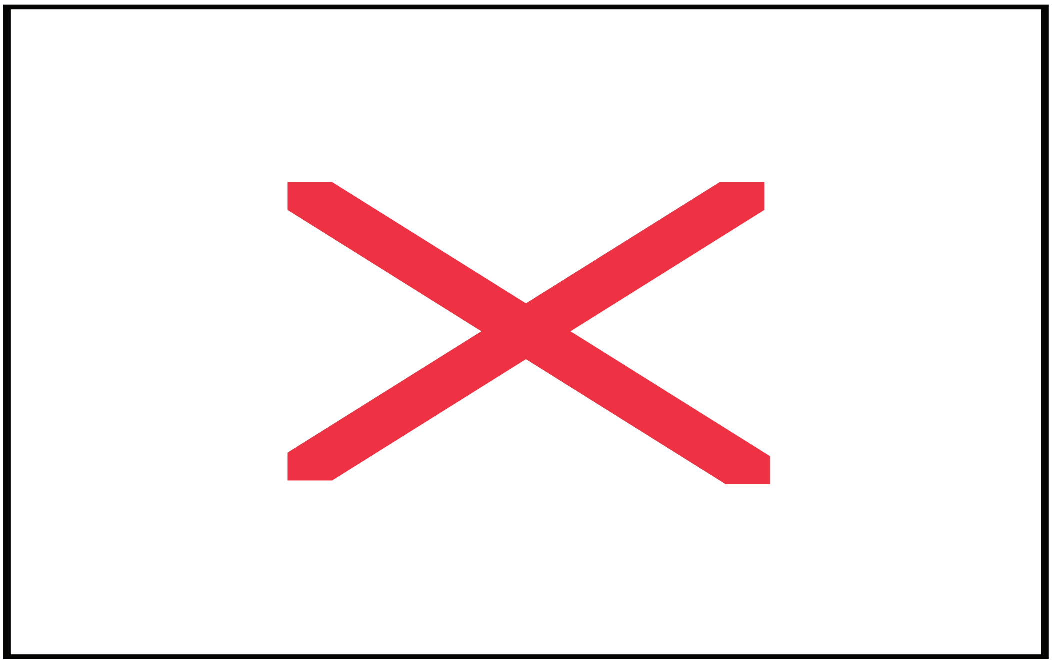
Green turtles occur in tropical and subtropical environments of the Indo-Pacific region, and are usually closely associated with seagrass beds. In Australia, they occur along the eastern, western and northern coastlines, feeding in shallow seagrass meadows and migrating through deeper and oceanic waters between feeding and nesting habitats. Green turtle populations in Australia are represented by a number of genetically distinct stocks. On the east coast, the largest concentrations of nesting turtles occur on Moulter Cay, Raine Island, Sandbank No. 7, Sandbank No. 8 for the northern GBR stock, and on the Capricorn-Bunker Islands for the southern GBR stock. There is low density nesting on many islands (including Magnetic Island) and along the Queensland coastline (including Cleveland Bay) (DEW 2007).

5.5.2.2 ECOLOGY

Green turtles are highly dependent on seagrass beds for their food source, and like all marine turtles, display high nest site fidelity. They also tend to return to the same geographic region for the internesting period, and return to the same foraging areas between breeding cycles. The average migration distance is approximately 400km, but can exceed 2600km (Limpus et al. 1992). East coast populations in the northern and southern Great Barrier Reef regions appear to be under threat, as shown by a number of ecological characteristics such as smaller size of nesting turtles, longer intervals between breeding seasons, and a general lack of evidence for any population increase (Dobbs 2001).

5.5.2.3 POPULATION POTENTIALLY AFFECTED

Although Cleveland Bay is not recorded as a major nesting area for Green turtles along the Australian east coast, both nesting and feeding occur on the beaches and seagrass beds in this area. A survey conducted in 2000 estimated an average population of turtles in Cleveland Bay of 416 (+/- 105 S.E.), of which over 90% were Green turtles (Preen 2000). During aerial surveys, most turtles are sighted as they bask on the surface during feeding, and are therefore highly correlated with the location of seagrass meadows. This can include areas along the Strand, where nesting has also been observed (IPSTCG 2002), and habitats close the TOT Development site (Figure 35). One of the major impacts associated with coastal development is the impact of lighting on turtle hatchlings on adjacent beaches. In this instance, however, the seaward location of the Development site, and proximity to the active section of the Port of Townsville operations, minimises the potential for additional impact to be experienced along the preferred turtle laying sections of the Townsville Strand.



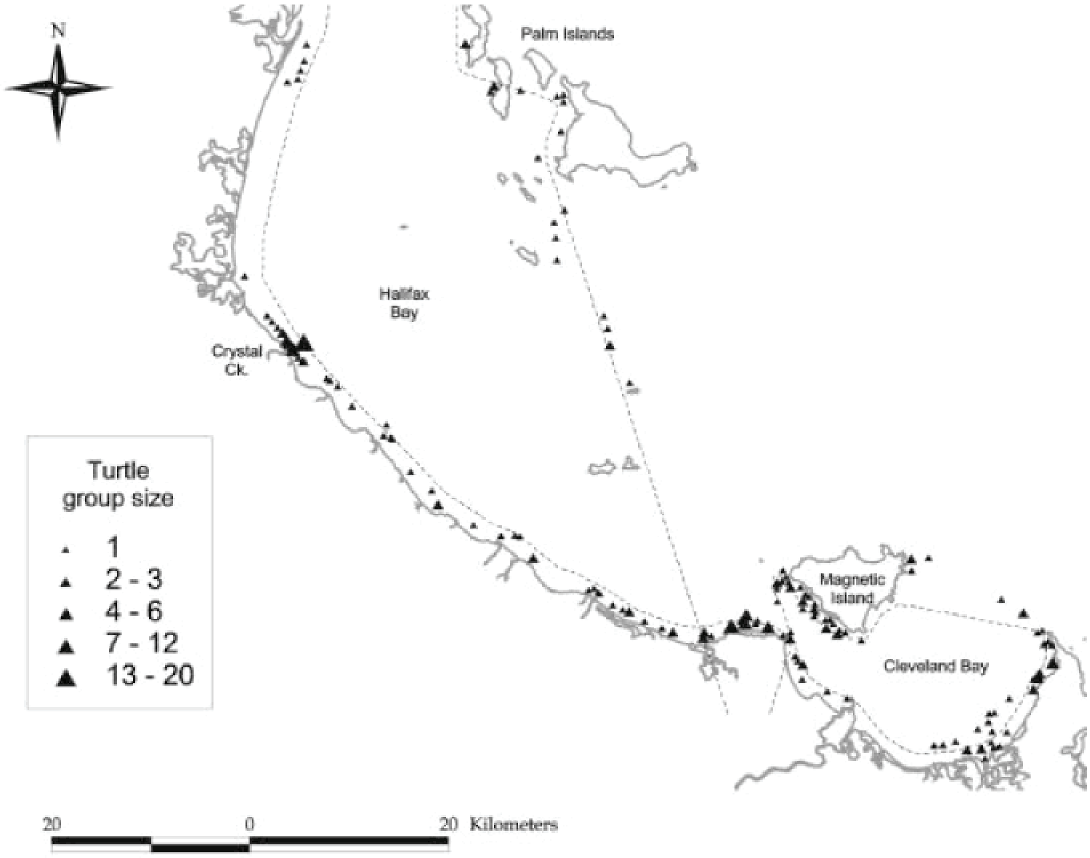


Figure 35. Turtles (of which the majority were Green turtles) recorded during aerial surveys conducted by A. Preen (top) and by G. Heinsohn (bottom). Dots indicate turtle sightings (from Preen 2000).

5.5.2.4 *Current Pressures*

Threats to the survival of Green turtles include boat strike, Indigenous harvest of adults and eggs, increased incidence of disease, ingestion of synthetic materials, incidental catch in shark control programme and commercial fishing nets, predation of eggs at nesting beaches, and tourism (Dobbs 2001). In coastal areas subject to human activities, Green turtles are particularly at risk from a virus known as Green turtle fibropapillomatosis (GTFP). While this is most commonly found in Green turtles, it can also affect other species (e.g. Loggerhead, Hawksbill, Olive Ridley and Flatback turtles). On the Queensland coast, it is especially prevalent in Green turtles frequenting nearshore seagrass beds adjacent to large human populations and areas with low water turnover (e.g. lagoons). The exact cause of the disease is not known (Dobbs 2001). Green turtles are also known to be sensitive to noise pollution, with maximum sensitivity between 300 and 500 Hz (Preen 2000). Coastal lighting has also been shown to interfere with turtle hatchling migration to coastal waters. In this instance, however, the Development site is seaward of the potential breedng area and directional interference is not expected to be any greater than is already experienced along the preferred turtle laying sections of the Townsville Strand.

Cleveland Bay is considered to have a high incidence of vessel strikes, with evidence of collision with vessels found on between 10 and 56% of stranded carcasses each year (Preen 2000). The impacts of noise pollution, disease and vessel strike are likely to increase as a result of the TOT Development. Individual Green turtles that venture into the constructed canals will be at greatest risk of these impacts. If seagrass beds are affected by operational or accidental declines in water quality, Green turtles will additionally be affected by loss of food resources.

5.5.2.5 EXISTING CONTROLS AND PLANNING REGIMES

In Australia, the EPBC Act is the core legislation applicable to marine turtles. The Green turtle is listed as vulnerable and migratory. Seagrass beds, on which Green turtles depend, are also protected within the GBRWHA under this Act. Furthermore, Green turtles are included in the marine turtle recovery plan (Environment Australia 2003).

5.5.3 Loggerhead turtle (*Caretta caretta*)

5.5.3.1 DISTRIBUTION

Loggerhead turtles are globally distributed from temperate to tropical waters. It occurs in a diverse range of habitats, and in Australia it has been recorded in the coastal waters of all states. Nesting occurs primarily on subtropical beaches, and in Australia is concentrated in southern Queensland and Western Australia. The eastern Australian population is the most significant in the southern Pacific Ocean, but declined by 50-80% in the 10 years between 1980 and 1995 (DEW 2007).

5.5.3.2 ECOLOGY

Loggerhead turtles feed on a wide variety of benthic and pelagic organisms, allowing them to exploit a range of habitats, including rocky and coral reefs, muddy bays, sandflats, estuaries and seagrass beds (DEW 2007). They are primarily carnivorous, but can feed on algae in their juvenile stages. In Australia, breeding and nesting occurs primarily on offshore islands in southern Queensland (Capricorn-Bunker Islands; Sandy Cape, Swains Complex) and on the mainland near Bundaberg (Elliott River to Round Hill Head) (Dobbs 2001). In 2001, it was estimated that 300 females nest annually in this region. The high rate of decline in this population in recent years means that the loss of each adult or sub-adult from the population contributes to a significant threat to population recovery.

5.5.3.3 POPULATION POTENTIALLY AFFECTED

No direct records have been found of Loggerhead turtles feeding or nesting in Cleveland Bay. This area is within the range of both their migratory routes and contains favourable foraging habitats, and the presence of this species should not be discounted (TCC 2007).

5.5.3.4 CURRENT PRESSURES

Threats to the survival of Loggerhead turtles include boat strike, Indigenous harvest of adults and eggs, increased incidence of disease, ingestion of synthetic materials, incidental catch in shark control programme and commercial fishing nets, predation of eggs at nesting beaches, and tourism. Predation of eggs by introduced species such as foxes has been identified as one of the most important contributors of the recent population decline of this species. Noise pollution can also affect Loggerhead turtles, with the highest sensitivity between 250 and 1000 Hz (Dobbs 2001).

5.5.3.5 EXISTING CONTROLS AND PLANNING REGIMES

In Australia, the EPBC Act is the core legislation applicable to marine turtles. The Loggerhead turtle is listed as endangered and migratory, and is also provided for under the marine turtle recovery plan (Environment Australia 2003).

5.5.4 Leatherback turtle (*Dermochelys coriacea*)

5.5.4.1 *Distribution*

Leatherback turtles are primarily oceanic, feeding in temperate waters and nesting primarily on tropical beaches throughout the world. In Australia, they feed and nest within the GBRWHA with nesting recorded at Wreck Rock and adjacent beaches near Bundaberg, and sporadic nesting at other widely scattered sites in Queensland. It is expected that turtles nesting in Queensland are at the edges of their range, and no large rookeries occur in Australia.

5.5.4.2 *Ecology*

The Leatherback turtle is the only species of marine turtle that remains pelagic throughout its life cycle, returning to land only for nesting purposes. It is primarily carnivorous and feeds on jellyfish and other soft-bodied pelagic organisms. Foraging can occur from coastal waters to depths of over 200m, and from equatorial to boreal waters. It is believed that Leatherback turtles that feed in Australian waters migrate to neighbouring countries (e.g. Indonesia, Papua New Guinea) to breed and nest (DEW 2007).

5.5.4.3 *Population potentially affected*

No direct records have been found of Leatherback turtles feeding or nesting in Cleveland Bay (but see TCC 2007).

5.5.4.4 *Current Pressures*

The most important threats to the survival of Leatherback turtles include Indigenous harvest for food (primarily overseas), ingestion of synthetic materials, incidental catch in shark control programmes and commercial fishing nets, and predation of eggs at nesting sites. It is believed that noise pollution is also likely to displace the turtles or cause deviations from migration pathways. Due to the absence or low numbers of Loggerhead turtles in Cleveland Bay, it is currently believed that the TOT Development poses minimal threat to populations of this species.

5.5.4.5 *Existing Controls and Planning Regimes*

In Australia, the EPBC Act is the core legislation applicable to marine turtles. The Leatherback turtle is listed as vulnerable and migratory. It is also covered in the marine turtle recovery plan (Environment Australia 2003).

5.5.5 Hawksbill turtle (Eretmochelys imbricata)

5.5.5.1 *Distribution*

The distribution of Hawksbill turtles is circumglobal and includes tropical, subtropical and temperate waters, with nesting primarily occurring on tropical beaches. There are two major nesting populations in Australia; one on Great Barrier Reef islands and one that includes Arnhem Land and the NW Shelf. On the east coast, nesting is known to occur only north of Princess Charlotte Bay, with the best-known high-density nesting site at Milman Island. This nesting population is the largest remaining rookery in the world (DEW 2007).

5.5.5.2 *Ecology*

Even in Australia, which supports the largest remaining population of Hawksbill turtles, numbers are declining. They are pelagic as juveniles, often associated with rafts of *Sargassum*, and forage on coral and rocky reefs as adults. They are often described as sponge specialists, but are able to feed on a large variety of benthic invertebrates and algae. Little is known about the movement and migration cycles of most Hawksbill turtle populations, but there appears to be a large degree of variability in their carapace size at maturity, clutch size, breeding cycle and diet.

5.5.5.3 POPULATION POTENTIALLY AFFECTED

No direct records have been found of Hawksbill turtles feeding or nesting in Cleveland Bay, and it is not considered an important habitat for this species (see also TCC 2007).

5.5.5.4 CURRENT PRESSURES

Current pressures for this species include harvest of immature and adult turtles for tortoiseshell, Indigenous harvest of adults and eggs both within Australia and overseas, predation of eggs at nesting beaches, ingestion of synthetic materials, vessel strike, increased incidence of disease, incidental catch in shark control programme and commercial fishing nets. Noise is also expected to affect marine turtles, but its impacts on Hawksbill turtles are unknown. Due to the absence or low numbers of Loggerhead turtles in Cleveland Bay, it is currently believed that the TOT Development poses minimal threat to populations of this species.

5.5.5.5 CONTROLS AND PLANNING REGIMES

In Australia, the EPBC Act is the core legislation applicable to marine turtles. The Hawksbill turtle is listed as vulnerable and migratory.

5.5.6 Olive Ridley turtle (*Lepidochelys olivacea*)

5.5.6.1 DISTRIBUTION

The Olive Ridley turtle has a worldwide tropical and subtropical distribution. In Australia, they occur in shallow, protected waters along the coast from southern Queensland and the Great Barrier Reef to the Joseph Bonaparte Gulf in Western Australia. Most nesting occurs in north west Arnhem Land (annually 500-1000 females), but there are no records of large rookeries in Australia. Irregular and sparse nesting also occurs along the Queensland and NSW coast. Detailed information on the distribution of nesting and foraging aggregations is not available for Australia (DEW 2007).

5.5.6.2 ECOLOGY

The Olive Ridley turtle is considered the most abundant marine turtle species. It is carnivorous and feeds primarily on shellfish and crustaceans. They can exist both in pelagic and benthic habitats as adults, but in Australia it is likely that they primarily occur over the continental shelf. Nesting is thought to occur throughout the year. Little is known about the biology and ecology of this species in Australia, but tagging programmes have begun in Arnhem Land (WWF 2007).

5.5.6.3 POPULATION POTENTIALLY AFFECTED

No direct records have been found of Olive Ridley turtles feeding or nesting in Cleveland Bay (see TCC 2007).

5.5.6.4 CURRENT PRESSURES

The main pressure on Olive Ridley turtles in Australia may be the impact of trawlers. Other threats include ingestion of synthetic materials, incidental catch in shark control programme and commercial fisheries gear, entanglement in discarded and lost nets, predation of eggs at nesting sites and Indigenous harvest overseas for food. Not enough information exists for determining the stability of the Olive Ridley turtle population in Queensland (Dobbs

2001). Due to the absence or low numbers of Olive Ridley turtles in Cleveland Bay, it is currently believed that the TOT Development poses minimal threat to populations of this species.

5.5.6.5 CONTROLS AND PLANNING REGIMES

In Australia, all marine turtles are protected under the EPBC Act. The Olive Ridley turtle is listed as endangered and migratory, and is included in the marine turtle recovery plan (Environment Australia 2003).

5.5.7 Estuarine crocodile (*Crocodylus porosus*)

5.5.7.1 DISTRIBUTION

Estuarine crocodiles occur from India, throughout south-east Asia and New Guinea, to northern Australia, Vanuatu and the Solomon Islands. On the east coast of Australia, they are associated with estuaries north of Gladstone. They are most commonly seen in tidal reaches of rivers, but can sometimes be found in freshwater lagoons, rivers, and swamps hundreds of kilometres inland from the coast, and on beaches and offshore islands in the Great Barrier Reef and Torres Strait. Sightings south of the Fitzroy River are very infrequent (QPWS 2007).

5.5.7.2 ECOLOGY

Estuarine crocodiles are opportunistic carnivores, feeding on a variety of aquatic and terrestrial animals. They are long-lived and mature at a relatively late age; approximately 12 years for females and 17 years for males. Hatchling survivorship is low, with less than 5% reaching 5 years of age, and less than 1% of surviving crocodiles reaching sexual maturity.

Crocodile populations in Australia are recovering after the ban on hunting that drove them nearly to extinction, but this recovery is slower in Queensland than in the Northern Territory. A recent survey recorded 0.3 crocodile per linear kilometre of waterway (+/- 0.34 S.D.) in rivers north of the Boyne River system (QPWS 2007).

5.5.7.3 POPULATION POTENTIALLY AFFECTED

A recent survey sighted no crocodiles in the Ross River (QPWS 2007), but recent sightings of Estuarine crocodiles off the Strand in Cleveland Bay caused beach closure (Johnston 2006). Crocodiles occasionally frequent marine areas in close proximity to the TOT Development site, but this does not form part of their usual habitat. It is not possible to say whether crocodile populations in the area will increase in the future, but if Cleveland Bay makes part of a common migration pathway between key estuarine habitats, the local population of crocodiles may be affected by TOT construction and operation activities.

5.5.7.4 CURRENT PRESSURES

Pressures affecting the recovery of crocodile populations in Queensland include the modification of suitable nesting habitats through urban development, the removal of ‘problem crocodiles’ from their habitat (usually large individuals of breeding age), predation on nests, intensive agriculture and other sources of pollution. Increasing public antagonism, driven by the increasing human population in coastal Queensland, is also seen as a threat to the conservation of crocodiles. New nearshore urban developments and canal estates are unlikely to improve the perception of the value of crocodile conservation (QPWS 2007).

5.5.7.5 *Existing Controls and Planning Regimes*

The Estuarine crocodile is listed as migratory under the EPBC Act, and a *Nature Conservation (Estuarine crocodile) Conservation Plan 2007* is currently being drafted under Queensland's *Nature Conservation Act 1992*. The Plan relates primarily to the handling of 'problem crocodiles', but also provides for the protection of the crocodiles from hunting.

5.6 Birds

Birds may be disturbed primarily as they overfly the TOT Development site, and if they use the site for foraging during construction and operation. No bird nesting or roosting habitats currently exist at the Development site, but this may change as it becomes populated. Depending on what plant species are chosen for public and private gardens, the TOT Development can increase populations of pest birds or attract native birds. The choice of vegetation must be closely managed if pests are to be avoided, and expert advice should be sought if the intention is to provide habitat for native, threatened or migratory species. Currently, some birds use the Development site for feeding. The listed birds that may use this area are described briefly below.

5.6.1 Red goshawk (Erythrotriorchis radiatus)

5.6.1.1 *Distribution*

The Red goshawk is endemic to Australia and is considered one of the world's rarest birds of prey. It occurs in a range of habitats in northern and eastern Australia, including coastal and subcoastal tall open forests and woodlands (Figure 36). The widespread destruction of suitable habitat in NSW means that it is now virtually extinct there.

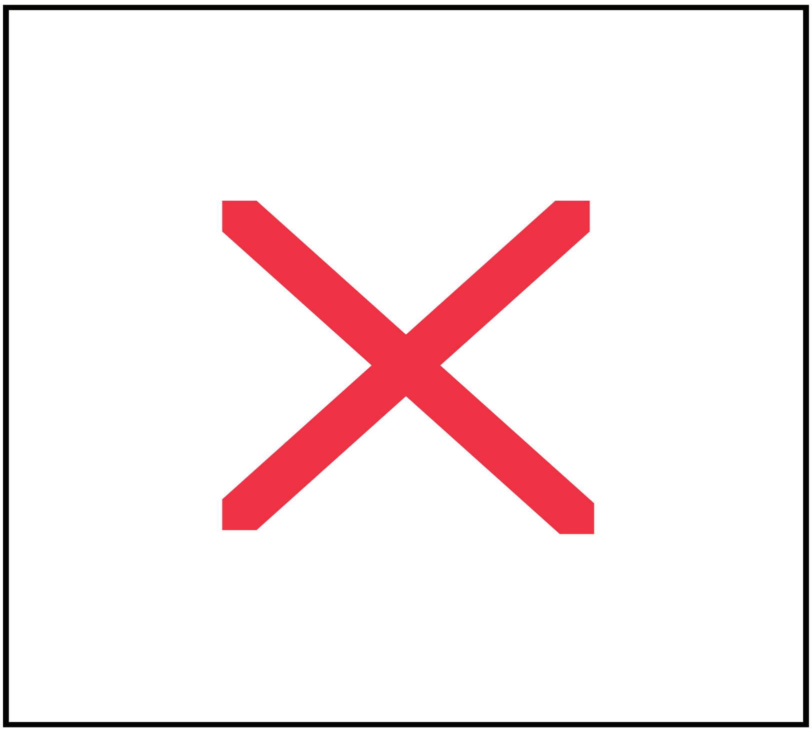


Figure 36. Current distribution of the Red goshawk in Queensland (from Ryan 2006).

5.6.1.2 *ECOLOGY*

The Red goshawk preys primarily on large birds, but may also hunt mammals, reptiles and insects. Individual birds have extensive home ranges that cover between 50 and 220 km^2. Breeding habitat requirements are very specific, including a minimum tree height and maximum distance from water, and there is high nest fidelity. Habitats that are too dense or too open are generally avoided. It has recently been estimated that fewer than 1,000 individuals remain.

5.6.1.3 *POPULATION POTENTIALLY AFFECTED*

The Development site and open areas above Cleveland Bay do not make part of the Red goshawk's preferred habitat. It is likely that this species is present in terrestrial areas surrounding Cleveland Bay.

5.6.1.4 *CURRENT PRESSURES*

Threats to the Red goshawk include habitat clearing, which has caused a dramatic decline in this species throughout much of its range, prey reduction through grazing and burning, illegal shooting and egg collecting. Human disturbance to nesting sites may disturb breeding pairs (Ryan 2006). The TOT Development is unlikely to add to the existing pressures for this species.

5.6.1.5 *EXISTING CONTROLS AND PLANNING REGIMES*

The Red goshawk is listed as vulnerable under the EPBC Act, and a draft recovery plan exists. Monitoring of nesting sites is occurring to determine breeding success and prevent disturbance.

5.6.2 White-bellied sea-eagle (*Haliaeetus leucogaster*)

5.6.2.1 *DISTRIBUTION*

White-bellied sea-eagles occur primarily in coastal habitats from India to Australia. In Australia, they occur around the country, but are absent from dry inland habitats. Their distribution patterns are closely linked to bodies of water, which can include both freshwater and marine environments.

5.6.2.2 *ECOLOGY*

White-bellied sea-eagles are carnivorous, and often 'fish' for their prey in coastal or freshwater habitats. They are territorial, defending a territory of approximately 3 km^2 within a much larger home range of about 150 km^2.

5.6.2.3 *POPULATION POTENTIALLY AFFECTED*

White-bellied sea-eagles are common in the Townsville area and can often be seen fishing in Cleveland Bay (TCC 2007). Individuals may well occur and feed above or within the TOT Development site (Figure 37).

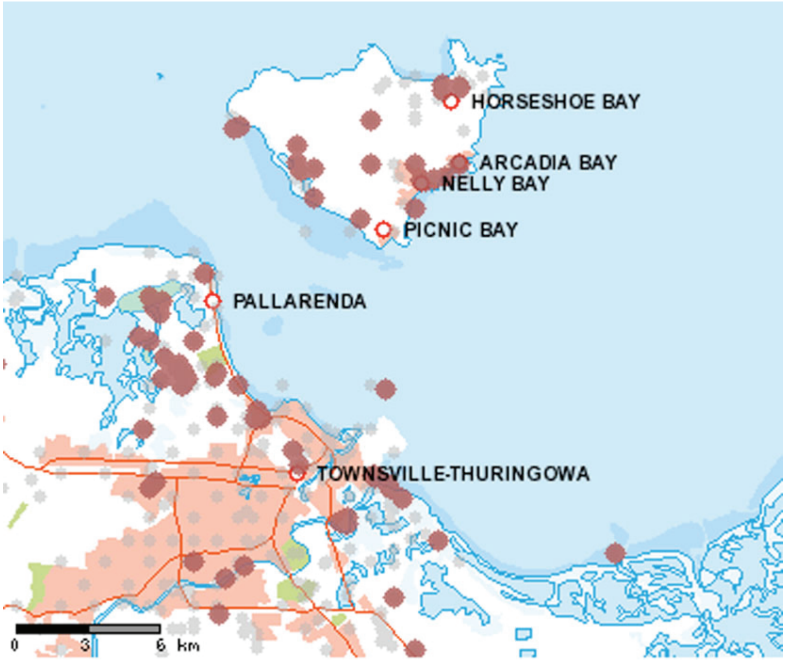


Figure 37. Records of White-bellied sea-eagles in the Townsville region (from Birds Australia 2007).

5.6.2.4 CURRENT PRESSURES

The most significant threat to White-bellied sea-eagle populations is habitat destruction, which results in the loss of nesting sites and therefore declines in reproductive success. Other direct and indirect effects include poisoning, deliberate shooting, eggshell thinning because of the past use of DDT, and food chain contamination by heavy metals. Accidental pollution as a result of TOT Development activities may cause contamination of the food chain, potentially affecting White-bellied sea eagles through marine prey species.

5.6.2.5 EXISTING CONTROLS AND PLANNING REGIMES

White-bellied sea-eagles are listed as migratory under the EPBC Act, and are protected by the legislation in some States.

5.6.3 White-throated needletail (*Hirundapus caudacutus*)

5.6.3.1 DISTRIBUTION

The White-throated needletail is a large swift that breeds in central Asia and southern Siberia, and migrates to eastern and northern Australia over winter, from October to May-August. While in Australia, the birds do not breed, but can roost in trees and shrubs.

5.6.3.2 ECOLOGY

White-throated needletails feed on flying insects, caught in flight, utilizing rising thermal currents and wind fronts usually associated with storms and bushfires. Breeding takes place only in Asia between May and August, and no breeding takes place during their winter migrations to Australia. Population numbers are unknown, but recent studies on a number of bird species report declines in numbers of White-throated needletails (Olsen et al. 2006).

5.6.3.3 POPULATION POTENTIALLY AFFECTED

In Townsville they have been recorded from terrestrial and wetland habitats, but no clear records exist of them using coastal habitats around Cleveland Bay (TCC 2007).

5.6.3.4 CURRENT PRESSURES

In Australia, White-throated needletails are primarily vulnerable to habitat destruction for urbanization and agriculture. Competition for food by non-native pest species can put increasing pressure on populations of this species. The TOT Development is not expected to significantly contribute to existing pressures.

5.6.3.5 CONTROLS AND PLANNING REGIMES

The White-throated needletail is listed as migratory under the EPBC Act. No other specific protection plans currently exist.

5.6.4 Barn swallow (*Hirundo rustica*)

5.6.4.1 DISTRIBUTION

The Barn swallow occurs in coastal areas of Queensland, the Northern Territory and WA. Very little is known about their exact distribution in Australia. They undertake long-distance migrations between the northern and southern hemispheres, breeding in the northern hemisphere in summer and overwintering in southern Africa and Australia.

5.6.4.2 ECOLOGY

Barn swallows share similar feeding and migratory characteristics with the White-throated needletail. They are specialized to feed on insects while in flight, and are known to land only infrequently during their overwintering period.

5.6.4.3 POPULATION POTENTIALLY AFFECTED

This species has often been observed in the Townsville area, both inland and in coastal habitats. Although they are expected to land only very infrequently, they have been observes to roost in nearshore habitats (Birding Aus 2000). It is possible that Barn swallows overfly the TOT Development site, but this area is not expected to be key habitat for this species.

5.6.4.4 CURRENT PRESSURES

In Australia, Barn swallows are primarily vulnerable to habitat destruction for urbanization and agriculture. Competition for food by non-native pest species can put increasing pressure on populations of this species. The TOT Development is not expected to significantly contribute to existing pressures.

5.6.4.5 EXISTING CONTROLS AND PLANNING REGIMES

The Barn swallow is listed as migratory under the EPBC Act. International agreements between the Australian and Chinese and Japanese Governments (CAMBA, JAMBA) further protect this species from harm in either country.

5.6.5 Black-faced monarch (*Monarcha melanopsis*)

5.6.5.1 DISTRIBUTION

The Black-faced monarch is native to Australia and Papua New Guinea, and may migrate as far as New Zealand. It occurs along the entire Australian east coast, and is more abundant at the northern end of its range. It migrates south during summer months, primarily for breeding purposes (IUCN 2007).

5.6.5.2 ECOLOGY

The diet of the Black-faced monarch consists of insects and spiders, caught in flight. Preferred habitats include primarily forested areas, such as rainforest, wet broad-leafed forests and denser eucalypt forests, damp gullies, mangroves and sometimes in open woodlands. Foraging can also occur over marine areas. Breeding occurs between October and January in the southern regions of its range.

5.6.5.3 POPULATION POTENTIALLY AFFECTED

The Black-faced monarch is relatively abundant in the Townsville region, and has been observed overflying nearshore marine areas (TCC 2007). It is possible that this species overflies the TOT Development site for foraging purposes, but this area is not expected to be key habitat for this species.

5.6.5.4 CURRENT PRESSURES

Similarly to other passerines, Black-faced monarchs are vulnerable to habitat destruction for urbanization and agriculture. Competition for food by non-native pest species can put increasing pressure on populations of this species. The TOT Development is not expected to significantly contribute to existing pressures.

5.6.5.5 EXISTING CONTROLS AND PLANNING REGIMES

The Black-faced monarch is listed as migratory under the EPBC Act.

5.6.6 Australian painted snipe (*Rostratula australis*)

5.6.6.1 DISTRIBUTION

The Australian painted snipe is thought to be endemic to Australia, and generally inhabits inland wetlands throughout the eastern half of the country (Figure 38). They are poorly known, and no site has been identified in which they are resident or regular in occurrence. This may suggest the species is nomadic, but its cryptic behaviour makes this difficult to ascertain.

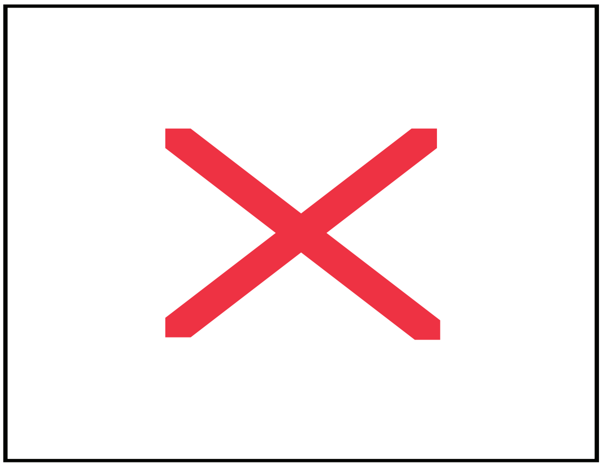


Figure 38. Known distribution of the Australian painted snipe (from Birds Australia 2007).

5.6.6.2 ECOLOGY

The Australian painted snipe feeds at the water's edge and on mudflats, primarily in inland wetlands but occasionally in coastal habitats. Their diet includes seeds and insects. Little is known of their ecology, exact habitat requirements and reproductive biology, possibly due to its perceived cryptic behaviour.

It is relatively rare and there is the perception of a decline in population numbers in recent years. The current population estimate is 1,500 birds.

5.6.6.3 POPULATION POTENTIALLY AFFECTED

The Townsville region is well within the range of the Australian painted snipe, and it has been recorded in nearby wetlands (e.g. Town Common, Bowling Green Bay) and coastal mudflats (e.g. Pallarenda). It is unlikely that favourable habitat occurs within or adjacent to the TOT Development site.

5.6.6.4 CURRENT PRESSURES

The species has suffered primarily from wetland drainage and the diversion of water from rivers. Nest predation by introduced mammals, over-grazing of shallow swamps and contamination of coastal mudflat sediments are also of concern (Birds Australia 2007). The TOT Development is not expected to significantly contribute to existing pressures.

5.6.6.5 CONTROLS AND PLANNING REGIMES

The Australian painted snipe is listed as vulnerable under the EPBC Act. International agreements between the Australian and Chinese Governments (CAMBA) further protect this species from harm in either country.

6 POTENTIAL IMPACTS OF THE TOT DEVELOPMENT ON MATTERS OF NES

6.1 SUMMARY OF TOT CONSTRUCTION IMPACTS

The primary construction component of the Development is the reclamation of land for the cruise ship terminal and proposed residential area, now requiring approximately 1,650,000m^3 of rock, sand and engineered fill material.

With reference to the Hyder Consulting Construction Methodology Report also provided with the EIS, the Proponent's preferred option includes the re-use of approximately 1,700,000 m^3 of on-site materials, reducing the need to bring in such material from off-site. This has been a significantly beneficial change since the Initial Advice Statement for the Development was released. It abrogates the need for new external extraction sites (which had initially been considered for sand in Ross Creek and elsewhere) and their inherent environmental impacts.

The major construction activities for the TOT Development include:

- the construction of the Strand breakwater on the western side of the Development site and extensions to the northern breakwater, and dredging of an entrance channel to the site;
- the sealing off and draining of the site itself;
- the construction of the reclaimed land;
- the reintroduction of water into the site;
- the construction of the berth and swing basin for the Ocean Terminal; and
- construction activities on the reclaimed land.

There are potential impacts associated with each of these stages. The construction of the Strand breakwater, berth and swing basin and dredging of the entrance channel will include the disturbance of sediments. Draining the Development site will lead to the exposure of the benthos and the mortality of seagrasses and algae. During the draining of the site, marine animals trapped inside the site may suffer injury, stress or mortality as the water levels drop and water quality and dissolved oxygen levels decline. Once dry, the habitat will be unavailable to marine animals, but seabirds and shorebirds may target exposed benthic invertebrates and may therefore be at risk from construction machinery.

After construction of the reclaimed land is completed, water will be reintroduced to the site. Sediments inside the site consist of extremely fine 'ooze', which is easily resuspended when disturbed and may take a long time to re-settle. A portion of this ooze will remain exposed to the inflow of water and may be disturbed. Once the site is filled with water, there may be a high level of suspended ooze, delaying access to the site for re-colonising organisms. Continuing construction works on the reclaimed land may also introduce spills, contaminants (Section 6.3.2), noise (Section 6.3.5) and garbage (Section 6.3.6) to the Development site.

6.2 SUMMARY OF TOT OPERATION IMPACTS

Coastal developments designed for human use and habitation generally bring with them an increase in pollution, noise, small vessel traffic. In the case of the TOT Development, an increase in the traffic of large vessels is expected to occur, together with an increased risk of marine pest incursions.

Although pollution can be regulated and monitored to a certain extent, accidental, negligent, deliberate or unlawful pollution cannot be planned for or controlled. Unfortunately, high-density human habitation areas are places where such events are almost certain to occur. Therefore an increase in pollutants and in garbage and marine debris is an almost certain by-product of the operational stage of the TOT Development (see Section 6.3.6).

An increase in noise pollution is also likely to persist after the construction phase, through the general noise levels generated by human communities and through the increase in large and small vessel use in Cleveland Bay (see Section 6.3.5). Increased vessel traffic also poses a direct hazard to marine mammals and reptiles, either by displacing them or striking them (see Section 6.5.4).

All of the above potential impacts during both the Construction and Operation of the TOT need to be placed into the context of "no significant proportional increase over existing ambient conditions in the Cleveland Bay area".

6.3 IMPACTS ON WORLD HERITAGE VALUES OF THE GBRWHA

The construction and operation of the TOT Development have the potential to adversely affect the World Heritage value of the GBRWHA as represented by Cleveland Bay coral reefs, seagrass beds, benthic communities and rare, threatened and migratory species that rely on these habitats. Cleveland Bay is a small area of the overall GBRWHA (~0.07%), but contains important inshore coral reefs and seagrass beds that offer a core habitat to the east coast Dugong population. However, The TOT site is located within a complex mix of terrestrial and marine environments that include a backdrop of a relatively large coastal city of Townsville that supports an active industrial, mining and grazing hinterland which exports and imports through the Port of Townsville (sited immediately adjacent to the TOT Development), and a location that is also within the coastal waters of Cleveland Bay with zones of Marine National Parks and World Heritage Areas supporting a complex array of protected species and habitats. This complexity needs to be considered when assessing impacts on world Heritage Values of the GBRWHA, but it also needs to be considered during future monitoring procedures when it may be necessary to differentiate between external adverse impacts and the perceived actions of the TOT.

Adverse impacts, described in more detail below, have the potential to:

- modify or inhibit ecological processes in a World Heritage property, by interfering with the health of coral reefs, seagrass beds and benthic communities through water and sediment quality reduction;
- reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property, by causing mortality to the more vulnerable species of seagrasses, corals and benthic invertebrates;
- fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage property, by reducing seagrasses and therefore removing an important food resource for Dugongs;
- cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property, by affecting populations of threatened and migratory species;
- fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage property.

It is stressed that the above impacts are generally localised and may or may not have a significant proportional increase of impact on the World Heritage Areas of the Great Barrier Reef Marine Park. However this is largely dependent on the success or otherwise of the mitigation methods set in place, and while the impact from the TOT Development alone may be considered only of local importance the instigation and installation of mitigation options specifically designed to reduce the impact of unnecessary adverse impacts on the surrounding areas are still appropriate. The primary impacts specific to the GBRWHA are described in more detail in the following sections.

6.3.1 Dredging

Dredging is expected to occur at the northwestern opening of the TOT Development site. Dredging activities affect water quality (e.g. turbidity), and if contaminated sediments are disturbed and transported, dredging activities will also affect sediment quality. Declines in both sediment and water quality are likely to have their greatest negative effect on seagrass beds (e.g. contamination, macroalgal growth, smothering, shading), benthic invertebrates (e.g. contamination) and coral reefs (e.g. light attenuation, sediment deposition, pollution). Declines in the quality and health of seagrasses, benthic invertebrates and corals will have flow-on effects on all dependent species, such as Green turtles, Dugongs and commercially important fish species.

Initial construction requirements for the project will require the dredging of an external access channel (see Construction Methodology Report). However, modelling of flushing and water quality indicates that regular annual maintenance dredging will be required in the internal channelway, and in the northeastern and southeastern arms of the Development. This will ensure that water and sediment quality are maintained to the recommended investigation and intervention levels provided in the Water Quality Report, principally in Appendices 1a and 1b. All annual maintenance dredging will be conducted within the marina areas of the Development itself.

The Construction Methodology is such that the area of the Development will be totally dewatered during construction, with all flora and fauna removed. Thus no impacts will be sustained to the marina basin as a consequence of dredging. Since both flushing and water and sediment quality modelling indicate that appropriate guideline levels will be met, it is likely that marine flora and fauna will begin to re-establish in the marina areas although species type and composition may vary within the sediments. However, in order to maintain both water and sediment quality, annual maintenance dredging is vital, any flora and fauna present will be disrupted on an annual basis.

6.3.2 Oil and Chemical Spills

Accidental spills (oil or chemicals) can occur during both the construction and operation phases of the Development. Due to the proximity of the TOT to the GBRWHA, even a small spill can be damaging in certain weather and tidal conditions. A large oil or chemical spill can cause a slick, trapping inshore-dwelling organisms in a situation where their exposure to toxic compounds could be prolonged (Volkman et al. 1994). The potential risk to wide-ranging pelagic species, such as whales, is smaller, and they are less likely to suffer significant exposure and any lasting toxic effects (Bannister et al. 1996). Marine mammals and reptiles may be particularly vulnerable to the effects of oil pollution, as they spend time on the ocean's surface to breathe (Volkman et al. 1994, Bannister et al. 1996).

While these risks may be small in comparison to the scale of the adjoining Port of Townsville operations, the instigation and installation of mitigation options specifically designed to reduce the impact of unnecessary advrse impacts on the surrounding areas are still appropriate.

6.3.3 Release of Contaminants

Marine structures and vessels can release biological and chemical contaminants into the marine environment, especially harmful antifouling agents. The most commonly used antifouling agent has been tributyltin (TBT), which is a highly effective antifoulant, but is also extremely toxic in the marine environment. There is still no suitable alternative that can be widely used, although many trials are in progress.

Many countries have banned TBT since the late 1970s, but traces of TBT continue to be found in the tissues of oceanic organisms (Lewis 2001). Areas with high shipping traffic, such as ports, are particularly at risk from accumulated antifouling pollution (IMO 1991). The most widely reported impact of TBT is its role as the cause of 'Imposex' in shellfish. Imposex leads to the development of a penis in females, resulting from a disruption in endocrine function and reproduction. It occurs in over 100 shellfish species, and is irreversible (Mortimer 2004).

Through bioaccumulation, TBT becomes concentrated in organisms at higher trophic levels, leading to illness and mortality in large predators such as sharks, dolphins and toothed whales (Kannan et al. 1996). It can accumulate in the tissues of marine organisms, even long distances away from the source. A further concern is the accumulation of TBT in shellfish and large pelagic fishes that are targeted and consumed by humans. TBT in the water column dissolves into less harmful substances within days. In areas of high shipping traffic, however, micro layers of TBT have been detected in open waters. TBT also accumulates in sediments, where it takes over ten years to break down.

In Australia, the accumulation of TBT and its associated problems primarily affect areas around ports with shallow water and heavy shipping traffic. Since 1987, all States and Territories in Australia either restricted the use of TBT antifouling paint on vessels over 25m length, and/or reduced the leaching rate of TBT from the paint to 5 $mg/cm^2/day$. The sale of this paint and its removal and reapplication is also restricted. Additionally, most Australian States have adopted legislation that prohibits the in-water cleaning of hulls (in order to prevent marine debris and TBT paint flakes accumulating on the seabed), and requires ship maintenance facilities to contain and dispose of hull marine debris in an approved manner. It appears that TBT levels in sediments around many Australian ports have declined as a result of these measures (Mortimer 2004).

The Australian Shipowners Association (ASA) advises that since 2003, commercial ships have ceased using exposed TBT on their hulls. According to the Convention, by 2008 all commercial vessels will have either adopted different anti-fouling agents, or covered the TBT on their hulls with substances to prevent the TBT from leaching into marine environments. However, it is still known to be used on small, private vessels. The use of TBT on stationary marine structures and on smaller vessels is difficult to determine, but leaching of TBT into the marine environment can be avoided through the careful development of the management plan.

Other contaminants that may be introduced into the marine environment from the TOT development include a range of heavy metals in stormwater runoff. Refer to Section 5.5 and Section 4.5 in the Water Quality Report.

By 2008, it is anticipated that all commercial vessels will have adopted different anti-fouling procedures. While this should negate the problems associated with the use of TBT, it is recommended that negotiations should be undertaken with the Port Authority to establish a programme that will effectively control the entry of vessels using TBT into the Marina and Port areas.

6.3.4 Stormwater Runoff

The effects of stormwater drainage on the water quality of the development area have been modeled using a combined MUSIC and PHREEQC approach. Models have related to worst case, first flush scenarios after an extensive period (9 months) of dry weather within a minimal flushing event of 12.5mm. Likely compositions of the atmospheric dust were introduced into this scenario assuming Total dissolution of the dust material or Total incorporation of the dust material into the bottom sediment.

These data are discussed in Sections 4, 5, 6 and 7 of the Water Quality Report. It was concluded that provided regular maintenance dredging is undertaken to ensure adequate flushing, all data indicate that all flushed water quality exiting the development will be within current ambient range or 95% ANZECC 2000 Species Protection Guidelines or both, and that all sediments produced from the development will be within current ambient ranges (e.g. HIL-A Compliant).

6.3.5 Noise

Noise pollution is likely to occur during all stages of the Development, and is increasingly recognised as having adverse effects on a variety of marine fauna. Sound travels much more efficiently through water than through air, and noise from dredging, other machinery and large ships is especially concentrated in Port and coastal areas. Reactions of marine mammals to ship noise include tolerance, attraction to vessels, behavioural change or avoidance (Bannister et al. 1996). In some areas, Humpback whale densities may be inversely related to the daily amount of boat traffic. Dugongs can be displaced from their feeding areas as a response to boat noise (Anderson 1982, Preen 1992).

Deleterious effects of noise on marine mammals stem primarily from the interference with the ability of individuals to detect calls from conspecifics, echolocation pulses or other important natural noises (Bannister et al. 1996), while for marine turtles, noise causes behavioural changes (Dobbs 2001). The three most common negative reactions to noise are:
Cessation of feeding, resting or social interactions
Changes in surfacing, respiration or diving cycles
Onset of avoidance of noise source

Incessant or repeated acoustic disturbance could cause abandonment of important habitats such as narrow migration paths, breeding and nursery sites and feeding areas. This can affect individuals and, in areas of high shipping traffic, it is likely to affect populations. Long-term effects of noise on organisms other than cetaceans are mostly unknown (DoIR 2002).

Other concerns include the interruption of the mammals' normal activities and the loss of hearing sensitivity. Mortality is uncommon as a result of noise, but long-term displacement is of concern. It has been assessed that during the operation phase of the TOT

Development, the following activities will increase noise levels in the marine environment (Hyder Consulting 2007):

- dredging activities associated with construction of the Breakwater Cove Precinct;
- increase in commercial and private watercraft due to the Breakwater Cove Precinct Development;
- increase in operation and berthing of cruise and military vessels at the Townsville Port Terminal; and
- increase in sea traffic movements.

The assessment states that these noise sources have the potential to severely affect cetaceans, and outlines a number of mitigation options (Hyder Consulting 2007).

6.3.6 Key Threatening Processes: Harmful marine debris

Although outside the scope of the ToR, it is noted that the EPBC Act also provides for a number of Key Threatening Processes, one of which is the "Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris". This process is relevant to the TOT Development, as it will lead to greater human use and waste production during construction and operation, both from vessels and from land-based activities.

Marine debris can include both garbage and other objects, from small eating utensils to lost containers and other large objects. It is generally dominated by non-biodegradable plastic materials, but can also include biodegradable wastes. Some forms of plastic are broken down by micro-organisms and ultraviolet (UV) radiation in sunlight and may degrade within a few years or decades, while others are highly resistant, and remain a threat for decades or hundreds of years (Derraik 2002). It has been estimated that in coastal marine environments, between 60% and 80% of marine debris is land based, while a higher proportion of debris in open ocean environments is ship-sourced (O'Brien 2001). Floating debris tends to accumulate in particular areas, depending on points of origin, coastal topography, transport by currents and the influence of oceanic gyres (Bannister et al. 1996).

Marine debris is as an increasing and persisting problem for marine environments and species (DEW 2003, AMSA 2004) (Table 6). It poses a threat to marine fauna, affects marine fisheries, can act as a vector for marine pests and poses a navigational hazard. The primary dangers for marine wildlife coming into contact with garbage and debris are the risks of entanglement and ingestion. Wildlife becoming entangled in garbage may suffer cuts, abrasions or amputations, drowning or starvation, while the ingestion of synthetic material may result in internal damage, starvation or poisoning (Bannister et al. 1996). Due to their relatively large body size and frequent time spent near the surface of the ocean, marine debris especially affects marine mammals, reptiles and seabirds, many of which are threatened (Derraik 2002, Kiessling and Hamilton 2003). Marine debris can also smother benthic communities, therefore degrading feeding and breeding habitats (Alderman et al. 1999). Non-biodegradable plastic marine debris accumulates in the oceans and provides a growing opportunity for fouling organisms to spread on ocean currents (Derraik 2002, Edyvane et al. 2004). Tourism and fisheries can also be negatively affected by accumulations of garbage and marine debris, and through pollution, propeller fouling and a general loss of amenity value (AMSA 2004).

Table 6. Potential and recorded biological and ecological impacts of marine debris. (From O'Brien 2001).

Potential Impact	Description
Entanglement	• Recorded on the sea floor, ocean surfaces and surrounding terrestrial habitats such as rookeries, mudflats, mangrove habitats, and islands. • Causes mortality and has a serious impact on population levels of endangered species. • Impairs swimming and feeding behaviour (causes drag which results in inability to catch prey). • May cause wounds that become infected.
Ingestion	• Ingestion material is six to seven times more abundant than entanglement material. • About 166 species world wide (including 99 seabird, 24 marine mammal, and six turtle species) have been recorded to ingest debris, mainly plastic. • Ingestion can cause physiological problems such as gastric blockage, starvation, ulceration, reduced absorption of nutrients, and transfer of toxins from plastics into tissues and blood.
Plastic substrate	• Synthetic debris provides a substrate for epiphytic organisms, potentially promoting the long distance transfer of organisms, which may contaminate foreign environments. • There is concern that persistent marine debris could augment the natural processes of colonisation on islands, threatening these ecosystems.
Micro plastic pieces smothering benthic fauna and beach infauna	• Micro-plastic particles can become part of beach sand and be incorporated in low trophic levels such as by benthic filter feeders. The plastic particles can transfer toxins or contain heavy metals. • Debris may smother communities in soft strata and abrade against hard substratum communities. • Smothering of coastline prevents establishment of flora which contributes to loss of habitat and erosion. • Buried plastic may limit the vertical transfer of oxygen and water in soils and sediments.
Ecosystem health	• Debris may be contributing to declining ecosystem health. Evidenced by increasing numbers of species of marine vertebrates presenting with immuno-suppression disorders such as lesions, tumours, and infection.

6.3.7 Algal Blooms

Marine scientists agree that blooms of toxic and/or nuisance marine microalgae, cyanobacteria or dinoflagellates are becoming more frequent around the Townsville region. The prevalence of slicks of the algae *Trichodesmium* (colloquially known as ‘red tide’) has become more frequent. The blooms develop in coastal areas and are washed onto beaches and headlands, creating unpleasant smells. The accumulation of these blooms in inshore waters and on the shore can be a hazard to humans, to whom they can cause irritation and allergic reactions, and to marine life, as they use up the available oxygen and can cause mortality to fishes and invertebrates. The reasons for the increase in algal blooms are unclear, but are believed to include relatively nutrient content in marine waters off the coast of Townsville, and increasing sea surface temperatures.

The TOT Development has a high potential for algal blooms to develop, if not adequately flushed. The development of plumes is almost certain to occur in the high temperature, low tidal amplitude (e.g. neap tides) months if flushing is inadequate. If this occurs, it can lead to highly unpleasant and/or toxic conditions which will significantly impact on marine life within the Development waters, and on human wellbeing among the Development's inhabitants. The management plan and monitoring programme must make provisions for the prevention of algal blooms, particularly by ensuring that adequate flushing and regular annual maintenance dredging occurs.

Additionally, flushing, chemical and stormwater modeling indicate that if flushing is adequate, algal blooms are unlikely to develop even after a small, first flush, freshwater input into the waters of the Development.

6.4 IMPACTS ON RAMSAR WETLANDS: BOWLING GREEN BAY WETLANDS

Due to the distance between the TOT Development site and the Ramsar-listed Bowling Green Bay Wetlands, construction and operation of the TOT are not likely to result in:

areas of the wetland being destroyed or substantially modified

a substantial and measurable change in the hydrological regime of the wetland for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland;

the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected;

a substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or

an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.

6.5 IMPACTS ON LISTED THREATENED OR MIGRATORY SPECIES

The construction and operation of the TOT Development have the potential to adversely affect populations of EPBC-listed threatened and migratory species for which Cleveland Bay represents a key habitat. Potential impacts vary, depending on the range and habitat requirements of the listed species. The most relevant impacts on threatened or migratory species, described in more detail below, have the potential to:

lead to long term decrease in the size of a population (Dugongs, Australian snubfin dolphins);

reduce the area of occupancy of the species (I-P humpbacked dolphins, Australian snubfin dolphins, Dugongs, Green turtles, Flatback turtles);

adversely affect habitat critical to the survival of the species (Dugongs, Australian snubfin dolphins);

modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline (Dugongs, Australian snubfin dolphins);

result in invasive species that are harmful to the species becoming established (introduced birds and mammals, introduced marine pests);

introduce disease that may cause the species to decline (Green turtles, algal blooms); or

interfere with the recovery of the species (Dugongs).

The TOT Development is unlikely to:

fragment an existing population into two or more populations; or

disrupt the breeding cycle of a population.

For listed migratory species in particular, the TOT Development has the potential to:
substantially modify, within the Development site, an area of important habitat for a migratory species (Dugong, Humpback whale, Australian snubfin dolphins);
result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species (Green turtle); and
seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species (Dugong, Australian snubfin dolphins).

EPBC-listed species potentially affected by the TOT Development, and the primary potential impacts, include:

- Dugong (*Dugong dugon*) – contamination and reduction of feeding areas and key habitat, noise pollution, increased boat strike
- Humpback whale (*Megaptera novaeangliae*) – disruption of migration pathway, noise pollution, increased boat strike
- Australian snubfin dolphins (*Orcaella heinsohni*) – destruction of feeding habitat, contamination or mortality of prey species, noise pollution, increased boat strike
- Indo-Pacific humpbacked dolphin (*Sousa chinensis*) – destruction of feeding habitat, contamination or mortality of prey species, noise pollution, increased boat strike
- Flatback turtle (*Natator depressus*) – noise pollution, increased boat strike, ingestion of or entanglement in marine garbage and debris
- Green turtle (*Chelonia mydas*) – contamination or reduction of feeding areas, noise pollution, increased boat strike, ingestion of or entanglement in marine garbage and debris
- White-bellied sea-eagle (*Haliaeetus leucogaster*) – contamination or reduction in prey species, increased competition from introduced birds

EPBC-listed species unlikely to be significantly affected by the TOT Development include:

- Bryde’s whale (Balaenoptera edeni)
- Blue whale (Balaenoptera musculus)
- Estuarine crocodile (*Crocodylus porosus*)
- Loggerhead turtle (*Caretta caretta*)
- Leatherback turtle (*Dermochelys coriacea*)
- Hawksbill turtle (Eretmochelys imbricata)
- Olive Ridley turtle (*Lepidochelys olivacea*)
- Red goshawk (Erythrotriorchis radiatus)
- White-throated needletail (*Hirundapus caudacutus*)
- Barn swallow (*Hirundo rustica*)
- Black-faced monarch (*Monarcha melanopsis*)
- Australian painted snipe (*Rostratula australis*)

The primary impacts specific to listed species are described in more detail in the following sections.

6.5.1 Dredging

TOT construction activities such as dredging can potentially affect water quality (e.g. turbidity). If contaminated sediments are disturbed and distributed by currents, dredging activities will also affect sediment quality. Negative effects from reductions in water and sediment quality, such as seagrass, coral and benthic invertebrate mortality, have the potential to affect listed or migratory species that depend on these resources, including

Dugongs and Green turtles. All cetaceans and turtles are also directly affected by declining water quality. The amount of potential dredging in both construction and maintenance stages specifically related to this Development is proportionally very small (<5%) in comparison to that undertaken by the Port Authority.

6.5.2 Oil and Chemical Spills

Accidental spills (oil or chemicals) can occur during both the construction and operation phases of the Development, and also have the potential to cause water and sediment quality decline. Indirect effects on listed species can include the reduced health or increased mortality of coral reef, seagrass and benthic resources, and all species that must spend time at the water's surface to breathe can be directly affected (Volkman et al. 1994, Bannister et al. 1996).

Spilled oil and chemicals can affect air-breathing marine species by contaminating the skin and mucous membranes, blocking the digestive tract, and causing acute and chronic poisoning by inhaled and ingested toxic compounds. Marine mammals, turtles and fish may also be indirectly affected by oil and chemicals damaging their habitats and reducing populations of staple prey. Many species of zooplankton absorb dissolved hydrocarbons (from spilled oil) directly from the water and ingest contaminated food. Species feeding exclusively on these crustaceans (e.g. baleen whales) could be exposed to this source of contamination (Bannister et al. 1996).

6.5.3 Noise

Noise pollution is likely to occur during all stages of the Development, and is increasingly recognised as having adverse effects on a variety of marine fauna. Sound travels much more efficiently through water than through air, and noise from dredging, other machinery and large ships is especially concentrated in Port and coastal areas. In Cleveland Bay, it is likely that noise-sensitive species are already under pressure from shipping and Port-associated noise.

Reactions of marine mammals to ship noise include tolerance, attraction to vessels, behavioural change or avoidance (Bannister et al. 1996). In some areas, humpback densities may be inversely related to the daily amount of boat traffic. Dugongs can be displaced from their feeding areas as a response to boat noise (Anderson 1982, Preen 1992).

Deleterious effects of noise on marine mammals stem primarily from the interference with the ability of individuals to detect calls from conspecifics, echolocation pulses or other important natural noises (Bannister et al. 1996), while for marine turtles, noise causes behavioural changes (Dobbs 2001). The three most common negative reactions to noise are:

- Cessation of feeding, resting or social interactions
- Changes in surfacing, respiration or diving cycles
- Onset of avoidance of noise source

Incessant or repeated acoustic disturbance could cause abandonment of important habitats such as narrow migration paths, breeding and nursery sites and feeding areas. This can affect individuals and, in areas of high shipping traffic, it is likely to affect populations. Long-term effects of noise on organisms other than cetaceans are mostly unknown (DoIR 2002).

Other concerns include the interruption of the mammals' normal activities and the loss of hearing sensitivity. Mortality is uncommon as a result of noise, but long-term displacement is of concern. It has been assessed that during the operation phase of the TOT Development, the following activities will increase noise levels in the marine environment (Hyder Consulting 2007):

- dredging activities associated with construction of the Breakwater Cove Precinct;
- piling activities associated with construction of the Townsville Ocean Terminal;
- increase in commercial and private watercraft due to the Breakwater Cove Precinct Development;
- increase in operation and berthing of cruise and military vessels at the Townsville Ocean Terminal; and
- increase in sea traffic movements.

The assessment states that these noise sources have the potential to severely affect cetaceans, and outlines a number of mitigation options (Hyder Consulting 2007). Increasing noise and human use of the area must be treated as a serious threat to a number of species listed as threatened and/or migratory under the EPBC Act, especially Dugongs, Australian snubfin dolphins, Indo-Pacific humpbacked dolphins, and to a slightly lesser extent the other marine mammals and reptiles described in this report.

6.5.4 Increased Visitation

Increased boating activity, visitation, and exploitation of marine communities (e.g. recreational fishing) is likely to occur during operational phases of the Development and can lead to habitat destruction and increased incidences of boat strikes to vulnerable marine mammals and reptiles.

Larger vessels pose the greatest risk to large marine mammals, and smaller inshore marine species such as dugongs, dolphins and turtles are particularly vulnerable to faster, smaller vessels. Collisions with commercial ships are likely to be fatal even for a large whale (Bannister et al. 1996). Cleveland Bay is already subject to heavy vessel traffic, with very few mitigation measures in place.

6.5.5 Key Threatening Processes: Harmful marine debris

Although outside the scope of the ToR, it is noted that the EPBC Act also provides for a number of Key Threatening Processes, one of which is the "Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris". This process is relevant to the TOT Development, as it will lead to greater human use and waste production during construction and operation, both from vessels and from land-based activities.

Marine debris can include both garbage and other objects, from small eating utensils to lost containers and other large objects. It is generally dominated by non-biodegradable plastic materials, but can also include biodegradable wastes. Some forms of plastic are broken down by micro-organisms and ultraviolet (UV) radiation in sunlight and may degrade within a few years or decades, while others are highly resistant, and remain a threat for decades or hundreds of years (Derraik 2002). It has been estimated that in coastal marine environments, between 60% and 80% of marine debris is land based, while a higher proportion of debris in open ocean environments is ship-sourced (O'Brien 2001). Floating debris tends to accumulate in particular areas, depending on points of origin, coastal topography, transport by currents and the influence of oceanic gyres (Bannister et al. 1996).

Marine debris is as an increasing and persisting problem for marine environments and species (DEW 2003, AMSA 2004). It poses a threat to marine fauna, affects marine fisheries, can act as a vector for marine pests and poses a navigational hazard. The primary dangers for marine wildlife coming into contact with garbage and debris are the risks of entanglement and ingestion. Wildlife becoming entangled in garbage may suffer cuts, abrasions or amputations, drowning or starvation, while the ingestion of synthetic material may result in internal damage, starvation or poisoning (Bannister et al. 1996). Due to their relatively large body size and frequent time spent near the surface of the ocean, marine debris especially affects marine mammals, reptiles and seabirds, many of which are threatened (Derraik 2002, Kiessling and Hamilton 2003). Marine debris can also smother benthic communities, therefore degrading feeding and breeding habitats (Alderman et al. 1999). Non-biodegradable plastic marine debris accumulates in the oceans and provides a growing opportunity for fouling organisms to spread on ocean currents (Derraik 2002, Edyvane et al. 2004). Tourism and fisheries can also be negatively affected by accumulations of garbage and marine debris, and through pollution, propeller fouling and a general loss of amenity value (AMSA 2004).

7 RISK ASSESSMENT

7.1 RISK ASSESSMENT INTRODUCTION

The Townsville Ocean Terminal (TOT) site is located on, and adjacent to, the existing Townsville foreshore and incorporates the existing Townsville Port western and northern breakwaters, the existing perimeter of the land around the Townsville Casino, the Townsville Convention Centre and Mariners Drive Peninsula.

The proposed development is sited within an area of complex interactions between Local, State and Federal jurisdictions, each with their own specific, and often inconsistent, environmental assment criteria. The most contentious points of conflict possibly result from the existence of a relatively large coastal city with an active export and import Port within zones of Marine National Parks and World Heritage Areas. The anthropogenic settlement and associated activities imply a degree of impact, whereas National Parks and World Heritage Areas imply relatively pristine conditions. This contradiction means that while the Development itself has to be assessed against the stringent conditions relating to developments in protected areas, these conditions themselves have to be assessed against the background impacted conditions. Thus, in these circumstances, it is believed that a criteria of “no significant proportional increase over existing ambient conditions in Cleveland Bay overall” should be used as an assessment criteria.

To ensure that the environmental health and sustainability of the Development is maintained as independently as possible from its immediately adjacent environments, it is essential that the Development adopt the highest possible environmental standards. This means that the potential for contamination and algal blooms within the Development must be minimised by adequate flushing and suitable Operational Management Strategies. This flushing must be such that it can cope with the inputs from small freshwater storm in-flow events. This has been modelled to be the case.

Even though some of the immediately surrounding waters may be of lower environmental standards, it is essential that the water and sediment quality within the Development area are efficiently flushed so that the possibility of contaminant and nutrient build-up within the partially enclosed waters of the Development is minimised. Locally, the immediate downflow receptors of the waters flushed from the Development may be significantly impacted from anthropogenic activities. However the waters adjacent to these, within the Marine National Park and World Heritage Area will be less impacted. It is into these higher quality waters that the mixed waters from the Development will eventually flow. Thus, for there to be no impact on these specific waters from those of the Development, then it is necessary for the flushed waters to meet these higher standards even though they may initially interact with waters of lower quality. Additionally, as indicated earlier, for the waters of the Development with their restricted flow regime to be both environmentally sustainable and healthy, then the waters present within and flushed from the Development must be of a high standard. Such a strategy will prevent the development of undesirable environmental features such as algal blooms.

These requirements imply that while assessments can be made of the Development in isolation, the assessment must also include its local context within an impacted area. The argument is made throughout this document that for the sustainability of the Development itself, water quality standards should possibly be higher than those applied to the immediately adjacent waters. However, in other areas, the proportionality mantra of “no significant proportional increase over existing ambient conditions in Cleveland Bay overall" should be applied. Such areas include noise, light and environmental impact, and undoubtedly the Development will lead to an increase in these parameters, but given the background of the Port and the City of Townsville, any increase is expected to be within the level of background variation.

Within an isolated context of just the Development on its own, many of the risks would carry a risk level of very high to extreme. When modified by the proportionality mantra, the risk level has to be reduced to low to very low risk. For example the death of one mammal per year is, in the absolute sense, too high and totally undesirable, but the increase in the probability of this event occurring due to factors relating to this Development alone, are extremely low. However, this statistical reasoning must not be considered a license to abuse the legislation and all care must be taken to ensure that this statistically low probability is not supplemented by numerous other events to bring about a "death by a thousand cuts" scenario.

In this section, quantitative extensions to standard risk assessment levels are implicit in the terminology used. Use of the terminology is consistent with those often used in major organisations (e.g. Department of Defence) to assess probability, political consequences, and financial magnitude of risk. This terminology is:

1: Likelihood

Highly unlikely	Probability of occurrence	0 – 20%
Unlikely	Probability of occurrence	20 – 40%
Moderately likely	Probability of occurrence	40 – 60%
Highly likely	Probability of occurrence	60 – 80%
Almost certain	Probability of occurrence	80 – 100%

The implications of this quantification are that events classed as likely (moderately likely) may still have a better than even chance of occurrence. Thus, their inclusion in risk assessment matrices as significant events is necessary.

2: Political Consequences are based on the level of reporting of the particular event.

Minimal significance	Publication of event in "yellow" literature
Minor significance	Publication of event in local news media
Significant	Publication of event in States media
Major significance	Publication of event in National news media
Maximum significance	Publication of event in International news media

3: Economic Significance

Minimal significance	Rectification costs	< $10,000.00
Minor significance	Rectification costs	$10,000.00 - $100,000.00
Significant	Rectification costs	$100,000.00 - $1,000,000.00
Major significance	Rectification costs	$1,000,000.00 - $10,000,000.00
Maximum significance	Rectification costs	> $10,000,000.00

Generally, a catastrophic event will be one with a greater than 60% probability of occurrence, have major to maximum political consequences, and be of maximum economic significance.

7.2 RISK ASSESSMENT

7.2.1 Extreme Risk

Impacts that pose an extreme risk are those that are almost certain or highly likely to occur, and have major to catastrophic consequences if they do occur. In the case of matters of NES, in Cleveland Bay this includes impacts that cause widespread damage to or destruction of habitats such as seagrasses and coral reefs in the GBRWHA, or injury or death to a threatened or migratory species. Impacts are also classed as being of extreme risk if they lead to national media attention, community dissatisfaction and political consequences. However, the proportional increase above background levels of the highly modified urban and industrial area utilising the foreshores of Cleveland Bay, will be relatively small.

In this risk assessment, activities causing noise pollution, the increased potential for boat strikes and the risk of harm from marine debris are classed as extreme risk activities. An increase in noise pollution is a highly likely consequence of construction and operation activities of this Development, and can cause injury to dugongs, dolphins, whales and turtles. It will therefore be imperative to explore and implement noise reduction strategies before initiating the construction phase. The Development is also certain to cause an increase in large and small vessel traffic, increasing the vulnerability of marine mammals and reptiles that frequent the shallow waters of the Bay to boat strikes. Death and injury of marine mammals and reptiles already attract media attention, and may cause significant controversy if linked to the operation of the Development. Harmful marine debris is likely to be an almost inevitable consequence of the TOT Development, either through deliberate or accidental discharge of construction waste into the marine environment, or by the increased human habitation in areas directly adjacent to the marine environment. Given the laws that govern the dumping of plastics at sea, garbage and debris will most likely be discharged through individual careless, negligent or unlawful behaviour, and is therefore almost impossible to control. It may be necessary to introduce specific management practices throughout the construction and operational phases of the Development to reduce this risk. The combined effects of increased noise, vessel traffic, and the disturbance to key habitat of the Australian snubfin dolphin are also classed in the extreme risk category.

Death and injury of marine mammals and reptiles already attract media attention, and may cause significant controversy if linked to the operation of the Development. The overriding catastrophic (extreme risk) impact that can occur in the Development is the total degradation of water and sediment quality due to inadequate flushing and dredging. If flushing and annual maintenance dredging occurs, then the chances of a catastrophic event will be minimised. Additionally, the likelihood and consequences of most other environmental impacts are minimised if water and sediment quality are maintained.

7.2.2 High Risk

High risk activities are those that have impacts of moderate to catastrophic consequences, depending on the likelihood of their occurrence. An impact with minor or moderate consequences can be classed as high risk if it is almost certain to occur. Conversely, an impact with major or catastrophic consequences will be classed as high risk even if it is only moderately likely or even unlikely to occur. Moderate consequences include localised habitat damage, species reduction and ecological community deterioration, and also include the disturbance to a key World Heritage value (in this case, the Great Barrier Reef World Heritage Area).

Primary high risk activities of the TOT Development are those that can lead to oil, chemical or sewage spills, and contamination of important habitats of species protected under the EPBC Act. Management Plans for the construction and operation phases of the Development must outline procedures to lower the likelihood of introducing oil, chemicals, sewage or other contaminants into the marine environment. Protected species that use this environment are vulnerable to all contaminants that float on the surface, as well as those that can be taken up in the food chain or degrade habitats.

High risk activities in Cleveland Bay are those that adversely affect water quality through increased turbidity, causing light attenuation and sediment deposition to seagrasses and corals. These are the primary impacts leading to the loss of seagrasses and reef-building corals, and because these are key habitats that make a major contribution to the ecological values of Cleveland Bay, their loss is considered a major consequence. Further high risk activities are those that can lead to contamination of seagrasses, corals, benthic communities and water quality from oil, chemical or sewerage spills. The consequences of a spill would be major (e.g. off-site effects, significant deterioration of an ecological community), and should therefore be treated as high risk even though the likelihood is only moderate.

The effects of noise on fishes are less well known. However, given the high value of Cleveland Bay as a nursery area for many species of commercially important fish, noise pollution should be treated as a high risk for fishes as well as for mammals. Fishes in Cleveland Bay may also be at high risk of increased recreational exploitation, as a result of the increased visitation caused by the Development. The combined effects of all possible impacts is likely to lead to reductions in suitable, accessible and undisturbed habitat, breeding areas and food resources for all species dependent on Cleveland Bay for all of parts of their life cycles.

In this risk assessment, activities causing noise pollution and the increased potential for boat strikes are classed as highly likely risk activities but of moderate consequence. Noise pollution is a highly likely consequence of construction and operation activities of this Development, and can cause injury to dolphins and whales. It will therefore be imperative to explore and implement noise reduction strategies before initiating the construction phase. These recommendations are recorded in the Hyder Construction Report.

It is acknowledged that noise levels will increase as a result of the Development, both during the construction phase, and in response to increased marine traffic during the operational phase of the Marina and the Cruise Ship Terminal. However, it is highly unlikely that this increase will be of major significance given the size and type of Port activities already taking place in the Townsville region. Nevertheless, the issue is an Australia-wide problem and although beyond the scope or requirements of this study, co-ordinated efforts should be undertaken to assess the potential impacts of port and harbour noise on endangered species

7.2.3 Medium Risk

Medium risk activities can occur along a decreasing gradient of likelihood, with a corresponding increasing gradient of consequence. For example, a medium risk activity may almost certainly have an impact with insignificant consequences, or a moderately likely impact of moderate consequences, or an impact of catastrophic consequences that is very unlikely to occur.

Medium risk activities in Cleveland Bay are those that will elevate nutrient contents, endangering seagrasses and corals through the increased growth and shading by macroalgae, and increase in contaminants in the sediments and water, which will affect all sessile (attached or non-mobile) organisms. Also of medium risk is the smothering of seagrass beds or benthic communities through the accumulation of garbage on the seabed. Despite the unlikely event of these occurrences, nutrient levels must be monitored and managed, because the impacts of macroalgal overgrowth would have major consequences, and macroalgal blooms would almost certainly attract negative media attention. Similarly, detailed protocols on garbage management will probably prevent the smothering of large areas of seagrass, but accidental losses of garbage into the sea are likely to affect localised seagrass areas. There is a medium risk of marine pest incursion into seagrass beds and benthic communities. The likelihood of incursion is relatively low in permanent seagrass beds (e.g. those near Cape Cleveland), but higher in ephemeral seagrass beds closer to the Development site. The consequences of a large population of marine pests in seagrass beds will be major if this leads to seagrass loss and therefore loss of habitat and food for species of conservation and commercial significance. Furthermore, many benthic communities in the Bay have been disturbed through dredging and trawling, putting them at higher risk of marine pest incursion than undisturbed areas. This would have the potential for causing damage to fish stocks and fisheries through the depletion of fish food resources and nursery grounds.

There is a medium risk of reduced food resources for some EPBC-listed marine mammals, reptiles and birds through the potential impacts on seagrass beds. These more indirect assessments of risk reflect the connectivity between different ecological communities and species, in that a direct impact on one community (e.g. seagrass reduction) can cause indirect impacts to other communities or species (e.g. reduced food for Dugongs).

7.2.4 Low and Minimal Risk

Low risk activities are those that are likely to moderately likely to cause adverse impacts with minor or insignificant consequences, or unlikely to very unlikely activities with moderate to major impacts. Minor consequences are those that lead to minor and localised reductions in ecological communities or species, have only on-site effects, and lead to some community dissatisfaction without media attention.

The Bowling Green Bay wetlands are considered at minimal risk of being affected by the TOT Development, due to their location upstream of the Development. It must be noted, however, that a large oil spill occurring in Cleveland Bay from a vessel directly associated with the TOT is likely to have an adverse impact on the wetlands where they border on Cleveland Bay. The overall ecological health of the Bay is therefore an important component when safeguarding the integrity of the Bowling Green Bay wetlands.

Table 7. Risk assessment for each type of impact from the Development on Cleveland Bay habitats and species.

Note: In this Risk Assessment Table, Best Professional Judgement has to be exercised with respect to the scale and significance of the likelihood and consequences in the evaluation of Risk. For example, a small (<10L fuel spill from a small boat within the marina is almost certain to occur, although the consequences may be minor but the potential effects are easily remediated given the confined area of the waterway. However, a major fuel spill from a large marine vessel entering the Port of Townsville may have a low likelihood of occurrence, but may well have major consequences. Thus, in the Table below ranges of risk are employed to indicate variations due to scale.

NES Matter	Habitat/Species	Threat	Likelihood	Consequence	= Risk
GBRWHA	Seagrass Beds	Sediment destabilisation through changes in sediment transport regime (e.g. dredging in adjacent areas)	Likely	Minor if area/size of disturbance is restricted to dredge areas only	Medium
		Light attenuation through, for example, increased turbidity associated with dredging activities	Moderately Likely	Minor to Major dependent on area, magnitude and nature of disturbance	Low to High
		Nutrient enrichment leading to increased macroalgal growth (e.g. effluent discharge)	Unlikely	Minor to Major dependent on magnitude of input	Minimal to Medium
		Contamination from spill (oil, chemicals)	Unlikely	Minor to major dependent on nature of contaminant and magnitude of spill.	Minimal to Catastrophic dependent on nature of contaminant.
		Contamination from disturbed contaminated sediments	Unlikely	Minor	Minimal

NES Matter	Habitat/Species	Threat	Likelihood	Consequence	= Risk
		Noise pollution (impact on organisms relying on seagrass beds)	Almost certain	Moderate (dependent on distance of organisms from noise source, volume and frequency of noise)	Moderate to High (dependent on species, volume and frequency of the sound waves)
		Smothering through garbage and debris accumulation	Unlikely	Major	Medium
		Marine pest incursion	Unlikely	Major	Medium
	Coral Reefs	Light attenuation through turbidity	Moderately Likely	Major	High
		Sediment deposition	Moderately Likely	Major	High
		Nutrient enrichment leading to increased macroalgal growth	Unlikely	Major	Medium
		Contamination and mortality from spill (oil, chemicals)	Moderately likely	Major	High
		Contamination from disturbed contaminated sediments	Unlikely	Major	Medium
		Smothering through garbage and debris accumulation	Unlikely	Moderate	Low
		Marine pest incursion	Unlikely	Moderate	Low
	Benthic Communities	Sediment deposition / burial	Moderately Likely	Minor	Low
		Nutrient enrichment leading to increased macroalgal growth	Unlikely	Minor	Minimal

NES Matter	Habitat/Species	Threat	Likelihood	Consequence	= Risk
		Contamination and mortality from spill (oil, chemicals)	Moderately likely	Moderate	Medium
		Contamination from disturbed contaminated sediments	Unlikely	Moderate	Low
		Reduction in predator populations	Unlikely	Moderate	Low
		Smothering through garbage and debris accumulation	Unlikely	Moderate	Low
		Marine pest incursion	Unlikely	Major	Medium
Bowling Green Bay Wetlands	All wetland habitats and associated species	All impacts associated with the TOT	Unlikely	Minor	Minimal
Threatened and migratory species	Marine Mammals and Reptiles	Noise pollution, during construction	Likely	Major	Extreme
		Disturbance of key feeding habitat for Australian snubfin dolphin	Likely	Major	Extreme
		Increased boat strikes (operation phase)	Moderately Likely	Major	High
		Harmful marine debris (through accidental or negligent actions by individuals)	Unlikely	Major	High
		Impacts on food resources (e.g. seagrass beds), during construction and maintenance dredging	Moderately Likely	Major	High
		Contamination and mortality from spill (oil, chemicals)	Unlikely	Major	Medium

NES Matter	Habitat/Species	Threat	Likelihood	Consequence	= Risk
		Contamination / reduction in breeding and nursery habitats, during construction	Moderately Likely	Major	High
		Effects of reduction in water quality, during construction and dredging	Moderately Likely	Moderate	Medium
	Birds	Harmful marine debris	Unlikely	Major	High
		Contamination / reduction of breeding areas	Unlikely	Major	High
		Impact on food resources, during construction	Moderately Likely	Moderate	Medium

8 IMPACT REDUCTIONS AND REMEDIATION STRATEGIES

8.1 AIMS AND OBJECTIVES

The Nature Conservation, Water Quality and Matters of National Environmental Significance studies have established that high ecological values exist in certain parts of the Cleveland Bay system, despite the proximity of the City and Port of Townsville and the existence of anthropogenic impacts. These areas contain a number of sensitive habitats and dependent species. The ecological value of this resource, particularly the accessibility of otherwise often remote Matters of NES, gives the proposed Development a large component of its economic value. Thus, in order to preserve these values, the overall aims and objectives of the Impact Reduction and Remediation Strategies are to -

- Prevent significant damage to Matters of NES in Cleveland Bay, consistent with the current biodiversity of the area;
- Monitor key aspects of the environment potentially at risk;
- Mitigate significant impacts of the proposed Development activities; and
- Should significant impacts occur, appropriate amelioration and remediation measures should be undertaken as necessary. Consistent with the Precautionary Principle this should involve immediate review and investigation of the activity, normally followed by appropriate intervention. In extreme cases, this may include cessation of the activities until the impact risk has been fully assessed and appropriate amelioration measures implemented.
- Where appropriate, opportunities should be taken to remedy past negative environmental impacts.

Nevertheless, the proposed development is sited within an area of complex interactions between Local, State and Federal jurisdictions, each with their own specific, and often inconsistent, environmental assment criteria. The most contentious points of conflict possibly result from the existence of a relatively large coastal city with an active export and import Port within zones of Marine National Parks and World Heritage Areas. The anthropogenic settlement and associated activities imply a degree of impact, whereas National Parks and World Heritage Areas imply relatively pristine conditions. This contradiction means that while the Development itself has to be assessed against the stringent conditions relating to developments in protected areas, these conditions themselves have to be assessed against the background impacted conditions. It is believed that in these circumstances that a criterion of “no significant proportional increase over existing ambient conditions in Cleveland Bay” should be used as an assessment criterion.

In this report, prevention, monitoring and remediation options are given specifically for NES Matters.

8.2 SPECIFIC PREVENTION AND REMEDIATION OPTIONS FOR NES MATTERS

Water and sediment quality will be the first environmental components affected by the Development and any impact on these qualities is almost certain to affect the flora and fauna of Cleveland Bay. Water quality in particular can be used as an “early warning system" for the protection of marine communities. If water and sediment quality are maintained at current conditions then it is considered that the Project is sustainable. It is stressed that given the high environmental values of the corals, seagrass beds and other flora and fauna of the Bay, maintenance of this water and sediment quality is vital to the sustainability of these ecosystems and the viability of the Project. To this end, a stringent monitoring programme is necessary. This Monitoring Programme should include:

- Continuous water quality monitoring, regular and event monitoring at designated locations of corals, seagrasses and their associated ecosystems, and
- Regular and event monitoring at the same designated locations of sediments and waters for a comprehensive range of chemical species including heavy metals and nutrients.

As is indicated in Section 9 the continuous water quality monitoring involving permanent data loggers should continue for the whole life of the Development. The other monitoring programmes should continue for at least 5 years after the completion of the whole Project.

8.2.1 Great Barrier Reef World Heritage Area

8.2.1.1 SEAGRASS BEDS

Seagrass beds are probably the most ecologically and economically valuable ecosystems in Cleveland Bay, and at the same time the most vulnerable to human impacts. They are ecologically and economically valuable because they stabilize the sediments, enhance water quality, provide food for vulnerable and endangered marine species, and provide shelter and nursery grounds to a range of commercially important organisms. They are vulnerable to human impacts because they occur in shallow waters near a major human population centre. All reasonable measures must be taken to avoid further pressures on seagrass beds in Cleveland Bay.

Prevention

The proposed construction methodology will significantly reduce the risks of sedimentation and turbidity impacts of sea grass beds, providing that dewatering sites are chosen to minimize environmental impact, are shifted on a regular basis to reduce duration of turbidity plumes, and are (if possible) sited along the northern breakwater in preference to the western breakwater. Once encapsulated, other than from water permeating into the site from beneath the sheet piling, and necessitating continuous dewatering of an estimated 90 to 500m^3 per day, the surrounding marine environment will be 'cut off' from the main excavation of land reclamation activities on site.

The main negative effects on seagrasses from the proposed Development will be the increased turbidity from dredging of the external access channel, the continuous dewatering process, and contamination from disturbed, potentially polluted sediments from the creation of the berth pocket.

It is noted that regardless of this Development, maintenance dredging of an access channel to the existing marina basin, and by the Townville Port Authority within the Platypus Channel and swing basin (adjacent to the proposed TOT berth) already occur and therefore this proposed dredging operation is not a "new" impact solely caused by this Development. The annual maintenance dredging of the internal channel and northeastern and southeastern arms of the Development, needed to maintain adequate flushing and water quality, will only be of the order of 1000m^3 per annum. This is less than 0.5% of the maintenance dredging undertaken by the Townsville Port Authority.

The most common prevention mechanisms successfully used against sediment plumes during dredging are silt curtains. These are devices that control suspended solids and turbidity generated by dredging and disposal of dredged material (Francingues and Palermo 2005). It is likely that the most useful configuration of a silt curtain in this situation is an elliptical curtain surrounding the dredge. A number of additional preventative mechanisms should be added to the implementation of the silt curtain:

- Dredging should not occur during times of strong wind-driven currents.
- Dredging should no occur during known migration or breeding times for marine mammals.

It is understood that subsequent to the initial dredging required for the construction of the berth pocket and the external access channel, maintenance dredging will be the responsibility of the new commercial marina operator. That operator will be responsible for obtaining appropriate approval for maintenance dredging works in future, subject to assessment and in accordance with proper environmental assessment regimes at any given time.

Monitoring

Monitoring should be conducted both for the seagrass beds themselves, and for turbidity in the water column surrounding seagrass beds. Both regular monitoring (seasonal sampling to establish background temporal variability in seagrass beds) and reactive monitoring (one-off sampling of seagrasses in areas where impacts are likely to have occurred) should be conducted. Monitoring of seagrass beds should include the following components and considerations:

- Event based monitoring of seagrass density and species composition at the sites established during this Baseline Study, and possibly at additional sites as considered necessary;
- reactive monitoring of seagrass density and species composition at sites where increases in turbidity of 10% above baseline levels are measured, with equivalent Control sites;
- seasonal monitoring to assist in establishing the natural seasonal variability in seagrass density and species composition; and
- sampling of macroalgae and other organisms present in seagrass beds during regular monitoring, to establish seasonal variations in macroalgal growth and to assess the potential for detrimental macroalgal overgrowth of seagrasses.

Turbidity monitoring should take into account the following:

- turbidity meters to be installed upflow and downflow of the dredging sites, to compare turbidity in areas not impacted by the dredging to those where an impact could occur;
- dredging activities to cease when a 10% increase over ambient turbidity levels is measured at downflow monitoring sites;
- turbidity to be sampled at the top and bottom of the water column at all seagrass sampling sites, on a weekly basis.

Remediation

It is acknowledged that construction will impact on the seagrasses currently existing within the Project Site. However, the value of these grasses to local fauna is minimal compared to the more established meadows nominated within the Bay. While an off-set programme is a possibility, it is considered that the size and distribution of the grasses in this area does not warrant such a programme.

In relation to the Operational Phase of the Development, should an impact on the established seagrass meadows external to the site be determined and is found to be linked to dredging activities associated with this Development, such as a reduction in seagrass densities greater than 20%, dredging activities should be reviewed. Remediation activities must include the following components:

- More frequent sampling of seagrass density and species composition at the impacted sites, until a statistically significant increase is measured.
- The implementation of methods to stimulate seagrass growth, such as the addition of iron to sediments surrounding the active root zones of seagrasses (Holmer et al. 2005), in the case of seagrass density losses of over 50%; and
- The application of mechanical flushing in the area of impact.

Summary

Seagrass beds are both the most valuable and the most vulnerable asset to the ecology and economy of Cleveland Bay. While this Development by itself may not have significant and long-term effects on seagrass beds, it will add to the cumulative impacts already at work in Cleveland Bay. It is imperative that all possible measures be taken to avoid damage to seagrass beds. The most important measures to be taken should include:

- The use of silt curtains during any dredging operation;
- Seagrass and turbidity monitoring, both on a regular basis during the dredging operation, and on a reactive basis when required;
- The cessation of dredging if turbidity levels exceed a 10% increase over levels at Control sites;
- Consideration of active remediation of dredging impacts if there is a 20% loss (or more) in seagrass density in areas downstream of the dredging site.

8.2.1.2 BENTHIC FAUNA:

Introduction

Subtidal benthic communities in Cleveland Bay support a large number of commercially important fish species, and contribute significantly to the overall biodiversity of the Bay. They play a large role in aerating the sediments, and the most vulnerable communities to contamination of sediments with heavy metals, hydrocarbons, etc. Very little is known about these communities, and the precautionary principle must be applied when there is the potential of disturbing contaminated sediments.

Prevention

The primary negative effect on benthic communities from the proposed Development will be the risk of contaminating their habitat with disturbed, potentially polluted sediments during dredging of the berth pocket. Benthic invertebrates readily absorb contaminants from the water and sediments surrounding them, causing mortality to the organisms themselves and the transmission and concentration of contaminants through the food chain when they are consumed by larger organisms (e.g. fishes). The most effective ways to avoid this is the detailed analysis of sediments in all areas where dredging is proposed, and the use of silt curtains (Section 8.2.1.1). Preventative mechanisms for safeguarding the integrity, biodiversity and abundance of benthic communities are as follows:

- Maps should be produced detailing the exact location and extent of areas to be dredged, and/or disturbed, during other construction works;
- Sediment sampling should occur in a manner that adequately covers the areas subject to dredging and construction works (refer to Water and Sediment Quality report for details);
- Silt curtains should be used during all dredging operations; and
- Dredging protocols should be established to ensure that dredging operates only during appropriate weather conditions (e.g. no dredging during times of strong SE winds).
- Ensuring adequate flushing and maintenance dredging occurs.
- Ensuring water quality is maintained by
  - The prevention of sediment plumes from dredging, by using silt curtains and regulating the timing of dredging activities (see prevention section for Seagrass Beds), and by avoiding the dredging of contaminated sediments;
  - The disposal of all dredge spoil on land;
  - The prevention and containment of accidental spills;
  - The setting of conservative water quality investigation and intervention levels to determine when dredging, and all other activities, must cease; and
  - A policy of no off-site movement of chemicals, building materials, sewerage, ballast water, etc.; and

Monitoring

Monitoring should include the sediment in and around the dredging area, the sediments at selected benthic sampling sites, and the benthic communities themselves at the same sites. It is expected that the sites will be those used during this Baseline Study, with additional sites included if necessary. It is expected that benthic community structure and density is not as seasonal as that of seagrass beds. More specifically, monitoring should include:

- Regular monitoring of sediments during dredging operations;
- Annual sampling of benthic communities using grab samples, to gain estimates of density and species composition changes over time;
- Reactive monitoring of benthic communities and associated sediments if an impact is detected. Reactive monitoring should include monthly sampling at the sites where an impact is detected, with equivalent numbers of Control sites.
- In the event of a 50% increase in one or a few species, and/or a 50% reduction in species richness at any one site, which can be linked to dredging activities, dredging activities should cease immediately and remediation mechanisms should be implemented.

Remediation

Remediation mechanisms should be implemented as soon as the trigger levels of the designated contaminants, and/or a statistically significant increase in one species, and/or a statistically significant decline in species richness are detected. If impacts are identified during the construction period, development activities should be immediately reviewed to identify causes of impact and remediative measures set in place as and if required.

If changes in benthic community density or composition occur in the absence of any measurable contamination of the sediments, it is possible that there has been a decline in the predator (i.e. fish) community. In this case, it will be necessary to establish whether other impacts have occurred (e.g. impacts on water quality that cause seagrass loss and therefore a decline in nursery habitats for fish species that feed on benthic organisms), and remediation actions need to be taken to address those impacts (refer to Seagrass, Water Quality, and Fish Sections).

Summary

Benthic communities in Cleveland Bay add to the overall biodiversity value of the marine ecosystem, and supply vital food resources to commercially important fishes. Kettle et.al (2002) considers benthic communities the initial indicator of environmental damage caused by dredge spoil. The primary focus of prevention, monitoring and remediation of impacts will be the containment of any contaminated sediments during dredging activities and any other works that may disturb contaminated sediments. For this purpose, to following things are of importance:

- There is a need for detailed knowledge of the status of sediments in all areas that are likely to be disturbed.
- Prevention will include avoiding the disturbance of sediments that have significant levels of contamination.
- Silt curtains will need to be installed (see Seagrass Section).
- Monitoring should include both regular and reactive monitoring of sediment quality and benthic community density and structure.
- If trigger levels (refer above) are reached, and are considered to be a reaction to Development activities, these activities must cease and remediation measures must be implemented.

8.2.1.3 Coral Reefs

All coral reefs in Cleveland Bay occur within the Great Barrier Reef Marine Park and constitute one of the key values of the Park. Despite occurring in highly turbid inshore environment, Middle reef and the reefs around Magnetic Island have high species richness and a higher tolerance to temperature fluctuations and turbidity than many offshore reefs, making them increasingly important ecosystems in the face of increasing pollution, declining water quality, and temperature fluctuations expected to increase with climate change. These reefs protect the shorelines of Magnetic Island from erosion, and provide habitat and food for a variety of commercially important fish species, as well as habitat for vulnerable species (e.g. turtles). The reef of Magnetic Island will benefit from their distance from the proposed Development, but there is still the likelihood that higher turbidity levels, declining water quality and increased visitation will have adverse effects (e.g. light attenuation, sedimentation, anchor and diver damage, increased human exploitation). Middle Reef is the most vulnerable of the Cleveland Bay reefs, and will be the reef in most need of prevention, monitoring and possibly remediation activities.

Prevention

The potential impacts of turbidity on coral reefs can be largely prevented by using silt curtains and by avoiding dredging and other activities that cause turbidity at key times in the tidal cycle and during certain weather conditions (see Seagrass Bed Section above). It may be more important to manage the timing of dredging activities, by ceasing dredging during periods of strong currents that may carry suspended sediment towards reefs. The following prevention measures will need to be implemented:

- Silt curtains should be employed during all dredging activities;
- Dredging protocols should be established to ensure that dredging operates only during appropriate weather conditions (e.g. no dredging during times of strong SE winds);

- Dredging should not occur during times of strong wind-driven currents flowing in the direction of any of the reefs in Cleveland Bay and Magnetic Island;
- Maintenance of water quality exiting the Development site; and
- During operation of the Development, visitation will need to be managed through education of visitors, training of staff associated with visitor activities, and by placing strict restrictions on activities of residents of the proposed Development.

Remediation

Remediation measures should be implemented as soon as there are statistically significant declines in coral cover or signs of coral stress (refer above). Specific remediation measures may include:

- The application of mechanical flushing in the area of impact;
- Removal of excess macroalgal growth in the event of a macroalgal bloom caused by excess nutrients as a result of Development activities.

Summary

Coral reefs are of high ecological and economic values to Cleveland Bay, similarly to seagrass beds. These inshore reefs may be quicker to adapt to the effects of climate change than reefs further offshore, and therefore represent potential areas of high resilience from which other reefs may receive coral larvae during recovery from disturbance, and all possible measures must be put in place to safeguard them. The economic costs resulting from a large-scale loss of the coral reefs around Magnetic Island or elsewhere in Cleveland Bay could far outweigh the expected benefits of the proposed Development. Key points to consider are:

- Coral reefs in inshore environments are already subject to greater stresses than reefs further offshore, and any Development affecting these inshore reefs must be carefully considered and modified to prevent any damage to corals;
- Silt curtains must be employed at all times during dredging operations, and water quality (e.g. turbidity) carefully monitored;
- Monitoring of reef communities must replicate and expand previous studies (e.g. Ayling and Ayling 2005) to provide an estimate of long-term temporal dynamics against which potential impacts can be measured;
- If trigger levels are exceeded, Development activities must cease and remediation activities initiated (e.g. flushing, sediment or macroalgal removal, reactive monitoring).

8.2.2 Bowling Green Bay Wetlands

The Bowling Green Bay Wetlands are not expected to be affected by the TOT Development. There are no prevention, monitoring and remediation strategies suggested.

8.2.3 Listed Species: Marine Mammals and Reptiles

8.2.3.1 INTRODUCTION

Cleveland Bay provides temporary or permanent habitat to a number of threatened and migratory species listed on the EPBC Act. Activities that threaten the habitats, migratory pathways or food resources of these species must be avoided or strictly controlled, as Cleveland Bay holds vitally important habitat and food resources for some species (e.g.

Dugongs and Australian snubfin dolphins, and to a lesser extent Humpback whales, Green turtles and Flatback turtles). These species must spend time at the water's surface to breathe, and are thus more easily affected by spills of substances that are positively buoyant (e.g. oil, some chemicals) and by floating plastic debris.

8.2.3.2 PREVENTION OF IMPACTS

Preventing impacts from the Development on EPBC-listed threatened and migratory species during the construction phase involves protecting key habitats and habitat condition. It is more likely that for these species, the most problematic stage of the Development will be the operational phase, where marine mammals and reptiles will suffer from increased visitation, noise, recreational fishing and boating activities, increased large vessel traffic and increased marine garbage and debris (especially discarded fishing lines).

Operational impacts may be prevented through:

- Detailed contingency plans for the prevention, containment and remediation of accidental spills;
- Detailed contingency plans for the prevention, containment and remediation of garbage and debris dumping incidents;
- Effective noise reduction during construction
- Effective construction and operation staff, public and visitor education;
- Effective awareness raising for boat operators (including on cruise ships and naval vessels) about the sensitive nature of the habitat and the potential for their activities to cause harm;
- Provisions for vessel speed restrictions;
- The consideration and practical application of mitigation methods proposed by the Noise and Vibration Assessment (Hyder Consulting 2007).

In the case of the Australian snubfin dolphin, and to some extent the Indo-Pacific humpbacked dolphin, the construction phase of the TOT Development will disturb (through increased noise and human activity) a key part of their habitat. These species (especially the Australian snubfin dolphins) are relatively shy of humans and could easily be displaced through construction and increased boating activities. The rarity of this dolphin, and the high-profile nature of its recent discovery, makes it important to avoid a local extinction of the Cleveland Bay population. It is not possible to predict whether, once operational, the dolphins will be able to make use of the constructed breakwalls and canals.

8.2.3.3 REMEDIATION OF IMPACTS

Remediation of impacts on marine mammals and reptiles involves primarily the remediation of their habitats and food resources (see Section 8.2.1) and the cessation of detrimental activities. Specific remediation activities for mammals and reptiles include:

- Cleaning up and fencing off nesting beaches of sea turtles during nesting periods;
- Containing and cleaning up accidental spills as quickly as possible;
- Cleaning up of all plastic debris found in or adjacent to marine environments, and the written encouragement for all staff and users of the Development site to do so; and
- Effective public education programmes.

8.2.3.4 SUMMARY

The value of threatened and migratory marine species frequenting Cleveland Bay cannot be underestimated; both the ecological and economic significance of this extends beyond

Cleveland Bay and is of national and, for some species, international significance. Apart from the five-yearly aerial surveys of dugong populations, there has been very little data collected on marine mammals and reptiles in this area. Key considerations should include:

- The careful monitoring of water quality, biological communities and noise levels;
- Training and education of all staff during all phases of the Development in the value of these species and prevention methods, trigger levels and remediation measures to safeguard their populations and habitats;
- Immediate review of operational procedures and initiation of remediation procedures as considered relevant to the impact if and where the impact is deemed to be associated with the Development.

8.2.4 Listed Species: Birds

Birds that depend on intertidal and marine environments in Cleveland Bay greatly add to its biodiversity and aesthetic values. They also play an important role as predators, keeping fish and benthic populations healthy. A number of rare and vulnerable bird species frequent the Bay, adding value to the Development area and its expected future inhabitants. It is unlikely that the TOT Development will have direct effects on the species of threatened and migratory birds described in this report. However, the prevention, mitigation and remediation strategies outlined above are likely to be relevant for listed bird species.

9 MONITORING PROGRAMME

A comprehensive monitoring programme will be essential for two reasons:

- The protection of environmentally sensitive areas from activities associated with the Development, and
- Protectiong against mischief complaints.

In Section 8 the necessitory for continuous water quality monitoring and regular and event monitoring of ecosystems was explained. In this section the way in which the monitoring programme will be undertaken will be given. In particular, the time periods for monitoring will be:

- The water quality monitoring using permanent data loggers will continue for the life of the Project.
- The other monitoring programmes should continue for at least 5 years after the completion of the entire Project.

The fundamental tenet upon which this Monitoring Programme is based is the continuous monitoring of water quality, both within and exiting from the Developed Canal Estate of the Breakwater Precinct. If the water quality is maintained to the high standards specified in the Water Quality Report (identified below) then it is considered that most, if not all other impacts will be avoided and that the Development will be ecologically sustainable. Specific impacts during the Construction Phase will be short-term and will also be specifically identified by the continuous water quality, and other monitoring programmes carried out during the construction phase.

While it will be important to monitor the conditions of seagrass beds, coral reefs and intertidal and benthic communities during the construction period of the Development, for the future operation of the Development, the ‘early warning system’ will be the regular sampling of water and sediment quality in the vicinity of the habitats most susceptible to damage. Rather than monitoring on a seasonal, regular, or calendar-drive basis, the ‘event sampling’ method is proposed, as this is much more meaningful in the seasonally arid tropics. Monitoring all ecological and physical variables would therefore occur at the annual thermal maximum (January-February) and minimum (July-August), at the end of the wet season (e.g. March) and after unusual climatic conditions or events (e.g. intense rainfall events, extended periods of high turbidity, cyclones, etc.).

It is recommended that the Construction Impact Monitoring programme be continued for 5 years following completion of the construction period.

9.1 *CORAL REEFS AND SEAGRASS BEDS*

Monitoring of coral reefs and seagrass beds should be conducted by event sampling at locations close to the Development site (Impact sites) and locations further away (Control sites). Sampling locations used in this baseline study should be used to assess the most useful sites for ongoing monitoring.

Coral reef monitoring should include:

- Sampling at Middle Reef, Virago Shoal, Cockle Bay, Picnic Bay, Nelly Bay, Geoffrey Bay, Arthur Bay and Florence Bay;

- Use of the same sampling sites used in the baseline study and by previous studies conducted by Dr. Tony Ayling, plus additional sites established at Virago Shoal and Cockle Bay;
- Whenever possible, employing the same surveyors used for the baseline study to ensure observer fidelity with previous datasets;
- Monitoring of benthic composition and coral cover (including marine pest species) using the line intersect transect (LIT) method;
- Collecting and cataloguing of any garbage or debris found during coral reef surveys;
- Annual (summer) monitoring of coral reef fishes along the same transects used for benthic community surveys; and
- Bi-annual reporting on coral reef condition.

Seagrass bed monitoring should include:

- Sampling at sites to the west of the Development site, stratified into areas defined by the baseline study sites I2 to I4, I4 to I6, and I6 to I9. Within these areas, monitoring sites should be established both inshore and offshore, as seagrass communities differ at different depths. Seagrass surveys inside the Development site should commence as soon as possible after the completion of construction works;
- Control sites to be established in areas of high water quality, in the Shelly Beach area;
- Monitoring of seagrass species composition and shoot density using the methodology described in this study;
- Surveying of all other organisms present in and around the sampling units (quadrats) at the time of sampling, including percent cover estimates of macroalgae, and estimates of marine pest species;
- Collecting and cataloguing of any garbage or debris found during seagrass surveys;
- Bi-annual reporting on seagrass bed condition.

9.2 BENTHIC COMMUNITIES

Benthic community structure is likely to undergo smaller seasonal variability than coral reefs and seagrass beds, as the fauna is largely found living within the sediments, and therefore subject to a more stable physical environment than communities directly subject to the water column. Monitoring of these communities can therefore be restricted to thermal maximum (January-February) and minimum (July-August) sampling, as well as sampling after unusual climatic events.

Intertidal benthic community monitoring should include:

- Sites to the west of the Development site, including Rowes Bay, Pallarenda (including mangroves at Three Mile Creek), and Cockle Bay (including mangroves);
- Sites inside the Development site to be surveyed after the completion of construction works;
- Control sites located in areas of mangroves and sand / mud flats to the east of the Development site;
- Collection and sorting of samples, and species identification, to be carried out by the same surveyors used for the baseline study to ensure observer fidelity;
- During sample collection, visual surveys should be conducted along long transects (e.g. 500m), and all flora and fauna encountered should be recorded, especially introduced species, shorebirds and macroinvertebrates; and
- Bi-annual reporting of intertidal community condition.

Subtidal benthic community monitoring should include:

- Sampling at sites to the west of the Development site, stratified into areas defined by the baseline study sites I2 to I4, I4 to I6, and I6 to I9. Within these areas, monitoring sites should be established both inshore and offshore;
- Sites inside the Development site to be surveyed after the completion of construction works;
- Control sites should be established to the east of the Development site;
- Benthic monitoring to include replicate Van Veen grab samples at each location, to be processed and sorted as described in this baseline study, to be carried out by the same surveyors used for the baseline study to ensure observer fidelity;
- All garbage and debris should be collected and catalogued;
- Monitoring should be conducted in summer and winter; and
- Reporting of intertidal community condition in summer and winter.

9.3 LISTED SPECIES

Listed and threatened species inhabiting Cleveland Bay are those most directly at risk from potential impacts of the TOT Development, and will attract the most attention from conservation agencies (government and non-government), the media and the public. However, due to the existence of other contributing factors including those of anthropogenic origin, it will be extremely difficult to assign direct cause and effect to any impacts relating specifically to the TOT itself. However, in recognition of the precautionary principle, and in light of the absence of long term data (specifically in relation to the Snubfin Dolphin), then numerical monitoring for this specific species may be considered. It is therefore recommended, that in addition to the habitat and water quality monitoring strategies outlined above, consideration be given to a boat based monitoring programme designed to target dolphin populations, but also records other listed species in Cleveland Bay.

It must be identified, however, that should such numerical monitoring occur, it is unlikely that any direct causal correlation between species numbers and direct TOT activities could be discerned from other factors existing in Cleveland Bay.

10 RECOMMENDATIONS

The following recommendations represent a summary of the more specific recommendations relevant primarily to Matters of National Environmental Significance. They are relevant to both the EIS and the ongoing monitoring of the environmental values of Cleveland Bay.

- During all phases of this development, the highest priority must be placed on protecting water and sediment quality. These provide the core habitats of the GBRWHA and the support system of species listed as Listed and Migratory Species. It is considered that if these parameters are maintained at or below the current ambient levels, the seagrass beds and coral reefs will not be jeopardised by this Development.

- The monitoring programme should include water and sediment quality, seagrass beds, coral reefs, and dolphin populations. Monitoring surveys targeting dolphin populations should record other species of mammals, reptiles and birds encountered.

- Noise levels must be carefully monitored throughout construction and operation phases of the TOT Development. These noise levels are to be assessed in conjunction with known tolerance limits for marine mammals and reptiles, in consultation with relevant experts.

- Cleveland Bay, although anthropogenically impacted, is of high ecological value to species and communities of commercial and conservation significance. Providing adequate flushing and annual maintenance dredging occurs, water and sediment quality will be maintained. The maintenance of current water and sediment quality is critical to the project, both during the construction and operational phases of the Development.

- The full EIS and subsequent monitoring of Cleveland Bay ecosystems should follow the BACI design set out during this baseline study. Specific monitoring strategies described above should be initiated as soon as possible, so that sufficient data 'Before' the development activities begin is generated to represent the best possible scientific practice against which any future environmental impact can be judged.

- Ideally the location of future sampling sites should be based on information acquired from hydrodynamic models formulated around a variety of weather and climate patterns. Models for the predominant weather patterns/wind direction and strength, for unusual weather conditions (e.g. cyclones, floods, droughts), and for a number of predicted climate change scenarios (particularly sea level rise) are recommended.

- Early and efficient communication lines should be established between the developers, government and conservation agencies, scientists, managers and construction staff. This will allow the rapid transmission of information. The provision should be made for regular briefings during all stages of the Development.

- Data collected during the EIS and monitoring programme will be important in linking climate, weather and physical / chemical conditions to ecological variables such as coral cover and health, seagrass density, benthic diversity and marine mammal, reptile and bird populations. It is recommended that the publication of these data be encouraged and facilitated. It has previously been shown that publication of studies conducted during an EIS process can be valuable information for the public, media and scientific community, and has the added benefit of encouraging and demonstrating that Environmental Best Practice is maintained.

- Listed and threatened species inhabiting Cleveland Bay are those most directly at risk from potential impacts of the TOT Development, In recognition of the precautionary principle, and in light of the absence of long term data (specifically in relation to the Snubfin Dolphin), numerical monitoring for this specific species may be considered. It is therefore recommended, that in addition to the habitat and water quality monitoring strategies outlined above, consideration be given to a boat based monitoring programme designed to target dolphin populations, but also records other listed species in Cleveland Bay. It must be identified, however, that should such numerical monitoring occur, it is unlikely that any direct causal correlation between species numbers and direct TOT activities could be discerned from other factors existing in Cleveland Bay.

11 CONCLUSIONS

The TOT Development is in close proximity to the GBRWHA. The marine environment in Cleveland Bay harbours a host of valuable and vulnerable ecological communities and species that are easily accessible to residents and visitors of Townsville and Magnetic Island. The presence of marine mammals and reptiles, the access to popular recreational fishing grounds, the relatively unpolluted beaches, and the opportunity to visit coral reefs, are resources highly valued by the resident communities. This ease of access, and high levels of use, also adds to the vulnerability of these communities and species, as they already exist under the high levels of pressure associated with coastal environments in the vicinity of large human settlements. New developments must therefore be assessed, not as discreet impacts, but together with the cumulative impacts of a large city and a busy port.

The proposed development is sited within an area of complex interactions between Local, State and Federal jurisdictions, each with their own specific, and often inconsistent, environmental assment criteria. The most contentious points of conflict possibly result from the existence of a relatively large coastal city with an active export and import Port within zones of Marine National Parks and World Heritage Areas. The anthropogenic settlement and associated activities imply a degree of impact, whereas National Parks and World Heritage Areas imply relatively pristine conditions. This contradiction means that while the Development itself has to be assessed against the stringent conditions relating to developments in protected areas, these conditions themselves have to be assessed against the background impacted conditions. Thus, in these circumstances, it is believed that a criteria of “no significant proportional increase over existing ambient conditions in Cleveland Bay” should be used as an assessment criteria.

To ensure that the environmental health and sustainability of the Development is maintained as independently as possible from its immediately adjacent environments, it is essential that the Development adopt the highest possible environmental standards. This means that the potential for contamination and algal blooms within the Development must be minimised by adequate flushing and suitable Operational Management Strategies. This flushing must be such that it can cope with the inputs from small freshwater storm in-flow events. This has been modelled to be the case.

Water Quality

New developments must be assessed, not as discreet impacts, but together with the cumulative impacts of a large city and a busy port. It is believed that adequate prevention measures and monitoring will prevent impacts from this development occurring. These prevention measures must include adequate flushing and annual maintenance dredging to ensure all current water and sediment qualities are maintained.

During all phases of this development, the highest priority must be placed on protecting water quality, sediment quality, seagrass beds and coral reefs. Cleveland Bay is of high ecological value to species and communities of commercial and conservation significance. Providing adequate flushing and annual maintenance dredging occurs, water and sediment quality will be maintained. The maintenance of current water and sediment quality is critical to the project, both during the construction and operational phases of the Development.

Water and sediment quality will be the first environmental components affected by the development,, and any impact on them is almost certain to affect the flora and fauna of Cleveland Bay. Water quality in particular can be used as an "early warning system" for the protection of marine communities.

Water Quality Monitoring

If adequate flushing occurs and annual maintenance dredging of the marina bottom sediments is carried out, then:

- Water quality will be better than the ANZECC (2000) 2000 95% Species Protection Guidelines, or within ambient ranges currently existing in the Bay close to the Development, or both; and
- Bottom sediment quality will be very similar to that already existing in the Bay, and will meet Queensland HIL-A Soil Guidelines. An implication of this level is that all sediment dredged from the marine must be disposed of to land.

If water and sediment quality are maintained at current conditions, then it is considered that the project is sustainable. It is stressed that given the high environmental values of the corals, seagrass beds, and other flora and fauna of the Bay, maintenance of this water and sediment quality is vital to the sustainability of these ecosystems and the viability of the project. To this end, a stringent monitoring programme involving:

- Continuous water quality monitoring, regular and event monitoring at designated locations, of corals, seagrasses, and their associated ecosystems;
- Regular and event monitoring at the same designated locations, of sediments and waters for a comprehensive range of chemical species including heavy metals and nutrients is necessary.

It is essential that the water and sediment within the Development area are efficiently flushed even though some of the immediately surrounding waters may be of lower environmental standards. Efficient flushing will ensure that the possibility of contaminant and nutrient build-up within the partially enclosed waters of the Development is minimised.

Locally, the immediate downflow receptors of the waters flushed from the Development may be significantly impacted from anthropogenic activities. However the waters adjacent to these, within the Marine National Park and World Heritage Area will be less impacted. It is into these higher quality waters that the mixed waters from the Development will eventually flow. Thus, for there to be no impact on these specific waters from those of the Development, it is necessary for the flushed waters to meet the higher standards even though they may initially interact with waters of lower quality.

Additionally, as indicated earlier, for the waters of the Development with their restricted flow regime to be both environmentally sustainable and healthy, then the waters present within and flushed from the Development must be of a high standard. Such a strategy will prevent the development of undesirable environmental features such as algal blooms.

These requirements imply that while assessments can be made of the Development in isolation, the assessment must also include its local context within an impacted area. The argument is made throughout this document that for the sustainability of the Development itself, water quality standards should possibly be higher than those applied to the immediately adjacent waters. However, in other areas, the proportionality mantra of “no significant proportional increase over existing ambient conditions in Cleveland Bay overall” should be applied. Such areas include noise, light and environmental impact, and undoubtedly the Development will lead to an increase in these parameters, but given the background of the Port and the City of Townsville, any increase is expected to be within the level of background variation.

Within an isolated context of just the Development on its own, many of the risks would carry a risk level of very high to extreme. When modified by the proportionality mantra, the overall, additional, risk level has to be reduced to low to very low risk. For example the death of one mammal per year is, in the absolute sense, too high and totally undesirable, but the increase in the probability of this event occurring due to factors relating to this Development alone, are extremely low. However, this statistical reasoning must not be considered a license to abuse the situation and all care must be taken to ensure that this statistically low probability is not supplemented by numerous other events that will ultimately bring about a “death by a thousand cuts” scenario.

This document, therefore, has been produced in an attempt to meet the stringent requirements of the Marine National Park and World Heritage Area legislation, but structured within a fabric of pragmatism for an environment that is already heavily modified.

It is highly probable that adequate prevention measures and careful monitoring will minimise impacts from this Development, but these prevention measures must include adequate flushing and annual maintenance dredging to ensure all current water and sediment qualities are maintained.

Adequate education and training of construction employees, future staff and residents will be imperative during all stages of the Development if water quality in its many forms is to be maintained. Visitor and resident education on the concept of “no off-site migration of pollutants” will be necessary to ensure water quality continuity during the operation of the Townsville Ocean Terminal,, It is also recommended that special regulations and restrictions be put in place regarding marina, household and gardening activities as part of the Body Corporate by-laws to maintain the quality of the waters and to avoid pollution of adjacent marine habitats.

It is concluded that if adequate flushing occurs and annual maintenance dredging of the marina bottom sediments is carried out, then water quality will be better than the ANZECC 2000 95% Species Protection Guidelines, or within ambient ranges currently existing in the Bay close to the Development, or both. Bottom sediment quality will be very similar to that already existing in the Bay, and will meet Queensland HIL-A Soil Guidelines. An implication of this level is that all sediment dredged from the marina must be disposed of to land.

If water and sediment quality are maintained at current conditions, and if the impacts from noise, marine debris, and vessel traffic are strictly controlled during construction and operation, then it is concluded that the Development is viable. However, it is stressed that given the high environmental values of the corals, seagrass beds, and other flora and fauna of the Bay, and their existence within an already highly modified environment, maintenance of this water and sediment quality is vital to both the sustainability of these ecosystems and the viability of the Development. To this end, a monitoring programme involving:

- Continuous water quality monitoring,
- Annual and event monitoring at designated locations, of corals, seagrasses, dolphins and their associated ecosystems, should be considered;
- Annual and event monitoring at the same designated locations, of sediments and waters for a comprehensive range of chemical species including heavy metals and nutrients. should continue for a minimum period of 5 years after the Development is completed.
- The assessment criteria of “no significant proportional increase over existing ambient conditions in Cleveland Bay overall” should be used as an assessment criteria.

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13 APPENDIX 1 – CORAL SPECIES LIST

Coral species list for Magnetic Island, supplied by Dr. C. Wallace from the Museum of Tropical Queensland database.

Family	Genus	species
Acroporidae	Acropora	aculeus
	Acropora	acuminata
	Acropora	aspera
	Acropora	cerealis
	Acropora	digitifera
	Acropora	cf glauca
	Acropora	cytherea
	Acropora	digitifera
	Acropora	elseyi
	Acropora	formosa
	Acropora	glauca
	Acropora	humilis
	Acropora	hyacinthus
	Acropora	latistella
	Acropora	longicyathus
	Acropora	microphthalma
	Acropora	millepora
	Acropora	muricata
	Acropora	nasuta
	Acropora	nobilis
	Acropora	pulchra
	Acropora	samoensis
	Acropora	tenuis
	Acropora	valida
	Acropora	spathulata
	Acropora	florida
	Anacropora	forbesi
	Montipora	aequituberculata
	Montipora	crassituberculata
	Montipora	digitata
	Montipora	efflorescens
	Montipora	floweri
	Montipora	foliosa
	Montipora	hispida
	Montipora	informis
	Montipora	mollis
	Montipora	peltiformis
	Montipora	spumosa
	Montipora	tortuosa

Family	Genus	species
	Montipora	turtlensis
	Montipora	undata
	Montipora	venosa
Astrocoeniidae	Madracis	kirbyi
Dendrophylliidae	Turbinaria	bifrons
	Turbinaria	frondens
	Turbinaria	mesenterina
	Turbinaria	peltata
	Turbinaria	reniformis
Faviidae	Cyphastrea	serailia
	Favia	favus
	Favia	maritima
	Favia	veroni
	Favites	abdita
	Favites	bennettae
	Favites	cf acuticollis
	Favites	flexuosa
	Favites	pentagona
	Favites	russelli
	Goniastrea	aspera
	Goniastrea	australensis
	Goniastrea	favulus
	Goniastrea	palauensis
	Goniastrea	pectinata
	Goniastrea	retiformis
	Leptastrea	purpurea
	Montastrea	valenciennesi
	Moseleya	latistella
	Moseleya	latistellata
	Oulophyllia	crispa
	Platygyra	daedalea
	Platygyra	lamellina
	Platygyra	sinensis
Fungiidae	Podabacia	crustacea
Merulinidae	Hydnophora	exesa
Mussidae	Lobophyllia	hataii
	Lobophyllia	hemprichii
	Scolymia	vitiensis
	Symphyllia	radians
Oculinidae	Galaxea	astreata
Poritidae	Goniopora	djiboutiensis
	Goniopora	lobata
	Goniopora	stutchburyi
	Porites	australiensis
	Porites	cylindrica
	Porites	lobata
	Porites	nigrescens
Siderastreidae	Coscinaraea	columna

Family	Genus	species
	Pseudosiderastrea	tayamai

14 APPENDIX 2: LIST OF PROTECTED SPECIES

List of vulnerable species compiled by ERIN for the Cleveland Bay area. Species listed by ERIN for the Development site itself are marked in bold.

	Species	Common Name	Qld[1]	EPBC[2]	J/C[3]	CMS[4]	CITES[5]	IUCN[6]
Birds	Anseranas semipalmata	Magpie goose		LM				LC
	Apus pacificus	Fork-tailed swift		LM	J			LC
	Ardea alba	Great egret		LM	C,J			
	Ardea ibis	Cattle egret		LM	C,J			
	Charadrius mongolus	Mongolian plover		LM	C,J			LC
	Erythrotriorchis radiatus	Red goshawk	E	V				VU
	Esacus neglectus	Beach stone curlew	V					
	Gallinago hardwickii	Japanese snipe		LM	C,J			LC
	Haliaeetus leucogaster	White-bellied sea-eagle		M, LM	C			LC
	Hirundapus caudacutus	White-throated needletail		M,LM	C			LC
	Hirundo rustica	Barn swallow		M,LM	C,J			LC
	Macronectes giganteus	Southern giant petrel	E					
	Macronectus halli	Northern giant petrel	V					
	Merops ornatus	Rainbow bee-eater		LM				LC
	Monarcha melanopsis	Black-faced monarch		M,LM				LC
	Monarcha trivirgatus	Spectacled monarch		LM				LC
	Myiagra cyanoleuca	Satin flycathcer		M,LM				LC
	Nettapus coromandelianus albipennis	Australian cotton pygmy-goose		LM				
	Numenius madagascariensis	Eastern curlew	R	LM	C,J			LC
	Numenius minutus	Little curlew		LM	C,J			LC
	Numenius phaeopus	Whimbrel		LM	C,J			LC
	Pterodroma arminjoniana heraldica	Herald petrel	E					
	Rhipidura rufifrons	Rufous fantail		M,LM				LC

	Species	Common Name	Qld[1]	EPBC[2]	J/C[3]	CMS[4]	CITES[5]	IUCN[6]
	Rostratula australis	Australian painted snipe		V				
	Rostratula benghalensis	Painted snipe	V	LM	C			LC
	Sterna albifrons	Little tern	E	LM	C			LC
Mammals	Balaenoptera acutorostrata	Minke whale		C			App I	LR/nt
	Balaenoptera edeni	Bryde's whale		M,C		App II	App I	DD
	Balaenoptera musculus	Blue whale		E,M,C		App I	App I	EN
	Delphinus delphis	Common dolphin		C			App II	LR/lc
	Dugong dugon	Dugong	V	M		App II	App I	VU
	Grampus griseus	Risso's dolphin		C			App II	DD
	Megaptera noaeangliae	Humpback whale	V	V,M,C		App I	App I	VU
	Orcaella heinsohni	Australian snubfin dolphin	R	M, LM				DD
	Sousa chinensis	Indo-Pacific humpbacked dolphin	R	M,C		App II	App II	DD
	Stenella attenuata	Spotted dolphin		C			App II	LR/cd
	Tursiops aduncus	Spotted bottlenose dolphin		C			App II	DD
	Tursiops truncatus	Bottlenose dolphin		C			App II	DD
Reptiles	Acalyptophis peronii	Horned seasnake		LM				
	Aipysurus duboisi	Dubois' seasnake		LM				
	Aipysurus edouxii	Spine-tailed seasnake		LM				
	Aipysurus laevis	Olive seasnake		LM				
	Astrotia stokesi	Stokes' seasnake		LM				
	Caretta caretta	Loggerhead turtle	E	E,M,LM		App I		EN
	Chelonia mydas	Green turtle	V	V,M,LM		App I	App I	EN
	Crocodylus porosus	Estuarine crocodile	V	M,LM		App II	App II	LR/lc
	Dermochelys coriacea	Leatherback turtle	E	V,M,LM		App I	App I	C&R
	Disteria kingii	Spectacled seasnake		LM				
	Disteria major	Olive-headed seasnake		LM				

	Species	Common Name	Qld[1]	EPBC[2]	J/C[3]	CMS[4]	CITES[5]	IUCN[6]
	Enhydrina schistosa	Beaked seasnake		LM				
	Eretmochelys imbricata	Hawksbill turtle	V	V,M,LM		App I		
	Hydrophis elegans	Elegant seasnake		LM				
	Hydrophis mcdowelli	Seasnake		LM				
	Hydrophis ornatus	Seasnake		LM				
	Lapemis hardwickii	Spine-bellied seasnake		LM				
	Laticauda colubrina	Sea krait		LM				
	Laticauda laticaudata	Sea krait		LM				
	Lepidochelys olivacea	Olive Ridley turtle	E	E,M,LM		App I		
	Natator depressus	Flatback turtle	V	V,M,LM				
	Pelamis platurus	Yellow-bellied seasnake		LM				
Ray-finned fishes	Acentronura tentaculata	Hairy pygmy pipehorse		LM				
	Campichthys tryoni	Tryon's pipefish		LM				
	Choeroichthys brachysoma	Short-bodied pipefish		LM				
	Choeroichthys suillus	Pig-snouted pipefish		LM				
	Chorythoichthys amplexus	Brown-banded pipefish		LM				
	Chorythoichthys flavofasciatus	Network pipefish		LM				
	Chorythoichthys intestinalis	Banded pipefish		LM				
	Chorythoichthys ocellatus	Ocellated pipefish		LM				
	Chorythoichthys paxtoni	Paxton's pipefish		LM				
	Chorythoichthys schultzi	Schultz's pipefish		LM				
	Cosmocampus darrosanus	D'Arros pipefish		LM				
	Cosmocampus maxweberi	Maxweber's pipefish		LM				
	Doryrhamphus dactyliophorus	Ringed pipefish		LM				
	Doryrhamphus excisus	Blue-stripe pipefish		LM				
	Festucalex cinctus	Girdled pipefish		LM				
	Festucalex gibbsi	Gibbs' pipefish		LM				

Species	Common Name	Qld[1]	EPBC[2]	J/C[3]	CMS[4]	CITES[5]	IUCN[6]
Halicampus dunckeri	Duncker's pipefish		LM				DD
Halicampus grayi	Gray's pipefish		LM				
Halicampus macrorhynchus	Ornate pipefish		LM				
Halicampus nitidus	Spiny-snout pipefish		LM				
Hippichthys cyanospilos	Blue-spotted pipefish		LM				
Hippichthys heptagonus	Reticulated freshwater pipefish		LM				
Hippichthys penicillus	Steep-nosed pipefish		LM				
Hippichthys spicifer	Banded freshwater pipefish		LM				
Hippocampus bargibanti	Pygmy seahorse		LM			App II	DD
Hippocampus histrix	Spiny seahorse		LM			App II	DD
Hippocampus kuda	Yellow seahorse		LM			App II	VU
Hippocampus planifrons	Flat-face seahorse		LM			App II	
Hippocampus zebra	Zebra seahorse		LM			App II	DD
Micrognathus andersonii	Anderson's pipefish		LM				
Micrognathus brevirostris	Thorn-tailed pipefish		LM				
Nannocampus pictus	Painted pipefish		LM				
Siokunichthys breviceps	Soft-coral pipefish		LM				
Solegnathus hardwickii	Pipehorse		LM				DD
Solenostomus cyanopterus	Robust ghost pipefish		LM				
Solenostomus paradoxus	Ornate ghost pipefish		LM				
Syngnathoides biaculeatus	Alligator pipefish		LM				
Trachyrhamphus bicoarctatus	Short-tailed pipefish		LM				
Trachyrhamphus longirostris	Straight stick pipefish		LM				

15 APPENDIX 3: RISK ASSESSMENT TABLES

Risk rating table, using both the likelihood and consequence of a potential impact.

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	High	High	Extreme	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Moderately likely	Low	Low	Medium	High	High
Unlikely	Minimal	Minimal	Low	Medium	High
Very unlikely	Minimal	Minimal	Low	Low	Medium

Marine Protected Areas Measures of consequence or impact (source: DEH).

Descriptor	Meaning (one or more of these may apply)
Insignificant	No injuries, damage to habitat, impact on species, or impacts on achievement of programme objectives Low financial loss or damage
Minor	First aid treatment Minor localised damage to habitat Minor impact on species Slight reduction in the abundance of one or more species (non-threatened) Slight deterioration in ecological communities in a limited area Medium financial loss Some community dissatisfaction Park or programme area is less able to achieve one or more objectives effectively On-site effects, immediately contained (e.g. fire, pollution) Low likelihood of legal action against Director National Parks
Moderate	Medical treatment of casualties required Significant localised habitat or environmental damage Some reduction of a species (non-threatened) Some deterioration in ecological communities in a substantial area High financial loss Park or programme area is unable to achieve one or more objectives effectively On-site effects, contained with outside assistance Disturbance of individual members of a species that is a key value of the Commonwealth Reserve Disturbance of a key value of the Commonwealth Reserve

Descriptor	Meaning (one or more of these may apply)
Major	Frequent repetition of an event that is of 'minor' consequence Adverse local media attention, significant community dissatisfaction and/or minor damage to Environment Australia's reputation and goodwill Medium likelihood of legal action against Director National Parks Fatalities and extensive injuries Expansive habitat or environmental damage Major reduction in abundance of several species (non-threatened) Significant deterioration in ecological communities in a substantial area Very high financial loss Disturbance of an aggregation of a species that is a key value of the Commonwealth Reserve
Catastrophic	Unnatural injury or death of a cetacean, a member of a listed threatened species, a member of a listed migratory species, a member of a listed marine species, or a member of a listed protected species (EPBC Act) Damage to a listed threatened ecological community Damage to a key value of the Commonwealth Reserve Repetition of an event that has moderate consequence The Department of the Environment and Heritage unable to achieve one or several principal objectives Off-site effects Adverse national media attention, strong community dissatisfaction and/or significant damage to Environment Australia's reputation and goodwill Significant political effects High likelihood of legal action against the Director National Parks Multiple fatalities Total destruction of habitat or environment Extreme reduction in abundance (or extinction) of one or more species Significant reduction in abundance of a threatened species Loss of ecological communities Loss of a key value of the Commonwealth Reserve Huge financial loss The Department of the Environment and Heritage unable to achieve many or all principal objectives Off-site effects with widespread detriment Sustained adverse national media coverage, intense community dissatisfaction and major damage to Parks Australia's reputation and goodwill Major political effects Very high likelihood of legal action against Director National Parks

Table 13: Marine Protected Areas measures of likelihood

Descriptor	Meaning
Almost certain	The event is expected to occur
Likely	The event will probably occur
Moderately likely	The event may occur in normal circumstances
Unlikely	The event may occur in unusual circumstances
Very unlikely	The event may occur in exceptional circumstances

16 APPENDIX 4: FISH SPECIES LIST

Explanations: CB: Cleveland Bay; RR: Ross River/Ross Creek. Migration: O: Oceanodromous: migrates within saltwater; A: Amphidromous: migrates between salt and freshwater, but not for breeding; An: Anadromous: live in saltwater, breed in freshwater; P: Potadromous: migrates within freshwater; C: Catadromous: live in freshwater, breed in saltwater; F: Commercial fisheries; *: minor, x: common, X: highly important; R: Recreational fisheries; A: Aquaculture; Q: Aquarium; IUCN: LR/nt: Low Risk / near threatened; DD: Data Deficient; LC: Least Concern; V: Vulnerable.

Family	Species	Common Name	CB	RR	Migration	F	R	Q	A	IUCN
Ambassidae (Asiatic glassfishes)	Ambassis interruptus	Long-spined glass perchlet		x	C					
	Ambassis nalua	Scalloped perchlet		x	A					
	Ambassis telkara	Vachelli's glass perchlet		x	O	*				
	Amniataba caudavittata	Yellowtail trumpeter		x						
Apogonidae (Cardinalfishes)	Apogon aureus	Ring-tailed cardinalfish	x		A	*		x		
	Apogon ellioti	Flag-in cardinalfish	x							
	Apogon kiensis	Rifle cardinal	x							
	Apogon poecilopterus	Pearly-finned cardinalfish	x							
	Apogon quadrifasciatus	Twostripe cardinal	x							
	Apogon septemstriatus	Seven-striped cardinalfish	x							
	Apogon sp.	Cardinalfish	x							
	Glossamia aprion	Mouth almighty		x						
	Siphamia roseigaster	Pink-breasted siphonfish	x							

Family	Species	Common Name	CB	RR	Migration	F	R	Q	A	IUCN
Ariidae (Catfishes)	Arius maculatus	Spotted catfish	x		P	x				
	Arius thalassinus	Giant seacatfish	x		A	x	x			
Atherinidae (Silversides)	Atherinomorus endrachtensis	Eendracht land silverside		x						
	Hypoatherina temminckii	Samoan silverside		x						
Belonidae (Needlefishes)	Strongylura strongylura	Spottail needlefish	x	x		x				
Bothidae (Left-eye flounders)	Engyprosopon grandisquama	Largescale flounder	x			x				
	Pseudorhombus argus	Peacock flounder	x							
	Pseudorhombus arsius	Large-toothed flounder	x	x	O	x	x			
	Pseudorhombus dupliciocellatus	Ocellated flounder	x			x				
	Pseudorhombus elevatus	Deep flounder	x			x				
	Pseudorhombus jenynsii	Small-toothed flounder	x			x				
	Pseudorhombus spinosus	Spiny flounder	x			x				
Callionymidae (Dragonets)	Callionymus sagitta	Arrow dragonet		x						
	Callionymus superbus	Proud dragonet	x							
	Dactylopus dactylopus	Fingered dragonet	x					x		
Carangidae (Trevally)	Absalom radiatus	Fringe-finned trevally	x			*	x			
	Alectis indicus	Indian threadfish	x			x	x	x		
	Alectis ciliaris	African pompano	x			*	x	x		
	Alepes djedaba	Shrimp scad	x			x	x			
	Alepes sp.	Scad	x			x				
	Atule mate	Yellowtail scad	x			*	x			
	Caranx bucculentus	Bluespotted trevally	x			*	x			
	Caranx ignobilis	Giant trevally	x	x		x	x	x	x	
	Caranx melampygus	Bluefin trevally	x			x	x	x	x	
	Caranx para	Razorbelly scad	x			*				
	Caranx sexfasciatus	Bigeye trevally	x	x	A	x	x			
	Carangoides chrysophrys	Longnose trevally	x			x	x			
	Carangoides	Blue trevally	x			x	x			

Family	Species	Common Name	CB	RR	Migration	F	R	Q	A	IUCN
	ferdau									
	Carangoides fulvoguttatus	Yellowspotted trevally	x			x	x			
	Carangoides hedlandensis	Bumpnose trevally	x			x	x			
	Carangoides humerosus	Duskyshoulder trevally	x							
	Carangoides malabaricus	Malabar trevally	x		A	x	x			
	Carangoides talamparoides	Imposter trevally	x			x				
	Carangoides uii (coeruleopinnat us)	Coastal trevally	x			*	x			
	Megalaspis cordyla	Torpedo scad	x			X				
	Scomberoides commersonianu s	Talang queenfish	x	x	A	*	x			
	Scomberoides lysan	Double-spotted queenfish	x	x		x	x			
	Scomberoides tala	Barred queenfish	x	x		*				
	Scomberoides tol	Needlescaled queenfish	x	x		*	x			
	Scomberomorus semifasciatus	Broadbarred king mackerel	x	x	O	x	x			
	Selar boops	Oxeye scad	x			x				
	Selar crumenophthal mus	Bigeye scad	x			X	x			
	Selaroides leptolepis	Yellowstripe scad	x		A	x				
	Trachinotus blochii	Snubnose pompano	x	x		*	x	x	x	
	Ulua aurochs	Silvermouth trevally	x			*				
Carcharhinidae (Requiem sharks)	Carcharhinus brevipinna	Spinner shark	x		O	x	x			LR/nt
	Carcharhinus cautus	Nervous shark	x			*				DD
	Carcharhinus fitzroyensis	Creek whaler	x			*				LC
	Carcharhinus melanopterus	Blacktip reef shark	x		A	x		x		LR/nt
	Carcharhinus sorrah	Spottail shark	x			*				
	Loxodon macrorhinus	Sliteye shark	x			x	x			LC

Family	Species	Common Name	CB	RR	Migration	F	R	Q	A	IUCN
	Negaprion acutidens	Sicklefin lemon shark	x			x				V
	Rhizoprionodon acutus	Milk shark	x		A	x	x			LC
	Rhizoprionodon taylori	Australian sharpnose shark	x							LC
Centriscidae (Razorfishes)	Centriscus scutatus	Grooved razorfish	x					x		
Chanidae (Milkfish)	Chanos chanos	Milkfish		x	C	x	x		x	
Chirocentridae (Wolf herring)	Chriocentrus dorab	Dorab wolf-herring	x		A	x	x			
Cichlidae (Cichlids)	Oreochrimis mossambicus	Moxambique tilapia		x						
Clupeidae (Sardine, herring)	Amblygaster sirm	Spotted sardinella	x			x				
	Anodotostoma chacunda	Chacunda gizzard shad	x	x	An	x				
	Dussumieria elopsoides	Slender rainbow sardine	x			*				
	Escualosa thoracata	White sardine	x	x	A	x				
	Herklotsichthys castelnaui	Castelnau's herring		x		*				
	Herklotsichthys koningsbergeri	Koningsberger's herring	x		An					
	Herklotsichthys lippa	Australian spotted herring	x							
	Ilisha sp.	Ilisha	x							
	Nematalosa come	Western Pacific gizzard shad	x	x						
	Nematalosa erebi	Bony bream		x	P	x				
	Pellona dayi	Day's pellona	x							
	Pellona ditchella	Indian pellona	x		An	x				
	Sardinella albella	White sardinella	x	x		x				
	Sardinella gibbosa	Goldstripe sardinella	x			X				
Cynoglossidae (Tongue soles)	Cynoglossus bilineatus	Fourlined tongue sole	x			x				
	Cynoglossus macrophthalmus	Big-eyed tongue sole	x							
	Cynoglossus puncticeps	Speckled tonguesole		x		x				
	Paraplagusia bilineata	Doublelined tongue sole	x	x						

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	Paraplagusia guttata	Flatfish		x						
Dasyatidae (Stingrays)	Himantura uarnak	Honeycomb stingray		x	A	x	x	x		
Diodontidae (Porcupinefishes)	Tragulichthys jaculiferus	Longspine burrfish	x							
Eleotridae (Sleepers)	Butis butis	Duckbill sleeper		x	A	*				
Elopidae (Tenpounders)	Elops hawaiiensis	Hawaiian ladyfish		x	An	x			x	
Engraulidae (Anchovy)	Encrasicholina devisi	Devis' anchovy		x		*				
	Setipinna tenuifilis	Common hairfin anchovy	x		A	*				
	Stolephorus carpentariae	Gulf of Carpentaria anchovy		x						
	Stolephorus commersonii	Commerson's anchovy		x	An	x				
	Stolephorus indicus	Indian anchovy	x		O	*				
	Stolephorus nelsoni	Nelson's anchovy	x	x						
	Stolephorus devisi	Devis' anchovy	x			*				
	Thryssa aestuaria	Estuarine thryssa	x							
	Thryssa hamiltoni	Hamilton's thryssa	x	x	A	x				
	Thryssa setirostris	Longjaw thryssa	x	x		*				
Ephippidae (Batfishes)	Drepane punctata	Spotted sicklefish	x	x	A	x		x		
	Drepane longimana	Concertina fish	x		A	*		x		
	Platax teira	Tiera batfish	x		A	*	x	x		
Fistulariidae (Flutefishes)	Fistularia commersonii	Bluespotted cornetfish	x			*		x		
Formionidae (Eye-brow fishes)	Apolectus niger	Cobia	x		O	*		x	x	
Gerreidae (Silver biddies)	Gerres erythrourus	Deep-bodied mojarra		x	A	*				
	Gerres filamentosus	Whipfin silver-biddy	x	x	A					
	Gerres oyena	Common silver-biddy		x		x				
	Gerres subfasciatus	Common silver belly	x							

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	Pentaprion longimanus	Longfin mojarra	x			*				
Gobiidae (Gobies)	Acentrogobius viridipunctatus	Spotted green goby		x	O					
	Bathygobius cocosensis	Cocos frill-goby		x				x		
	Ctenogobius criniger	Hair-finned goby		x						
	Glossogobius celebius	Celebes goby		x	A	*				
	Istiogobius ornatus	Ornate goby		x				x		
	Psammogobius biocellatus	Twinspot gudgeon		x	A					LR/nt
	Taenioides cirratus	Bearded worm goby		x	A					
	Yongeichthys nebulosus	Shadow goby		x						
Gymnuridae (Butterfly rays)	Gymnura australis	Australian butterfly ray	x			*				
Haemulidae (Sweetlips)	Pomadasys argenteus	Silver grunt	x	x		x				
	Plectorhinchus gibbosus	Harry hotlips	x			x	x			
	Pomadasys kaakan	Javelin grunter	x	x		x	x		x	
	Pomadasys maculatus	Saddle grunt	x	x	A	x				
Hemigaleidae (Fossil sharks)	Hemigaleus microstoma	Sicklefin weasel shark	x			*				LC
Hemiramphidae (Garfish)	Arrhamphus sclerolepsis	Northern snubnose garfish		x	A	x	x			
	Hyporhamphus affinis	Tropical halfbeak	x	x						
	Hyporhamphus quoyi	Quoy's garfish		x						
Lactariidae (False trevally)	Lactarius lactarius	False trevally	x			x				
Latidae (Barramundi)	Lates calcarifer	Barramundi	x	x	C	X	X	x	x	
Leiognathidae (Ponyfishes)	Gazza achlamys	Small-toothed ponyfish	x	x		*				
	Gazza minuta	Toothpony	x	x		x				
	Leiognathus bindus	Orangefin ponyfish	x	x	A	*				
	Leiognathus blochii	Twoblotch ponyfish	x		A	x				
	Leiognathus decorus	Decorated ponyfish	x	x	A					
	Leiognathus	Common	x	x		x			x	

Family	Species	Common Name	CB	RR	Migration	F	R	Q	A	IUCN
	equulus	ponyfish								
	Leiognathus moretoniensis	Moreton Bay ponyfish	x	x						
	Leiognathus smithursti	Smithurst's ponyfish		x		*				
	Leiognathus splendens	Splendid ponyfish	x	x	A	x				
	Secutor insidiator	Pugnose ponyfish	x		A	x				
	Secutor ruconius	Deep pugnose ponyfish	x	x	A	*				
Leptobranmidae (Salmon)	Leptobrama mulleri	Beachsalmon	x	x						
Lutjanidae (Snapper)	Lutjanus argentimacultus	Mangrove jack	x	x	O	x	x			
	Lutjanus fulviflamma	Dory snapper	x	x		x	x	x		
	Lutjanus erythropterus	Crimson snapper	x			x			x	
	Lutjanus malabaricus	Malabar blood snapper	x			X	x	x		
	Lutjanus russelli	Russell's snapper	x	x		x			x	
Macrouridae (Rattails)	Trachyrincus longirostris	Slender unicorn rattail		x						
Megalopidae (Tarpons)	Megalops cyprinoides	Tarpon		x	A	*			x	
Monacanthidae (Leatherjackets)	Monacanthus chinensis	Fan-bellied leatherjacket	x			*				
	Paramonacanthus filicauda	Threadfin leatherjacket	x							
	Paramonacanthus japonicus	Hairfinned leatherjacket	x							
Monodactylidae (Fingerfishes)	Monodactylus argenteus	Siver moony		x		*		x		
Mugilidae (Mullet)	Liza subviridis	Greenback mullet		x	A	x			x	
	Liza vaigiensis	Squaretail mullet		x	A	x		x	x	
	Mugil cephalus	Flathead mullet	x	x	C	X	x		x	
	Valamugil buchanani	Bluetail mullet		x	A	x				
Mullidae (Goatfishes)	Parupeneus chrysopleuron	Yellow striped goatfish	x							
	Upeneus asymmetricus	Asymmetrical goatfish	x							
	Upeneus bensasi	Bensasi goatfish	x			*				
	Upeneus luzonius	Drak-barred goatfish	x							

Family	Species	Common Name	CB	RR	Migration	F	R	Q	A	IUCN
	Upeneus moluccensis	Goldband goatfish	x			x				
	Upeneus sulphureus	Sulphur goatfish	x	x	O	*		x		
	Upeneus sundaicus	Ochre-barred goatfish	x			x				
	Upeneus tragula	Freckled goatfish	x			x		x		
Nemipteridae (Threadfin bream)	Nemipterus furcosus	Forktailed threadfin bream	x			x				
	Nemipterus hexodon	Ornate threadfin bream	x			*				
	Nemipterus mesoprion	Mauvelip threadfin bream	x			*				
	Nemipterus nematopus	Yellow-tipped threadfin bream	x							
	Nemipterus peronii	Notchedfin threadfin bream	x			x				
Pegasidae (Seamoths)	Pegasus volitans	Longtail seamoth		x						DD
Platycephalidae (Flatheads)	Elates ransonneti	Dwarf flathead	x			*				
	Inegocia japonica	Japanese flathead	x			*				
	Platycephalus arenarius	Sand flathead		x			x			
	Platycephalus endrachtensis	Bar-tailed flathead	x	x						
	Platycephalus fuscus	Dusky flathead		x		x	x			
	Suggrundus harrisii	Harris's flathead	x							
Plotosidae (Eel-tailed catfish)	Euristhmus nudiceps	Naked-headed catfish	x							
	Cnidoglanis macrocephalus	Cobbler	x			*	x			
Polynemidae(Threadfin salmon)	Eleutheronema tetradactylum	Fourfinger threadfin		x	A	X			x	
	Polydactylus multiradiatus	Australian threadfin	x							
	Polydactylus plebeius	Striped threadfin	x			x	x			
Priacanthidae (Big eyes)	Priacanthus hamrur	Moontail bullseye	x			*		x		
	Priacanthus	Red bigeye	x		O	x				

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	macracanthus									
	Priacanthus tayenus	Purple-spotted bugeye	x			*				
Psettodidae (Flat fish)	Psettodes erumei	Indian spiny turbot	x			x				
Pseudomugilidae (Blue-eyes)	Pseudomugil signifer	Southern blue-eye		x						
Rhynchobatidae (Shovel-nosed rays)	Rhynchobatus djiddensis	Giant guitarfish	x			x	x	x		V
Scatophagidae (Scats)	Scatophagus argus	Scat		x	A	x		x	x	
	Selenotoca multifasciata	Spotbanded scat		x	A	*		x		
Sciaenidae (Jewfishes)	Atrobucca brevis	Drum/croaker	x							
	Austronibea oedogenys	Yellowtail croaker	x			*				
	Johnius amplycephalus	Bearded croaker	x			*				
	Johnius borneensis	Sharpnose hammer croaker		x		*				
	Johnius coitor	Coitor croaker	x		A	*				
	Johnius vogleri	Sharpnose hammer croaker	x			*				
	Nibea semifasciata	Sharpnose croaker	x			x				
	Pennahia macrocephalus	Bighead pennah croaker	x			X				
	Otolithes ruber	Tiger-toothed croaker	x		A	x	x			
Scombridae (Mackerels)	Auxis rochei	Bullet tuna	x		O	X	x			
	Rastrelliger brachysoma	Short mackerel	x		O	X	x			
	Scomber australasicus	Blue mackerel	x		O	x	x			
	Scomberomorus commerson	Narrow barred Spanish mackerel	x		O	X	x			
	Scomberomorus guttatus	Indo-pacific king mackerel	x		O	X	x			
	Scomberoides lysan	Doublespotted queenfish	x			*	x			
	Scomberomorus munroi	Australian spotted mackerel	x		O	x	x			
	Scomberomorus	Queensland	x		O	x	x			

Family	Species	Common Name	CB	RR	Migration	F	R	Q	A	IUCN
	queenslandicus	school mackerel								
	Scomberomorus semifasciatus	Broadbarred king mackerel	x		O	x	x			
	Scomberomorus tala	Barred queenfish	x			*				
Scorpaenidae (Scorpionfishes)	Apistops caloundra	Short-armed waspfish	x							
	Dendrochirus zebra	Zebra turkeyfish	x			*		x		
Serranidae (Rock cod)	Epinephelus coioides	Orange-spotter grouper	x	x		x			x	NT
	Epinephelus malabaricus	Malabar grouper	x	x	A	X	x		x	NT
	Epinephelus sexfasciatus	Sixbar grouper	x			x				
Siganidae (Rabbitfishes)	Siganus fuscescens	Mottled spinefoot	x		O	x			x	
	Siganus lineatus	Golden-lined spinefoot	x	x		x		x		
	Siganus spinus	Little spinefoot		x		*		x		
Sillaginidae (Whiting)	Sillago analis	Golden-lined sillago		x		x			x	
	Sillago burrus	Western trumpeter sillago	x	x	O	*				
	Sillago ciliata	Sand sillago		x		X	x			
	Sillago maculatum burra	Northern whiting	x	x	A				x	
	Sillago sihama	Winter whiting	x	x			x			
	Sillago vittata	Banded sillago	x		O	*				
Soleidae (Soles)	Dexillichthys muelleri	Tufted sole	x	x		x				
Sparidae (Porgies)	Acanthopagrus australis	Surf bream		x	O	x	x		x	
	Acanthopagrus berda	Picnic seabream		x	O	x	x	x	x	
Sphyraenidae (Barracudas)	Sphyraena forsteri	Bigeye barracuda	x			x	x			
	Sphyraena obtusata	Obtuse barracuda	x			x	x			
	Sphyraena putnamiae	Sawtooth barracuda	x			x				
	Sphyraena barracuda	Great barracuda	x	x		*	x	x		
Synanceiidae (Stonefishes)	Synancea horrida	Estuarine stonefish		x				x		
Synodontidae (Lizardfishes)	Saurida gracilis	Gracile lizardfish		x		x				

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	Saurida longimanus	Longfin lizardfish	x			x				
	Saurida micropectoralis	Shortfin lizardfish	x							
	Saurida sp.	Lizardfish	x							
	Saurida tumbil	Greater lizardfish	x		A	x				
	Saurida undosquamis	Brushtooth lizardfish	x		A	x				
	Synodus hoshinonis	Blackear lizardfish	x			*				
Terapontidae (Tigerperches)	Pelates sexlineatus	Six-lined trumpeter	x	x						
	Pelates quadrilineatus	Four-lined terapon	x	x		*				
	Terapon jarbua	Jarbua terapon		x	C	*			x	
Tetraodontidae (Puffers)	Arothron stellatus	Starry toadfish		x						
	Arothron manilensis	Narrow-lined puffer		x						
	Chelonodon patoca	Milkspotted puffer	x	x	An	*				
	Marilyna pleurosticta	Pufferfish		x	An					
	Tetractenos hamiltoni	Pufferfish		x						
Tetrarogidae (Waspfishes)	Tetraroge barbata	Bearded roguefish		x						
Uranoscopidae (Stargazers)	Ichthyscopus lebeck	Longnosed stargazer		x						