CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

Chapter B7: Marine Ecology

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B7.1 Introduction

This chapter describes the existing ecology of the marine environment in the vicinity of the Cairns Shipping Development Project (the project), and identifies potential impacts associated with the project. This chapter principally addresses Section 5.4.3 of the Environmental Impact Statement (EIS) Terms of Reference (ToR) (The Coordinator-General 2012); and Sections 5.6, 5.9 and relevant parts of Section 5.10 of the Commonwealth Guidelines for the Cairns Shipping Development Project EIS (DSEWPAC/GBRMPA 2013).

The chapter specifically describes:

- the key features of the existing environment in the study area, focusing on important or sensitive marine ecological resources and the integrity of coastal ecosystems
- possible impacts on marine ecology values and components from dredging and tailwater discharges associated with the project
- potential impacts on the marine environment from the construction and operation of the expanded port facilities
- options for managing and mitigating identified impacts.

B7.1.1 Nomenclature and Terminology

For the purpose of this chapter, the following terminology has been adopted (**Figure B7-1**):

- The term study area refers to all waters within Cairns Harbour, Trinity Inlet, and adjacent waters extending just past Double Island to the north and Cape Grafton to the east
- The project areas include:
    - *Terminal site* – refers to the Cairns Cruise Liner Terminal (CCLT) and the proposed minor wharf infrastructure upgrade construction footprint and immediate surrounds for the project, including existing cruise shipping wharves 1-5 and the construction footprint for associated ship services, including fuel supply, potable water and fire-fighting services
    - *Northern Sands dredged material placement area (DMPA)* – the onshore placement site for soft clay material on the Barron delta
    - *Dredge Pump-out and pipeline alignment* – the proposed location offshore from Richters Creek for pumping material from the dredge to the Northern Sands DMPA
    - *Existing (and alternative) offshore DMPA* – the existing offshore dredge material placement site for maintenance dredging associated with this project and an alternative site in deeper water that was investigated as part of the previous EIS
    - *Dredge footprint* refers to the outer channel, swing basins, inner channels and berth pockets that will be subject to capital dredging, and subsequent future maintenance, as a result of this project

The *surrounding area* refers to the intertidal and subtidal waters within 20 km of the study area.

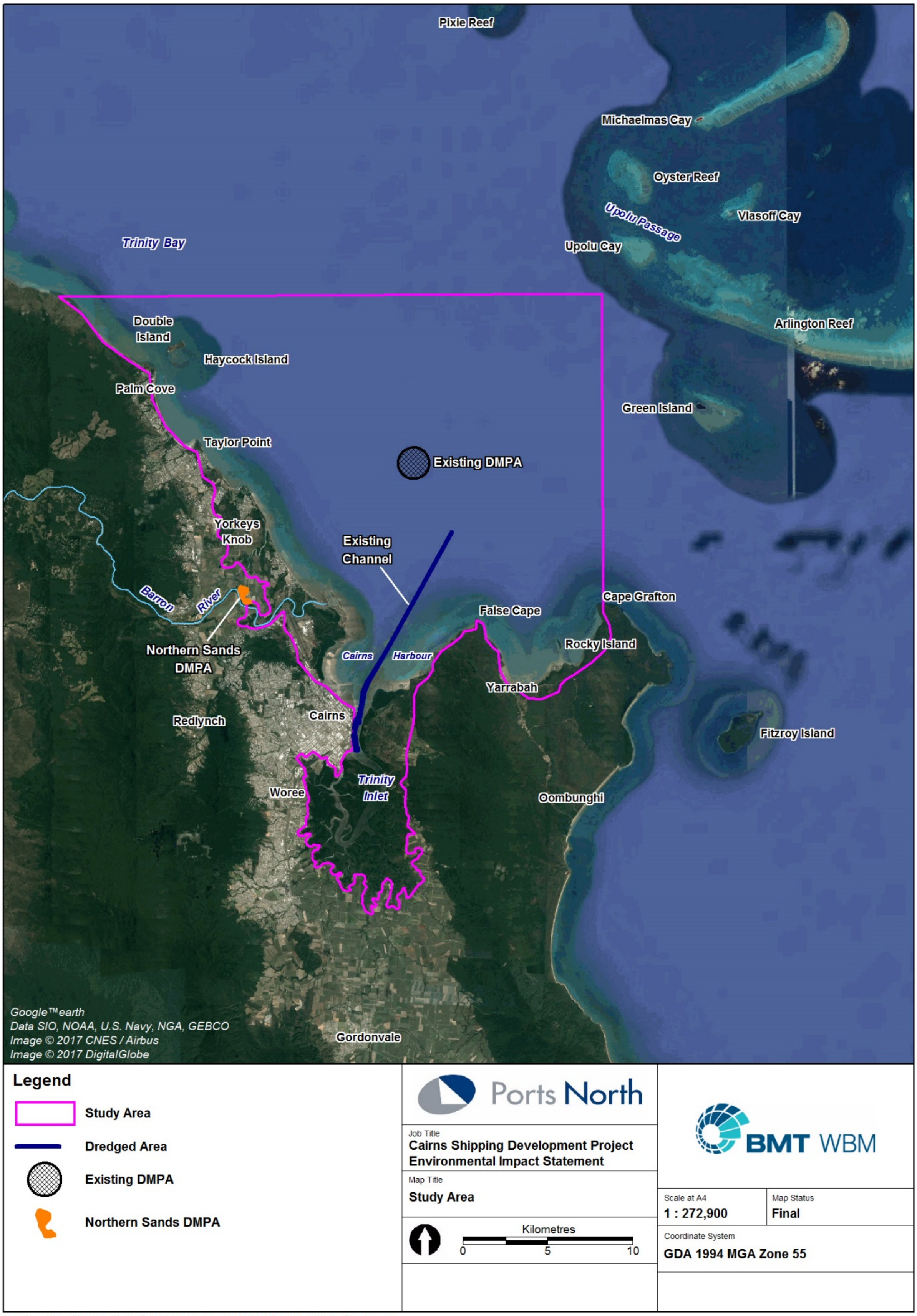

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Figure B7-1 Location of the Study Area and Project Areas.

B7.2 Existing Situation

B7.2.1 Methodology

Flora and fauna species, communities and habitats within the study area and surrounds were defined through searches of relevant databases, a review of previous studies, and where there was inadequate existing information, through supplementary field investigations. Searches were undertaken through the following databases: EPBC Protected Matters Search Tool; DEHP Wildlife Online database and DEHP StrandNet database. Relevant studies are cited in the text.

In order to source additional locally-specific information on marine megafauna in the Cairns area (e.g. turtles, dolphins, dugongs, etc.), consultation was undertaken with representatives from a range of state and federal government departments and local business operators, including:

- Mark Read (Great Barrier Reef Marine Park Authority).
- Ian Osbourne and Julie Dutoit (Department of National Parks, Recreation, Sport and Racing).
- Col Limpus and Justin Meager (Department of Environment and Heritage Protection).
- Jeffrey Krause (Department of Agriculture, Fisheries and Forestry).
- Noleen Brown (Department of Science, Information Technology, Innovation and the Arts).
- Dale Mundraby (Djunbunji Land and Sea Program).
- Isabel Beasley (James Cook University).
- Jennie Gilbert (Cairns Turtle Rehab Centre).
- Emma Scott (Wavelength Charters).
- Tim North (Reef Magic Cruises).

Information gaps were identified in the initial stages of the baseline reporting process; hence supplementary field surveys were undertaken to fill key gaps. The following field surveys were undertaken:

- Soft sediment habitat types and epifauna communities. Soft sediment habitats within and adjacent to the project areas were mapped using acoustic techniques. Single beam sonar data were analysed using Quester Tangent Corporation (QTC) software packages and a preliminary acoustic habitat class map was derived. Ground- truthing was then carried out to assess the sediment types within each acoustic habitat class, and to characterise epibenthic communities within each habitat class. Sediment types were sampled through grab based sampling and subsequently subject to sieve analysis to determine particle grain size distribution. Epibenthic communities were sampled using either a towed underwater video camera, or beam trawl, which was deployed at a total of 25 sites. The relative abundance of taxa recorded at each site (as recorded on a single transect line, standardised for four minutes) was then assessed.
- Side-scan acoustic surveys at locations in Trinity Bay and the Barron River. The presence of hard and structural habitat was investigated using side-scan sonar in the pipeline alignment offshore from Richters Creek and throughout the Lower Barron River. Remote assessments of seagrass communities along the northern beaches were also conducted.
- Benthic infauna communities. A total of 47 sites were sampled at representative areas within the project areas and additional 'control' areas outside the disturbance footprint but within the study area and surrounds. Replicate 1.28 m2 van Veen grab samples were collected at each site, sieved through a 0.5 mm screen and preserved in a 10 percent buffered formalin solution. Samples were sent to Stephen Cook (Dardanus Scientific) for identification and enumeration of each taxa. Summary statistics for abundance and taxa richness were derived, and multivariate statistical analysis was used to explore spatial patterns in community structure.
- Shoreline Assessment. Intertidal communities were surveyed during spring low-tide periods to assess the major community constituents of rocky shores at East Trinity, False Cape, and Rocky Island.

- Coral Surveys. Surveys of coral community composition and gross reef geomorphology were undertaken at Double Island and Rocky Island. Methods focused on i) quantifying benthic communities at various distances from the reef edge, and ii) mapping an indicative boundary of the reef edge and different reef habitats (i.e. ecotones). This was undertaken using a combination of photographic transects for Coral Point Count analysis, together with GPS and GIS mapping tools.
- Fishing and Crabbing Surveys. A single dry season survey of commercially and recreationally significant fish and crab species was conducted at 8 sites in East Trinity and Trinity Inlet, while seasonal surveys were conducted at 4 sites in the Barron River.
- Baseline mapping of seagrass and benthic macroinvertebrate communities. James Cook University (JCU) conducted baseline mapping assessments of seagrass and macroinvertebrate communities specifically for this EIS. These assessments focused on Trinity Inlet, Cairns Harbour and Trinity Bay. Specific methodologies can be found in the relevant JCU reports (McKenna *et al.* 2013, Rasheed *et al.* 2013, Jarvis *et al.* 2014, York *et al.* 2016).

A description of sampling and analysis methods, including maps of sampling locations, is provided in Appendix AN (Additional Marine Ecology Baseline Studies).

Extensive detailed seagrass and macrobenthic surveys were also undertaken by James Cook University (JCU) TropWATER throughout the Trinity Inlet and Cairns harbour area. Key findings of these surveys have been incorporated into the following existing environment description. The detailed TropWATER reports – including full methodology and results – are attached as Appendix AN (Additional Marine Ecology Baseline Studies).

B7.2.2 Background

Cairns harbour is a shallow, north-facing coastal embayment located adjacent to the city of Cairns. Cairns harbour is a low energy environment that is the receiving environment for several coastal drainages, including Trinity Inlet, Barron River and several coastal creeks. Due to its shallow depths and the plentiful supply of fine terrigenous sediments from the Barron River and other coastal drainages, wind and tidal currents regularly result in re-suspension of sediments and high turbidity within Trinity Bay.

Trinity Inlet is a large estuary that is fed by several minor drainages including Skeleton, Chinaman, Blackfellows, Wrights, Redbank, Wahday, Falls and Seelee Creeks. It is thought that the Trinity Inlet once formed the mouth of the Mulgrave River, but was diverted southwards as a result of sediment accumulation on the coastal plain. As Trinity Inlet is not flushed by a major river, it represents a tidally dominant system with less variation in salinity than is usual in estuaries in high rainfall areas (Perry 1995). The coastal drainages, together with Admiralty Island, form a complex bio-physical setting that provides important habitats for a range of estuarine plant and animal species (Perry 1995; WBM 1997).

The Barron River is a highly modified system; the major factors influencing its water quality and ecology include alterations to its catchment (particularly in the lower reaches), flow regulation further upstream of the project, and fishing pressure. The catchment surrounding the lower Barron River is heavily modified and only a thin strip of native riparian vegetation remains over much of its length since it was cleared in the late 1800s. Prior to 1939, the Barron River mouth opened into Trinity Inlet further south, towards Ellie Point.

The East Trinity Reserve area consists of a large wetland complex that is transitioning from a highly degraded acid lake into a modified intertidal wetland. Tidal influence was removed from the site in the early 1970s when a bund wall and tide gates were installed. The combined loss of tidal regime and earthworks resulted in intense acidification. The State Government began remediation from the mid 2000's using tide gates to dampen the tidal signal and neutralise acidity by adding soluble lime during incoming tide phases. These changes have resulted in extensive vegetation changes, dieback phases and subsequent mangrove re-colonisation upon return to a tidal state.

Cairns harbour, Trinity Inlet, East Trinity, and the Barron River contain highly valued ecological communities including:

- A wide diversity of marine habitat types including sandy beaches, mangrove forests, saltmarshes, intertidal shoals, seagrass meadows, subtidal soft sediment habitats, rock walls and rocky shores
- An extensive area of mangroves exhibiting a range of species and community types, some of which are limited in their distribution elsewhere
- Seagrass beds which represent one of the only two major seagrass areas between Hinchinbrook Island and Cooktown (however, the meadow size is presently far smaller than previously mapped)
- Mangroves, saltmarsh seagrass meadows and 'unvegetated' soft sediment habitats and other associated wetlands which have been recognised as important nursery areas for juvenile fish and prawns of commercial importance
- Habitats for a wide range of fish and shellfish species of direct economic significance
    - A range of habitat types that significantly underpin the biodiversity values of the region
    - Habitats that are important to migratory waders of international significance (see Chapter B8, Terrestrial Ecology)
    - Potential feeding areas for marine turtles, dugongs, whales, and dolphins, which are listed as threatened or migratory under Commonwealth and/or Queensland legislation.

This report section describes these environmental values and the condition/integrity of underpinning marine habitats (including benthic primary producer habitats such as seagrass, mangroves and saltmarsh communities) within the study area.

B7.2.3 Marine Protected Areas and Wetlands of Conservation Significance

Protected and other ecologically significant areas represented within the study area include the following, as shown on **Figure B7-2:**

- Areas designated as matters of national environmental significance under the EPBC Act, including the GBRMP) and GBR World Heritage Area (GBRWHA).
- Areas specifically protected under state legislation, namely Fish Habitat Areas (Trinity Inlet FHAs and other smaller FHAs located within the study area), GBR Coast Marine Park, GBR Wetlands, and wetlands listed as MSES (Cairns/ Trinity Inlet wetlands listed as a HES Wetland under MSES).
- Wetlands listed in the Directory of Important Wetlands in Australia (DIWA), which are not specifically protected under legislation but have recognised high conservation significance. Two DIWA wetlands occur in the study area: GBRMP and Port of Cairns/Trinity Inlet wetlands.

Information detailing the relevance of these protected areas and relevant management considerations are provided in **Chapter B2** (Nature Conservation Areas). Note that no Dugong Protection Areas occur within the study area, with the nearest being located approximately 150 km south at Hinchinbrook.

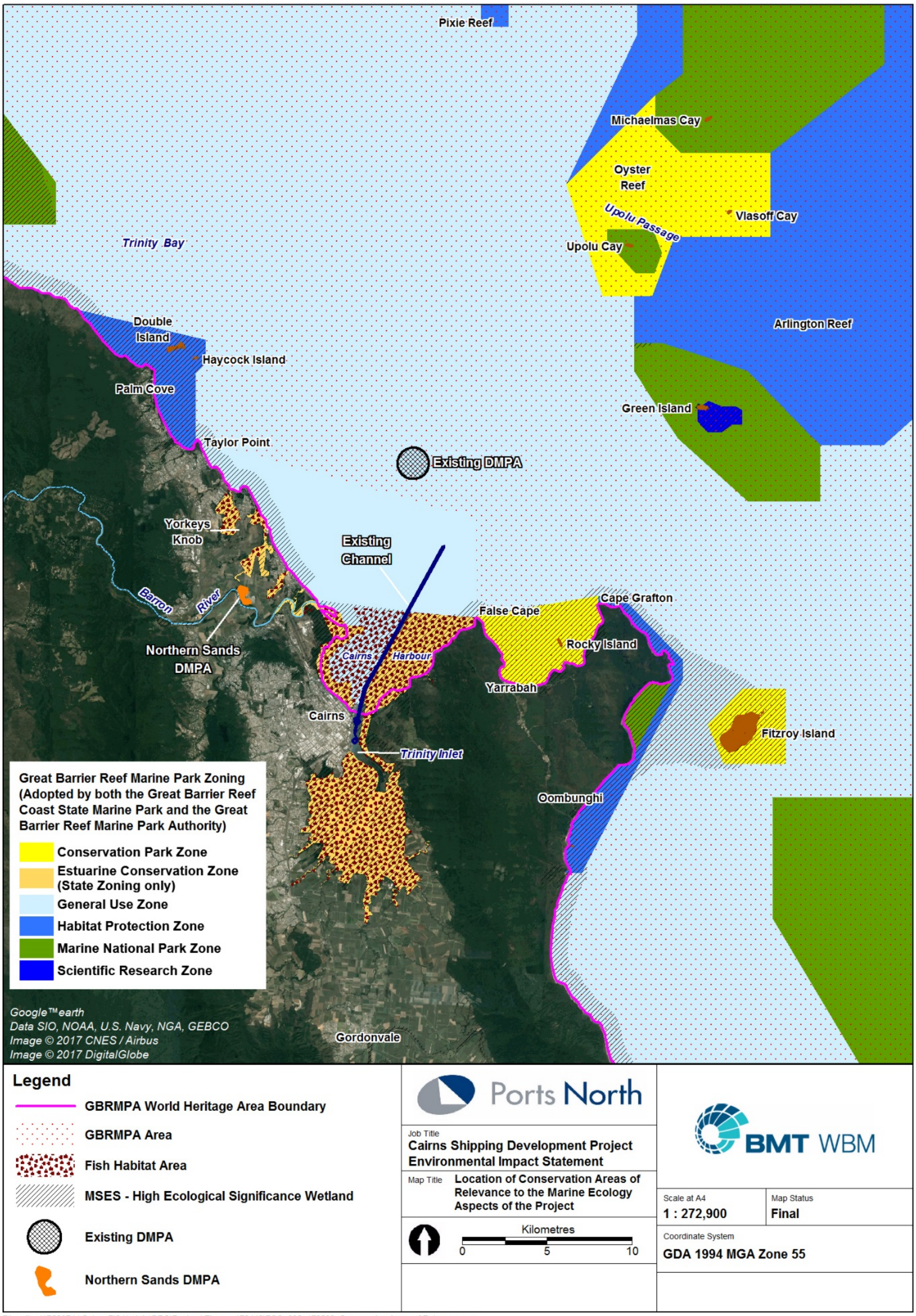

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Figure B7-2 Location of Conservation Areas of relevance to the marine ecology aspects of the project.

B7.2.4 Mangroves and Saltmarsh

B7.2.4.a General

At least 24 mangrove species from 15 genera have been recorded growing within Trinity Inlet as listed in **Table B7-1** (Dowling 1983). No similar comprehensive inventory of saltmarsh species has been undertaken in the study area to date. Dominant saltmarsh species in the study area include *Sporobolus virginicus*, *Suaeda* spp., *Sarcocornia quinqueflora* and *Tecticornia* spp. None of the mangrove or saltmarsh species occurring in the study area and surrounds are considered threatened or near threatened under legislation, and tropical saltmarsh and mangroves are not listed as threatened ecological communities under the EPBC Act.

Mangroves and saltmarshes represent benthic primary producer habitats, and support a range of functional ecosystem values. Mangrove and saltmarsh communities have a high ecological value as they provide food and shelter resources for a range of invertebrates, birds and fish (Robertson and Duke 1997).

TABLE B7-1 MANGROVE SPECIES OF TRINITY INLET (ADAPTED FROM DOWLING 1983)

COMMON NAME	SPECIES
holly-leaf mangrove	*Acanthus ilicifolius*
mangrove fern	*Acrostichum speciosum*
club mangrove	*Aegialitis annulata*
river mangrove	*Aegiceras corniculatum*
grey mangrove	*Avicennia marina*
ribbed-fruited orange mangrove	*Bruguiera exaristata*
large-leafed orange mangrove	*Bruguiera gymnorhiza*
small-leafed orange mangrove	*Bruguiera parviflora*
flat-leafed yellow mangrove	*Ceriops decandra*
yellow mangrove	*Ceriops australis*
long-fruited yellow mangrove	*Ceriops tagal*
wrinkle-pod mangrove	*Cynometra iripa*
milky mangrove	*Excoecaria agallocha*
looking-glass mangrove	*Heritiera littoralis*
red-flowered black mangrove	*Lumnitzera littorea*
white-flowered black mangrove	*Lumnitzera racemosa*
myrtle mangrove	*Osbornia octodonta*
tall-stilted red mangrove	*Rhizophora apiculata*
long-fruited red mangrove	*Rhizophora mucronata*
red mangrove	*Rhizophora stylosa*
yamstick mangrove	*Scyphiphora hydrophylacea*
mangrove apple	*Sonneratia alba*
cedar mangrove	*Xylocarpus moluccensis*
cannonball mangrove	*Xylocarpus granatum*

Many of the fish and shellfish species inhabiting mangals (mangrove forests) and saltmarshes are of direct recreational and commercial fisheries value. Mangroves and saltmarshes are also highly productive (Hutchings and Saenger 1987), are important in the stabilisation of the beds and banks of estuaries (Carlton 1974), and more recently, are increasingly being recognised for their high carbon sequestration potential. In accordance with these potential values, mangroves, saltmarshes and other marine plants are protected plants under the *Fisheries Act 1994* and a permit is required for their disturbance/removal.

B7.2.4.b Spatial Patterns

In Queensland's regional ecosystem (RE) mapping, mangrove forest is mapped as RE 7.1.1 (mangrove closed forest to open shrubland on areas subject to regular tidal inundation) and saltmarsh communities are comprised of RE 7.1.2 (*Sporobolus virginicus* grassland, samphire open forbland and bare salt pans, on plains adjacent to mangroves). The distribution of these REs within the study area and surrounds is shown on **Figure B7-3**, noting extensive mangrove forest occurring within Trinity Inlet and the less urbanised sections of Cairns harbour. These REs are listed as least- concern remnant vegetation under the *Vegetation Management Act 1999* (VM Act). Other coastal REs in the study area include dune and foreshore vegetation dominated by melaleucas, acacias and eucalypts (e.g. REs 7.2.3, 7.2.7, 7.2.8).

These latter REs are typically of concern, with 7.2.7 and 7.2.8 listed as endangered (note that 7.2.7 fringes the coastline at Ellie Point). Refer to Chapter B8, Terrestrial Ecology for a description of RE types outside the intertidal zone.

There are three main estuarine wetlands within and directly adjacent to the study areas that support remnant and regrowth mangrove forest and saltmarsh: Trinity Inlet/Admiralty Island, East Trinity and the Barron River estuary (**Figure B7-3**). Saltmarsh communities are poorly developed and patchily distributed in the wet tropics as high rainfall limits the development of hyper-saline soils, allowing mangroves to dominate the intertidal zone (Smith and Duke 1987).

Based on the RE mapping, the total area of mangrove forest in the study area (RE 7.1.1) was 4420 hectares, whereas saltmarsh and saltpan covered an area of 257 hectares. There are no mangrove and saltmarsh areas within 100 m of the CCLT, dredging area or dredged material placement area (DMPA).

The distribution and community structure of mangroves and saltmarsh plants is controlled by four primary environmental factors: salinity, tidal range, degree of wave and current action, and the physical nature of the substrate (King 1981; Odum *et al.* 1985). Saltmarsh and mangroves grow in the intertidal zone, typically within calm, protected environments. The estuarine wetlands of the study area were comprised of a mosaic of community types, with the distribution and extent of communities varying among tidal zones. The following broad zonation patterns occur:

- Areas of closed *Aegiceras* (and in places) *Avicennia +/- Rhizophora* forest often formed a narrow band near the low tide mark
- Closed *Rhizophora* forest tended to numerically dominate areas towards the low water mark (typically landward of the *Aegiceras* and *Avicennia*), whereas mid-tide levels were dominated by a closed *Ceriops* forest
- Saltpan/saltmarsh formed small isolated patches in places. Saltmarsh areas were dominated by salt couch grasses (e.g. *Sporobolus virginicus*) and samphire (*Sarcocornia* spp).

Trinity Inlet has one of the most extensive coastal mangrove forests in the region between Port Hinchinbrook and Cooktown (WBM 1998). Elsewhere in the region, the steep terrain limits the development of extensive mangrove forests on the open coast (WBM 1998). However, estuaries in the region can contain mangrove forests that are similar in size and structure to those found in the study area (DEHP 2013).

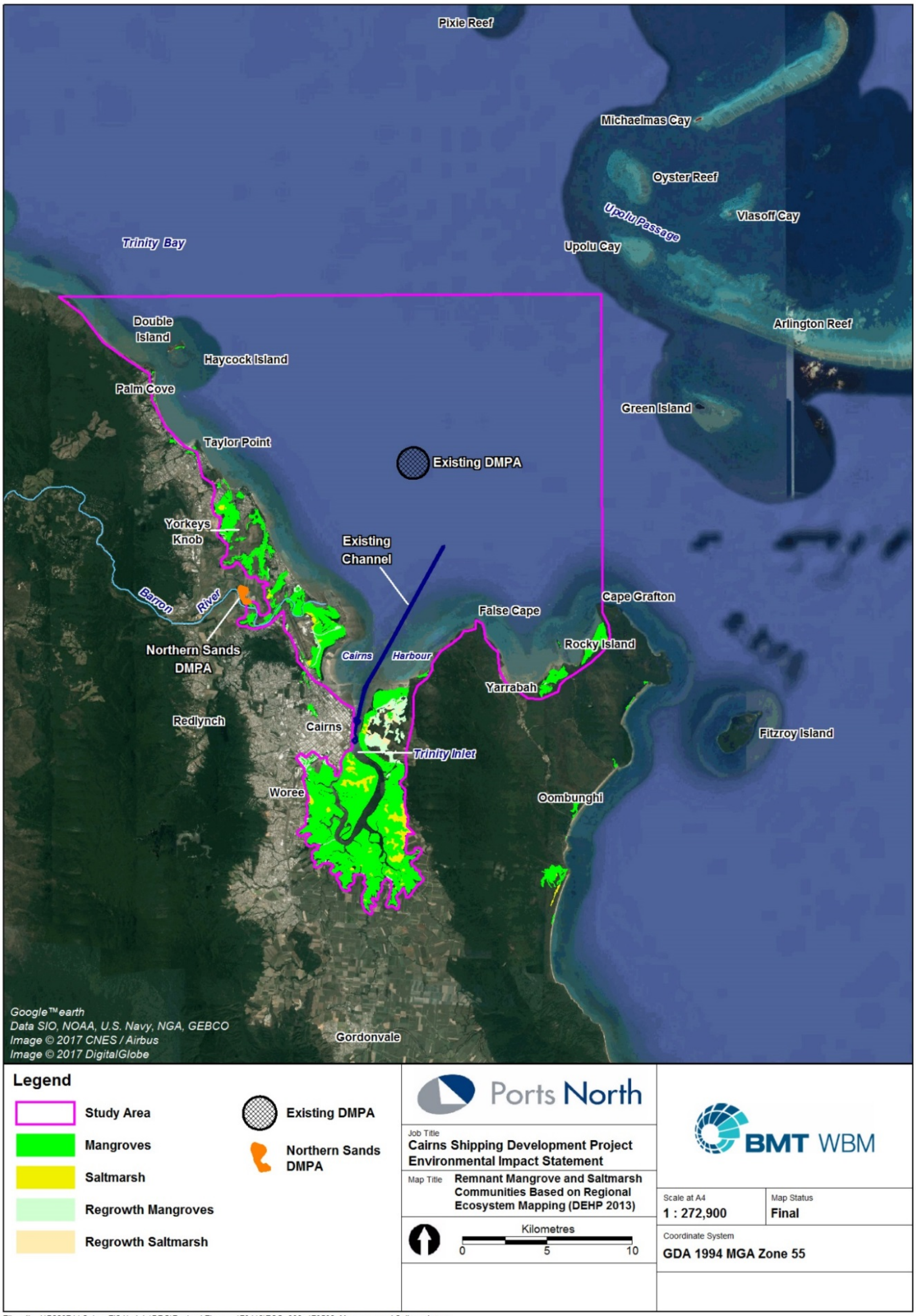

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Figure B7-3 Remnant mangrove and saltmarsh communities based on Regional Ecosystem mapping.

Source: DEHP (2013).

B7.2.4.c Temporal Changes

The mangrove forests and saltmarshes of the study area have undergone extensive changes over time in response to land clearing/draining activities, and long-term changes in physical processes. Mangrove and claypan/saltmarsh habitats have been progressively removed in the broader Cairns harbour and Trinity Inlet area over the past few decades in association with airport development, agriculture (especially sugarcane farming on the eastern side of Trinity Inlet) and similar activities as the city of Cairns has developed. In contrast, a slight rise in sea level, together with increased sedimentation over the past 40 to 50 years (Goudkamp and Chin 2006), has led to increases in mangrove area within other parts of the study area. A comparison of modelled pre-clearing and recent (1999) regional ecosystem mapping for the Innisfail lowland subregion (including Cairns harbour and Trinity Inlet) indicates that the total area of mangroves has declined from 21 777 hectares to 9078 hectares in 1999 (a net loss of 58 percent) (Accad and Neil 2006).

Similarly, claypan/saltmarsh communities were estimated to cover an area of 340 ha prior to European settlement, but now cover 65 ha (WBM 1997). This suggests that 80 percent of the original area has been lost over time. While clearing and draining were key contributors to saltmarsh/claypan losses, a landward expansion of mangroves has also resulted in net losses in saltmarsh/claypan extent. Olsen (1983) estimated approximately 40 percent of the saltmarsh/claypan area in Trinity Inlet was lost as a result of the landward progression of mangroves between 1952 and 1978.

B7.2.4.d Resistance, Resilience and Condition

Clearing and draining of freshwater wetlands, saltmarshes and mangrove forests has reduced the extent of these communities, and the loss of connectivity among terrestrial, freshwater and marine habitats (Perry 1995). Despite suffering major losses over time, the mangroves habitats of the study area are thought to be in good condition.

Furthermore, rehabilitation and remediation works at the East Trinity Reserve have allowed mangroves and saltmarsh to recolonise areas previously severely affected by hydraulic modifications, clearing and exposure of acid sulfate soils (ASS) (refer regrowth values for East Trinity, **Table B7-2**). New mangrove colonisation has also recently been evident progressing seaward adjacent the channel south of Bessie Point, extending south towards Stafford Point. The wetlands, while in a state of recovery, are providing locally important habitat for species of fisheries significance, as well as wader birds (see **Chapter B8** (Terrestrial Ecology)).

Mangroves and saltmarsh are relatively tolerant of low to moderate increases in sediment loads, which is a necessary adaptation for living in a depositional environment. However, major increases in sediment loading can lead to burial of mangrove pneumatophores and saltmarsh plants, changes to sediment types, and/or changes to benthic fauna species, causing physiological stress and possible mortality to plants.

TABLE B7-2 AREA OF REMNANT MANGROVE AND SALTMARSH REGIONAL ECOSYSTEMS (RE) MAPPED IN THE STUDY AREA

WETLAND	MAPPED AREA IN HECTARES OF REMNANT (AND REGROWTH) RES	
	Mangroves	**Saltmarsh**
Trinity Inlet/Admiralty Island	2,936 (<5)	216 (<1)
East Trinity	282 (270)	7 (83)
Barron River mouth	468 (<5)	18 (<1)

Source: DEHP (2013).

B7.2.4.e Seagrass Meadows

Spatial Patterns

A total of seven species of seagrass have been recorded in the study area (Coles *et al.* 1993; Rasheed *et al.* 2013), namely *Zostera muelleri* (formerly Z. *capricorni*), *Halodule uninervis, Halophila decipiens, Halophila ovalis, Cymodocea serrulata, Cymodocea rotundata* and *Thalassia hemprichii* (**Table B7-3**). This compares with the 15 species known from the GBRWHA (UNESCO 2011).

TABLE B7-3 LIFE-HISTORY CHARACTERISTICS OF SEAGRASS FOUND IN CAIRNS HARBOUR AND TRINITY INLET

SPECIES	DISTRIBUTION[2]	SENSITIVITY TO DISTURBANCE	REPRODUCTIVE MODE
Zostera muelleri	• Among the largest Zostera beds in northern Queensland[1] • Abundant in intertidal and shallow subtidal waters throughout Cairns Harbour.	• Large growing species providing large stores of primary energy reserves • High capacity to endure unfavourable conditions and tends to be stable in its distribution and abundance.	• Seed and vegetative • Moderate rhizome persistence, growth and reproductive output c.f. Halophila spp. • Recovery times longer than Halophila spp.
Halodule uninervis	• Generally co-dominant in intertidal and shallow subtidal waters with • *Z. Muelleri* • The dominant species in intertidal and subtidal areas on the eastern side of Cairns harbour (Bessie Point to False Cape).	• Small stores of energy reserves (owing to small plant size) • Rapidly declines when conditions become unfavourable for growth.	• Seed and vegetative • Fast growth and high reproductive output
Cymodocea serrulata	• Transient species, previously recorded in low abundance throughout Cairns harbour.	As for *Z. muelleri* above.	• Seed and vegetative • Low to moderate growth and reproductive output c.f. Halophila spp., high rhizome persistence • Recovery longer than • *Halophila* spp.
Cymodocea rotundata	• Transient species, previously recorded in low densities near Ellie Point.	As for *Z. muelleri* above.	As for *C. serrulata* above
Thalassia hemprichii	• Recorded in Cairns harbour in 1993 but not thereafter.	As for *Z. muelleri* above.	• Seeds and vegetative • High rhizome persistence • Low growth • Seeds are buoyant and can disperse over long distances [4]
Halophila ovalis	• Dominant in intertidal and shallow subtidal waters around Trinity Inlet and Cairns harbour	• Small stores of energy reserves (small plant size) • Rapidly declines when conditions become unfavourable for growth.	• Seeds and vegetative • Colonising growth strategy • Fast growth and high reproductive output • Seeds can remain viable in sediments for years [3]

(Continued over)

SPECIES	DISTRIBUTION[2]	SENSITIVITY TO DISTURBANCE	REPRODUCTIVE MODE
Halophila decipiens	• Subdominant in places along the mainland coast, and dominant (but sparse) in deep water environments.	• As for *H. ovalis* above.	• Seeds • As for *H. ovalis* for other characteristics

Notes: [1] = Coles et al. (1992); [2] = Rasheed et al. (2013); [3] = Rasheed and Taylor (2008); [4] = Olsen et al. 2004); [5] = Unsworth (2010)

Overall, up to a total area of 800 ha of seagrass habitat has been mapped in the study area and surrounds, with these meadows representing the only major seagrass resource between Hinchinbrook Island and Cooktown (Lee Long *et al.* 1993, 1996; Campbell *et al.* 2002, 2003; Jarvis *et al.* 2014). Historically, seagrass meadows have been recorded on shallow mud banks along the perimeter of Cairns harbour, and absent from deeper waters near the existing channel and the central section of Cairns harbour. Aggregated patches of seagrass have also been recorded in deeper waters north of False Cape and north-west of the existing channel, and along the foreshore of Trinity Inlet adjacent to Admiralty Island (mostly *Halophila spp*.).

Meadows tend to be denser and more structurally complex in the intertidal and shallow subtidal areas than those in deeper offshore waters (Rasheed *et al.* 2013). On the western side of the shipping channel, seagrass meadows have been dominated by *Zostera muelleri*, while *Halodule uninervis* has dominated the eastern side of the channel in the Bessie Point meadows. Narrow fringes of *Halophila* species have been found on the subtidal slopes of Trinity Inlet with *Zostera muelleri* found in some areas of the inlet on shallow intertidal/subtidal banks. Shallow waters favour the growth of larger growing species such as *Zostera muelleri* and *Halodule uninervis*, as well as *Halophila* species, which is a consistent pattern across most seagrass areas in North Queensland (Lee Long *et al.* 1993). The most well developed shallow water meadows were located along the foreshores on both sides of Cairns harbour (Rasheed *et al.* 2013).

Halodule uninervis has previously been detected as sparse isolated strands in the vicinity of the existing offshore DMPA (Neil *et al.* 2003) and is infrequently observed within the channel and shallow marina berths by Ports North staff during annual monitoring of marine sediment and pests.

Seagrass meadows are not well established along the northern beaches or associated bays due to unsuitable habitat and substrate, however, a robust meadow is located around Double Island (refer **Section B7.2.5.a**).

Temporal Patterns

Since 2001, staff from JCU – TropWATER (formerly of the Department of Primary Industries and Fisheries) have undertaken seagrass meadow surveys on an annual basis, representing 15 years of monitoring data over the Trinity Bay and Trinity Inlet regions of the study area. Rasheed *et al.* (2013) and Jarvis *et al.* (2014) collated monitoring data to assess spatial and temporal patterns in the structure of seagrass meadows within the study area. This data primarily comprised that from the long-term seagrass mapping conducted in the study area by the JCU, including mapping of all seagrasses in 1984 (Coles *et al.* 1985), 1988, 1993, 2001 and 2012. Surveys have been conducted at the same time of year to prevent seasonal variability confounding long-term trends.

Survey effort conducted by the TropWATER in 2015 is shown on **Figure B7-4**. Species present included *Zostera muelleri, Halodule uninervis*, *Halophila decipiens*, *Halophila ovalis*, and *Cymodocea serrulata*. The long-term maximal distribution of seagrass, the present (2015) distribution and additional survey effort provided by BMT WBM are shown on **Figure B7-5**. Note that 2016 seagrass data was not available at the time of writing, but preliminary indications are that the extent is similar to 2015.

The past 15 years of monitoring has shown great variation in the distribution, extent, biomass and density of seagrass assemblages (**Figure B7-6**). The most recent survey (York *et al.* 2016) showed a general improvement in seagrass cover and biomass compared to 2014; however, cover and biomass were still very low compared to pre-2009 conditions (**Figure B7-6**). The reduction in cover and biomass between 2009 and 2010 sampling episodes coincided with above average rainfall associated with 2010/11 La Niña events and Tropical Cyclone Yasi.

It is likely that these conditions reduced the light available for seagrasses causing dieback, as broad-scale reductions in seagrass cover were observed throughout Queensland (McKenzie *et al.* 2012).

As per previous monitoring, the most well developed shallow water meadows were located along the foreshores on both sides of Trinity Bay. The changes in extent that have occurred in in these meadows are shown on **Figure B7-7** and **Figure B7-8**. Between 2014 and 2015 there has been a substantial increase in meadow extent in front of the Cairns Esplanade and much more moderate increase in cover near False Cape. Meadow 34 near the Cairns Esplanade was composed of dense *H. uninervis* along its eastern margin and light *C. serrulata* with *H. uninervis* along the western (landward) border. Most of the meadows south-west of False Cape were composed of light-cover aggregated patches of *H. uninervis*, with the meadows situated just north of East Trinity consisting of light *C. serrulata* with *H. uninervis*.

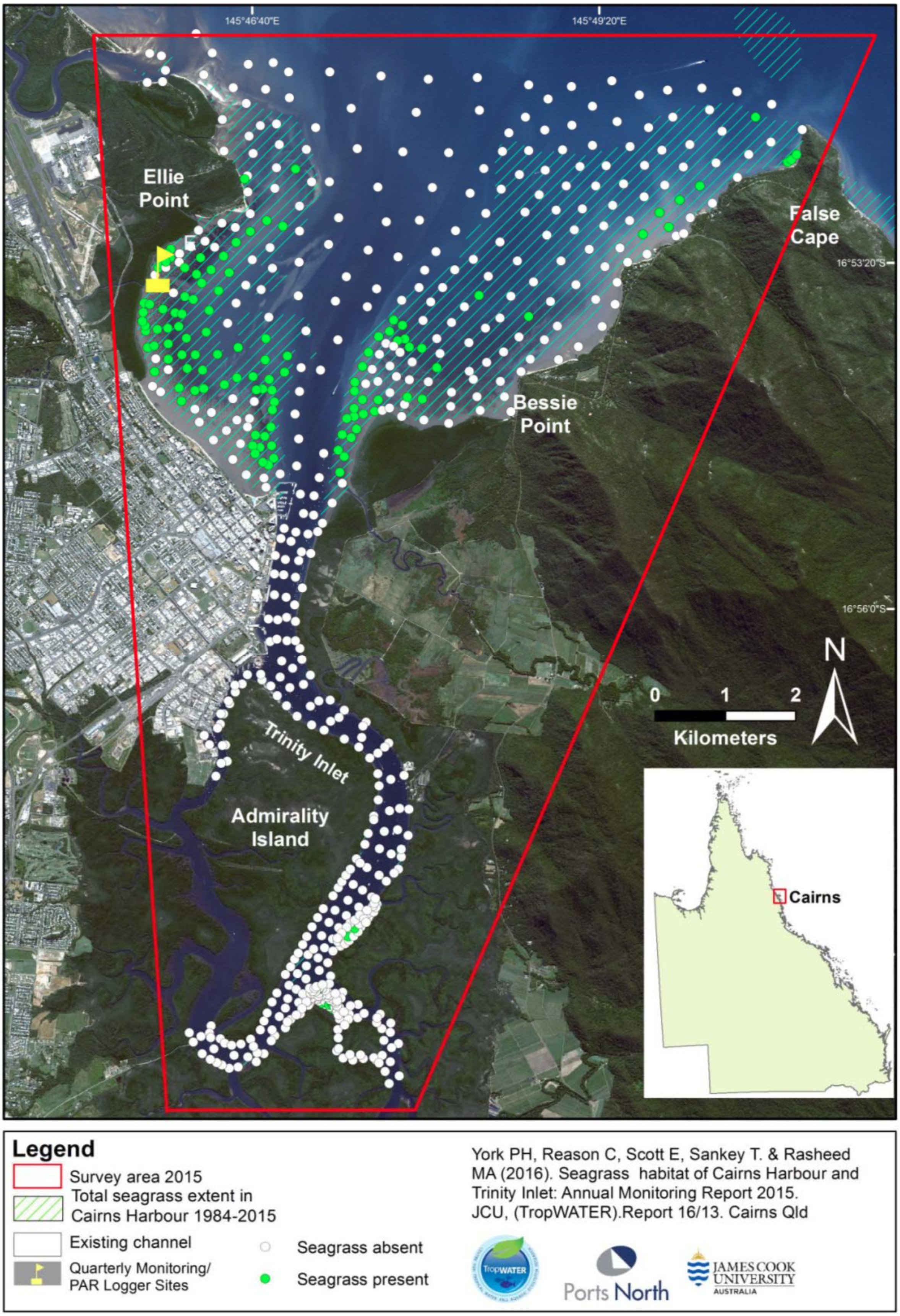

Figure B7-4 Present (2015) Seagrass distribution in Cairns Harbour and Trinity Inlet.

Source: York *et al.* (2016).

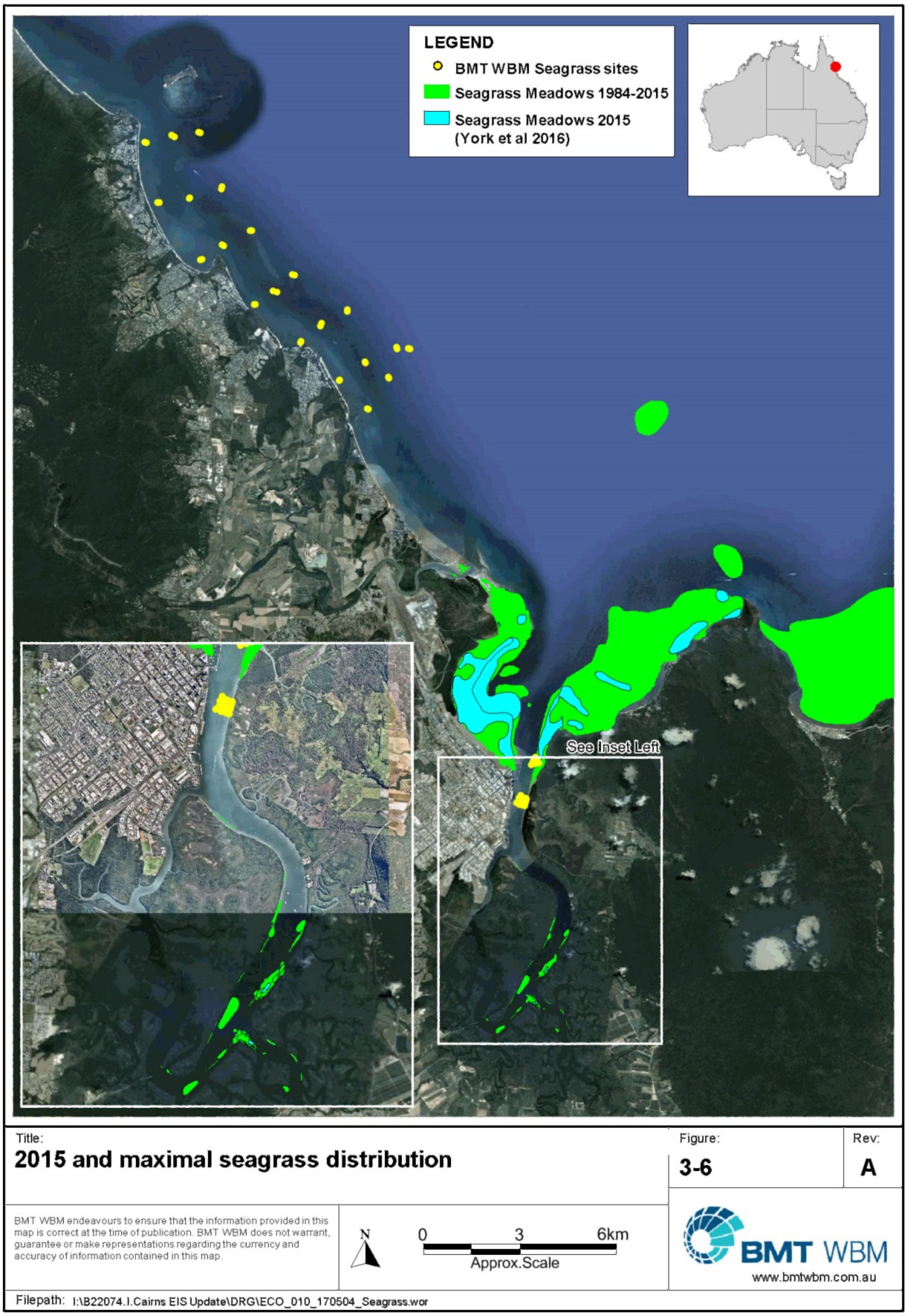

Figure B7-5 Present (2015) Seagrass distribution in Cairns Harbour and Trinity Inlet.

Source: York *et al.* (2016).

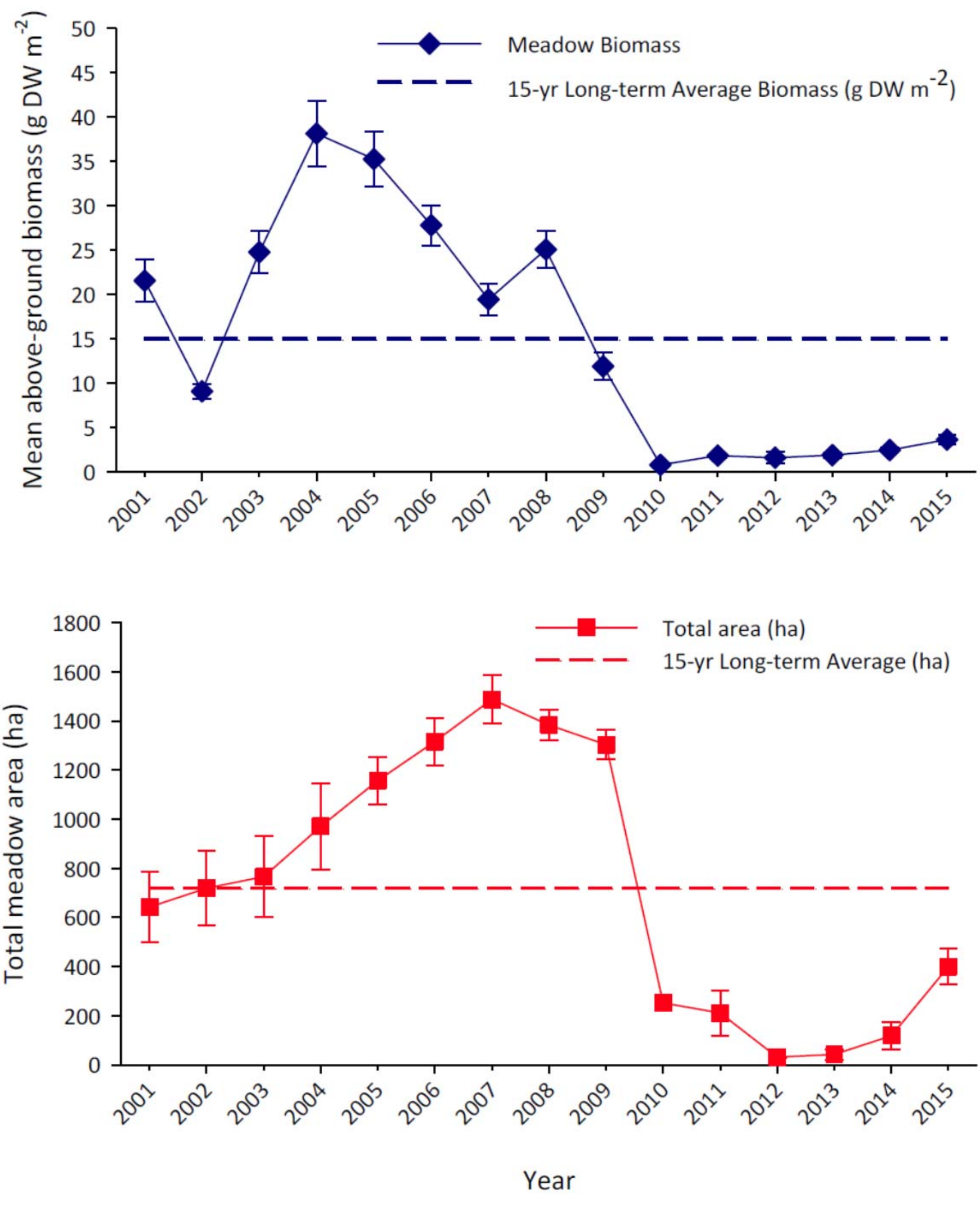

Figure B7-6 Seagrass biomass (above) and cover (below) for the Cairns region between 2001 and 2015 (Error Bars – Standard Error).

Source: York *et al.* (2016).

Temporal changes in seagrass meadows at the southern end of Trinity Inlet are shown on **Figure B7-9**. The extent of these meadows reduced most recently between 2012 and 2014, reflecting some of the lowest cover that has been observed in the last 10 years.

Seed bank monitoring in Cairns harbour suggests that the total seed density in 2015 was low, and that much of the recovery between 2014 and 2015 has been observed near the Esplanade was due to vegetative expansion of existing fragments or patches, rather than recolonization from seeds (York *et al.* 2016).

The results of these monitoring studies indicate the distribution, extent, biomass and density of seagrass assemblages within the study area can show great variation over a range of temporal scales. At seasonal scales, seagrass meadows in nearshore waters of the Great Barrier Reef region typically display a seasonal growth cycle in intertidal and shallow subtidal seagrass meadows (Waycott *et al.* 2005; Unsworth *et al.* 2009), with higher percentage cover of seagrass in late spring-summer than winter. McKenzie (1994) and Rasheed (1999) similarly describe distinct seasonality for seagrass communities at Cairns.

Interacting with these general seasonal growth patterns are longer term (inter-annual) cyclic changes in seagrass meadows due to climate-driven disturbance and subsequent periods of recovery. Large inter-annual changes in seagrass meadow extent and community structure resulting from disturbance have been documented by Rasheed *et al.* (2013) and Jarvis *et al.* (2014). In summary:

- Seagrass meadow extent showed an overall increase between 2001 and 2007, and a slight reduction in 2008 and 2009. This period was coincident with below average rainfall conditions.
- There was a major reduction in seagrass above-ground biomass and extent between 2009 and 2010 sampling episodes. This was coincident with above average rainfall associated with 2010/11 La Niña events and Tropical Cyclone Yasi.
- Surveys in 2011 and 2012 indicated there was a further decline in seagrass meadow extent and biomass. In November 2012 there was very little seagrass remaining within the study area. This is despite the study area experiencing favourable growing conditions in 2012.
- Seagrass meadow extent in 2010-2012 was far below historical baseline levels observed during the 1980s and 1990s. These longer term (e.g. inter-annual, irregular) changes also interact with general seasonal growth patterns, resulting in a dynamic (and not necessarily predictable) community (**Figure B7-10**).

The 2013 to 2015 monitoring period reported an increase in both above ground biomass and total seagrass area since 2012. This presumably indicates the commencement of the recovery process.

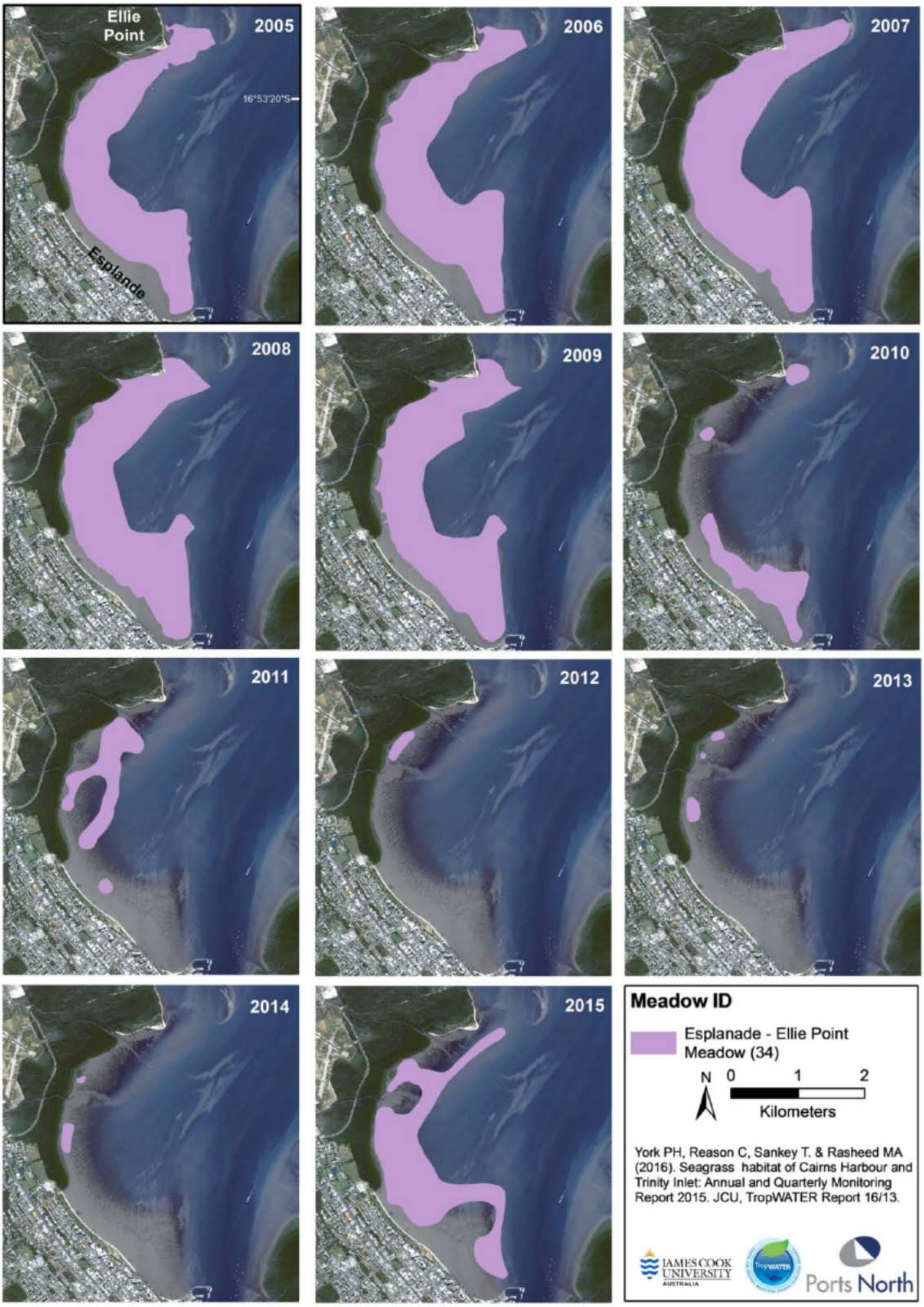

Figure B7-7 Changes in seagrass meadow extent between 2005 and 2015 for the Cairns Esplanade and Ellie point.

Source: York *et al* (2016).

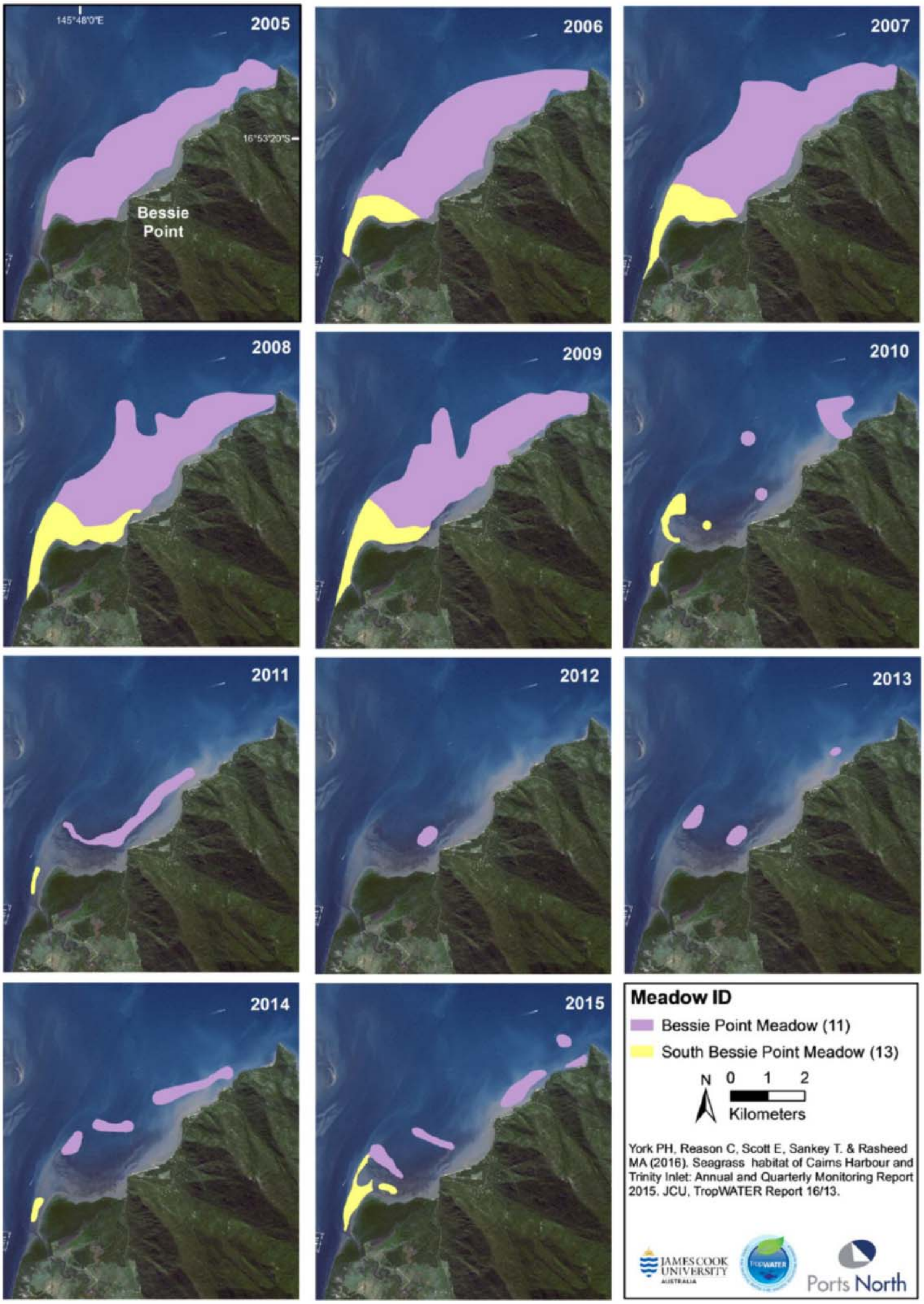

Figure B7-8 Changes in seagrass meadow extent between 2005 and 2015 for meadows south-west of False Cape.

Source: York *et al* (2016).

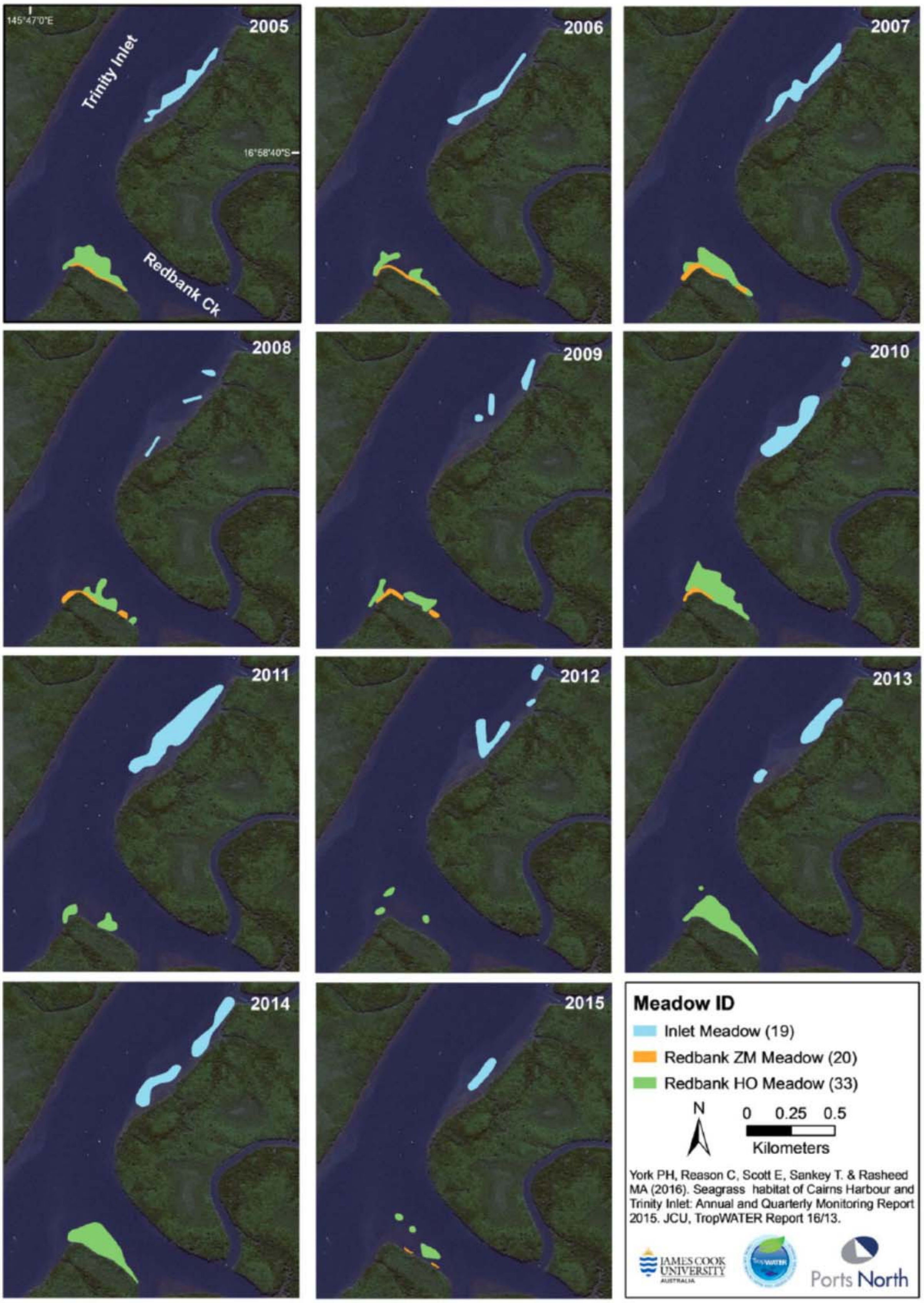

Figure B7-9 Changes in seagrass meadow extent between 2005 and 2015 for meadows in southern Trinity Inlet.

Source: York *et al.* (2016).

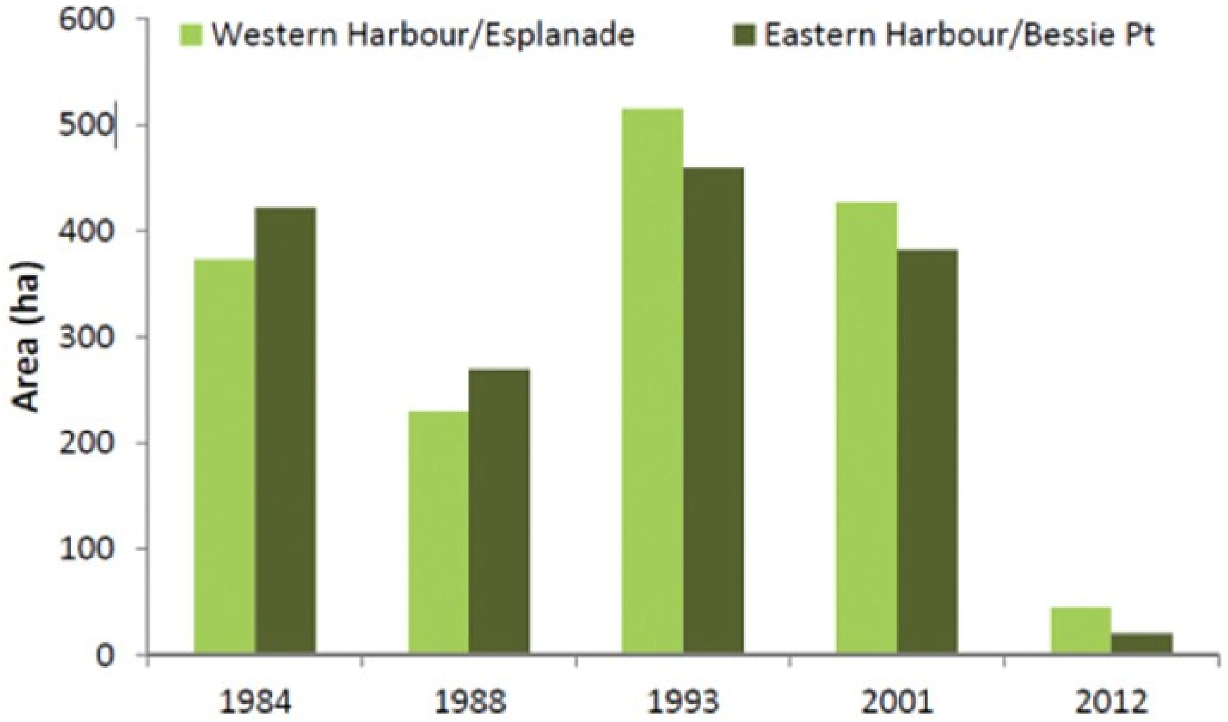

Figure B7-10 Comparison of seagrass meadow area in the western and eastern sides of Cairns Harbour; 1984, 1988, 1993, 2001 and 2012.

Source: Rasheed *et al.* 2013.

The combination of high rainfall, high river flow and cyclones can negatively impact seagrass either physically (burial, scouring, direct removal of plants and seed-banks) or physiologically (light limitation, excess nutrients and herbicides, and changes in salinity) (Rasheed *et al.* 2013). All years in the period 2007 to 2012 had above average rainfall, particularly in 2010 and 2011, while rainfall was below average in 2013 (Jarvis *et al.* 2014).

Barron River flow volumes were also well above average in 2007/08 and 2010/11. McKenzie *et al.* (2012) estimated that approximately 98 percent of intertidal seagrass areas in the regions directly affected by the path of Tropical Cyclone Yasi were lost as a consequence of destructive winds, and only a few isolated shoots remained in many coastal and reef habitats.

Light limitation is a key driver of spatial and temporal patterns in seagrass distribution and abundance, and is thought to be a key driver of the observed long-term temporal patterns in seagrass. As discussed in Chapter B5, Marine Water Quality, the light climate of the study area is a function of high total suspended sediment concentrations, plankton biomass and concentrations of dissolved organic carbon (e.g. tannins). Periods of high suspended sediment concentrations within the study area are controlled mainly by wave driven bed sediment remobilisation, and inputs of terrigenous sediments in flood waters from Barron River and the smaller coastal drainages entering Trinity Inlet and Cairns harbour (see Chapter B5, Marine Water Quality). Conversely, when local climate conditions are in a drought-like state, subtidal seagrasses can thrive due to higher light levels reaching the seabed (Rasheed *et al.* 2013).

Seagrass Resistance, Resilience and Condition

Seagrass species differ in their sensitivity to disturbance (i.e. resistance) and capacity to recover following disturbance (i.e. resilience). The degree of resistance and resilience of seagrass depends on a number of often interactive factors including (Kenworthy 2000; Taylor and Rasheed 2009):

- carbohydrate (energy) reserves to draw on during low light periods (resistance)
- ability for photosystems to recover (resilience)

- capacity for vegetative propagation (resilience)
- seed bank occurrence (resilience)
- historical and future disturbance regimes, including frequency, timing, duration and magnitude of disturbance (resistance and resilience).

Table B7-3 outlines the key life history characteristics of the seven seagrass species known from the study area. In general, small species such *Halophila* spp. tend to have low carbohydrate reserves compared to larger species, and are therefore the most sensitive species to low light conditions (i.e. low resilience). However, *Halophila* species also have adaptations that allow rapid recovery, including high reproductive output, rapid growth rates and the production of long-lived seeds that can remain viable in sediments for many years (i.e. high resilience). Larger species such as *Zostera muelleri* and *Cymodocea serrulata* have higher carbohydrate reserves and can therefore endure unfavourable periods for longer than small-bodied species (i.e. high resilience). However, these larger bodied species are slower to recover when lost (Rasheed 2004).

All seagrass species found in the study area are also capable of vegetative regrowth, which increases the capacity to recover following disturbance (i.e. rather than being solely dependent on sexual reproduction). Nonetheless, if all seagrass is lost from an area, some form of initial sexual colonisation would be required before seagrass is able to grow vegetatively. Recovery can be expected to be slower in instances where sexual colonisation is required to initiate the recovery process.

The capacity to recover following disturbance also depends on seagrass condition, which is a function of the previous disturbance history (magnitude, and spatial and temporal scale of disturbance). Successive periods of disturbance (i.e. multiple wet years) can deplete seagrass energy stores, seed banks and standing crop (i.e. seagrass condition), which greatly decreases the capacity for seagrasses to recover following disturbance. For example, the Reef Rescue Marine Monitoring Program (McKenzie *et al.* 2010) assessed the condition of seagrass meadows in the wider wet tropics region, with the sites nearest to the study area being located at Green Island. Overall, for the 2009/10 survey period, seagrass meadows of the wet tropics region were classified as being in a ‘poor state’ in coastal intertidal habitats, and a ‘moderate state’ at intertidal reef habitats (McKenzie *et al.* 2010).

York *et al.* (2016) applied a recently developed condition index to monitoring meadows, based on the results of annual monitoring of seagrass biomass, area and species composition. **Figure B7-11** presents a summary of the present condition of seagrass monitoring meadows in the harbour and Trinity Inlet. All meadows in the harbour were rated as being in ‘poor’ to very poor condition on account of poor biomass and area.

In summary, seagrasses in the Cairns harbour are currently in a poor state, but showing signs of recovery. The next few growing seasons will be critical for the recovery trajectory of seagrasses in Cairns since propagule sources for recolonisation are limited and seed banks are ageing with reduced seed viability. This means that it will be critical to maintain conditions suitable for seagrass growth over the coming years.

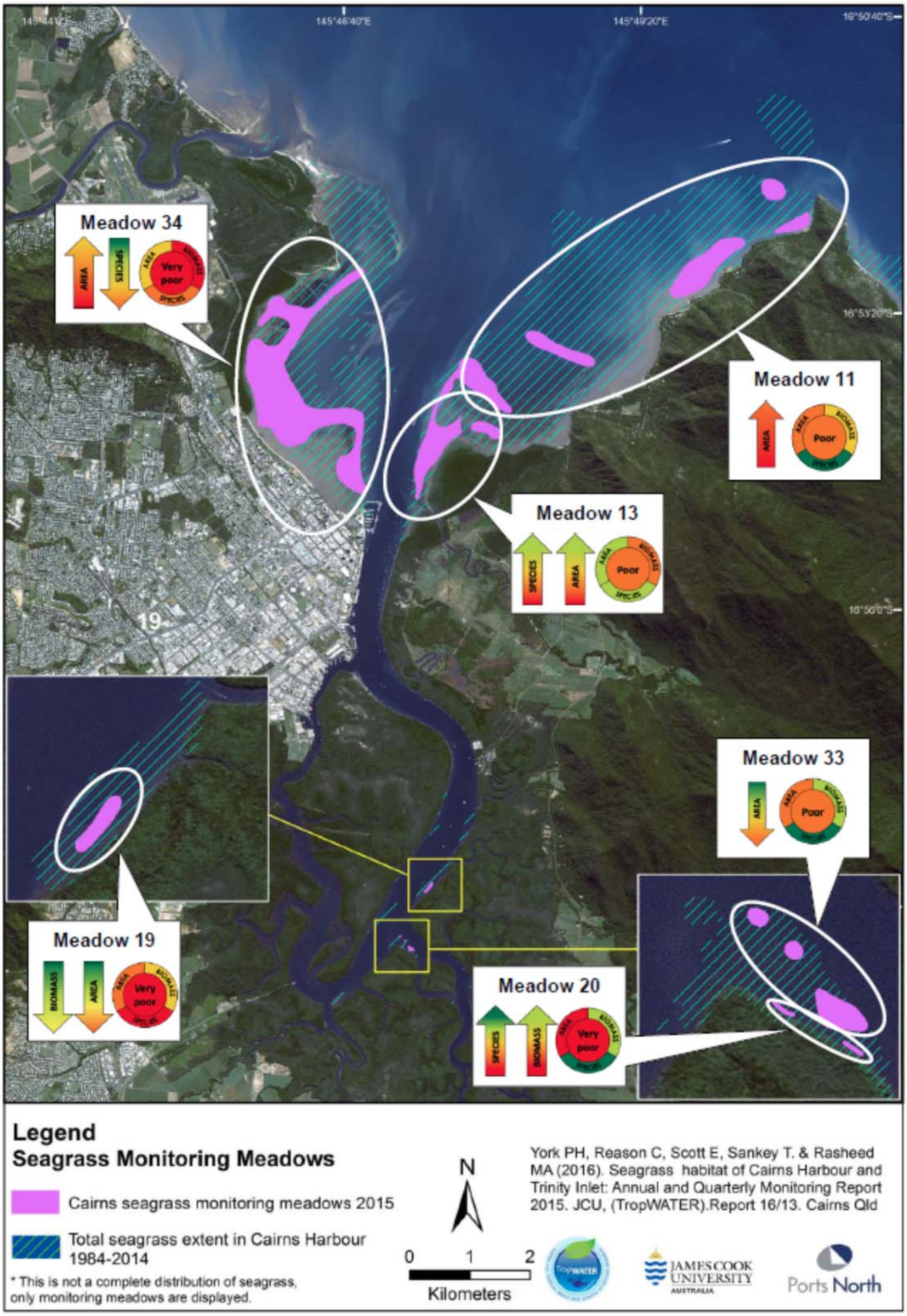

Figure B7-11 Seagrass Monitoring Meadow Condition in Cairns Harbour, October 2013.

Source: Jarvis *et al.* (2014).

B7.2.5 Hard Benthic Substrata and Associated Communities

B7.2.5.a Habitats and Communities

Coral reefs form a benthic primary producer habitat. Based on mapping from the GBRMPA Gazetteer (**Table B7-4**; **Figure B7-13**), the total area of reef habitat within the study area is approximately 196.3 hectares. It includes mainland shallow fringing reefs and rocky shores, and well-developed reef platforms around nearshore islands. Habitat characteristics of reefs vary greatly among locations, reflecting differences in reef morphology.

Mainland Reefs and Rocky Shores Cairns Harbour/Yorkeys Knob

Within Cairns harbour and Trinity Inlet, rocky shores and boulders are present along sections of the coastline near East Trinity (Bessie Point, Lyons Point) and surrounding False Cape. Rocky shores of East Trinity are mostly located in the intertidal zone, and consist of granite boulders and small outcrops surrounded by sand and mud substrata. The sedimentary coastline along the western side of the harbour and inlet are not known to support rocky shores. Site inspections undertaken as part of this EIS indicated rocky shore communities here were comprised of species typically found in turbid nearshore environments. At East Trinity, the granite boulders of the upper intertidal zone were densely covered in oysters (**Figure B7-12-A**) with occasional low, closed mangroves present in places. The lower intertidal rock substrata were often covered in a dense mat of calcareous tubeworms (**Figure B7-12-B**) with occasional clusters of brown macroalgae (**Figure B7-12-E)** and a fine turf of filamentous green algae. Filter-feeding holothurians were the most common large conspicuous invertebrates observed (**Figure B7-12-C**) with occasional soft corals (**Figure B7-12-D**) and large molluscs also present (**Figure B7-12-F**).

The rocky shores surrounding False Cape provide a more substantial subtidal habitat than East Trinity, with continuous rocky shores along a steeper shoreline profile **Figure B7-12-G**). A variety of macroalgal species including Halimeda and Sargassum (**Figure B7-12-J**) dominated the lower intertidal area, with much of it covered in a thick turf of algae, encrusting sponges and bryozoans. Occasional encrusting faviid hard corals (**Figure B7-12-I**) were present but uncommon (<five percent cover).

Figure B7-12 East Trinity (A-F) and False Cape (G-J) Shoreline Assessment: Stilt Mangroves (*Rhizophora stylosa*) and Dense Oysters in the Upper Intertidal Zone (A); Encrusting Tubeworms cover the Lower Intertidal Zone(B); Filter Feeding Holothurians (*Pseudocolchirus violaceus*) were Common (C); Dendronephthyid Soft Coral (D); Brown Macro Algae (E); the Baler Shell (*Melo amphora*) (F) ; Dense Boulder Field (G); Turfing Algae and Halimeda (H); Hard Coral (*Favia stelligera*) (I) and Sargassum (J).

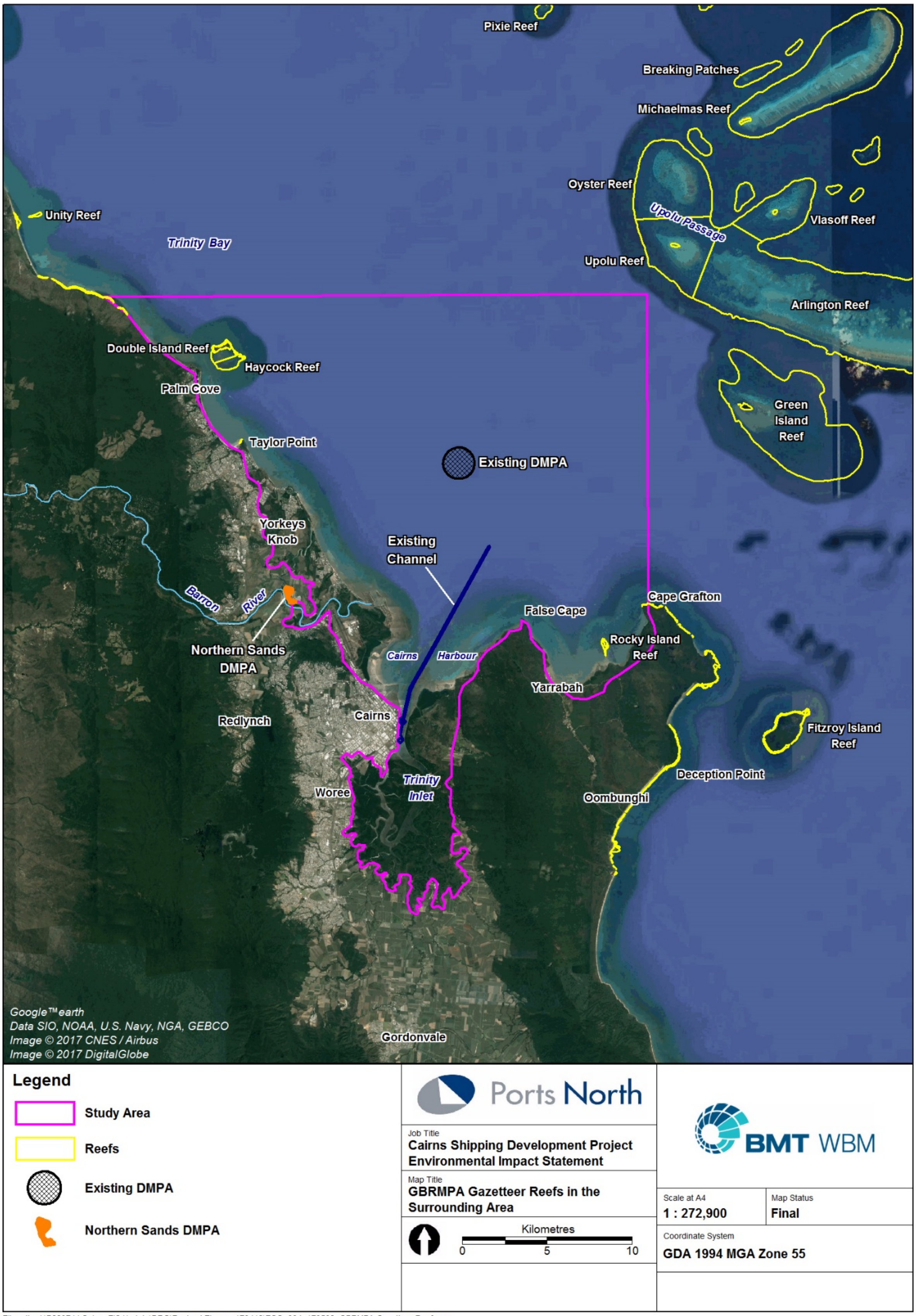

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Figure B7-13 GBRMP Gazetteer Reefs in the surrounding area.

Figure B7-14 Reef Communities at Rocky Island: Looking South across the Reef Flat (A); *Halimeda*, the Hard Coral *Galaxea* (B) and Soft Coral (*Briareum*) (C) were Dominant along the Reef Edge; Microatoll with *Turbinaria* and *Sinularia* (D); Hard Coral (*Goniopora*) (E); Dendrophyllid Hard Coral (F); Epaulette Shark (*Hemiscyllium ocellatum*) (G); Green Turtle (*Chelonia mydas*) (H); Ornate Crayfish (*Panulirus ornatus*) (I); and Bare Staghorn Coral (*Acropora*) Remnant Substrate (J).

TABLE B7-4 REEFS MAPPED WITHIN THE STUDY AREA AND SURROUNDING COASTAL AREAS BY THE GREAT BARRIER REEF

LOCALITY	GBRMPA GAZETTEER NAME AND NUMBER	AREA (ha)
Study Area		
Mission Bay	Rocky Island Reef 06-051	0.2
	U/N Reef 16-050	10.57
Cooks Bay South	U/N Reef 16-094	0.89
Double Island	Haycock Reef 16-048	88.47
	Double Island Reef 16-047	96.19
Surrounding Areas		
Palm Cove to Port Douglas	U/N Reef 16-093	2.96
	U/N Reef 16-092	25.68
	U/N Reef 16-091	2.45
	Unity Reef No. 1 16-045A	9.03
	Unity Reef No. 2 16-045B	8.54
	U/N Reef 16-090	2.27
	U/N Reef 16-089	17.8
	Garioch Reef 16-082	20.49
	Alexandra Reefs (No. 2) 16-039B	411.74
	Yule Reef 16-081	11.13
	Korea Reef 16-080	208.98
	Alexandra Reefs (No. 1) 16-039A	538.11
	Wentworth Reef 16-037	104.91
	Egmont Reef 16-038	10.68
Cape Grafton	U/N Reef 16-095	0.06
	U/N Reef 16-096	0.33
	U/N Reef 16-097	0.09
	U/N Reef 16-098	1.21
	U/N Reef 16-099	0.89
	U/N Reef 16-100	1.38
	U/N Reef 16-102	0.26
	U/N Reef 16-103	0.86
	U/N Reef 16-104	0.08
	U/N Reef 16-105	0.47
	U/N Reef 16-106	1.17
	U/N Reef 16-107	0.2

(Continued over)

LOCALITY	GBRMPA GAZETTEER NAME AND NUMBER	AREA (ha)
Turtle Bay/Little Turtle Bay/Wide Bay	U/N Reef 16-108	2.59
	U/N Reef 16-109	0.61
	U/N Reef 16-110	2.29
	U/N Reef 16-052	7.89
	U/N Reef 16-053	14.46
	U/N Reef 16-111	6.76
	U/N Reef 16-112	21.14
	U/N Reef 16-113	2.29
	U/N Reef 16-056	6.04
	U/N Reef 16-801/Gunjarra Island	17.31
	U/N Reef 17-074	0.43
	U/N Reef 17-075	0.36
	U/N Reef 17-076	0.88
Fitzroy Island	Little Fitzroy Reef 16-055	10.47
	U/N Reef 17-054G	4.64
	U/N Reef 17-054F	17.32
	U/N Reef 17-054C	0.61
	U/N Reef 17-054E	0.3
	Fitzroy Island Reef (No. 2) 16-054B	2.49
	Fitzroy Island Reef (No. 1) 16-054A	16.39

Further afield, Yorkeys Knob located approximately nine km north of Cairns harbour is a rock promontory that contains steep-gradient, plunging rocky shores with limited erosional bench or platform. Several rock promontories separated by a series of beaches occur along the coast to the north of Yorkeys Knob (e.g. Taylor Point at Trinity Beach and Buchan Point at Palm Cove). Taylor Point, located approximately 12 km north of Cairns, contains a small (0.89 ha) fringing reef that is mapped in the GBR Gazetteer (Reef 16-094).

Double Island

Double Island (Double Island and Haycock Reefs: GBR Gazetteer number 16-047 and 16-048) contains a narrow fringing reef to the north and an extensive reef platform to the south, and has a total mapped area of 185 ha. This represents the largest reef in the study area (**Table B7-4**).

The reef flat was comprised of a broad inner sediment zone that was surrounded by a rim of corals and algae along the reef front. The inner sections of the reef flat contained a mosaic of seagrass, macroalgae and bare sediments. A large sand spit extended in a north-south orientation along the north-western part of the reef flat.

Seagrass communities tended to dominate sandy substrates across the reef flat, whereas rubble substrates on and surrounding the reef flat were dominated by a variety of hard and soft corals and macroalgae. Extensive seagrass meadows were present on the reef flat east and south of the sand spit, whereas to the west of the spit, seagrass meadows were sparse and patchy. Seagrass communities were comprised of *Halophila ovalis*, *Halodule uninervis* [thin and thick forms], *Cymodocea serratula*, *Syringodium isoitefolia*. Seagrass cover and community composition was variable across the flat, but reached up to 70 percent in places. Dense meadows were dominated by *C. serratula* and *H. uninervis*.

The reef flat (particularly in the south-west) had numerous low-profile microatolls, consisting of *Porites* (massive and digitate forms), *Acropora*, and *Goniastrea*, but had low coral cover overall. Macroalgae and bare substrate was also abundant.

Quantitative transects located on the upper slope were dominated by bare substrate and in places hard corals, whereas corals and macroalgae co-dominated the deeper sections of the reef slope. The densest coral cover occurred on the reef front, with an overall average hard coral cover of 22.7 percent (%) ± 3.58 (S.E.) and average soft coral cover of 8.2 percent (%) ± 2.60 (S.E.). Hard coral cover was highest at the south-eastern edge of the reef (DI1-2; 36%), while the south- western reef edge (DI9-10) had high soft coral cover (17%) but lower hard coral cover (12.5%). The other surveyed sections of the reef slope had intermediate levels of hard and soft coral cover.

The dominant coral species varied among and within sites (**Figure B7-15**). Within locations, *Acropora* numerically dominated on the deep slope transect (3%-17% cover), but with the exception of DI.7 on the western reef margin (19%), generally had low cover on upper slope transects (0%-1%). *Montipora*, *Porites* and *Mycedium* were locally abundant, again more so in the deep slope than shallow slope transects. The relative abundance of soft corals varied marked across the reef, with *Efflatounaria* abundant at the north-west edge of the reef (DI9-10), and *Sinularia* abundant on the western reef edge (DI7-8).

Coral taxa (genera) richness varied marked among and within sites (**Table B7-5**). DI1-2 on the south-eastern edge had high hard (10 taxa) and soft (five taxa) coral richness. The northern fringing reef (DI5-6) and southern-western edge (DI9-10) had moderate to high hard coral richness (12 and seven genera, respectively), but only one=two soft coral genera.

Macroalgae were numerically dominant across the reef flat and along the ridge of reef edge (**Figure B7-15**). Turfing algae was abundant on all transects, ranging from 13-52 % cover (average = 26.6 percent ± 4.47 S.E.). The canopy forming *Sargassum* was locally abundant, particularly on the western margin (DI7-8) of the reef flat.

Figure B7-16 is a non-metric, multi-dimensional scaling ordination showing patterns in reef community similarity at Double Island Reef and Rocky Island. There was great spatial variability in communities at Double Island Reef, whereas those at Rocky Island were more uniform and distinctly different from those at Double Island Reef.

Overall, the reef community at Double Island was in excellent condition, particularly on the reef slope and areas mapped as ‘extensive hard and soft coral, sparse sargassum’ and ‘digitate *Porites* and *Acropora* with macroalgae’. Across these areas, corals were diverse in terms of species richness and in excellent condition, particularly for an inshore reef so close to the mainland. Being located inshore, most well-established species present at Double Island would have some resilience to windows of increased turbidity, to the extent that turbidity is increased during natural disturbance events in the northern beaches area.

TABLE B7-5 NUMBERS OF CORAL GENERAL RECORDED AT EACH TRANSECT AND SITE

LOCATION	SITE	TRANSECT	HARD CORALS	SOFT CORALS
Double Island	DI.A	DI.1	6	3
		DI.2	5	3
		Sum	10	5
	DI.B	DI.3	2	0
		DI.4	2	1
		Sum	3	1
	DI.C	DI.5	8	1
		DI.6	2	1
		Sum	12	2
	DI.D	DI.7	2	1
		DI.8	2	1
		Sum	3	1
	DI.E	DI.9	3	1
		DI.10	3	1
		Sum	7	1
Rocky Island	RKY.A	RKY.1	2	1
		RKY.2	1	1
		RKY.3	0	1
		Sum	2	1
	RKY.B	RKY.4	2	0
		RKY.5	4	1
		RKY.6	2	1
		Sum	5	1
	RKY.C	RKY.7	4	2
		RKY.8	1	2
		RKY.9	0	1
		Sum	4	2

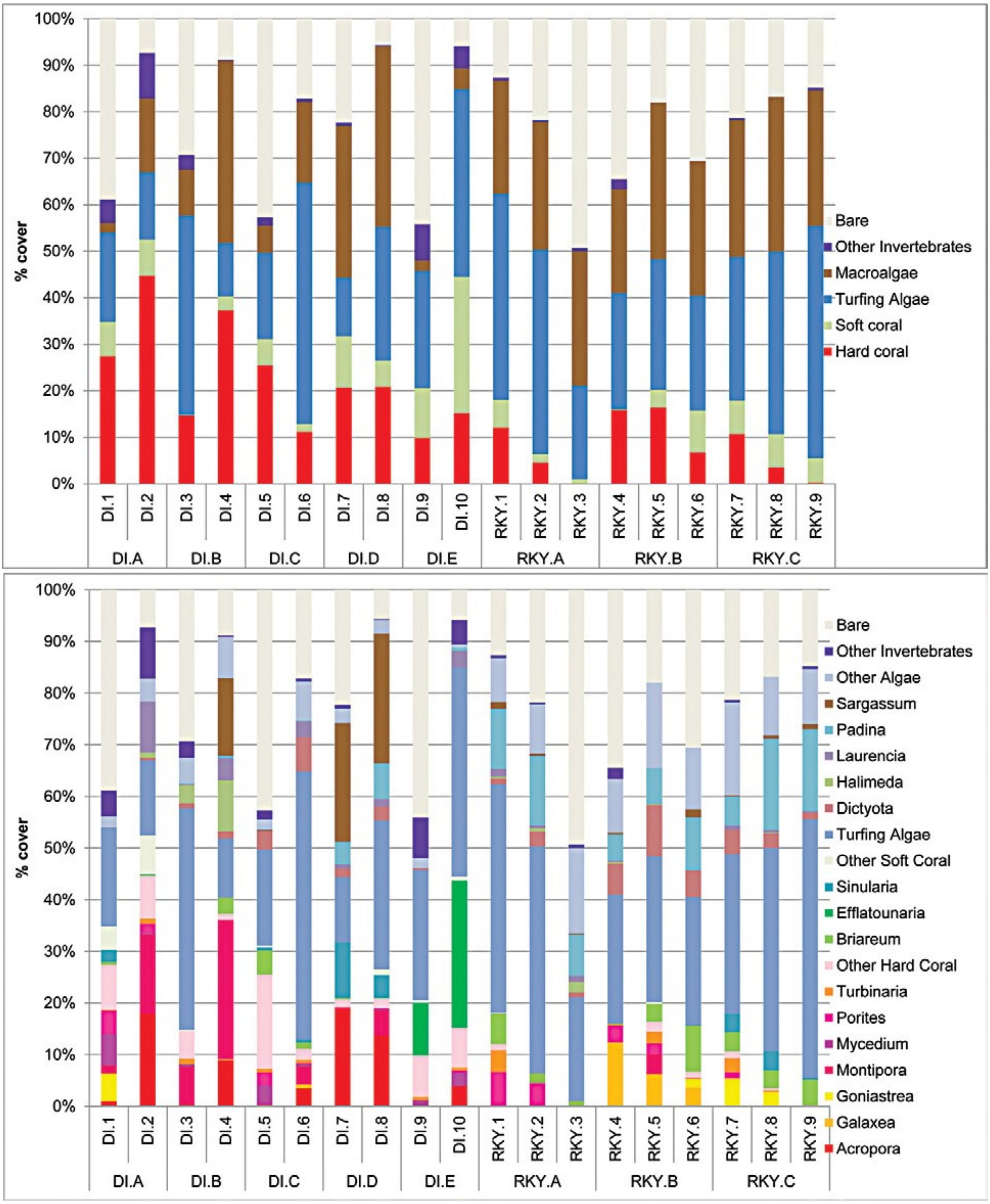

Figure B7-15 Percentage Cover of (i) Broad Benthic Groups (top) and (ii) Numerically Dominant Taxa (bottom). Note: Odd Number Transects at Double Island were Located on the Upper Edge of the Reef Slope, even Number Transects were Located on the Deep Margin of the Reef Slope.

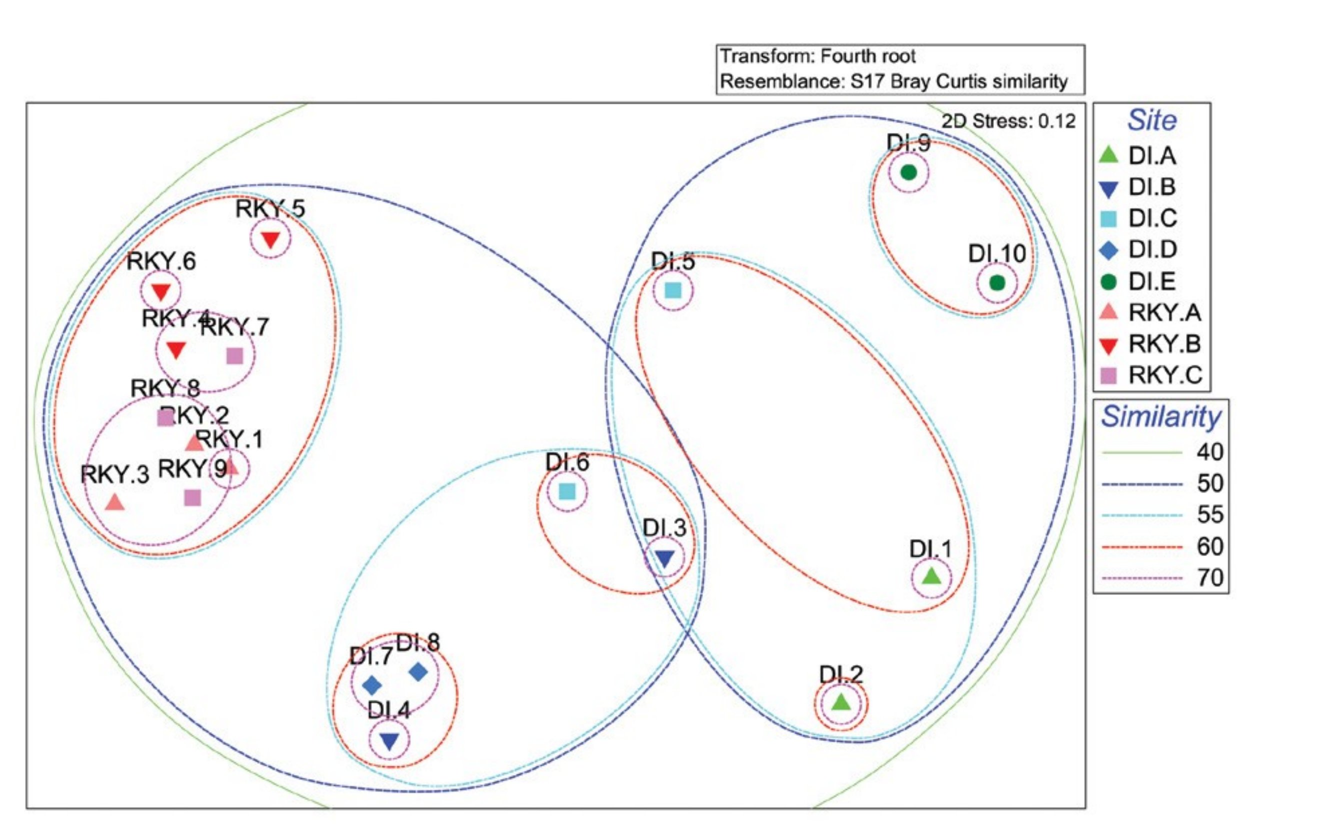

Figure B7-16 Non-metric MDS Ordination – Reef Communities.

Rocky Island/Mission Bay

The only reefs and rocky shores mapped by the GBRMPA Gazetteer within the southern parts of the study area are Rocky Island Reef and an associated unnamed fringing reef in Mission Bay (**Figure B7-13**).

Site inspections at intertidal platform reef surrounding Rocky Island identified a diverse assemblage of corals, algae, large vertebrates and invertebrates within a relatively small area on the north-west extremity of the reef. The reef was composed of granite boulders surrounding most of the island, covered by barnacles and oysters in the upper intertidal zone (**Figure B7-14-A**).

Coral cover was highest along the reef edge and attenuated to very low cover within approximately 50 m of the reef edge. Beyond the reef edge, the inter-reefal substrate consists of muddy sand interspersed with micro-atolls (**Figure B7-14-C**). Hard coral genera including *Turbinaria* (**Figure B7-14-D**), *Galaxea* (**Figure B7-14-B**), *Favia* (**Figure B7-14-E**), *Porites*, *Goniastrea*, and *Favites* dominant. The soft coral *Briareum* (**Figure B7-14-C**) was very abundant, while soft corals *Cladiella* and *Sinularia* (**Figure B7-14-D**) were found occasionally. Hard coral genera including *Dendrophyllids* (**Figure B7-14-F**), *Platygyra*, *Montipora*, and *Moseleya* were present in low numbers.

Generally speaking, highest percentage of living coral was present along the southern and eastern faces of the reef. Water clarity was reasonably turbid along the northern reef edge, despite the extremely calm conditions and lack of significant rainfall. The sea floor was extremely silty and contained more of the species associated with depositional environments such as sea whips, (*Junceella* sp.) and soft corals. This part of the reef edge was most sheltered from south-east trades given its orientation and proximity to the lee of the continental part of the island. The western and north-western reef edge was shallower than the southern and eastern reef slope and this was probably due to accretion from terrigenous sediments, perhaps due to remobilisation by refracted waves.

During the site assessment, numerous molluscs, crustaceans, and large vertebrates were sighted including epaulette sharks (**Figure B7-14-G**), three green turtles resting on the reef (**Figure B7-14-H**), and several ornate crayfish (**Figure B7-14-I**). Central parts of the reef flat contained a large number of broken fragments of staghorn (*Acropora*) coral (**Figure B7-14-J**).

In contrast to Double Island, the reef community at Rocky Island appeared to be in a degraded condition, as evidenced by the high extent of old dead corals present, compared with the smaller and sparse extent of live coral. Coral species remaining on Rocky Island tended to be those most resilient to environmental and physical disturbances (including, for example, windows of increased turbidity). However, this community may also be under significant stress, given its present condition.

Artificial Hard Substrate

In addition to natural reef systems, Trinity Inlet contains large areas of rock wall habitat, particularly within the port area and along the foreshore of Cairns city. Site inspections undertaken in the present study suggest the existing rock walls around the port support algal and invertebrate (primarily sponge and hydrozoan-dominated) communities. Rock wall habitats represent aggregation areas and habitat for a range of fish and shellfish species, and as such, can represent locally important fisheries habitats. Anecdotal observations of large numbers of boat-based recreational anglers adjacent to rock walls and other structures suggest that this area supports locally important fisheries habitats.

Surrounding Areas

The GBRMPA Gazetteer also identifies a series of unnamed rocky shores along the east side of Cape Grafton, several of which support fringing reefs. Fitzroy Island, located offshore from Cape Grafton, also supports well developed fringing reefs and rocky shores.

Mid-shelf reef systems (including Green Island, the Arlington Reef complex, etc.) are located more than 20 km to the north-east of the study area.

Studies undertaken along a portion of area offshore from the Northern Beaches (**Appendix AN** - Additional Marine Ecology Baseline Studies) indicated that epibenthos densities varied from bare substrate to low-density benthic communities. Furthermore, habitats in this study area do not contain hard substrates or abundant epibenthic communities.

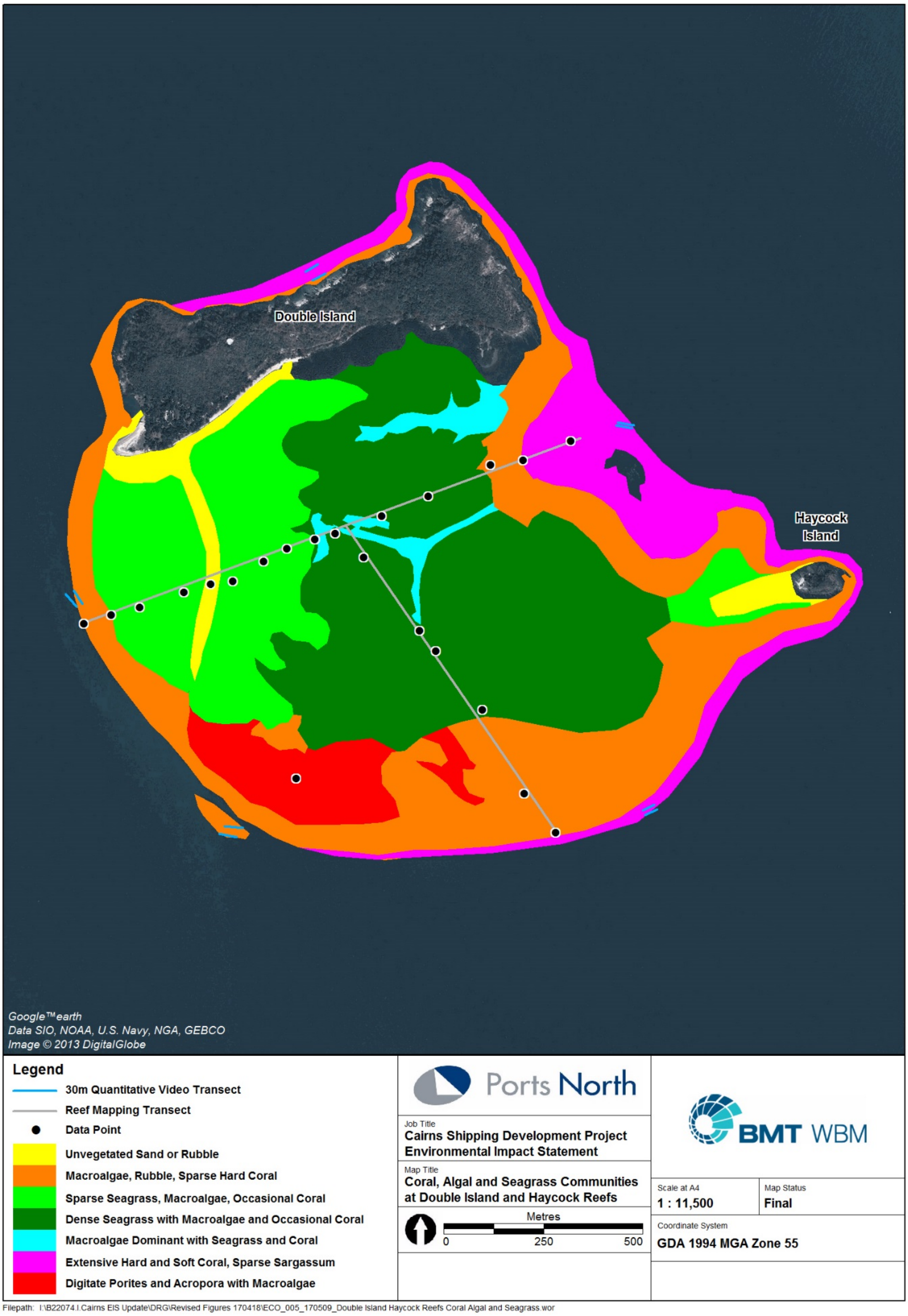

Figure B7-17 Coral, algae and seagrass communities at Double Island Reef.

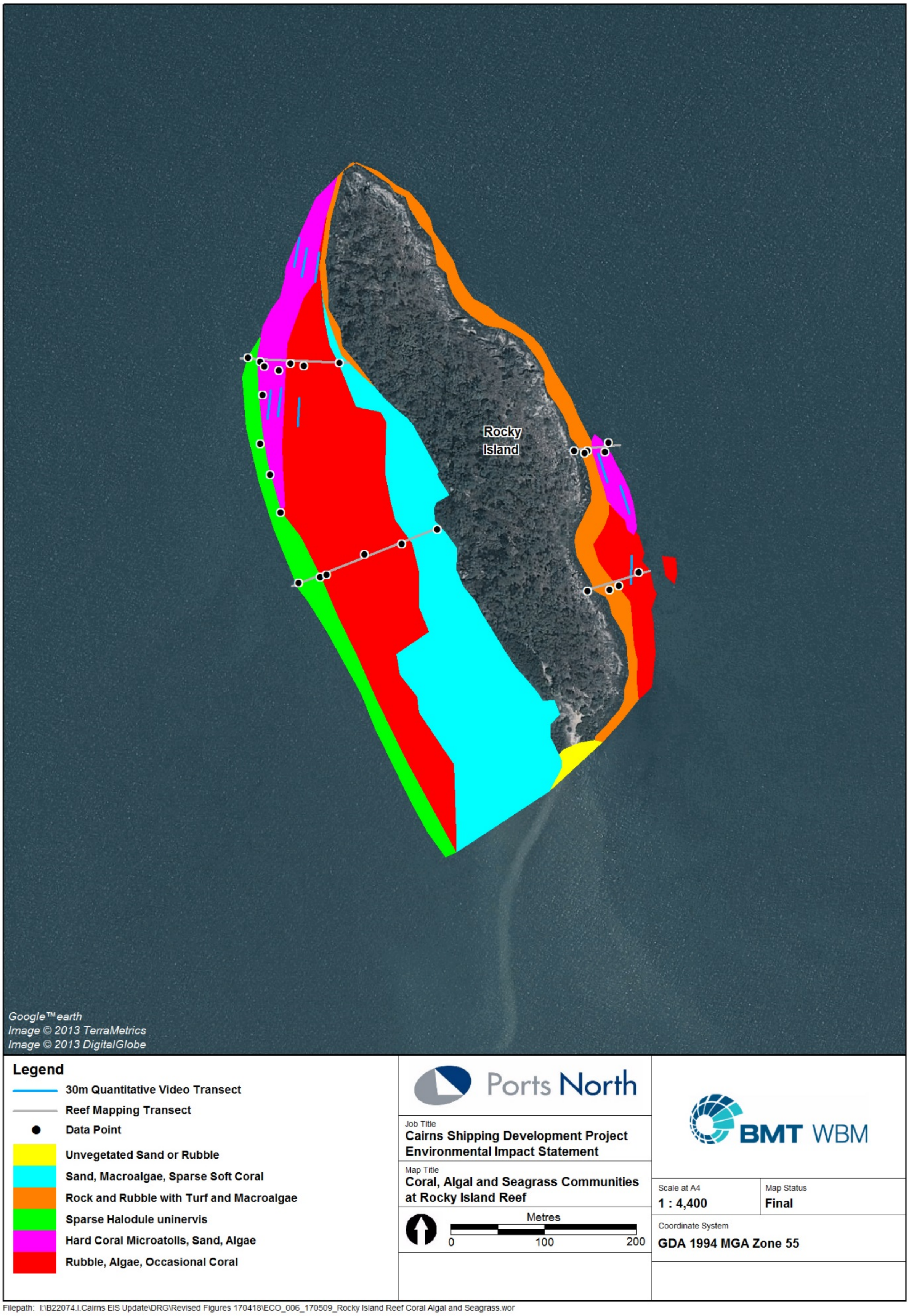

Figure B7-18 Coral, algae and seagrass communities at Rocky Island Reef.

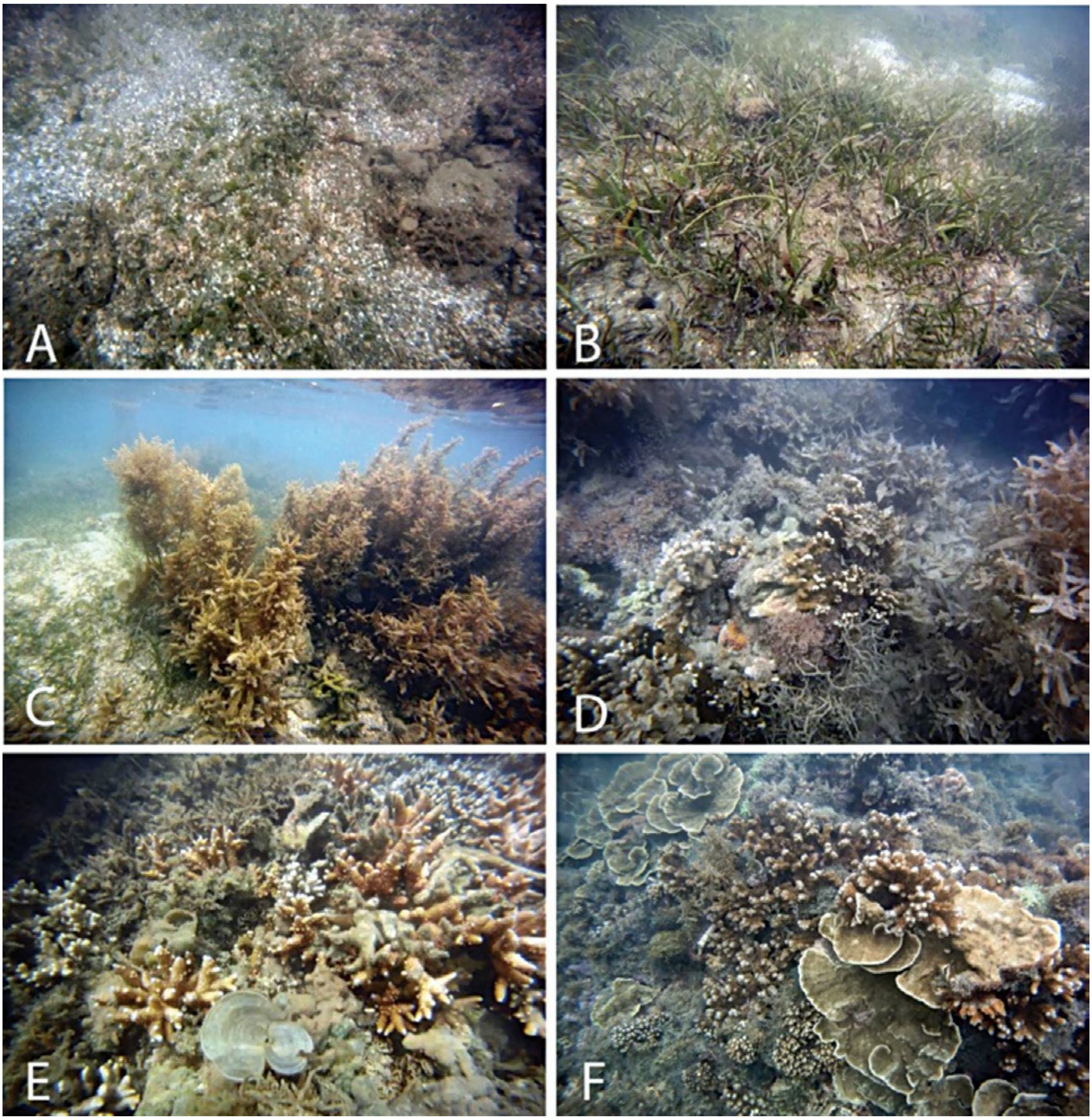

Figure B7-19 Reef Communities at Double Island Reef: Sparse Seagrass over Sand (A); Dense Seagrass with Macroalgae and Occasional Coral (B); Macroalgae Dominant with Seagrass and Coral (C); Macroalgae Dominant (Particularly Sargassum), Rubble and Hard Coral (D); Branching Portitid and Acroporid Hard Corals with Rubble (E); Extensive Hard and Soft Coral Communities (F) on the reef slope.

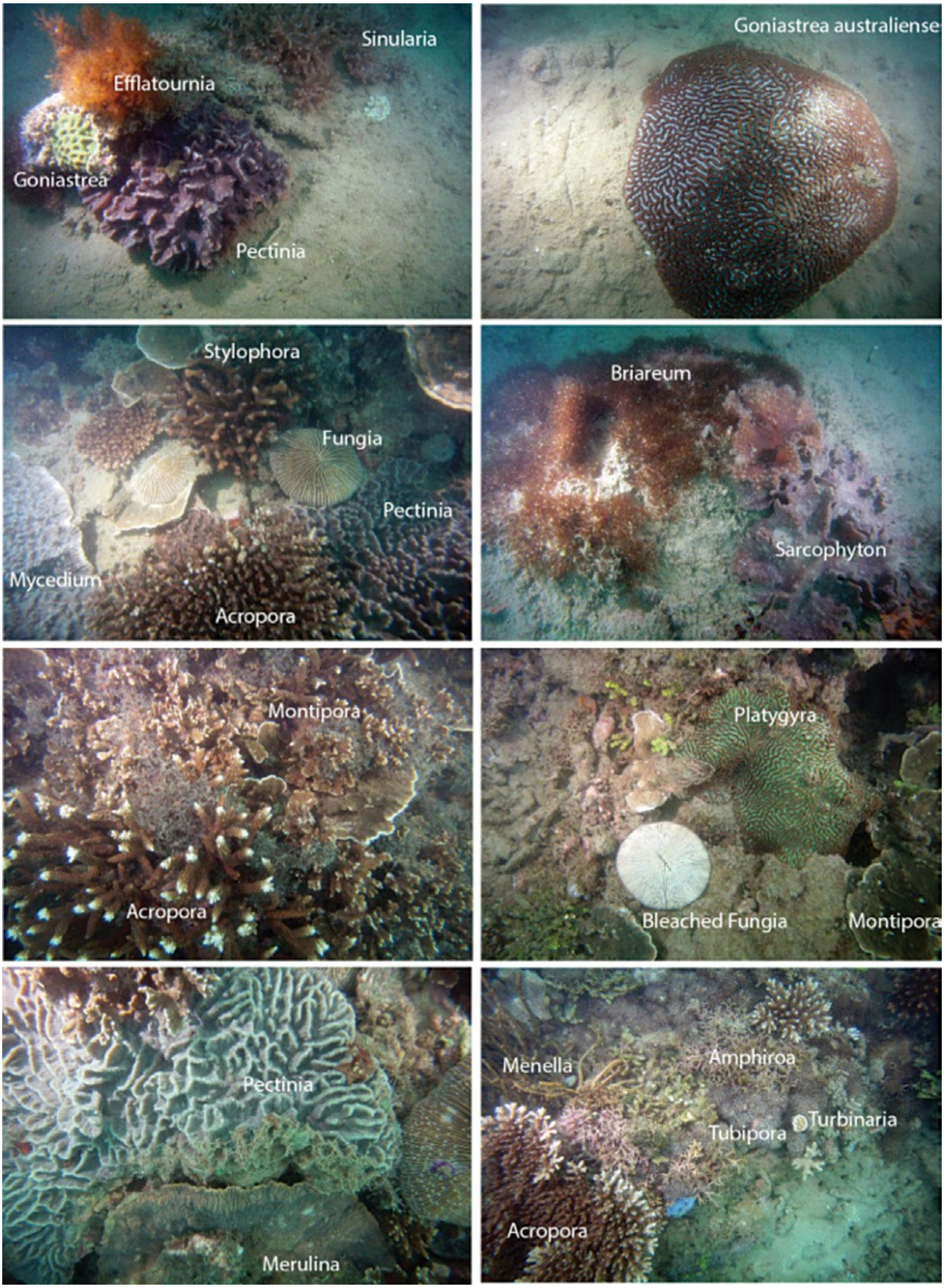

Figure B7-20 Sample photos of extensive hard coral communities at the Double Island Reef slope.

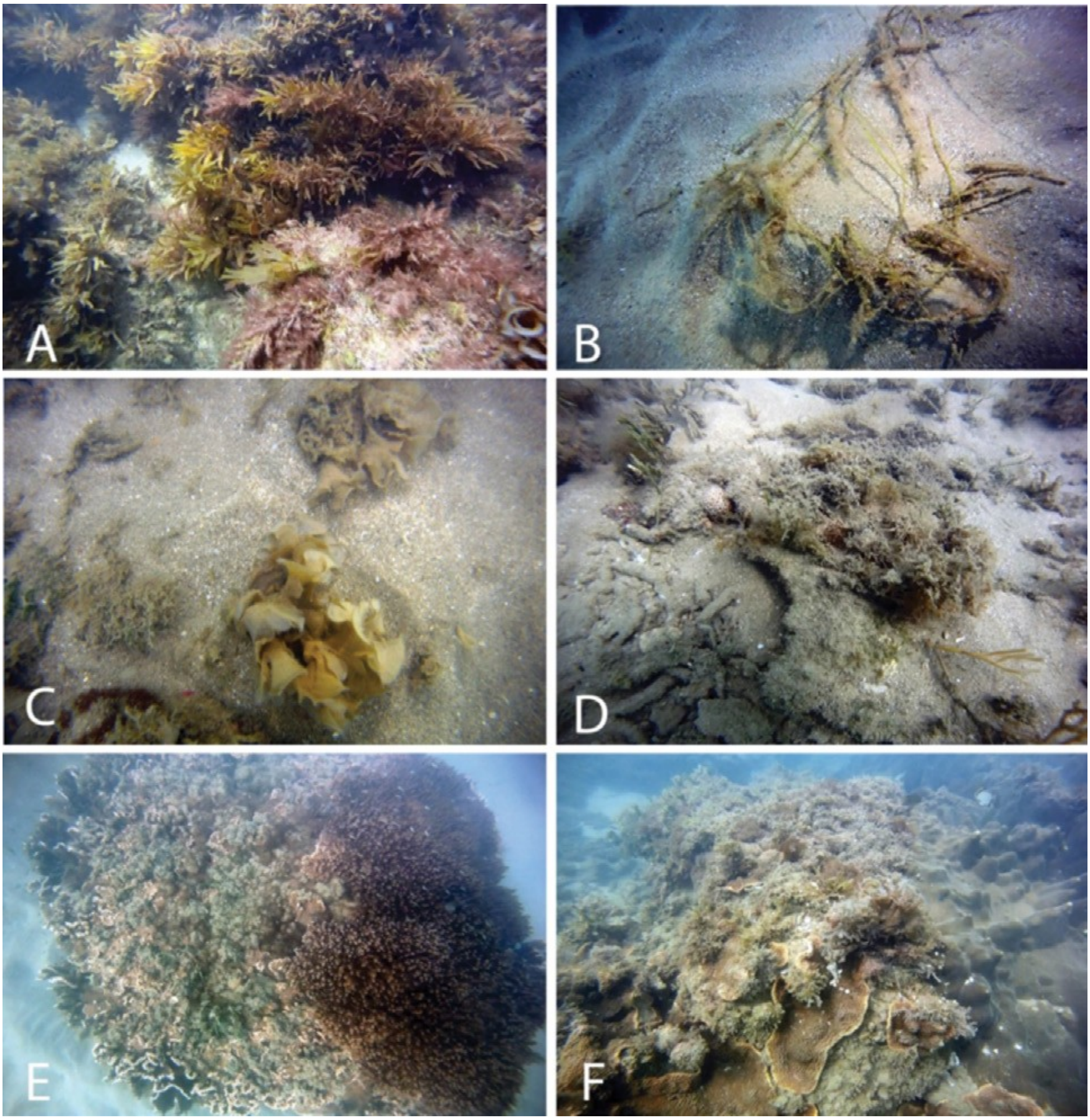

Figure B7-21 Reef Communities at Double Island Reef: Dense Macroalgal Cover Over Rock and Rubble (A); Sparse Seagrass over Sand (B); Macroalgae and Occasional Soft Coral over Sand (C); Rubble with Macroalgae and Occasional Hard Coral (D); Macroalgae Dominant with Seagrass and Coral (C); Macroalgae Dominant (Particularly Sargassum), Rubble and Hard Coral (D); Hard Coral Microatolls with Soft Coral, Sand and Algae (E, F).

B7.2.5.b Key Drivers

The Cairns harbour receives an abundant supply of alluvial sediments, and has high turbidity and sedimentation levels (see **Chapter B5** (Marine Water Quality)). Furthermore, it experiences periods of low salinity during floods (Coles *et al.* 1987). These are key drivers of the structure of rocky shore and reef communities, and in the case of sediment supply, the distribution and extent of hard substrate habitat. In this regard:

- No low-lying rocky reef or fringing coral reefs were present in the harbour. Exposed rock substrate was comprised entirely of massive boulders and rocky shore outcrops within the (hydro-dynamically active) intertidal zone
- Autotrophic species (i.e. macroalgae, hard corals) were poorly developed in the harbour and were primarily comprised of small, isolated colonies.

The few coral species observed on rocky shores in the harbour have adaptations that allow them to cope with high sediment loads. This includes for example, (i) the capacity for some corals to switch from phototrophic to heterotrophic feeding strategies by feeding on suspended sediments; (ii) rapid replenishment of energy reserves between turbidity events; (iii) rapid rates of photo-acclimation; and (iv) energy conservation through reduced respiratory and excretory losses (Anthony and Larcombe 2000). Many nearshore species also secrete mucus to eliminate settled sediment.

B7.2.6 Soft Sediment Habitat and Associated Communities

B7.2.6.a Distribution of Habitats

Soft sediment habitats within Trinity Inlet and Trinity Bay include sandy beaches, intertidal mudflats and subtidal soft sediments. Soft sediment habitats in shallow areas (where there is sufficient light to allow photosynthesis) contain microphytobenthos assemblages, which are often important drivers in coastal food chains. The extent of 'unvegetated' soft sediment habitats can show great temporal variability in response to temporal changes in the extent of seagrass meadows (see **Section B7.2.4.e**).

Surveys carried out to map soft sediment habitats surrounding the proposed terminal site, dredge area, dredge pump out and pipeline corridor and existing and alternative offshore DMPAs for maintenance dredge material showed the seafloor was comprised of numerous substrate classes (**Figure B7-22**). These classes were for the most part, serially ordinated over a large geographic area, with class 1-4 substrata found in inshore embayments, graduating to higher classes with distance offshore and increasing depth. Fine-scale heterogeneity in sediment types was found inside Trinity Inlet, in hydrological diverse channel areas and at the existing DMPA, which has received dredged material from elsewhere. Apart from these areas, changes in sediment classes occurred gradually over large geographic areas.

Summary particle size data for the acoustically defined substrate classes are shown on **Figure B7-23**. The distribution of silts and clay (fines) with respect to distance from shore followed a bell-shaped distribution, with the least amount of fines present in inshore (classes one-four) and offshore areas (classes 10-12), with the midshore region (classes six-nine) dominated by fines. While the inshore and offshore classes had similar particle size distributions, the nature of the sands and coarser material between these two areas differed greatly (see also **Figure B7-24**). Class 1 sediments consisted of fine, muddy, well-sorted sands, often with regular bedforms. Offshore classes 10, 11 and 12 had sand fractions consisting of large amounts of shell and shell grit. Video observations of these offshore areas also showed occasional patches of rubble.

The colour of the offshore material was also much lighter than material in the mid-shore regions, which was probably related to high concentrations of calcium carbonate. Offshore samples were much closer to Green Island; hence, have greater exposure to calcium carbonate originating from coral reefs. It should be noted that while the acoustic classification resolved 12 classes of sediment, the biological relevance of fine-scale changes in PSD between adjacent classes was in many cases very low (see below). In each sediment type, fines made up a significant proportion of the substrate, and a silt layer was ubiquitous over the sea floor. The acoustic substrate mapping was able to distinguish very fine-scale differences in sediment type, but in reality, each sediment class consisted of varying degrees of sand and mud, with occasional gravel. Soft sediments dominate vast parts of the study area, with reef, cobble and rock wall habitat contributing very little to the overall areas.

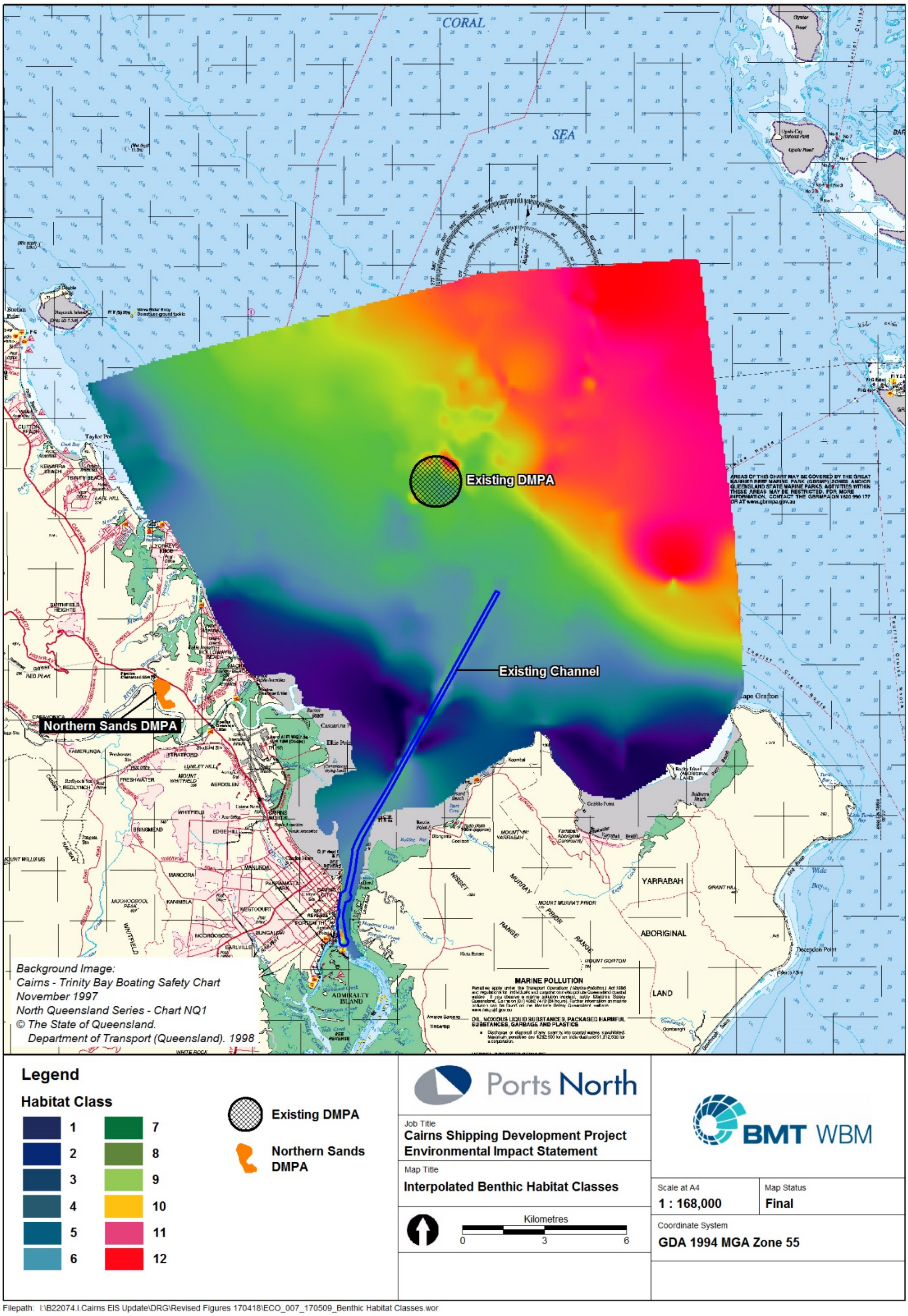

Figure B7-22 Interpolated soft sediment habitat classes.

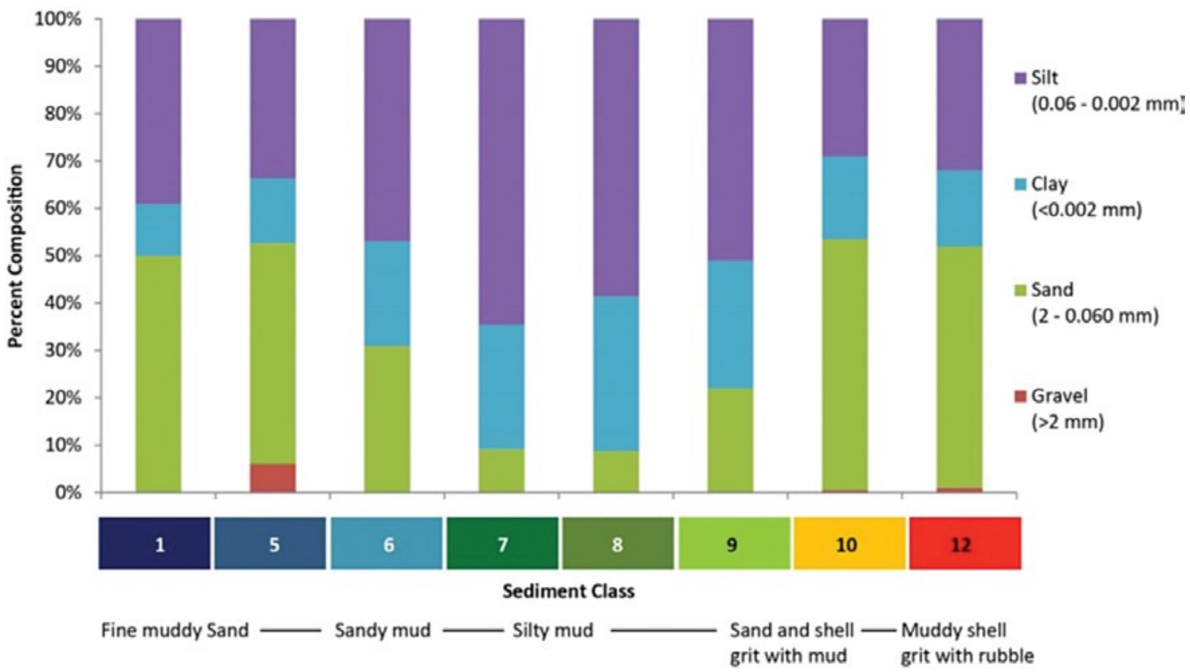

Figure B7-23 Particle size distributions for a selection of acoustic substrate classes.
Class Colours Correspond to **Figure B7-25**.

Overall, the sediment classes detected by the acoustic surveys, together with intertidal sediments, can be grouped into four broad sedimentary habitat types across the study area, including:

- Intertidal banks and mud flats – Primarily concentrated around the eastern and western sides of the Cairns harbour, Yorkeys Knob and the Barron River mouth, and southern Mission Bay.
- Subtidal inshore fine sandy mud – Distributed across subtidal sections of the harbour, Mission Bay, and remaining inshore marine reaches along the south western extent of the study area.
- Midshore mud – The dominant broad soft sediment habitat type within the study area, covering an area of 10,140ha (**Table B7-6**), including most of the northern section of the study area.
- Offshore muddy sand and shell – Confined to the north eastern corner of the study area, which extends into the deeper, offshore bathymetric contour.

Figure B7-25 provides an indicative summary of the distribution of these broad sedimentary habitat types, with total areas within the study area listed in **Table B7-6** (note: excludes muds in Trinity Inlet beyond the acoustic survey extent). Beyond the study area, broad sedimentary habitat types were largely dominated by: the 'mid-shore mud', extending across both near-shore and mid-shore waters; and 'offshore muddy sand and shell' in deeper offshore areas. The existing DMPA, together with DMPA Options 1, 2 and 3, are all largely comprised of the broad mid-shore mud sediments.

TABLE B7-6 AREA OF BROAD SOFT SEDIMENT HABITAT TYPES MAPPED IN THE STUDY AREA

	AREA (HA)
Intertidal flats	2142
Subtidal inshore fine sandy mud	6131
Mid-shore mud	10 140
Offshore muddy sand and shell grit	1267

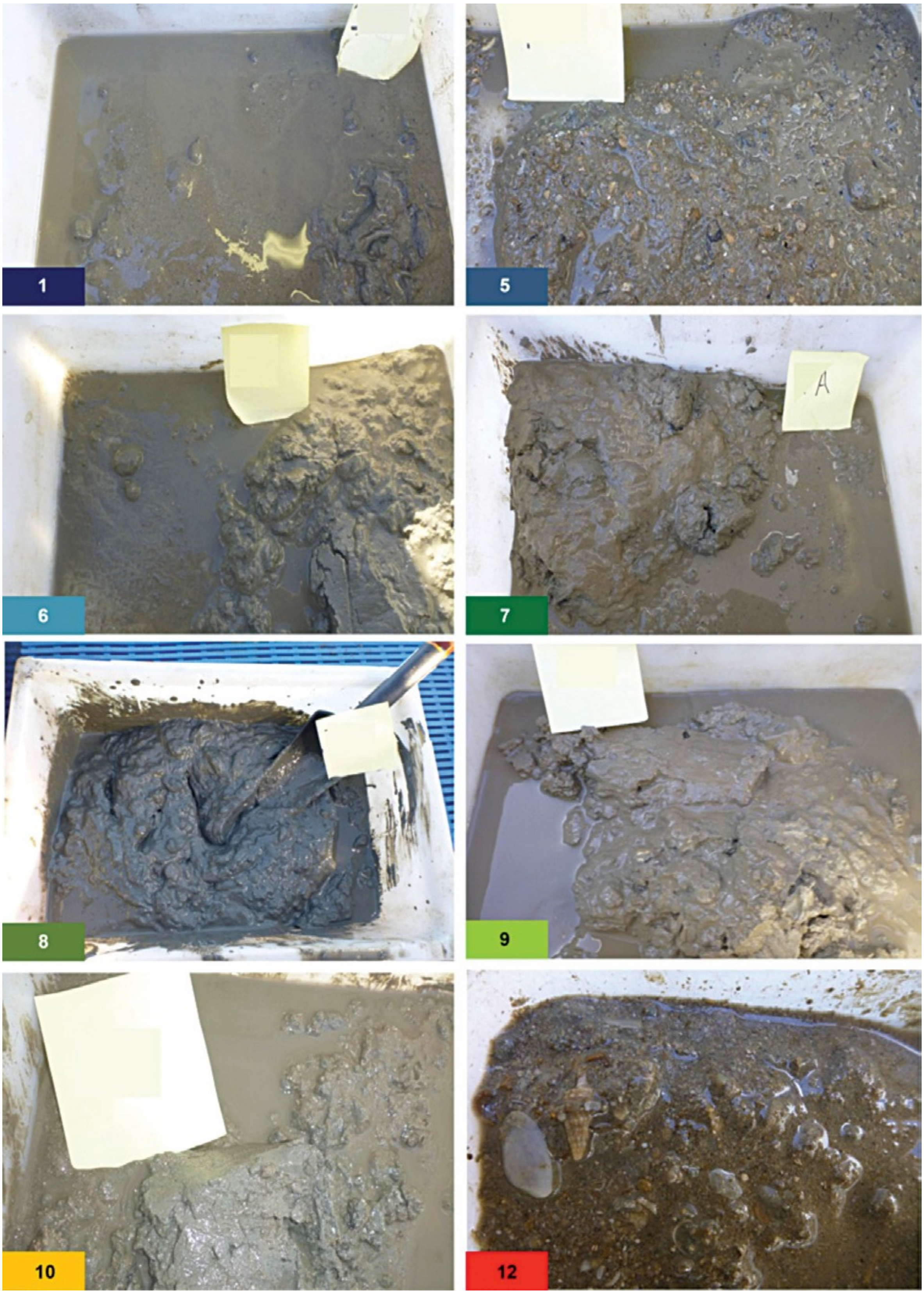

Figure B7-24 Photos of sediment from a selection of sediment classes.

Class Colours correspond to **Figure B7-23**, and Site Tags have been removed to allay confusion between Site Numbers and Sediment Classes.

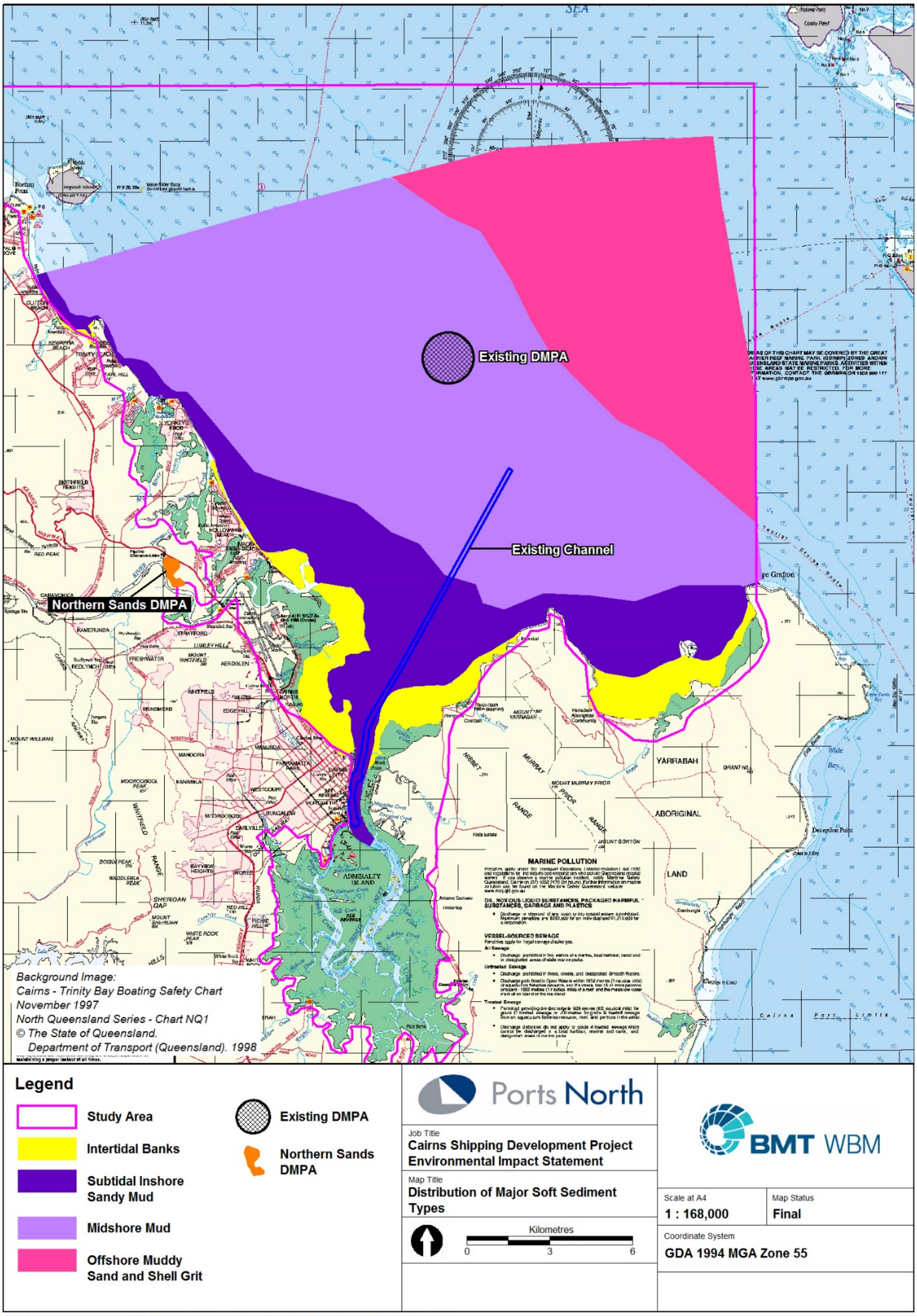

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Figure B7-25 Distribution of major soft sediment types.

B7.2.6.b Epibenthic Fauna

Video-based surveys undertaken simultaneously with the acoustic habitat mapping suggested epibenthic communities were sparse and patchy throughout the study area. Of the 14 useable video transects, seagrass was not observed and epifauna were recorded on 12 of the 14 transects. In total, 11 fauna taxa were recorded consisting of 64 animals, without seagrass or macroalgae.

Epibenthos assemblages observable in videos were dominated by burrowing gobies, sea pens (**Figure B7-26-A**) and crinoids (feather stars, **Figure B7-26-B**). Half of all specimens observed were burrowing gobies. There were 13 sea pens and seven crinoids. There tended to be more taxa (**Figure B7-27**), more individuals (**Figure B7-27**), and more burrows (**Figure B7-28**) at sites located farther from shore (higher sediment classes) than in sites closer to shore.

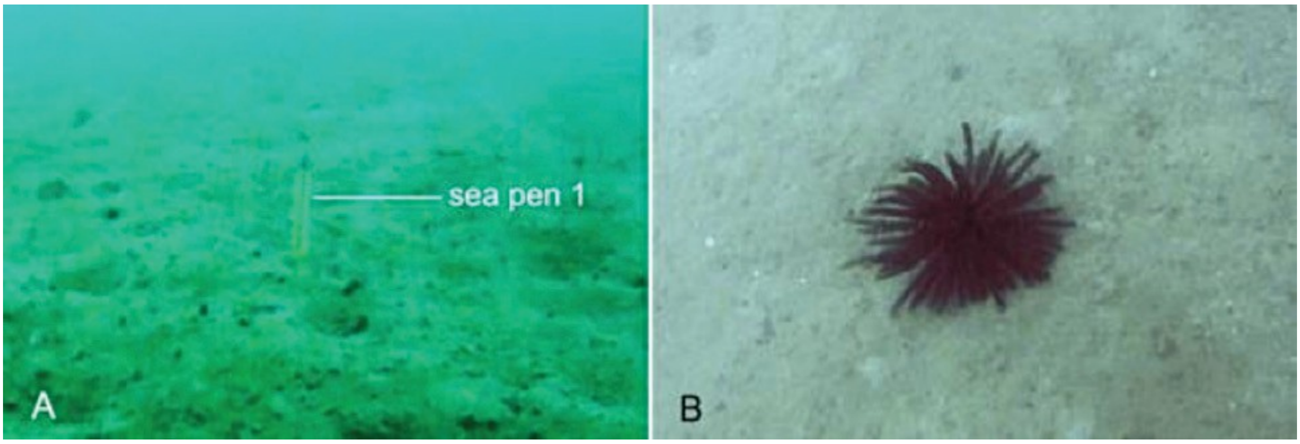


Figure B7-26 Small Sea Pens (A) and Feather Stars (B) were the most abundant sessile taxa.

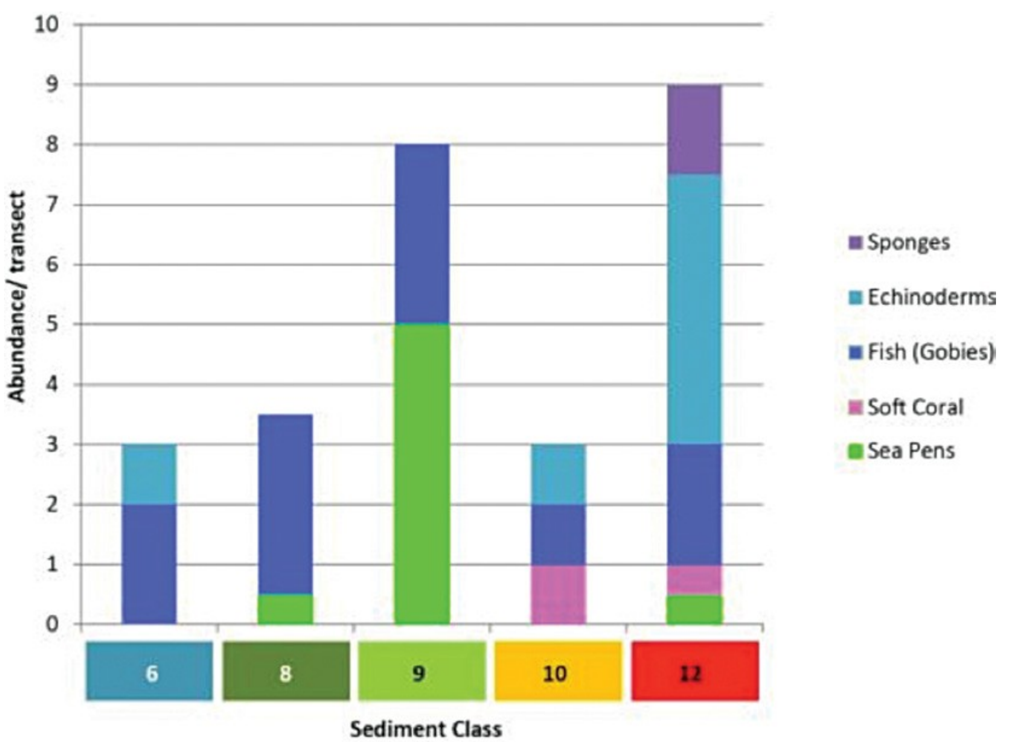


Figure B7-27 Mean abundances (per four minute video transect) of epibenthic fauna at representative sediment classes.

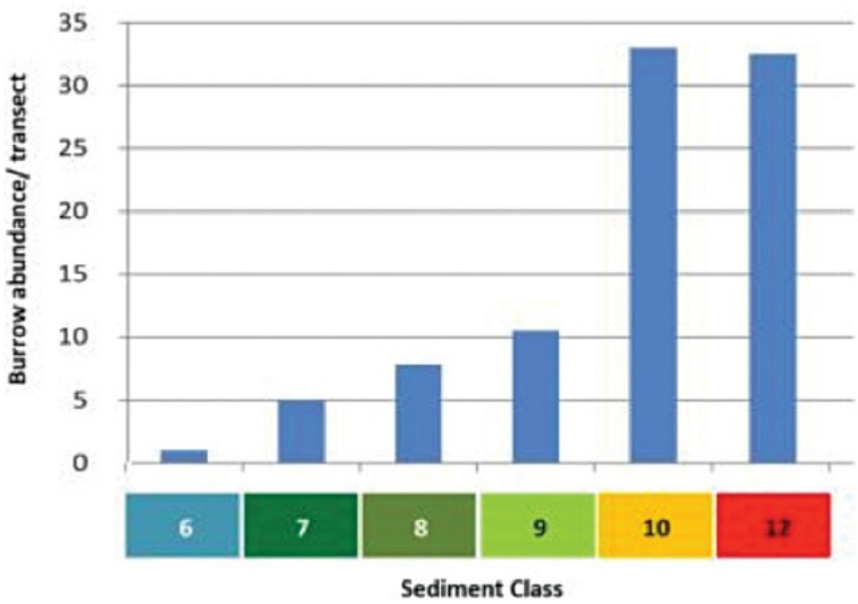


Figure B7-28 Mean burrow abundances (from three frame-grabs per transect) at representative sediment classes.

McKenna *et al.* (2013) surveyed epibenthic macroinvertebrates, seagrass and macroalgae from 572 sites over the study area between October 2012 and January 2013 (**Figure B7-29**). Similar to findings of the acoustic habitat validation, McKenna *et al.* (2013) reported habitat forming macro-invertebrates such as soft corals and bryozoans were predominantly found further offshore, with little to no epibenthos found in the inner port or Trinity Inlet. Overall, McKenna *et al.* (2013) found the dominant habitat feature to be open mud/sand substrate with a low cover of epibenthic life from a diverse array of taxa. There were no high density benthic communities (>80 percent cover), and there were no unique or unusual benthic macroinvertebrate or algal communities found within the survey area. Epibenthic invertebrates were typically observed as isolated individuals, with the exception of:

- High density soft coral and seapens at two locations (one near west of the shipping channel and one in the vicinity of the DMPA).
- Medium density polychaetes at one area (north of the end of the shipping channel), echinoids at one area (south of the DMPA), and bivalves along the inshore area between Bessie Point and False Cape.

Epibenthos density polygons are shown overlaying the acoustically defined sediment class map on **Figure B7-30**. A description of the various epibenthic macroinvertebrate regions identified by McKenna *et al.* (2013) is also provided in **Table B7-7**.

Benthic macroalgae was shown to have a wide distribution, occurring in isolated areas throughout the harbour and Trinity Inlet (McKenna *et al.* 2013). Despite the wide distribution, percentage cover of algae was typically low, with 77 percent of macroalgae regions mapped having less than 10 percent cover. No high density macroalgae coverage was recorded. Macroalgae was generally dominated by Sargassum spp., Halimeda spp., as well as various mosaics of unidentified turfing algae mats and filamentous algae. Algae concentrations tended to occur in areas of the inner port and Trinity Inlet rather than offshore, particularly along the western harbour adjacent to the Esplanade. Comparisons with past data indicated that macroalgae distribution and density can fluctuate greatly (**Figure B7-31**), partly in response to water quality (e.g. nutrients) and climatic factors (e.g. physical disturbance), as well as in response to changes in competitive phyto-oganisms (i.e. opportunistic growth following reductions in seagrass extent or condition) (McKenna *et al.* 2013).

Many of the algae and benthic macroinvertebrate communities described in their survey occurred in proximity to maintained channels, port facilities and the existing DMPA.

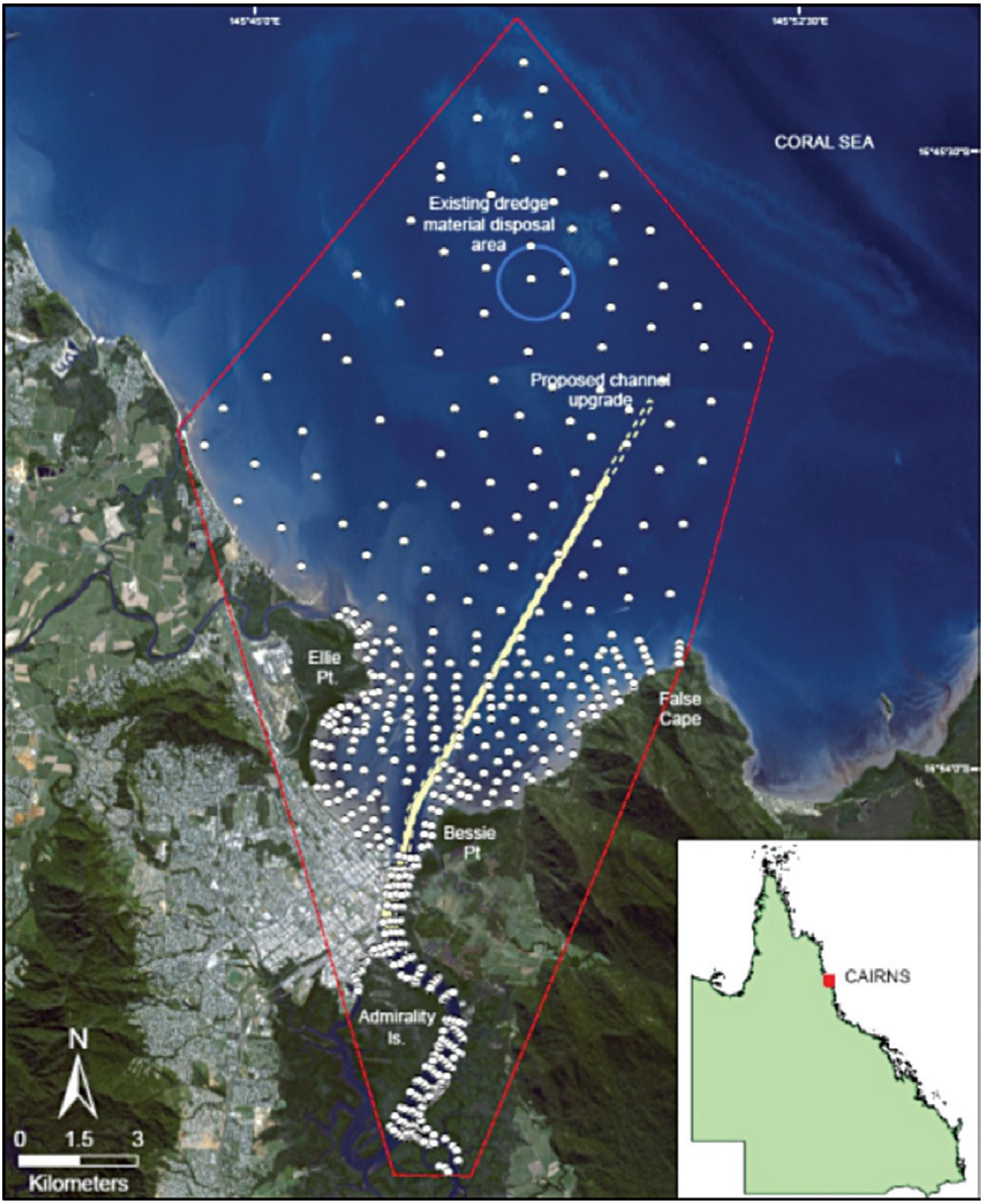


Figure B7-29 Extent and distribution of TropWATER benthic macroinvertebrate survey sites.

Source: McKenna *et al.* (2013).

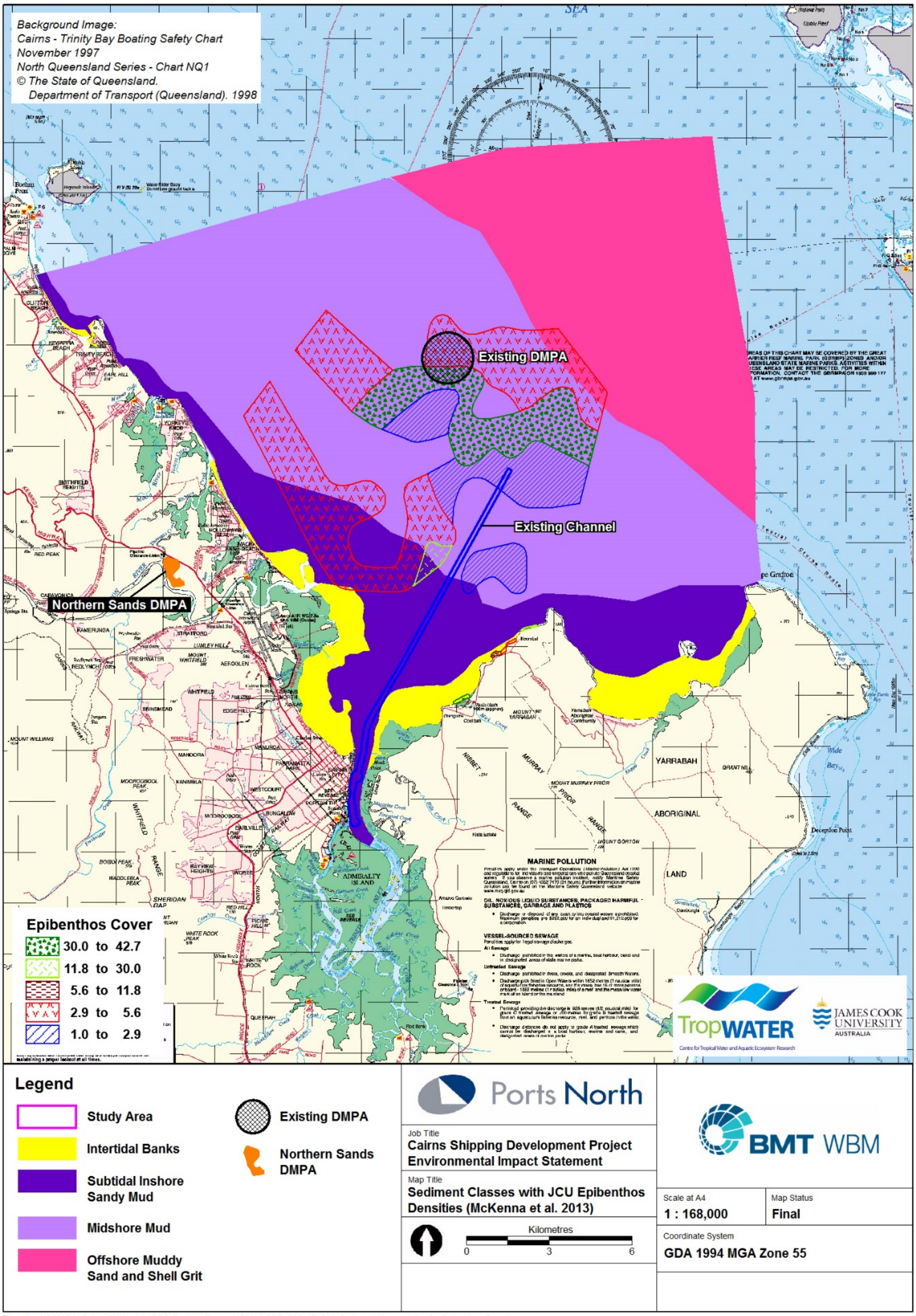


Figure B7-30 Interpolated sediment classes with JCU epibenthos densities.

Source: McKenna *et al.* (2013).

TABLE B7-7 EPIBENTHIC MACROINVERTEBRATE REGIONS AND DESCRIPTIONS WITHIN CAIRNS HARBOUR AND TRINITY INLET, REFER APPENDIX D13 FOR MAP OF REGION LOCATIONS (SOURCE: MCKENNA *ET AL.* 2013)

Density category	Benthic macro-invertebrate region description	Region ID (see maps 2 & 3)	No. of sites	Area ± R (ha)
Open substrate, occasional benthic individuals	Open substrate with isolated benthic individuals	1 (white survey sites on maps 2 & 3)	517	na
Low density benthic community	mostly open substrate with patches of low density bivalves & low numbers of individual polychaetes	2	2	6.59 ± 0.89
	mostly open substrate with patches of low density sea pens, hydroids and ascidians with low individual numbers of other taxa	3 & 6	9	1482.69 ± 561.99
	mostly open substrate with patches of low density bryozoans and hydroids and low individual numbers of other taxa	4 & 5	19	2248.81 ± 1730.27
	mostly open substrate with patches of low density sea pens, hydroids and ascidians with moderate numbers of individual polychaetes & low numbers of other taxa	7	9	1276.88 ± 604.34
	mostly open substrate with patches of low density sea pens, hydroids and ascidians with moderate numbers of individual echinoids	8	2	321.53 ± 76.96
Low/ Medium density benthic community	mostly open substrate with patches of medium density bivalves & low numbers of individual polychaetes	10	1	5.09 ± 0.48
	mostly open substrate with patches of low/medium density hard and soft coral with sea pens, and low numbers of individual echinoids and bivalves	12	1	90.33 ± 50
Medium density benthic community	patches of medium density bivalves & low numbers of individual polychaetes, with areas of open substrate	9 & 11	2	11.83 ± 1.41
	patches of medium density sea pens, hydroids & ascidians with areas of open substrate and low numbers of individual bryozoans, soft coral, echinoids, crustaceans & bivalves	13	10	1454.56 ± 837.26
Total		**13**	**572**	6898.29 ± 3863.60

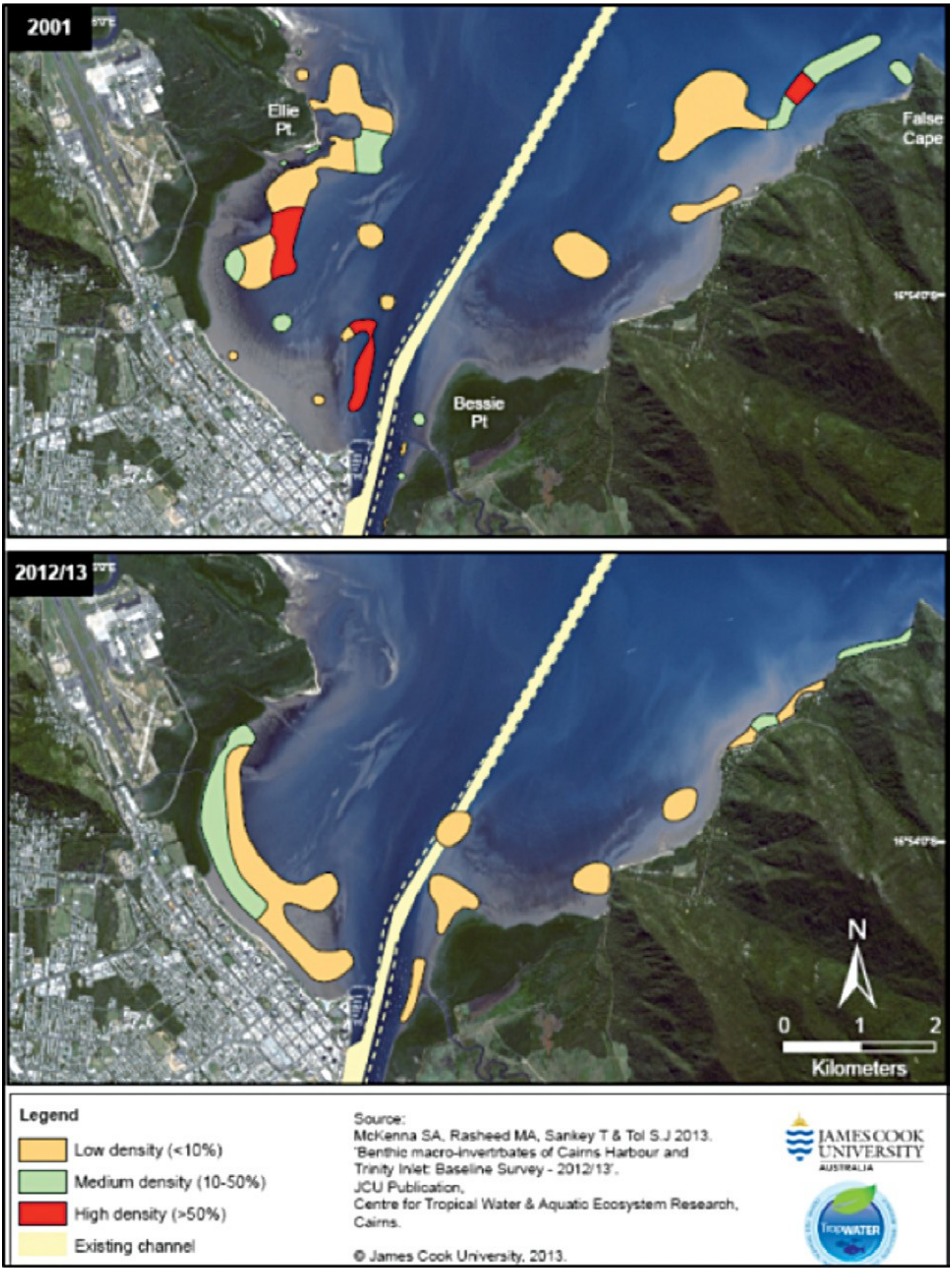


Figure B7-31 Comparison of algae community regions at Cairns Harbour over time, 2001 and 2012/13.

Source: McKenna *et al.* (2013).

B7.2.6.c Infauna Communities Associated with Sediment Classes

For macroinvertebrate infauna during the dry season, indices of taxonomic richness, abundance, and Shannon’s diversity were highest at the offshore sites 5C and 5D, found within sediment class 10.

Some sites within sediment classes five and seven tended to have lower abundance, richness and diversity than surrounding sites, but these low values were not consistent within either sediment classes. Diversity measures at the existing spoil ground, represented by sites 7A, 7B, and 7C were within the range of variation observed at surrounding sites. During the wet season, diversity indices were lower at all sites, however, variation in these indices was similar across sites and sediment classes with greatest richness, abundance and Shannon’s diversity seen in sediment classes one, five and 10. Once again, diversity measures at the existing spoil ground were within the range of variation observed at surrounding sites.

Higher abundance and richness within sediment class 10 reflected the large numbers of polychaetes and crustaceans (**Figure B7-32**) from numerous taxonomic groups. Although richness and abundance was lower at these same sites during the wet season, the taxonomic distribution at these sites remained similar, with crustaceans and polychaetes dominating. Higher richness and abundance at site 4A during the dry season, where large numbers of crustacean species were recorded, may be associated with local hydrodynamics, as this site was located at the edge of the outer shipping channel. It should be noted that site 1A from sediment class 11 was taken from Trinity Inlet and is unlikely to be representative of this sediment class in the offshore area, where it was predominantly found.

Sea-pen 1 (**Figure B7-26-A**) was large enough to be observed in video transects as a part of the epibenthos, and small enough to be captured within van Veen grabs with other infauna. It was particularly abundant around the existing DMPA (at sites 7A, 7B, 7C, 8A and 8B) and was seen in both surveys, although it was most abundant during the dry season. These results were consistent with the results of McKenna *et al.* (2013), where these small sea pens were major community components surrounding the existing maintenance dredge material DMPA.

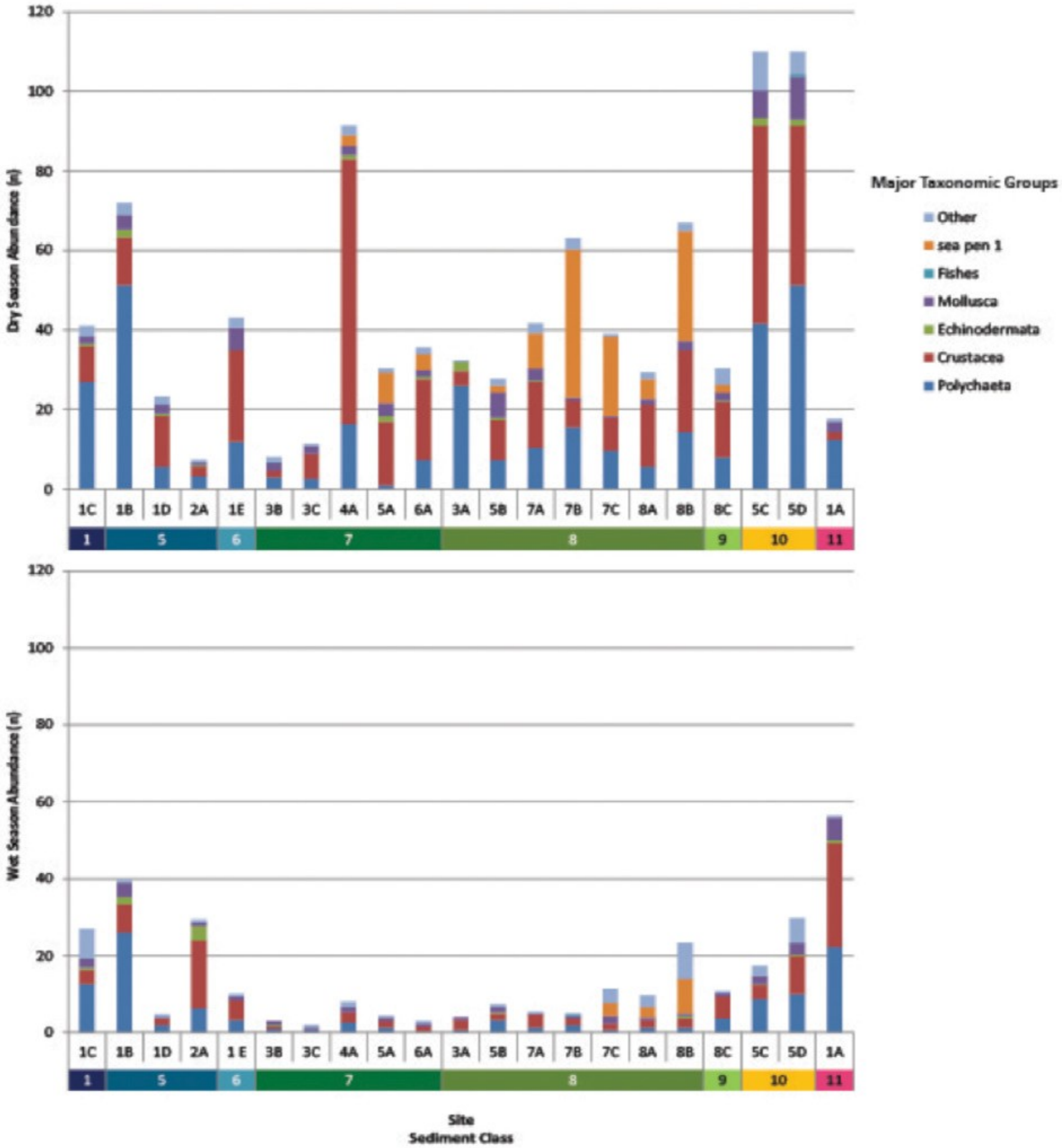


Figure B7-32 Proportion of each major taxon contributing to total abundance at each site during wet season and dry season surveys,

Multivariate analysis of dry season data showed that infaunal communities varied among acoustically derived substrate classes (ANOSIM global R=0.28, p=0.002). Communities from sediment class five occupied a central position within the plot and were very similar to a range of communities (not significantly different) including those from sediment classes one, 9 and 11. The most disparate communities came from sediment class eight, which were very different from communities in all other sediment classes except from class six. Typically, similar substrate types tended to have similar communities; sediment classes (e.g. one and five were similar, five and six were similar, and six and seven were similar, etc.). The only adjacent sediment classes with different communities were classes seven and eight, and classes nine and 10.

Because sediment classes seven and eight surrounded the existing DMPA, the potential effect of the existing DMPA was also explored in more detail.

While sediment class was a reasonable predictor of infaunal macroinvertebrate communities, location (with respect to coastline and depth) had better explanatory power (ANOSIM global R=0.664, p=0.0001). The inner channel consisted of channel sites inside Trinity Inlet, the outer channel was channel sites in the Cairns harbour, coastal sites were close to the shore and within the one metre LAT contour, inshore sites were between the five-10m LAT contours, mid-shore sites were within 10-20 m LAT contours, and offshore sites were deeper than 20 m LAT. Communities from all locations were significantly different to one another (p<0.002). The inner channel community was dominated by polychaetes (glycerids, maldanids, and capitellids) and tellnid bivalves, the outer channel was characterised by tellnids and amphipod crustaceans. The coastal sites were characterised by large numbers of marine worms (spionids, orbininids, nemerteans) and amphipods, inshore sites were dominated by amphipods, mid-shore sites by amphipods and sea pens, while the offshore sites had large numbers of crustaceans (tanaids, amphipods, callianassids ghost shrimp) and maldanid polychaetes.

B7.2.6.d Infauna Communities of Estuarine Waterways

A total 125 macroinvertebrate families were recorded from the 21 sites sampled from estuarine waterways including Trinity Inlet, East Trinity and the Barron River in the dry season of 2016. During the wet season (March 2017), a total of 87 macroinvertebrate families were recorded from 8 sites investigated in the Barron River and offshore from Richters Creek. The macroinvertebrate fauna reported in the dry season was numerically dominated by mytilid bivalves (particularly *Xenostrobus secures*), representing approximately 22% of the catch (Figure B7-34). This was due largely to very large numbers of the bivalve collected from site BF4 on the Barron River. Specimens of nereid polychaete worms were the next most abundant taxon collected, accounting for 18% of the catch. Other abundant taxa were bristle worms (Terebellida) families (Ampharetidae and Sternaspidae), which together accounted for 9% of the catch, spionid polychaetes (marine worms), amphipods and apseudid crustaceans.

The Barron River sites were by far the most abundant sites for macroinvertebrates, but this varied greatly from the dry season to the wet season. Upstream sites BF5 and BF4 were much more abundant in the dry season, while there was much greater abundance at more downstream sites BF2 and BF3 in the wet season. It is possible that greater abundance in the downstream and offshore locations is the result of greater river flow, which acts as a disturbance in the wet season.

In terms of species richness, Site TRIN2 in Trinity Inlet recorded the highest mean number of species during the dry season. High richness here was primarily driven by several types of amphipods that accounted for 21% of the catch. During the wet season, site RICHT1 offshore from Richters Creek had greatest mean number of species that was dominated by Apseudes spp (Apseudidae), which represented 26% of the catch. Site RICHT1 was also the most seasonally variable site for richness; during the dry season in 2016 it also had the reported the lowest average number of species. Such high variability in richness is likely due to the stability of bed habitat, as this site has the most wave exposure of all the sites investigated, being located at the mouth of Richters Creek.

For taxonomic diversity (Shannon's H') site TRIN2 in Trinity Inlet had the highest diversity, in the dry season, while site RICHT1 recorded the highest diversity in the wet season. The least diverse sites in the dry and wet seasons were BF5 and BF3, respectively.

In general, most sites had similar levels of diversity, with the Barron Rivers sites being less diverse than surrounding sites. This appeared to be driven largely by sporadically high abundance and low species richness in the Barron River. Of all the waterways considered, the Barron River has the largest catchment area and experiences the greatest freshwater flow. It is likely that these pulsed turbidity and freshwater events act as important drivers of abundance, diversity, and richness, and contribute to the spatial and temporal variability observed at these sites.

In summary, infaunal communities differed among broad habitat types, but these differences could not consistently be determined among all the acoustically-derived substrate classes. Physical location was a better community predictor, particularly when sites were grouped according to distance offshore and water depth.

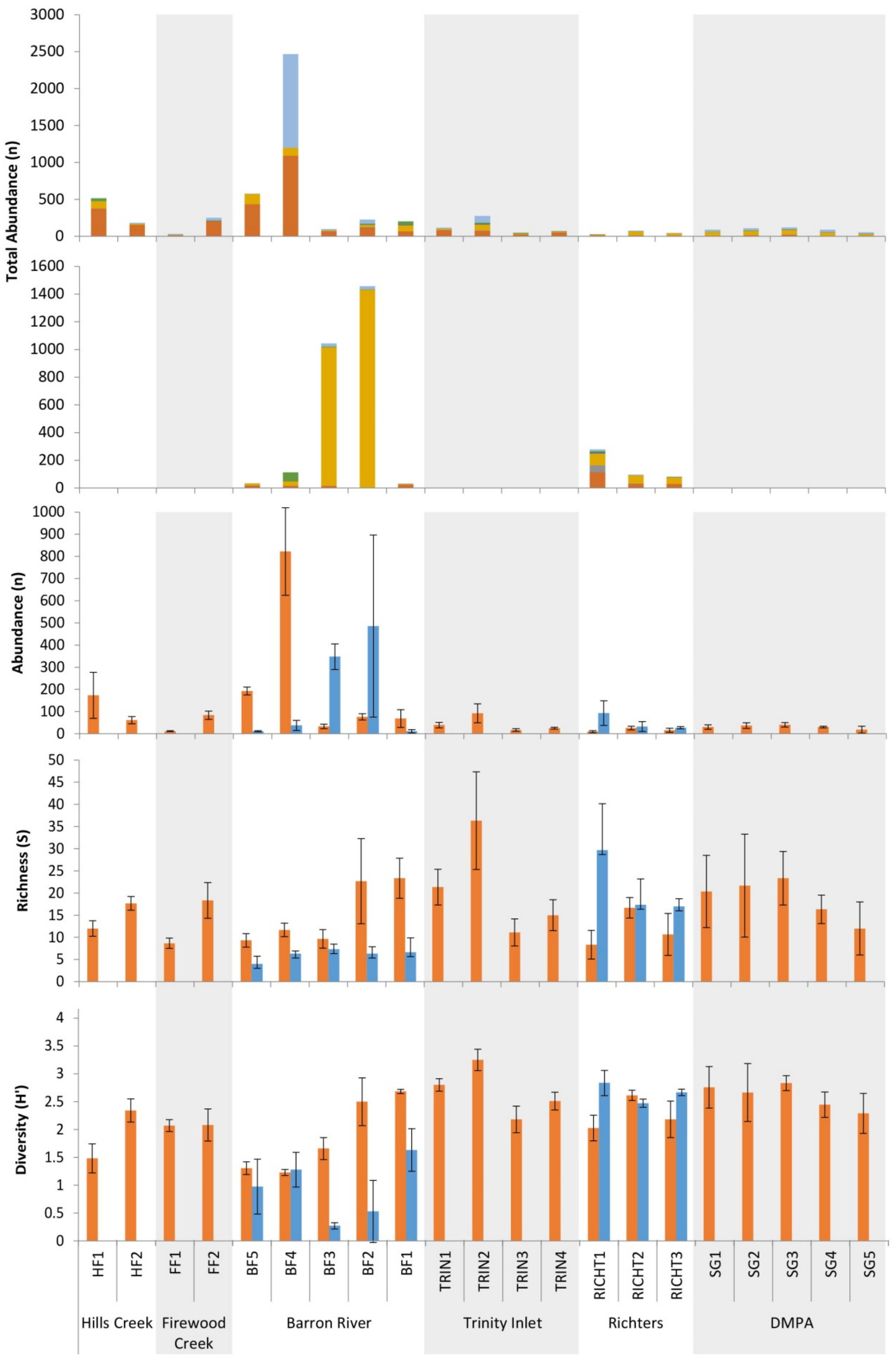


Figure B7-34 From top to bottom, differences in macroinvertebrate total abundance (dry season); total abundance (wet season); mean abundance (n); mean richness (S); and mean diversity (H').

B7.2.7 Marine Species of Conservation Significance

This description of marine species of conservation significance is based on a desktop review of existing information, together with advice acquired through liaison with local experts. In agreement with the relevant regulators, a targeted marine megafauna survey was not deemed necessary for this EIS on the basis that the proposal does not involve seabed reclamation or direct loss of seagrass, applicable mitigations measures are well understood, and that surveys will only provide a limited ‘snapshot’ for any given time. Further, any present surveys would likely grossly under-estimate typical population estimates and habitat utilisation for seagrass-dependent species (e.g. dugongs, turtles), given the limited availability and poor condition of local seagrass communities at this time.

While there is very limited data available describing the occurrence, habitat utilisation and populations of marine megafauna in the Cairns region, a conservative approach has been adopted, whereby it has been assumed that a species may occur: (i) if suitable habitat is available, and (ii) the area of concern is within its broader geographical range.

The EPBC Act Protected Matters Search Tool was used to identify threatened marine species and ecological communities that occur or could occur within the study area. In summary, the following were identified:

- threatened sharks: three species
- threatened marine mammals: two species
- threatened marine reptiles: six species
- no threatened ecological communities.

An additional seven species were listed as protected migratory species, including five mammals, one reptile and one shark.

Further to the threatened and migratory species, numerous species were listed only as ‘listed marine species’ (i.e. non- threatened, non-migratory). These additional EPBC Act listed marine species are not addressed in detail in this section but, for future reference, included 50 sygnathids (i.e. seahorses, pipehorses, pipefish), 15 sea snakes, and six mammals (minke whale and five dolphins).

Detail is provided for key fauna groups in the following sections.

B7.2.7.a Marine Turtles

Six species of marine turtle may occur in the harbour, Trinity Inlet and/or the surrounding area, although some species are more common than others (**Table B7-8**). All are considered threatened under the EPBC Act and NC Act. Marine turtles have been recorded in offshore, near-shore and intertidal habitats within the study area. These species primarily use the area as a feeding ground, as well as a transit area between other parts of the Queensland coast and the Great Barrier Reef. Low density nesting also occurs across the broader region, particularly low density nesting of Green and Flatback turtles (Limpus 2007, 2008).

TABLE B7-8 EPBC PROTECTED MATTERS DATABASE SEARCH RESULTS – THREATENED AND MIGRATORY MARINE REPTILES

SPECIES	STATUS (EPBC/ NCA)*	DISTRIBUTION / HABITAT	STUDY AREA (CAIRNS HARBOUR)	OFFSHORE MAINTENANCE DMPA
Caretta caretta Loggerhead Turtle	EPBC: E, M, LM NCA: E	Pelagic and benthic species. Cairns region is not known to represent a nesting site. Forages on marine invertebrates (Wilson and Swan 2004).	Likely – foraging habitat available at seagrass areas and coastal rocky shores.	Likely - suitable habitat located at surrounding reef areas.
Chelonia mydas Green Turtle	EPBC: V, M, LM NCA: V	Marine waters and near the seabed. Foraging habitat available at seagrass meadows, where it feeds mainly on seagrass and benthic invertebrates (Wilson and Swan 2004). Low density nesting occurs in broader region, with known hotspots at the sandy beaches between Cairns and Hinchinbrook (e.g. Cowley and Kurrimine Beaches).	Likely – strong association with seagrass (noting low seagrass occurrence at present), reefs (algae) and mangroves.	Likely - suitable habitat located at nearby reef and seagrass areas.
Dermochelys coriacea Leathery Turtle, Leatherback Turtle	EPBC: V, M, LM NCA: E	Oceanic species, feeds on jellyfish and other soft bodied invertebrates (DEWHA 2007, Wilson 2005). Rarely sighted in Cairns region and then only in deep waters. Rarely nests on northern Queensland coastline.	Unlikely – oceanic species.	Possible transient visitor.
Eretmochelys imbricata Hawksbill Turtle	EPBC: V, M, LM NCA: V	Forages on coral and rocky reefs, sponges major dietary component. Cairns region not a known nesting area (normally occurs north of Princess Charlotte Bay).	Possible transient visitor, some foraging.	Possible transient visitor.
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle	EPBC: E, M, LM NCA: E	Marine waters over soft sediments, but not common. No known nesting in Cairns region.	Unlikely – oceanic species	Possible - uncommon transient visitor
Natator depressus Flatback Turtle	EPBC: V, M, LM NCA: V	Marine species found around reef areas and soft sediment habitats; forages on invertebrates. Primarily nests south of Mackay, though low density nesting (<10 females per year) in Cairns region.	Likely – suitable habitat and common within GBR lagoon.	Likely – suitable habitat and common within GBR lagoon.
Crocodylus porosus Saltwater Crocodile	EPBC: M, LM NCA: V	Coastal waters, estuaries and reefs throughout geographic range, including Cairns region.	Likely – throughout study area	Possible – more common inshore

(*) E = endangered; V = vulnerable; M = migratory; NT = near threatened; LM = listed marine

Overall, the distribution and abundance patterns of turtles within the study and project areas are thought to be mainly a function of the availability of suitable food resources, as summarised below:

- Green turtle (*Chelonia mydas*) is listed as vulnerable under both the EPBC Act and the NC Act. It feeds directly on seagrasses and algae (Brand-Gardner *et al.* 1999) with most foraging activity concentrated around the seagrass beds of Cairns harbour and Trinity Inlet. Within the study area, a low incidence of nesting occurs along the northern beaches, tending to concentrate at Clifton Beach (pers. comm. J. Gilbert). There are also anecdotal reports of nesting at the northern end of the Cairns Esplanade. Beyond this, green turtle nesting has occasionally been observed at Green Island, Fitzroy Island and Michaelmas Cay. Green turtles are historically the most common marine turtle species in the study area but in recent years, since Tropical Cyclone Yasi in 2007, there has been increased strandings and mortality for this species (refer **Figure B7-33** for recent marine turtle stranding summary). The cyclone resulted in a drastic reduction in seagrass extent and condition, causing reduced food availability, which led to turtle starvation, mortality and reduced fecundity. The local population is likely to be subject to ongoing stress until significant seagrass recovery occurs.
- Loggerhead turtle (*Caretta caretta*) is listed as endangered under both the EPBC Act and the NC Act. It is a carnivorous species which feeds on jellyfish, crustaceans, echinoderms, and bivalve molluscs from seagrass meadows and reef areas (Limpus *et al.* 1994). Given the current reduced seagrass availability at present, this species is likely to be more abundant around the offshore reefs of the surrounding area, but may also potentially forage around the coastal rocky shores east of the Cairns harbour.
- Hawksbill turtles (*Eretmochelys imbricata*) are listed as vulnerable under both the EPBC Act and the NC Act. They feed primarily on sponges, but also feed on seagrasses, algae, soft corals and shellfish. Hawksbill turtles would most commonly occur around the offshore reefs of the surrounding area where sponges are likely to be abundant, but they may also potentially forage around the coastal rocky shores east of the Cairns harbour. Similar to green turtles, there have also been reports of hawksbill turtles suffering starvation in the Cairns area in recent times (pers. comm. J. Gilbert).
- Flatback turtles (*Natator depressus*) are listed as vulnerable under both the EPBC Act and the NC Act. They are carnivorous, feeding mainly on soft-bodied invertebrates (sea cucumbers, sponges, soft corals, jellyfish, etc.) from the sea floor (Wilson 2005; Wilson and Swan 2003).
- Olive Ridley turtles (*Lepidochelys olivacea*) are listed as endangered under both the EPBC Act and the NC Act. They are thought to be uncommon, occurring in very low numbers throughout the region and preferring waters over soft sediments. This species is thought to be mostly carnivorous, with a diet mostly comprised of urchins, small crabs, and molluscs (Wilson 2005).
- Leatherback turtles (*Dermochelys coriacea*) are listed as vulnerable under the EPBC Act and endangered under the NC Act. They are uncommon in the local area, typically occurring in deeper oceanic waters. Leatherbacks feed on jellyfish and other soft bodied invertebrates (DEWHA 2007; Wilson 2005).

With the exception of green turtles, there is a lack of data to describe key or preferred foraging habitats for the remaining marine turtles in the Cairns region, with the less common species (i.e. small resident populations) scarcely being studied nation-wide. It is likely, however, that marine turtles that exist within the study area are transients, rather than residents. This would primarily be due to the lack of: (i) optimal or perennial feeding resources in this area, and (ii) suitable nesting habitat (sandy beaches). However, it is likely that the sparse seagrass and epibenthic fauna assemblages in the study area are used sporadically or occasionally by some marine turtles.

While abovementioned stranding data refers to total marine turtles, the most recent available StrandNet database annual report (Meager and Limpus 2012) provides species-specific records of three turtle species confirmed stranded in the Cairns region (latitudinal grids 16 and 17) during 2011, and hence using the study area and surrounding waters relatively recently. These included green turtle (66), hawksbill (10) and flatback (1), with green turtle being by far the most commonly stranded at this time. Note that Hazel and Gyuris (2006) identified Cairns as one of five Queensland hot-spot areas for vessel-related sea turtle strandings based on analyses of StrandNet data (i.e. concentrated strandings).

The coastline of the study area is not a critical turtle breeding area, with most turtles residing in the study believed to have originated from rookeries elsewhere on the central and Far North Queensland coast and islands. The exceptions to this are green and flatback turtles. While low density nesting for these species may occur on sandy beaches within the study area (e.g. Yorkeys Knob), the majority of marine turtle nesting within the region occurs south of Cairns on the sandy beaches towards Hinchinbrook, and further north at Princess Charlotte Bay (Limpus 2007, 2008).

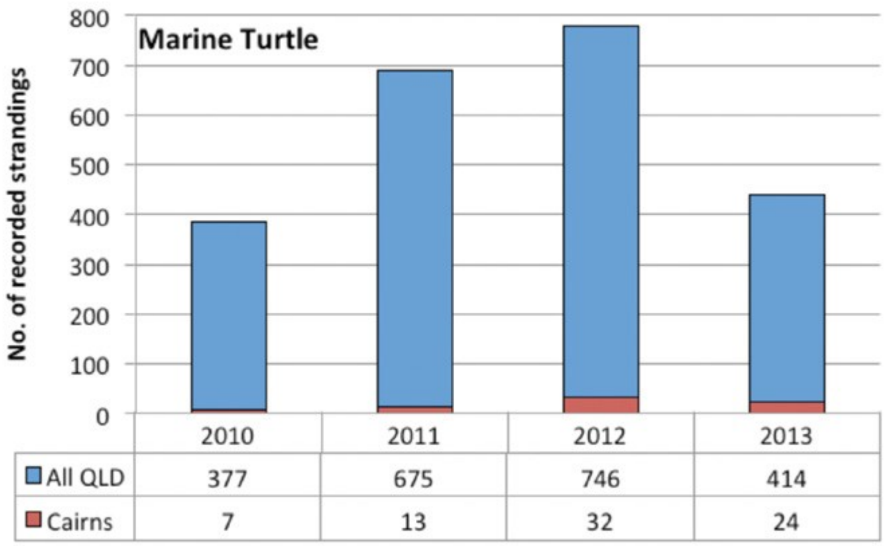


Figure B7-33 Number marine turtle strandings recorded in the Queensland Standings Database for 1 January – 30 June 2013, with comparison to the same period for previous years.

Source: Department of Environment and Heritage Protection (2013).

B7.2.7.b Other Marine Reptiles

Saltwater crocodile *Crocodylus porosus* is a listed migratory and marine species under the EPBC Act, and is considered a vulnerable threatened species under the NC Act. Saltwater crocodiles occur in the study area and surrounds, with multiple records within the study area registered on the Wildlife Online database (DSITIA 2013). Nesting sites and preferred feeding habitats in the study would likely be restricted to Trinity Inlet (i.e. typically prefers mangrove-lined estuaries).

The EPBC Protected Matters database search results indicate that 15 species of sea snake occur or could occur in the study area. These species are listed marine species and are protected under the EPBC Act, but are not considered to be threatened under Commonwealth or Queensland legislation.

B7.2.7.c Threatened Sharks

Three threatened shark species were identified as potentially occurring in the study area using EPBC Protected Matters search tool: whale shark *Rhincodon typus*, dwarf sawfish *Pristis clavata* and green sawfish *Pristis zijsron* (**Table B7-9**). The whale shark is a pelagic species that tends to prefer offshore tropical waters. There are occasional records of this species in the surrounding area, although it is considered to represent a transient visitor to the region.

Green sawfish and dwarf sawfish may occur in the study area from time to time, with Cairns representing the present day southern extent of their geographic distribution along the Queensland coast. Based on data from museums, research surveys and fisheries observations, Stevens *et al.* (2005) report that green sawfish have been recorded in the Cairns area in recent decades (i.e. since 1990). However, long-term data from the Queensland Shark Control Program indicate a major population decline has occurred since the 1970s, largely due to fishing pressure (targeted and bycatch) and net entanglement. While both green and dwarf sawfish may occur within the study area, it is likely that the local population is very small and/or transient. Dwarf sawfish are typically considered to be the more common *Pristis* species throughout northern Australia (Stevens *et al.* 2005), although there are no known recent records from east of Cape York (GBRMPA 2012).

While not a threatened species, the Porbeagle Shark *Lamna nasus* is listed under the EPBC Act as a migratory marine species. This shark is unlikely to occur within the study area or surrounding waters as it is typically associated with oceanic waters offshore and along the east coast it is thought to be limited to southern Queensland and south-eastern Australia.

The EPBC Protected Matters database search results indicate that 50 species of sygnathids (seahorse, pipe horse and pipefish) occur or could occur in the study area. These species are listed marine species and are protected under the EPBC Act, but are not considered to be threatened under EPBC or state legislation.

TABLE B7-9 EPBC PROTECTED MATTERS DATABASE SEARCH RESULTS – THREATENED AND MIGRATORY SHARK SPECIES

Species	Status (EPBC/ NCA)*	Distribution / Habitat	Study Area (Cairns Harbour)	Offshore Maintenance DMPA
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	EPBC: **V**	Cairns though to represent extent of southern distribution. Occurs in estuaries and river mouths, embankments and beaches. While more common nearshore, has been recorded offshore. Benthic feeder, found in to 70m (TSSC 2008).	Likely, though may be small or transient population.	Possible - uncommon transient visitor
Pristis clavata Dwarf Sawfish, Queensland Sawfish	EPBC: **V**	Cairns thought to represent extent of southern distribution. Occurs nearshore in estuaries and river mouths, embankments and beaches. Benthic feeder, found in depths from 1m to 10m (TSSC 2008).	Likely, though may be small or transient population.	Unlikely, near shore species
Rhincodon typus Whale Shark	EPBC: **V**, M	Wide ranging tropical species. Critical habitat in Australia includes Ningaloo Reef in WA, the Coral Sea and Christmas Island. Cairns region not known to represent an important habitat for this species.	Unlikely – Low abundance regionally and lack of deep waters limit habitat value of the study area.	Possible – uncommon transient
Lamna nasus Porbeagle, Mackerel Shark	EPBC: M	Pelagic and oceanic waters offshore, though likely limited to the cooler waters of southern Queensland`.	Unlikely – oceanic species and study area beyond known geographic distribution.	Unlikely – oceanic species and DMPAs beyond known geographic distribution.

(*) E = endangered; V = vulnerable; M = migratory; NT = near threatened; LM = listed marine

B7.2.7.d Marine Mammals

There are seven listed migratory marine mammals that could occur within or adjacent to the study area (**Table B7-10**). Five are considered to be threatened, or near threatened, under the EPBC Act and/or NC Act. Of the latter, the four marine mammal species with a likely occurrence in the study area and the project areas are the Australian snubfin dolphin (*Orcaella heinsohni*), Indo-Pacific humpback dolphin (*Sousa chinensis*), dugong (Dugong dugon) and humpback whale (*Megaptera novaeangliae*). These four species are discussed in further detail below.

TABLE B7-10 EPBC PROTECTED MATTERS DATABASE SEARCH RESULTS – THREATENED AND MIGRATORY MARINE MAMMALS

Species	Status (EPBC/ NCA)*	Distribution / Habitat	Study Area (Cairns Harbour)	Offshore Maintenance DMPA
Balaenoptera musculus Blue Whale	EPBC: E, M, LM	Oceanic waters	Unlikely – shallow water depths and port infrastructure limits values.	Unlikely – transient offshore
Megaptera novaeangliae Humpback Whale	EPBC: V, M, LM NCA: V	Oceanic waters	Unlikely – shallow water depths and port infrastructure limits values.	Possible - Breeding habitat
Balaenoptera edeni Bryde's Whale	EPBC: M LM	Oceanic waters off Australian and southern Africa where it searches for baitfish (Van Dyck and Strahan 2008).	Unlikely – shallow water depths and port infrastructure limits values.	Unlikely – transient offshore
Orcaella heinsohni (previously *O. brevirostris*) Australian Snubfin, Irrawaddy Dolphin	EPBC: M, LM NCA: NT	Shallow coastal and estuarine waters	Possible – Past records nearby around Ellis Beach area.	Possible – primarily an inshore species.
Orcinus orca Killer Whale, Orca	EPBC: M, LM	Oceanic, pelagic and relatively shallow waters over continental shelf. Marine mammals are key dietary component (Van Dyck and Strahan 2008).	Unlikely – shallow water depths and port infrastructure limits values.	Possible – may occur offshore waters (in part associated with Humpback Whale breeding)
Sousa chinensis Indo-Pacific Humpback Dolphin	EPBC: M, LM NCA: NT	Shallow coastal and estuarine waters preferred; recorded in offshore waters within GBR lagoon (i.e. sheltered by reef).	Possible – preferred habitat available, past records nearby around Ella Bay	Possible – though primarily an inshore species
Dugong dugon Dugong	EPBC: M, LM NCA: V	Inshore coastal and estuarine waters where notable seagrass meadows occur.	Likely – strong association with seagrass (noting low seagrass occurrence at present)	Possible - transient

(*) E = endangered; V = vulnerable; M = migratory; NT = near threatened; LM = listed marine

Dolphins

The two threatened dolphin species likely to occur, Snubfin and Indo-Pacific humpback dolphins, are considered a high priority by GBRMPA as numbers of these inshore species are thought to be in decline. Key threats driving this population decline are boating interactions, net entanglement and poor water quality, which can affect prey resources.

The Australian snubfin dolphin has a global IUCN listing of "near threatened" (IUCN 2010). It is listed as a migratory marine mammal under the EPBC Act and near threatened under the NC Act. Studies to date indicate that this species generally occurs in waters less than 15 m deep, within 10 km of the coast and within 20 km of a river mouth (Parra *et al.*2004). The species is an opportunistic generalist, feeding on fish and cephalopods (octopus, squid etc.) from coastal, estuarine and near-shore reef habitats (Parra 2006, Parra *et al.* 2006b). Meager *et al.* (2012) state that the only reliable population estimate for this species is from Cleveland Bay (Townsville), where the sub-population had been estimated between 64 and76 individuals in 2000-2001.

Indo-Pacific humpback dolphin has a global IUCN listing of "near threatened" (IUCN 2010). It is listed as a migratory marine mammal under the EPBC Act and near threatened under the NC Act. In Australia its distribution stretches from northern New South Wales along the coast of Queensland to Shark Bay in Western Australia. Studies to date indicate that this species like the Australian snub-nosed dolphin generally occurs in waters less than 15 m deep, within 10 km of the coast and within 20 km of a river mouth (Parra *et al.*2004). The species is also an opportunistic generalist, feeding on fish and crustaceans from coastal, estuarine and near-shore reef habitats (Parra 2006, Parra *et al.* 2006b). No reliable population estimates are available for northern Queensland regions (Meager *et al.* 2012).

Detailed marine mammal surveys undertaken for a port elsewhere in Queensland where these species commonly occur (Port of Gladstone: Parra 2006, GHD 2009) found that the Indo-Pacific humpback dolphin had important feeding and nursing areas in the vicinity of estuary/river mouths, and favoured shallow waters (one-two metres deep) where seagrass is present. In contrast, the snubfin dolphin favoured water two to five metres deep in dredged channels. If similar preferences are transferable to the present study area, it is likely that these species would prefer the shallow waters of Cairns harbour and the mouth of Trinity Inlet.

Sousa chinensis is occasionally recorded from the Cairns area in low numbers on the StrandNet database, with a total of four strandings from 2008 to 2010. Indo-Pacific Humpback dolphins have recently been sighted in the project area, including two individuals at the marina in Trinity Inlet in November 2013 and two individuals swimming in shallow waters off Ellis Beach in September 2013 (personal observations: Ms Emma Scott). There are no known recent sightings of snubfin dolphins in the project area. However, this species is known to regularly frequent the Port Douglas and Low Isles areas, approximately 35 km north of the project area, typically in groups of up to six individuals (personal observations: Ms Emma Scott). Given declining numbers and small population sizes, it is thought that these two threatened dolphin species can only sustain very small levels of anthropogenic mortality (Meager *et al.* 2012).

Dugong

The dugong has a global IUCN listing of “vulnerable to extinction” (IUCN 2010). It is ‘listed threatened’, ‘listed migratory’ and ‘listed marine’ species under the EPBC Act and the Queensland dugong population is considered “vulnerable” under the NC Act. Dugongs are principally herbivores and have been shown to be highly selective feeders, preferring certain species of seagrass to others. Dugongs have a preference for Halophila spp., which can be prevalent in seagrass meadows within the study area and surrounding waters, particularly the Cairns arbour and Trinity Inlet, and those areas along the eastern shoreline toward Bessie Point and Cape Grafton.

Most broad scale dugong surveys and population estimates have focused on the southern Great Barrier Reef, with limited coverage of the Cairns area (e.g. Marsh and Saalfeld 1990, Marsh *et al.* 1999). Marsh *et al.* (1996) also incorporated analysis of dugong records from historical shark net captures (i.e. Queensland Shark Control Program nets), whereby 101 dugongs were killed in shark nets off Cairns between 1962 and 1978. Overall, the general consensus of these studies is that there has been a strong decline in dugong catches since the 1960s, to the point that the sightings are now too few to enable a population estimate. As far as local distribution, targeted surveys by Marsh and Saalfeld (1990) confirmed that the dugongs recorded in the Cairns area were sighted close to inshore seagrass beds.

While dugongs can be common in Trinity Bay, it is thought that current population numbers are low due to the reduction in the extent and condition of local seagrass meadows. The year 2011 saw record dugong strandings throughout northern Queensland (Meager and Limpus 2012b; **Figure B7-34**), following the depletion of cyclone-affected seagrass food resources. Since then, it is likely that the majority of residents would have had to forage elsewhere in Queensland or Torres Straight to avoid malnutrition and starvation in the local area. A combination of emigration and past mortality is likely responsible for the reduced stranding records over the last two years (**Figure B7-35**), and may be considered a proxy for a reduction in the local population size as compared with previous years.

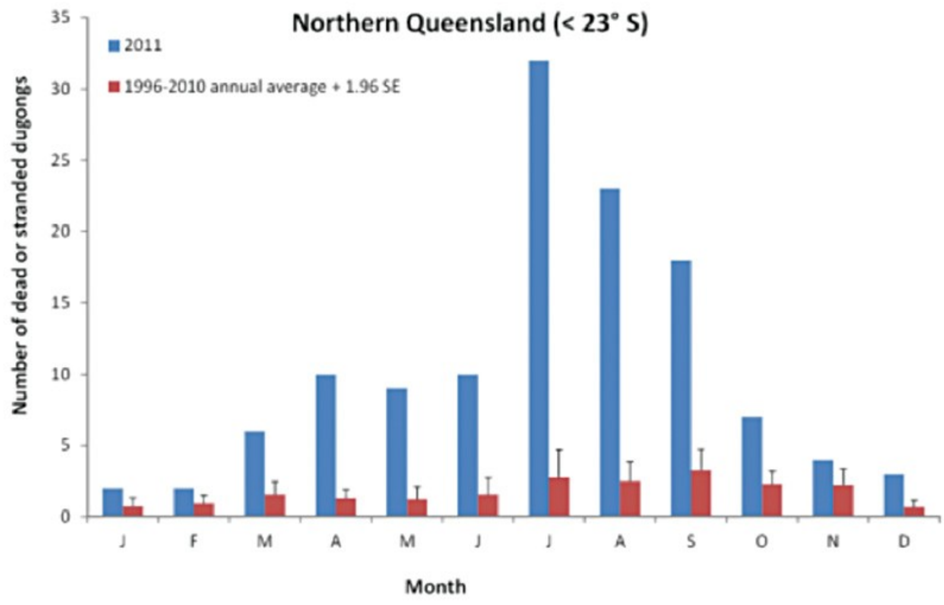
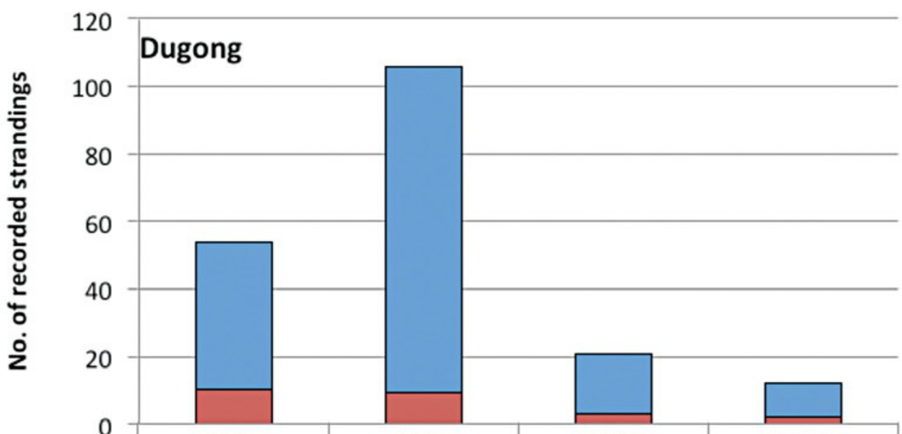


Figure B7-34 Monthly Dugong Strandings in Northern Queensland during 2011, Compared with Long-Term Average (1996-2012).

Source: Meager and Limpus (2012b).



	2010	2011	2012	2013
All QLD	44	97	18	10
Cairns	10	9	3	2

Figure B7-35 Number of dugong strandings recorded in the Queensland standings database for 1 January ‐ 30 June 2013, with comparison to the same period for previous years

Source: DEHP (2013).

Humpback Whale

The humpback whale has a global IUCN listing of least concern (IUCN 2010). It is listed as vulnerable under both the EPBC Act and the NC Act. Humpback whales calve in the protected waters of the GBR between July and August then travel along the Australian coast to Antarctic waters where they spend spring and summer before returning (DERM 2010). They feed on krill (*Euphausia superba*) and small fish.

The waters surrounding Cairns have been modelled to be of moderate environmental suitability for humpback whales compared to the highly suitable waters offshore from Mackay (**Figure B7-36**). Although the area off Cairns is comparably less suitable to other areas of the GBR lagoon, large numbers of whales are sighted off Cairns each winter. The regularity and increasing trend of sightings has led to the commencement of whale watching operations out of Cairns.

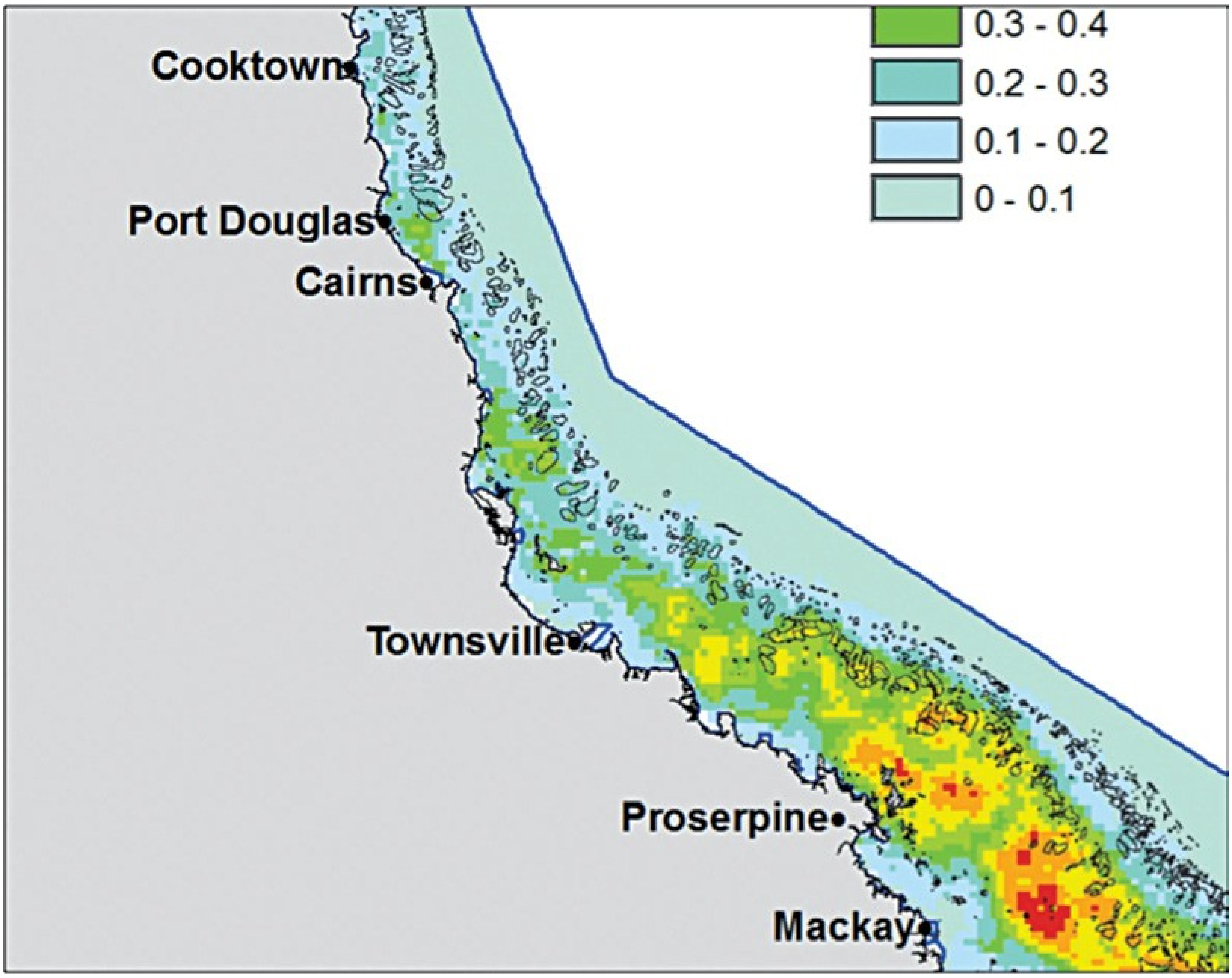


Figure B7-36 Model prediction of environmental suitability for humpback whales in the GBRWHA.

Source: Smith *et al.* (2012). Red = Most Suitable; Green = Moderate Suitability; Blue = Least Suitable)

B7.2.8 Exotic Marine Species and Pests

More than 250 non-indigenous marine species have been recorded in Australian waters (NIMPCG 2011). There are several potential vectors by which non-indigenous species may enter domestic waters; however it is thought that most species are unintentionally introduced through shipping and vessel movements, either in ballast waters or from biofouling on the hull of vessels (Hewitt and Campbell 2010). Other vectors include intentional transfer of aquaculture and mariculture organisms, transfer of food products for the aquarium trade and use of biological material for packing (Hewitt and Campbell 2010).

There are currently no known marine pests established in the Cairns area (Australian Government 2013). Risk tables, developed as part of the Australian Ballast Water Management Information System (ABWMIS), identify species of known or potential concern for Australian ports. The 2013 risk tables identify Cairns as a potential recipient port for the Asian date mussel *Musculista senhousia* and European fan worm *Sabella spallanzani*. At present, *S. spallanzanii* has not previously been recorded in Cairns but is known to occur as a pest at southern Australian ports in temperate waters.

M. senhousia was recorded fouling a Navy vessel at Cairns in 2007 (refer below) but has not been detected here since by either the Queensland Government, or though Ports North's routine marine pest monitoring activities.

Other introduced species have previously been identified from the Port of Cairns, including Asian green mussel *Perna viridis* and Caribbean tubeworm *Hydroides sanctaecrucis* (Environment North 2005, Souter 2009). While these species pose a potential threat, neither are considered to be pest species currently established in Australian waters. Both species are prolific fouling organisms with the potential for causing extensive nuisance growths. In 2001, government surveys recorded *Perna viridis* at Cairns in low numbers on both vessel hull(s) and in Trinity Inlet, with the variety of age classes present suggesting that successful local spawning had occurred. During the same year, *Hydroides sanctaecrucis* was recorded on hard substrata at the Port of Cairns, particularly between the Marlin Marina and Smith's Creek (Environment North 2005). Following the discovery of these species at Cairns in 2001, various eradication measures were implemented with neither species being detected during subsequent 2002 surveys (Environment North 2005).

In 2007 an outbreak of both *Perna viridis* and *Musculista senhousia* (Asian green mussel and Asian date mussel) were recorded fouling a vessel at Cairns, with *Perna viridis* again being recorded on a vessel in 2008 (Australian Government 2013). Appropriate control measures were implemented with subsequent monitoring undertaken following an initial quarantine period. The Australian Marine Pests website has not reported any further marine pest outbreaks for the Cairns region.

B7.2.9 Fish and Shellfish Resources

B7.2.9.a Existing Regional Data

Coles *et al.* (1993) undertook intensive sampling of fish communities within Cairns Harbour quarterly in 1988. Sites were positioned in seagrass meadows, and sampled using beam trawls, gill nets and seine nets. In total, 5614 fish were collected, comprised of 134 fish taxa. Of the 134 species recorded, only five were considered to be of high commercial or recreational fisheries value. The most numerous fish species were two small-bodied demersal species: a goby (*Yongeichthys criniger*) and a ponyfish (*Leiognathus splendens*). The highest biomass was contributed by larger-bodied species, namely Carcharhinus sharks, salmon *Polydactylus sheridani* and *Eleutheronema tetradactylum*, the *queenfish Scomberoides commersonnianus* and the catfish Arius proximus. Very few reef fish species were recorded; most species are pelagic or soft sediment-associated species.

Coles *et al.* (1993) found that small-bodied fish and juveniles dominated on seagrass meadows, and were found in similar abundance (and size range) reported between Cairns and Bowen, and at Mornington Island. This is consistent with case studies elsewhere (e.g. Carruthers *et al.* 2002; Bell and Pollard 1989) which demonstrate the importance of seagrass meadows as a fish nursery habitat. The presence of larger predators also highlights the importance of seagrass meadows as feeding habitats for fish.

Blaber (1980) surveyed the fish fauna of Trinity Inlet and unvegetated tidal sand banks within Cairns Harbour using seine nets, gill nets and stake nets. He found that unvegetated flats in Cairns Harbour had (i) fewer juveniles; (ii) higher numbers of piscivores (mostly adults); and (iii) fewer planktivores than sites in Trinity Inlet. On this basis, Blaber (1980) argued that mangrove-lined creeks within Trinity Inlet represented higher value nursery habitats for fish than those found in Cairns Harbour.

These two studies both demonstrate the importance of both mangrove-lined estuaries and seagrass meadows within the study area as nursery and adult feeding habitats. Unvegetated soft sediment habitats also represent important habitats for several species of commercial and recreational significance. For example, species of fisheries importance such as grunter/javelin fish (*Pomadasys kaakan*), nannygai (*Lutjanus malabaricus, L. erythropterus*), flathead all use unvegetated soft sediment habitat during one or more parts of their life-cycle (**Table B7-12**). Note that the fish species thought to dominate local recreational catches, coral trout and snapper (**Figure B7-37**), are typically reef- associated species.

Building on the above baseline surveys, the Queensland Department of Primary Industries annual assessments of stocks of key fisheries species at Trinity Inlet and the Cairns harbour from 1997 to 2000, which targeted barramundi, king threadfin, blue threadfin, mangrove jack, grunter, bream and mud crab (Helmke *et al.* 2003; **Figure B7-37**). While not all of these target species were captured, the surveys did record a total of

462 fish representing 65 species from 29 families. The most frequently caught species varied between both survey years and sites. Overall, barramundi and saltwater bony bream were the most commonly caught in 1997, compared with anchovy in 1998. The year 2000 recorded relatively low catches across all common species. In terms of differences in the distribution catches across the sites surveyed by Helmke *et al.* (2003), notably high catch rates included those for anchovy, saltwater bony bream and Burnett salmon in the main channel of Trinity Inlet, and barramundi at Saltwater/Little Barron River (**Table B7-11**).

The fish communities of the study area show great variability over a range of temporal scales. At seasonal time scales, many fish species found in the study area have a peak spawning and/or recruitment period in late spring-summer (Kailola *et al.* 1993; **Table B7-12**). Many estuarine fish also show great variability in abundance in response to cyclic feeding patterns (diel, tidal and lunar patterns), breeding and spawning activities, and in response to rainfall and other environmental processes.

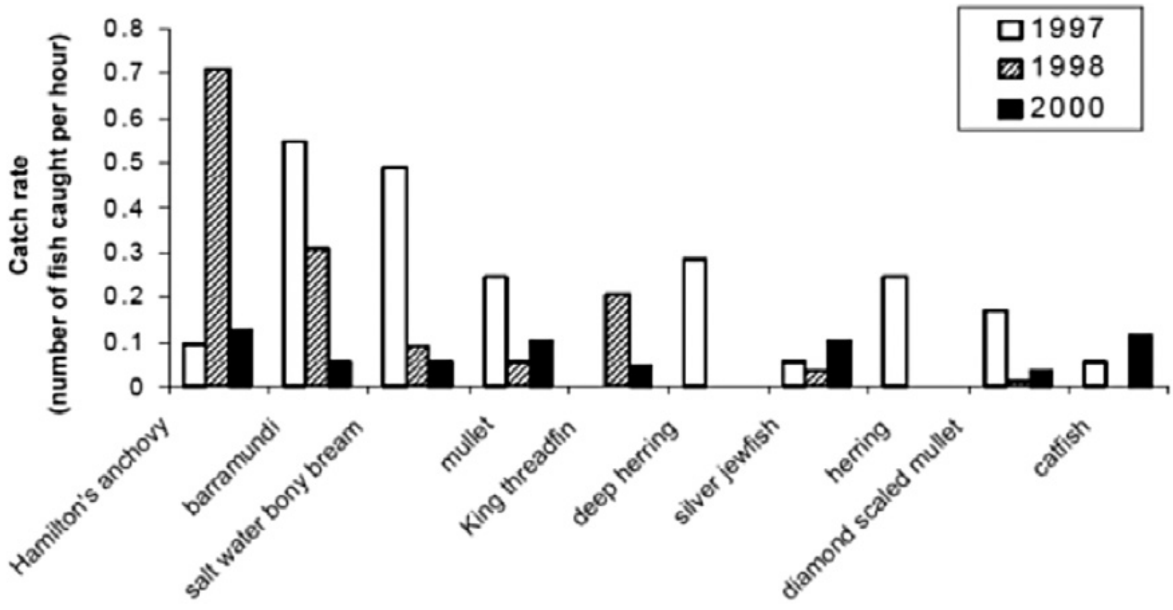


Figure B7-37 Catch rates of the most frequently caught fish from surveys at Trinity Inlet and Cairns Harbour, 1997, 1998, 2000.

Source: Helmke *et al.* (2003).

TABLE B7-11 TOTAL CATCHES OF THE MOST FREQUENTLY CAUGHT FISH FROM SURVEYS AT INDIVIDUAL SITES THROUGHOUT TRINITY INLET AND CAIRNS HARBOUR, 1997, 1998, 2000 (FROM HELMKE *ET AL.* 2003)

FAMILY	COMMON NAME	YEAR	TOTAL NUMBER	FALSE CAPE	CATCH RATE (NUMBER PER HOUR)					
					BESSIE POINT	SALTWATER - LITTLE BARRON	MAIN CHANNEL	SMITHS CREEK	REDBANK CREEK	SKELETON CREEK
Engraulidae	Hamilton's anchovy	1997	5	0.00	*	0.50	0.28	0.00	0.00	0.08
		1998	62	0.00	0.27	0.41	3.16	0.81	0.00	0.07
		2000	11	0.00	0.00	0.00	*	0.30	0.00	0.76
Centropomidae	barramundi	1997	29	0.00	*	6.25	0.00	0.08	0.20	0.00
		1998	27	0.12	0.55	0.90	0.00	0.16	0.18	0.15
		2000	5	0.00	0.05	0.09	*	0.07	*	0.00
Clupeidae	salt water bony bream	1997	26	0.00	*	0.50	0.00	0.50	0.00	0.08
		1998	8	0.00	0.00	0.00	2.42	0.24	0.00	0.39
		2000	5	0.00	0.00	0.00	*	0.23	*	0.10
Mugilidae	mullet	1997	13	0.25	*	0.25	0.00	0.66	0.00	0.16
		1998	5	0.27	0.09	0.08	0.00	0.00	0.00	0.00
		2000	9	0.00	0.00	0.00	*	0.69	*	0.00
Polynemidae	Burnett salmon	1997	0	0.00	*	0.00	0.00	0.00	0.00	0.00
		1998	18	0.18	0.09	3.39	0.00	0.00	0.00	0.00
		2000	4	0.00	0.05	0.47	*	0.00	*	0.00
Clupeidae	deep herring	1997	15	0.00	*	0.00	0.00	0.00	0.00	1.25
		1998	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2000	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scaenidae	silver jewfish	1997	3	0.00	*	0.00	0.28	0.00	0.10	0.00
		1998	3	0.00	0.09	0.22	0.07	0.00	0.00	0.00
		2000	9	0.00	0.05	0.36	*	0.00	*	0.00

FAMILY	COMMON NAME	YEAR	TOTAL NUMBER	FALSE CAPE	CATCH RATE (NUMBER PER HOUR)					
					BESSIE POINT	SALTWATER - LITTLE BARRON	MAIN CHANNEL	SMITHS CREEK	REDBANK CREEK	SKELETON CREEK
Clupeidae	herring	1997	13	0.00	*	0.00	0.00	0.40	0.00	0.75
		1998	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2000	0	0.00	0.00	0.00	*	0.00	*	0.00
Mugilidae	diamond scaled mullet	1997	9	0.87	*	0.00	0.14	0.00	0.00	0.08
		1998	1	0.00	0.00	0.08	0.00	0.00	0.00	0.00
		2000	3	0.00	0.59	0.00	*	0.00	*	0.00
Ariidae	catfish	1997	3	0.35	*	0.00	0.00	0.00	0.00	0.00
		1988	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2000	10	0.00	0.59	0.00	*	0.00	*	0.00

TABLE B7-12 KEY FISHERIES SPECIES PRESENT IN THE STUDY AREA AND THEIR PRIMARY HABITATS AT DIFFERENT STAGES OF THEIR LIFE-CYCLE (DATA: MOSTLY KAILOLA *ET AL.* 1993)

COMMON NAME	SPECIES NAME	SPAWNING PERIOD	ESTUARY					ESTUARY			
			MANGROVES	SEAGRASS	SHOALS	CHANNELS/ DEEPER SOFT SEDIMENT	FRESHWATER	INSHORE SEDIMENT	OFFSHORE SEDIMENT	OPEN WATER	REEFS
Fish	***Teleosti***										
Threadfin salmon	*Polydactylus macrochir, Eleutheronema tetradactylum*	Oct-Apr (peak Dec)	Juvenile (Juv)., Adult (Ad).	Juv., Ad.	Juv., Ad.	Juv., Ad					
Barramundi	*Lates calcarifer*	Oct-Mar (peak Dec)	Spw., Juv, Ad.	Juv., Ad.	Juv., Ad.	Juv.,Ad	Juv., Ad.	Juv.,Ad			
Dusky flathead	*Platycephalus fuscus*	Sep-Mar	Juv., Ad.	Spw., Juv., Ad.	Spw., Juv., Ad.	Ad., Juv.		Spw.			
Sand whiting	*Sillago ciliata*	Sep-Feb	Juv., Ad.	Juv., Ad.	Juv., Ad.	Juv., Ad.		Spw.	Spw., Ad.		Ad.
Large mouth nannygai	*Lutjanus malabaricus*	Oct-Feb (peak Oct-Dec)	Juv.	Juv.	Juv.	Juv.		Ad.	Ad.	Ad., Spw	Ad.
Small mouth nannygai	*Lutjanus erythropterus*	Sep-Apr	Juv.	Juv.	Juv.	Juv.		Ad., Juv.	Juv., Ad.	Ad., Spw	
Spanish mackerel	*Scomberomorus commerson*	Oct-Dec	Juv.	Juv.	Juv.	Juv.		Juv.		Ad., Spw	Ad., Spw
Grunter/Javelin fish	*Pomadasys kaakan, P. argenteus*	Sep-Mar (peak Sep-Nov)	Juv., Ad.	Juv., Ad.	Juv., Ad.	Spw.		Juv., Ad.			Ad.
Fingermark bream	*Lutjanis johnii*	Sep-Apr	Juv., Ad.	Juv., Ad.	Juv., Ad.	Juv., Ad.					Ad.
Mangrove jack	*Lutjanus argentimaculatus*	Sep-Mar (peak Dec)	Juv., Ad.	Juv., Ad.	Juv., Ad.	Juv., Ad.				Spw.	Ad.
Yellowfin bream	*Acanthopagrus australis*	Jun-Aug	Juv., Ad.	Juv., Ad.	Juv., Ad.	Juv., Ad.		Spw., Ad.			Ad.
Estuary cod	*Epinephelus malabaricus*	Mar-Jun	Juv.	Juv.	Juv.	Juv.				Spw?	Ad.

COMMON NAME	SPECIES NAME	SPAWNING PERIOD	ESTUARY					ESTUARY			
			MANGROVES	SEAGRASS	SHOALS	CHANNELS/ DEEPER SOFT SEDIMENT	FRESHWATER	INSHORE SEDIMENT	OFFSHORE SEDIMENT	OPEN WATER	REEFS
Queenfish	*Seriphus Politus*	No data	Juv., Ad.	Juv., Ad.	Juv., Ad.	Juv., Ad.			Spw.?	Spw?, Ad.	Ad.
Giant trevally	*Caranx ignoblis*	Warmer months and linked to the lunar cycle	Juv.	Juv.	Juv.	Juv., Ad.		Ad.	Ad.	Ad.	Spw., Ad.
Grey mackerel	*Scomberomorus semifasciatus*	Sept - Jan			Juv.	Juv.				Ad.	Ad.
Sea mullet	*Mugil cephalus*	Mar - Jun	Juv. Ad.	Juv.	Juv., Ad.	Juv., Ad.	Juv.	Ad., Spw?		Ad.	
Hamilton's anchovy	*Thryssa hamiltonii*	No data		Juv.		Juv., Ad.		Juv., Ad.			Juv., Ad.
Moses perch	*Lutjanus russelli*	No data	Juv.	Juv.		Juv., Ad.		Juv., Ad.	Ad.		Ad.
Snapper	*Pagrus auratus*	May - Aug		Juv.	Juv.	Juv.		Juv., Ad.	Ad.	Ad.	Juv., Ad., Spw
Sweetlip	*Lethrinus laticaudis, Lethrinus miniatus*	All year	Juv.	Juv.				Juv	Ad.		Juv. Ad., Spw
Saltwater bony bream	*Nematalosa erebi*	Sep – May (intensified by flooding)	Juv.	Juv.	Juv.	Juv.	Juv., Ad.		Ad.	Juv., Ad.	
Burnett salmon	*Polydactylus sheridani*	Oct – Mar (peak Dec)	Juv., Ad.		Juv., Ad.	Juv., Ad.		Juv., Ad.			
Silver jewfish	*Nibea soldado*	No data		Juv.		Juv., Ad.		Juv., Ad.			Juv., Ad.
Diamond scale mullet	*Liza vaigiensis*	Dec - Feb	Juv., Ad.	Juv.	Juv., Ad.	Juv., Ad.	Juv., Ad.		Ad., Spw		
Shellfish	***Crustacea***										
Mud crab	*Scylla serrata*	Spring to early Autumn	Juv., Ad.	Juv.	Juv.				Spw.		
Tiger prawn	*Penaeus esculentus,* *P. semisulcatus*	All year	Juv.	Juv.	Juv.	Juv.		Ad., Spw	Ad.		

COMMON NAME	SPECIES NAME	SPAWNING PERIOD	ESTUARY					ESTUARY			
			MANGROVES	SEAGRASS	SHOALS	CHANNELS/ DEEPER SOFT SEDIMENT	FRESHWATER	INSHORE SEDIMENT	OFFSHORE SEDIMENT	OPEN WATER	REEFS
Endeavour prawn	*Metapenaeus endeavouri, M. ensis*	All year (peak in spring)	Juv.	Juv.	Juv.	Juv.		Ad.	Ad., Spw.		
Banana prawn	*Fenneropenaeus merguiensis*	All year (peaks based on the monsoon: late dry season (Sep-Nov) and late wet season (Mar-May))	Juv., Ad.	Ad.	Juv., Ad.	Ad.		Ad., Spw			

B7.2.9.b Fishing and Crabbing Surveys

A total of 1,119 fish belonging to approximately 42 morpho-species were caught across the 12 sites in Trinity Inlet, East Trinity, and the Barron River (Appendix AN - Additional Marine Ecology Baseline Studies). The entire catch was comprised of native species, and none of these are considered threatened. The most abundant species collected were small planktivores including as Castelnau's herring (*Herlotsichthys castelnaui*), and the gizzard shad (*Anodontosoma chacunda*). Sea mullet (*Mugil cephalus*) ponyfish (*Leiognathus equulus*) and the northern whiting (*Sillago sihama*) were the next most abundantly collected taxa. The largest specimens collected consisted of dusky flathead (*Platycephalus fuscus* 485 mm), queenfish (*Scomberoides tala*, 473 and 445 mm), shield-headed catfish (*Plicofollis nella* 390 – 460 mm) mullet (*Valamugil buchanani* 405 mm) and giant trevally (*Caranx ignobilis* 400 mm).

Diverse and abundant fish communities were observed within Trinity Inlet, Barron River, Hills Creek and Firewood Creek. During the dry season event, fish abundance tended to increase with distance downstream in all estuarine waterways, but there were no clear spatial gradients in species richness in either season.

The Barron River had consistently high species richness across sites over both seasons, whereas abundance increased markedly with distance downstream during the dry season. During the wet season abundance was generally similar throughout the system. The highest richness was observed in the lower Barron River in both seasons, and the very high abundance at the Barron River mouth in the dry season (369 fish) was mostly due to a large catch of herring.

Sand crabs (Portunus pelagicus) dominated catches in the downstream reaches of the Barron River. Only two mud crabs were collected in the whole of the Barron River during the dry season, while a further four crabs were captured from the Barron in the wet season. High abundances of crabs were recorded at site BF1 on the Barron River (sand crabs).

B7.2.9.c Commercial Fishing and Crabbing Data

Commercial fish catch data (DAFF 2017) for the H16 grid covering the study area shows that there has great variability through time in both net (**Figure B7-38**) and line fisheries (**Figure B7-39**). The study area comprises approximately 25 percent of grid H16, which runs from south of Cape Grafton to Port Douglas. Net fishery data shows that the total catches from H16 have been generally declining since 2012. It should be noted that data are not available for instances where there are less than 5 licence holders.

The observed reduction in catch generally coincides with the buy-back and of a number of commercial licenses. The effects of the Trinity Bay net closure are difficult to determine, as data is generally deficient for the period beyond 2012 or 2014 for different species.

Catch per unit effort (CPUE) for the major species groups shown in **Figure B7-38** (expressed as kg/ day) does appear to be trending upwards since 1999, suggesting that effort reductions have potentially acted to increase biomass of the net fisheries.

For the line fishery, catch data of major species or species are sporadically available through the time series as data is available for periods where there are greater than 5 licence holders (**Figure B7-39**). Spanish mackerel is the only species which has consistent catch records available in the line fishery over the entire time period. Total catch and CPUE for Spanish mackerel show a quasi-cyclical pattern with peaks in catch appearing every 4-6 years. CPUE of the major line fishing species appears to be down trending through time.

The reported commercial catch of mud crabs shows relatively stable effort through time, with the total number of licences falling below five in 2013 and 2015 (**Figure B7-40**). There are two distinct peaks in CPUE, occurring in 1991 and 2009. Since 2009, CPUE and total catch appear to have steadily fallen to a low point, comparable with CPUE in the mid-1990s (where data is available).

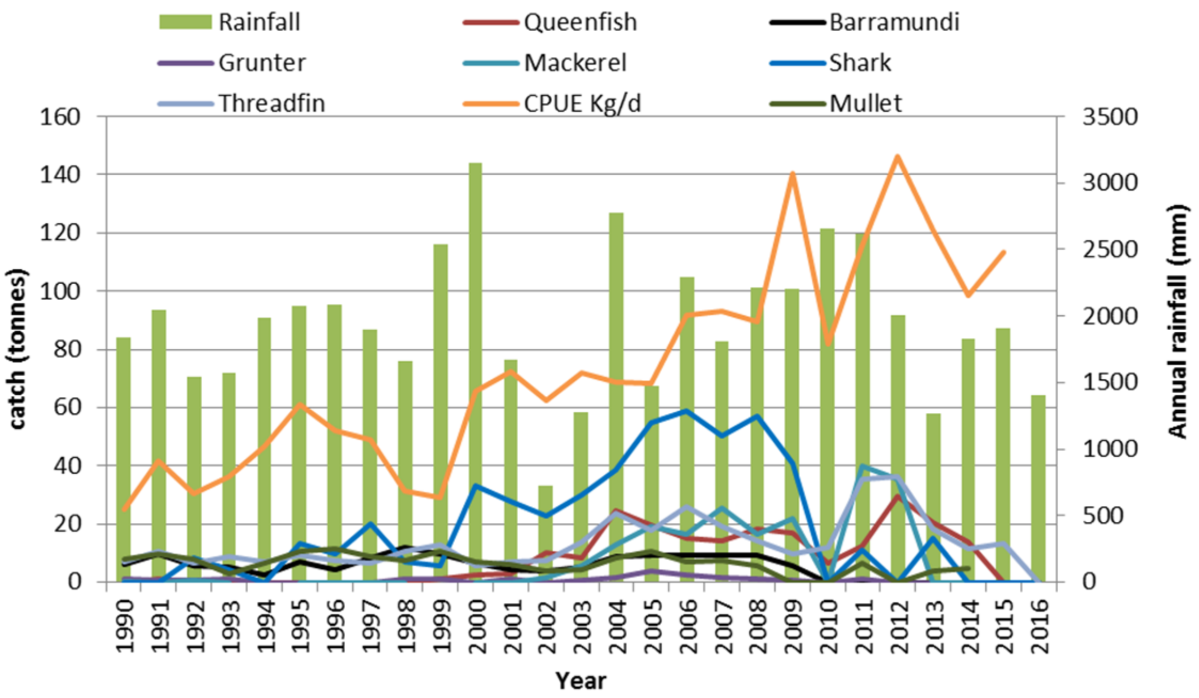


Figure B7-38 Net fishery commercial fish catch (tonnes) and rainfall for the Cairns area (Cell H16).
Source: Qfish DAFF (2017).

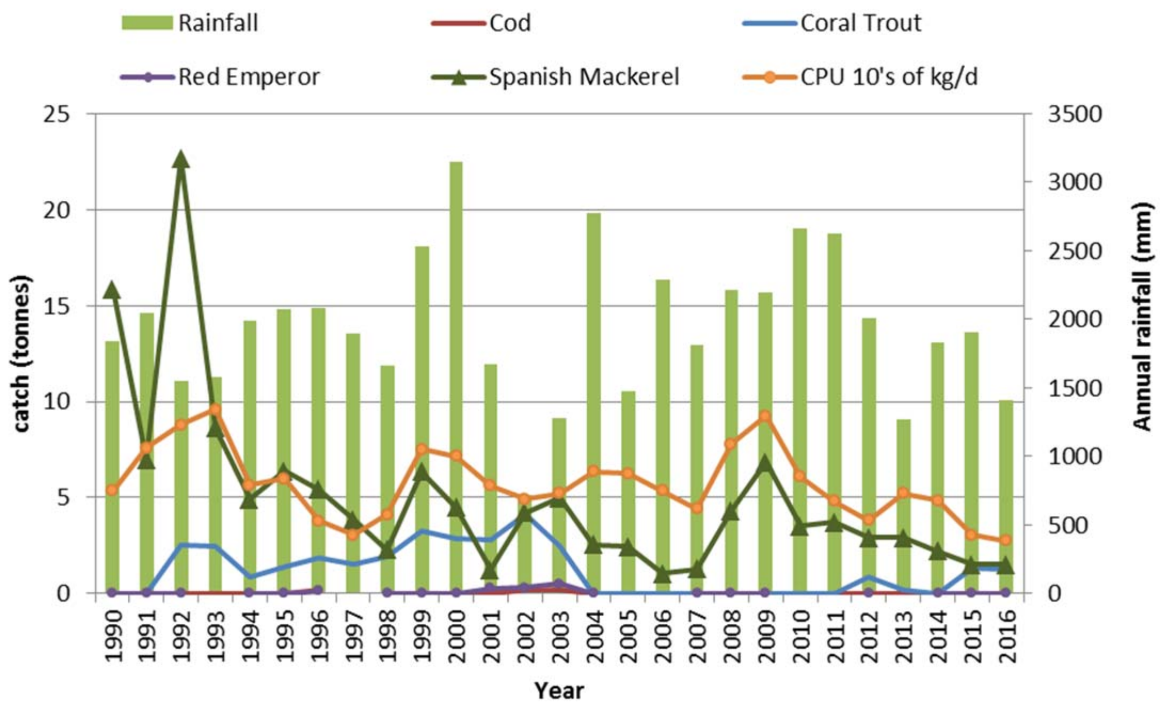


Figure B7-39 Line fishery commercial fish catch (tonnes) and rainfall for the Cairns area (Cell H16).
Source: DAFF Unpublished Data 2013, Nil Line Data available after 2005.

B7.2.9.d Commercial Fishing and Crabbing Data

For recreational fishing, results from the 2010 state-wide survey (Taylor *et al.* 2012, **Figure B7-40**) show coral trout, snapper and pikey bream to be the most commonly caught (and harvested) fish species in Cairns coastal waters. Helmke *et al.* (2003) interrogated the Queensland RFISH database for 1997 and 1999, and found that other key recreational target fish species for Trinity Inlet and the harbour include bream, cod, grunter, mackerel, mangrove jack, sardine, sweetlip and whiting (**Table B7-13**).

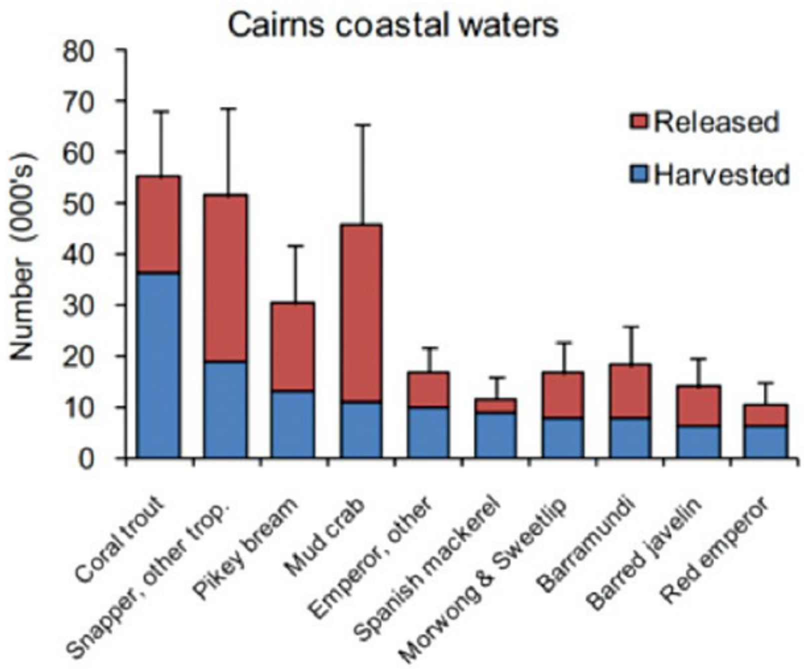


Figure B7-40 Estimated Recreational fishing catch for Cairns coastal waters in 2010 State-wide Recreational Fishing Survey.

Source: Taylor *et al.* (2012).

TABLE B7-13 NUMBER OF FISH KEPT AND NUMBERS RELEASED, FOR EACH SPECIES RECORDED IN THE RFISH DATABASE FOR TRINITY INLET AND CAIRNS HARBOUR IN 1997 AND 1999 (FROM HELMKE *ET AL.* 2003)

COMMON NAME	TOTALS		KEPT		RELEASED	
	1997	1999	1997	1999	1997	1999
archerfish	3	0	0	0	3	0
barramundi	7	8	2	5	5	3
batfish	0	6	0	5	0	1
bream	27	93	5	31	22	62
catfish	6	41	1	1	5	40
cod	22	11	10	4	12	7
coral trout	0	8	0	2	0	6
crab	0	330	0	65	0	266
diamond-fish/butterfish	8	0	8	0	0	0
eel	0	3	0	0	0	3
emperors	2	0	0	0	2	0
flathead	4	2	2	1	2	1

COMMON NAME	TOTALS		KEPT		RELEASED	
	1997	**1999**	**1997**	**1999**	**1997**	**1999**
grunter	4	117	0	26	4	91
jew	28	5	0	2	28	3
leatherjackets	5	0	0	0	5	0
mackerel	3	55	3	38	0	17
mangrove jack	15	43	1	33	14	10
moses perch	20	4	2	0	18	4
queenfish	1	2	0	0	1	2
remora	0	1	0	0	0	1
sardine	0	30	0	30	0	0
shark	14	19	0	5	14	14
sickle fish	1	10	1	0	0	10
snapper	25	47	2	10	23	37
stingray	1	3	0	0	1	3
sweetlip	31	5	7	3	24	2
threadfin	1	1	1	1	0	0
toad fish	1	2	0	0	1	2
trevally	0	7	0	4	0	3
Triggerfishes	5	0	0	0	5	0
tripod fish	0	1	0	0	0	1
white spotted guitarfish	1	0	0	0	1	0
whiting	0	14	0	11	0	3
Totals	**235**	**868**	45	**276**	**190**	**592**

B7.2.9.e Penaeid Prawn Assemblages

Penaeid prawns represented a significant proportion of the commercial fishery in the Cairns area. Tiger, Endeavour and banana prawns represented, respectively, 24, nine and two percent of the total commercial catch by weight, but together accounted for 56 percent of the monetary (gross value of production) value of the commercial fishery. Cairns also represents a key Australian location for the harvest of live prawns which are collected to supply broodstock for the prawn aquaculture industry. Generally, the mosaic of high quality wetland habitats (e.g. extensive juvenile prawn nursery habitat amongst intertidal seagrass meadows) together with the large area of flat, trawlable grounds, are important conditions that together contribute to high prawn productivity. Note that the present poor condition and extent of seagrass meadows are likely associated with the comparatively reduced abundances of juvenile prawns inshore.

Coles *et al.* (1993) sampled penaeid prawn assemblages within the Cairns harbour monthly between 1980 and 1987. Sites were positioned in seagrass meadows and unvegetated sediments, and were sampled using standardised hauls with a beam trawler.

Twenty penaeid prawn species were recorded, of which nine are marketed commercially. The most abundant commercial species recorded were tiger prawns *Penaeus esculentus* and *P. semisulcatus*, and the endeavour prawn *Metapenaeus endeavouri*. All collected prawns were juveniles. Significantly higher numbers of commercially important prawns were recorded in seagrass than in unvegetated habitats.

Furthermore, higher abundances of juvenile tiger prawns were recorded during summer, which is the key recruitment period for these species (**Figure B7-41**).

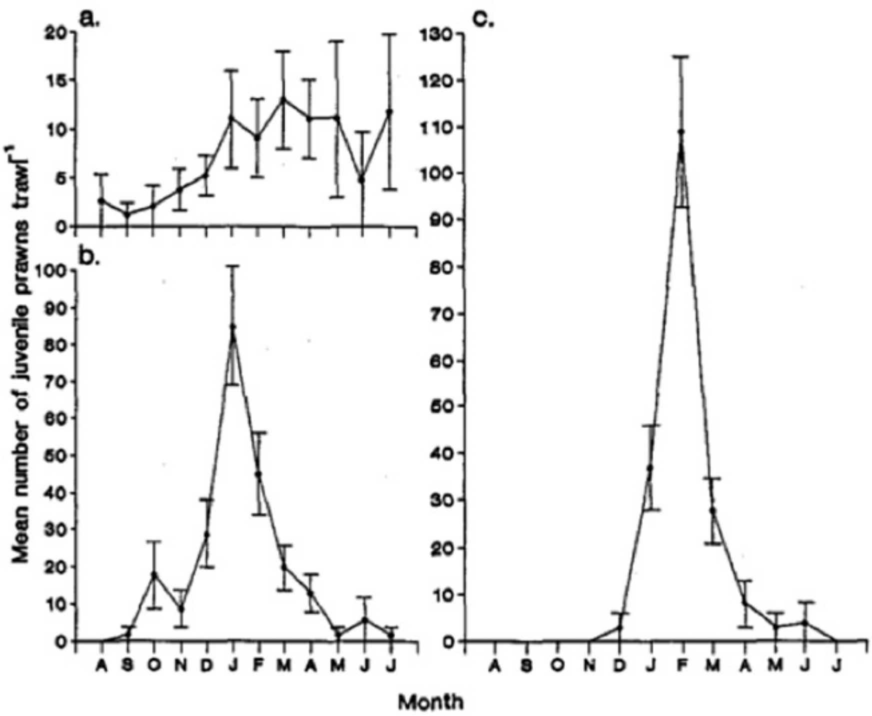


Figure B7-41 Means and standard errors of numbers of juvenile prawns of (a) Endeavour Prawn *Metapenaeus endeavouri*, (b) Brown Tiger Prawn *Penaeus esculentus* and (c) Green Tiger Prawn *P. semisulcatus* caught in each Month in Cairns Harbour 1980-87.

Source: Coles *et al.* (1993).

The catch prawns and total commercial catch for all methods in grid H16 are shown on **Figure B7-42** against annual rainfall. Prawn is a major contributor to total catch, particularly prior to 2001. There was a reasonably strong positive association between prawn catch and annual rainfall. While total catch for all species has generally declined since 2006, the catch of prawns has remained relatively steady since 2001. CPUE for prawns has also been steady through this period.

Consistent with patterns observed in juveniles prawns by Coles *et al.* (1993), tiger prawns (49 percent of the total catch) and Endeavour prawns (34 percent of the catch) dominated commercial prawn catches, followed by banana prawns (12 percent of the catch). This catch pattern was relatively consistent from among years, except in 1992 and 2000 when tiger and Endeavour prawn catches were similar.

Total annual tiger prawn catch tended to be greater in years following higher rainfall, whereas no such association was found in Endeavour prawn catches. Positive (and negative) correlations between commercial fish/shellfish catches and rainfall have been observed by a number of workers (Pen and Caputi 1986; Gillanders and Kingsford 2002; Meager 2003). Catchment rainfall can affect catches in a number of ways including (i) affecting 'catch-ability' of fish/shellfish (ii) increasing nutrient/food availability for recruits; (iii) flushing fish/shellfish from estuarine areas (Loneragan and Bunn 1999).

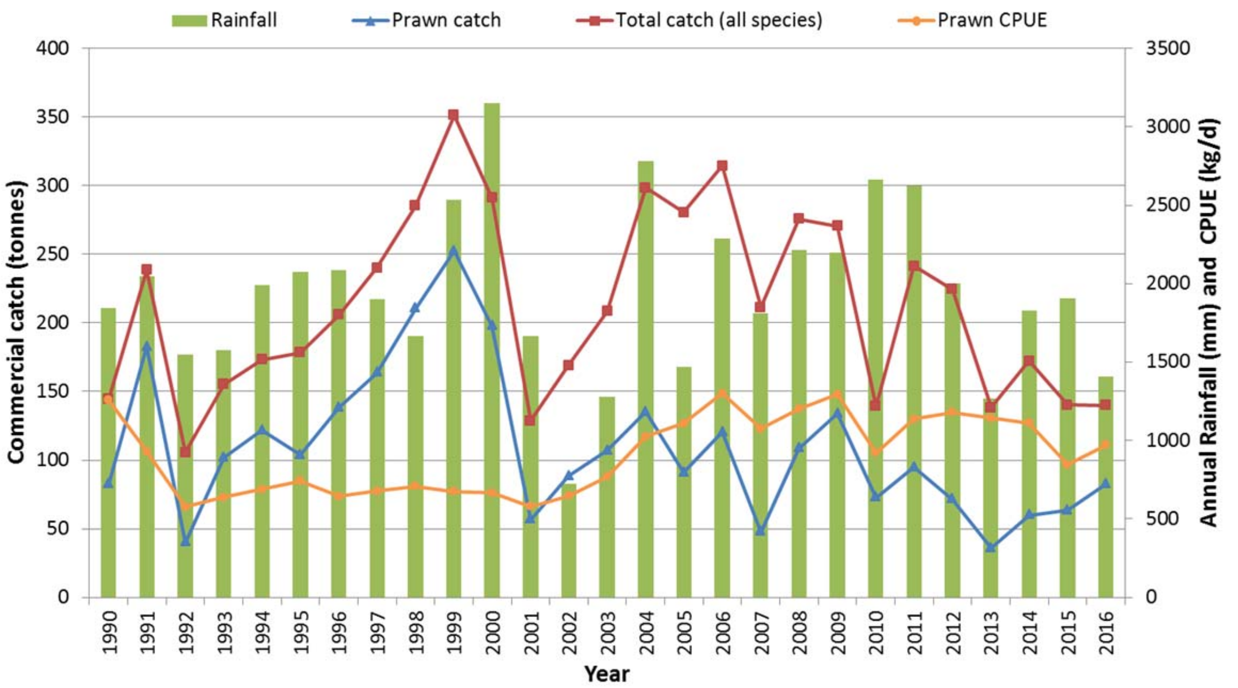


Figure B7-42 Commercial catch of prawns, total commercial catch, prawn CPUE (kg/d) and annual rainfall (mm)

Source: DAFF (2017).

B7.2.9.f Crabs and Other Shellfish

Mud crabs (*Scylla serrata*) primarily inhabit mangrove forests during their juveniles and adult life-cycle stages. Egg bearing females migrate from inshore mangrove areas to deep offshore waters for spawning (Heasman *et al.,* 1985; Hill, 1994). Spawning of mud crabs during the warmer months, and female mud crabs then return to estuaries after spawning (Hill 1994). Mud crabs would migrate from Trinity Inlet and through the harbour on the way to and from offshore spawning areas.

The numerous mangrove-lined creeks within Trinity Inlet represent locally important mud crab foraging and nursery habitat, as is apparent from commercial mud crab production values shown on **Figure B7-43** and **Figure B7-44**. There was great variability over time, which was partly due to changes in crabbing effort. While the mangrove areas of Trinity Inlet provide an important habitat role for local mud crabs, crabs are actually widely distributed across the area, with sites at both western (e.g. Ellie Point) and eastern (e.g. Bessie Point) Cairns harbour previously shown to support high mud crab catch rates, relative to Trinity Inlet (Helmke *et al.* 2003, **Figure B7-43**).

In terms of other commercially harvested shellfish species, bugs and to a lesser extent squid and scallops represented a locally important component of the fishery within the study area (**Figure B7-45**). There is little life history information available for Far North Queensland populations of these species. Bug species have different habitat requirements, with mud bugs (*Thenus orientalis*) occurring in turbid nearshore waters to a depth of 60 m, over sand, mud and gravel substrata (Kailola *et al.* 1993). Sand bugs (Thenus species) prefer clear deep water (Kailola *et al.* 1993), and are unlikely to present in the study area. Mud bugs are likely to occur in subtidal soft sediment habitats throughout Cairns harbour, and would spawn in offshore waters during spring-summer. Bugs and squid would also occur on soft sediment habitat throughout the harbour.

Mud crabs, in particular, are a key recreational target species, being the most commonly recreationally harvested species in 1999 (**Table B7-13**) and fourth commonly harvested species in 2010, based on the available reported information.

The catches of squid, scallops, and blue swimmer crab (**Figure B7-45**) have been highly variable through 26 year time period, with large gaps in data due to several periods where there were less than 5 licence holders.

Catches of bugs have been reported over the entire time period, with high and variable catches up until 2001, followed by relatively low and more stable catch rates to 2016. While catch rates of bugs appear to be down-trending CPUE appears relatively stable.

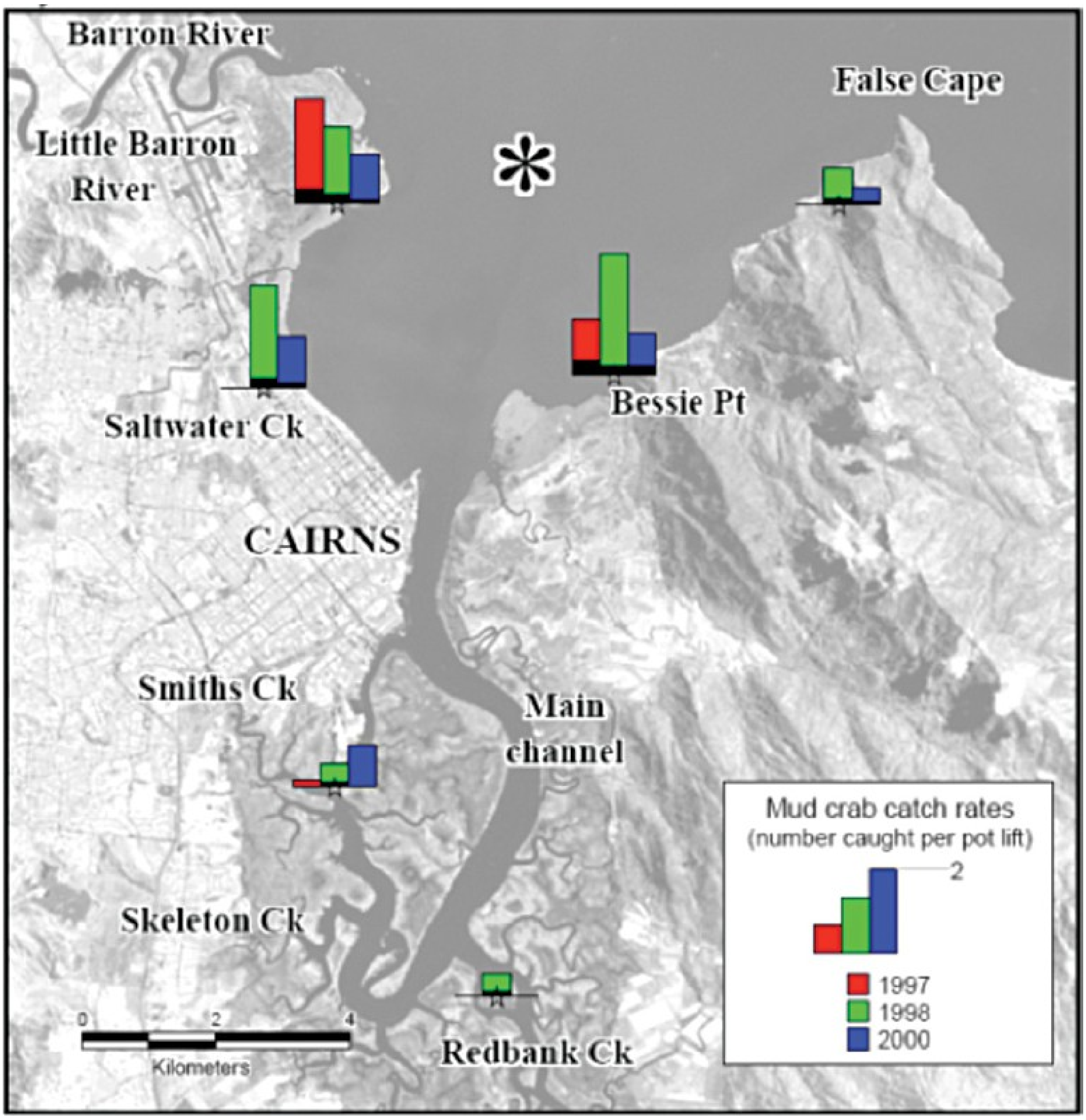


Figure B7-43 Total and legal catch rate (number caught per pot lift) of mud crabs between March 1997 and March 2000 at Trinity Inlet and Cairns Harbour.

Source: Helmke *et al.* (2003).

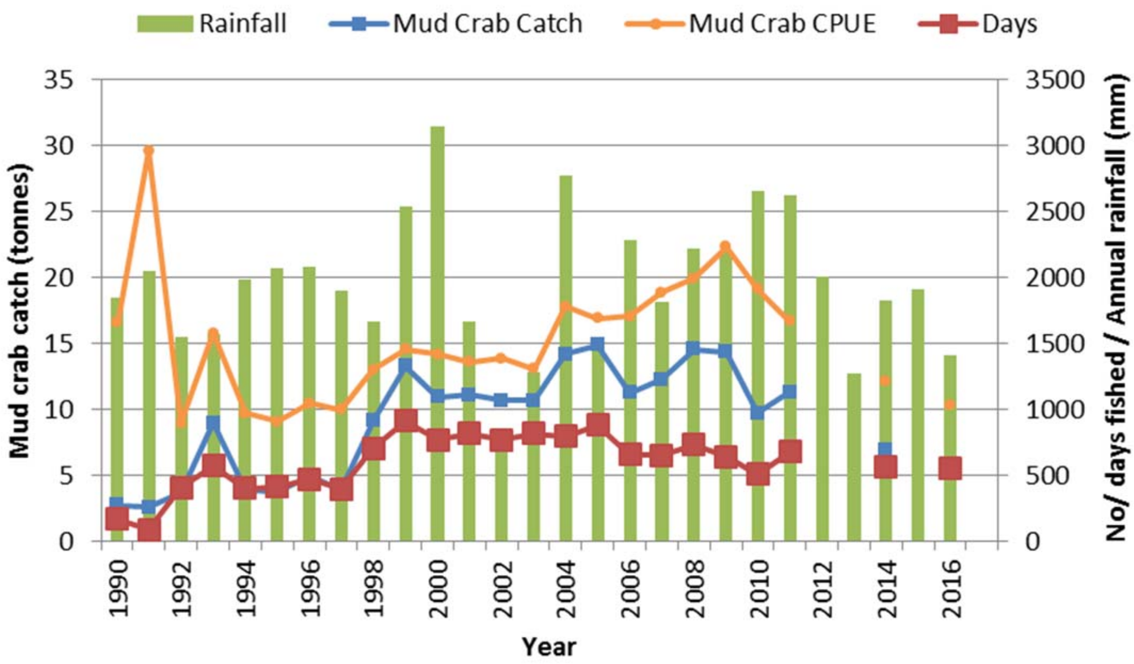


Figure B7-44 Commercial catch of mud crabs, annual rainfall (mm) and catch per unit effort (kg/d).

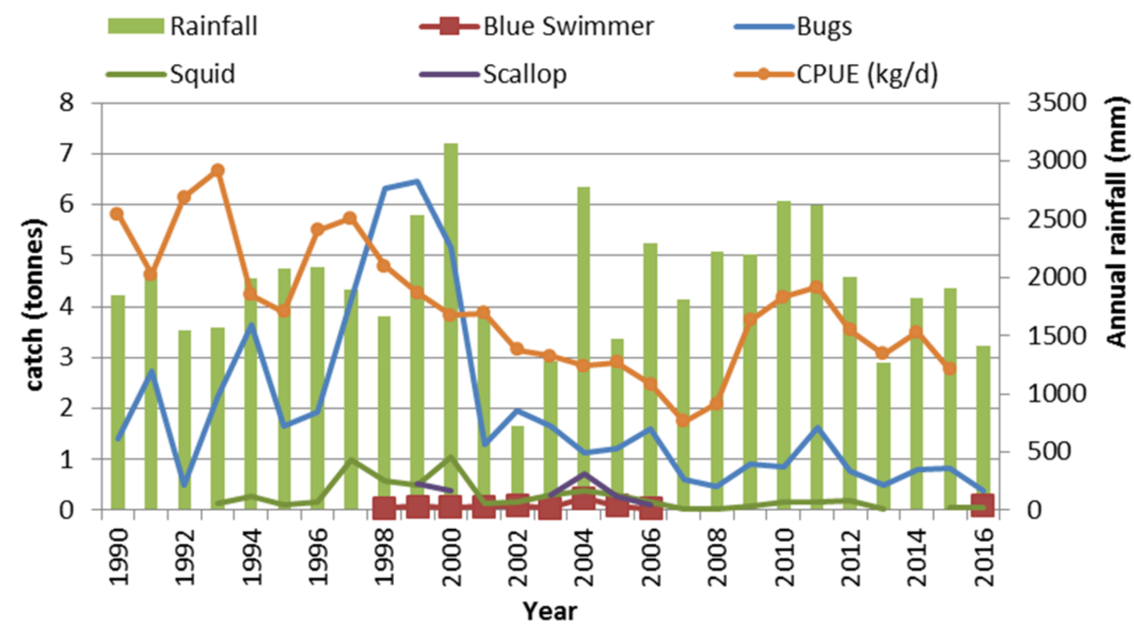


Figure B7-45 Commercial catch of squid, blue simmer crabs, scallops, bugs (tonnes), annual rainfall (mm) and catch per unit effort (kg/d).

B7.2.9.g Fisheries Habitat Values of the Study Area

Table B7-12 shows that most key fisheries species found in the study area are not found exclusively in any one habitat type during any part of their life-cycle. Rather, these species have relatively plastic habitat requirements, and are typically found in a variety of habitat types. Banana prawns were the only habitat specialists recorded in the study site, and are typically found in mangrove during their juvenile stages (Staples *et al.* 1985).

While it is apparent that the habitat types supported in the study area are of importance to fisheries productivity, there are few empirical studies demonstrating that habitat resource availability limits (c.f. influences) estuarine fish and nektobenthic crustacean population abundances. Most studies tend to suggest that non-equilibria processes (e.g. predation, mortality) are probably more important in controlling local-scale fish abundances rather than density-dependent habitat or food limitation during the post-settlement phase. It is therefore not especially practical to consider that all patches of a particular habitat type have equal value as a fisheries resource (see for example Tibbetts and Connolly 1998), or indeed that the removal of an area of habitat will result in a commensurate reduction in fisheries productivity.

For marine species with complex life cycles defining the spatial characteristics (i.e. location, shape, surface area or volume) of functional nurseries is a complex task because the locations (and times) of suitable habitats are determined by a range of biological processes, many of which are stochastic in nature. Ultimately functional nursery habitats are those which produce reproductive adults that contribute progeny to the next generation.

Helmke *et al.* (2003) examined the Trinity Inlet and Cairns harbour data in the Suntag database for 1985 to 2000, in order to assess fish movements in the area. It was found that, although most fish remain resident in Trinity Inlet, the inl*et al*so acts as a nursery habitat for species such as Barramundi, which spend the juvenile and sub-adult phases of their life cycle in fresh and estuarine waters (Helmke *et al.* 2003). The few recaptures recorded outside Trinity Inlet, or having moved into the area included: barramundi moving in from North Johnson, Daintree and Barron Rivers. Russell, *et al.* (2003) conducted tagging studies for the population biology of Mangrove Jack *Lutjanus argentimaculatus* and included findings of movements of tagged fish from Trinity Inlet up to 335 km north to Stapelton Reef near Princess Charlotte Bay, indicating estuary systems such as Trinity Inlet and the Mulgrave-Russell systems are important nursery habitats for such important recreational species.

When considering the fisheries habitat value of an area, it is important to consider the spatial organisation of habitat patches and types (i.e. degree of fragmentation), together with other attributes such as structural complexity and size of habitat patches, and the degree of tidal inundation/flushing. Recent studies have examined the importance of mangroves, seagrasses and saltmarsh as autotrophic nutritional sources for fish in adjacent unvegetated environments (Melville and Connolly 2005, Connolly and Guest 2004, Melville and Connolly 2003). Melville and Connolly (2003) also demonstrated that even on unvegetated soft sediment habitats, organic matter, particularly from seagrasses, was important as the base of food webs for fish species of commercial significance on adjacent unvegetated mudflats in Moreton Bay. Benthic microalgae also contributed a relatively high proportion of the nutrition of the species examined.

Seagrass beds also represent an important (and in some case obligatory) habitat resource for many nektobenthic crustaceans and some fish of commercial significance (see, for example, Bell and Pollard 1989, Connolly, *et al.* 1999, Edgar and Kirkman 1989) (Bell, *et al.* 1988, Haywood, *et al.* 1995). Furthermore, there is an emerging view that fish and nektobenthic crustacean community structure in mangroves and unvegetated habitats is influenced by their proximity to seagrass beds (e.g. Jelbart 2004, Olds 2002). Studies by Olds (2002) in Moreton Bay and Jelbart (2004) in central NSW both found that the suite of species inhabiting seagrass varied with distance from mangroves, whereby seagrass beds (particularly dense beds – Olds 2002) in close proximity to mangroves tend to contain more abundant nekton assemblages than seagrass remote from mangroves.

On this basis, the following broad conclusions are applicable to habitat values of the study area:

- Extensive areas of intertidal habitat are present in the study area, including well-flushed mangals, tidal channels with undercut banks (present along Trinity Inlet), and mud flats in the Cairns Harbour. These intertidal environments provide shelter and/or foraging areas for fish and nektobenthos during high tide.
- Subtidal habitats, which provide refugia during low tide, occur throughout the project area. This is a potentially important factor determining the 'values' of intertidal habitats. It is thought that the risk of predation is increased where fish need to move large distances between intertidal habitat patches (e.g. mangroves, saltmarsh, tidal flats) and permanent tidal pool habitats during low tide (Crowley and Tibbetts in (Tibbetts and Connolly 1998).
- Seagrass habitats in both intertidal and subtidal waters provide an important foraging and nursery habitat, particular where located in close proximity to the mangrove refugia of Trinity Inlet. However, relative to the other habitats available, seagrass extent and condition can fluctuate greatly over time in response to climate influences.
- Limited areas of saltmarsh plants. Saltmarsh communities within the study site are inundated tidally during high water spring events, and are known from case-studies elsewhere to provide functional habitats and foraging areas for a range of fish (typically small-bodied non-commercial species) and nektobenthic crustaceans (including Penaeid prawns and non-commercial crab species) of indirect and direct fisheries value (e.g. Morton, *et al.* 1987, Mousalli and Connolly 1998).

B7.3 Assessment of Potential Impacts

This section presents the findings of the assessment of potential impacts to marine ecology associated with the construction and operation of the project, with particular focus on the following:

- Construction related – primarily capital dredging and placement activities, and also construction of wharf infrastructure.
- Operation of the expanded port facilities, focusing on accommodating an increased number of larger cruise vessels at Trinity Inlet wharves, maintenance dredging of the entrance channel, and placement of maintenance dredge material at the approved marine DMPA.
- Options for managing and mitigating identified impacts.

The impact assessment addresses matters and issues relevant to aquatic and marine ecology as set out in:

- Queensland Government (2012) terms of reference (ToR) Section 5.4.3
- Australian Government (2012) Environmental Impact Statement (EIS) guidelines Sections 5.10, 5.10.7, 5.10.9, 5.10.10, 5.19 and 5.20 of the EIS guidelines.

The assessment of ecological impacts within this section associated with water quality changes is based on threshold values set out in Chapter B5 Marine Water Quality.

B7.3.1 Overview

Components of the project with potential to impact marine ecology include:

- Capital dredging, involving:
  - Widening and deepening of the existing inner and outer shipping channels, and lengthening of the outer channel
  - Establishment of a new swing basin at Smiths Creek to enable future expansion of the HMAS Cairns Navy base and increasing the extent of the Crystal swing basin
- Structural upgrades to the existing cruise shipping wharves 1-5 to accommodate larger and heavier cruise ships
- Installation of a temporary steel pipeline from an offshore dredge pump-out location near Richters Creek to the Northern Sands DMPA, and associated dredge vessel movement between the loading sites and the pump-out location
- Tailwater discharges from the Northern Sands DMPA into the Barron River.

The harbour and channel development works will primarily involve capital dredging of up to 1 million m^3 (M m^3) of material. The soft clay material will be pumped to the Northern Sands DMPA (DMPA) and de-watered into the Barron River. Stiff clays will be placed at the Tingira Street DMPA and will not require tailwater discharge. Potential impacts from placement at the Tingira Street DMPA will be managed on site in accordance with existing practices, and are not considered further in this assessment, as marine ecology impacts are not expected. Maintenance dredging of harbour and channel areas as well as placement at the existing and proposed DMPAs during the operational phase of the project is also considered.

Table B7-14 summarises the key processes for each project component that has the potential to affect ecological value of the marine environment, during either the construction and/or operational phases of the project. **Figure B7-46** shows the direct disturbance footprint for the project and the location of key sensitive marine ecology receptors. **Table B7-15** summarises the approximate area and type of each marine habitat affected by direct impacts at each location, as well as other anticipated direct habitat changes.

TABLE B7-14 SUMMARY OF IMPACTING PROCESSES, PRIMARY IMPACTS, SECONDARY EFFECTS DURING CONSTRUCTION (C) AND OPERATION (O) PHASES OF THE PROJECT

PHASE	IMPACTING PROCESS	PRIMARY IMPACT	SECONDARY EFFECTS	SECTION
C/O	Dredging and dredged material placement	Temporary loss or mobilisation of benthic fauna.	Change in prey availability for marine fauna.	B7.3.3.a
C		Long term change in benthic habitat conditions and benthic fauna.	Change in prey availability for marine fauna.	B7.3.3.a
C/O		Increased suspended solid concentrations and sedimentation.	Loss or degradation of seagrass and corals.	B7.3.4
C/O		Acoustic effects to marine fauna.	Avoidance of area by marine fauna.	B7.3.6.b 0
C/O		Direct effects of dredge plant on marine megafauna.	Injury or mortality to marine megafauna.	B7.3.6.a
C	Tailwater Discharges from the Northern Sands DMPA	Increased suspended sediment concentrations and altered salinity	Loss or degradation of seagrass and riparian habitat	B7.3.5.c B7.3.5.d
			Temporary mobilisation or loss of benthic fauna and fish	B7.3.5.b
C/O	Wharf and pipeline infrastructure development and operation	Direct changes to marine habitat.	Change in prey availability for marine fauna.	0
		Acoustic effects to marine fauna (e.g. physiological damage, masking of important sounds) associated with construction (e.g. piling) and operational vessel noise and vibration.	Adverse marine fauna behavioural responses, temporary avoidance or displacement of affected area.	B7.3.3.c B7.3.6.a B7.3.6.b 0
C/O	Increased vessel movements	Increase in boat strike (construction vessels and increased ship movements).	Injury or mortality to marine megafauna.	B7.3.6.a
		Increase potential for marine pest introductions.	Out-competition of native species and loss of biodiversity values.	B7.3.8.a
		Increase in vessel wash and disturbance of seabed habitats, flora and benthic fauna.	Change in prey availability for marine fauna.	B7.3.9
C/O	Construction plant and operational lighting	Increased light spill into the marine environment.	Disorientation of marine fauna, particularly marine turtles.	B7.3.6.b
C/O	Increased potential for debris and spills to enter the marine environment	Ingestion of debris or entanglement of marine megafauna. Toxicity effects to marine biota	Loss of biodiversity values.	B7.3.9

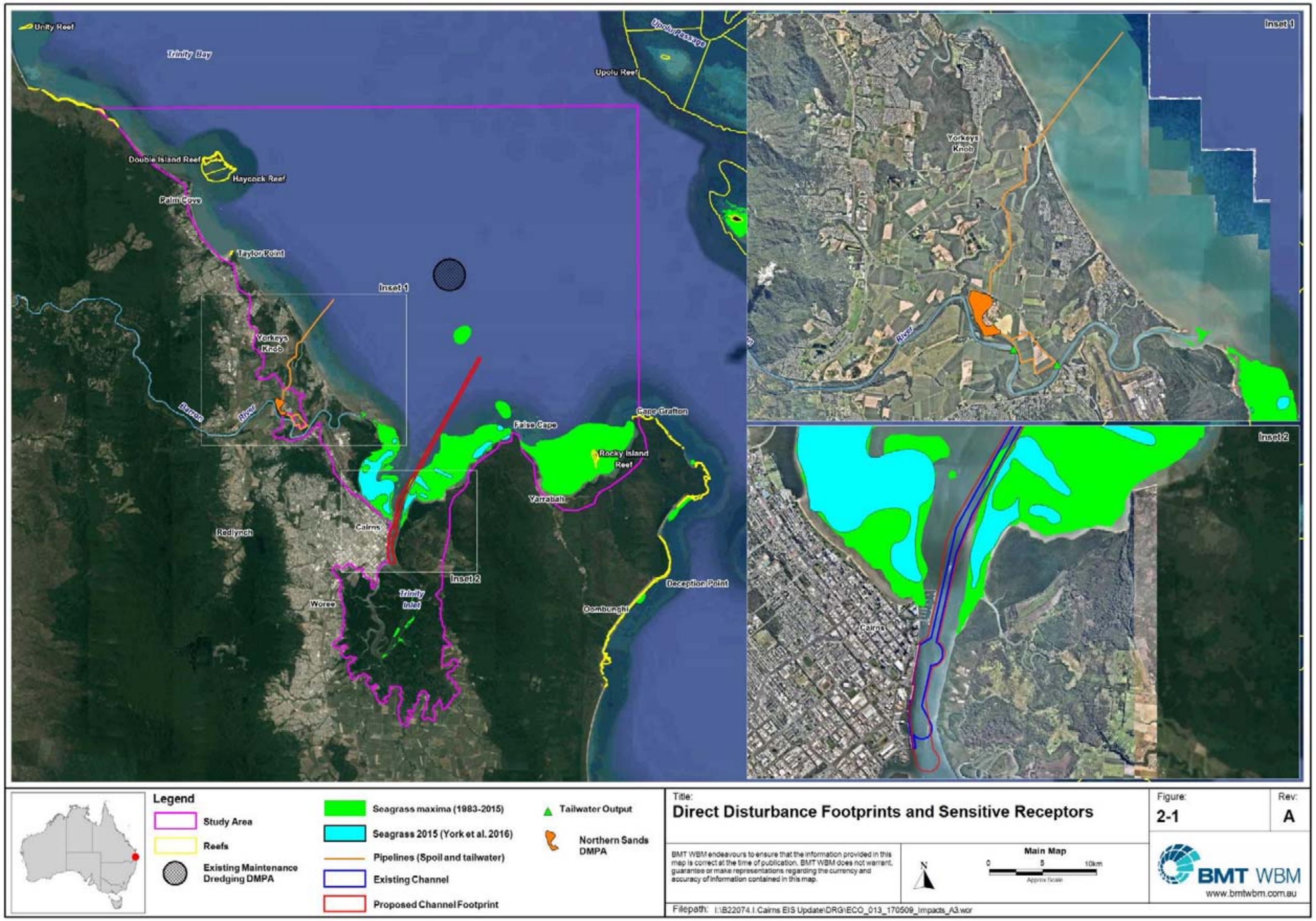


Figure B7-46 Direct Disturbance Footprints and sensitive receptors.

TABLE B7-15 AREA OF DISTURBANCE WITHIN EACH IMPACT LOCATION

LOCATION FIGURE B7-46	PHASE	ACTIVITY	EFFECT TYPE	HABITAT TYPE	AREA (HA) AFFECTED
Direct Irreversible Losses and Gains at Wharf					
Wharf area on inset 2	C	Wharf dolphin structures, associated piles for wharf infrastructure.	Loss of soft sediment habitat.	Subtidal soft sediments	0.005 ha
			Habitat modification – hard substrate habitat associated with wharf upgrade works (84 piles)	Hard substrate	~0.005 ha (gain)
Direct Habitat Disturbance Associated with Dredging Activities					
Blue channel area on inset 2	C, O	Dredging and deepening of inner port (previously dredged areas).	Habitat modification: • Increase depth in capital dredging footprint • Disturbance by maintenance dredging at similar frequency as existing maintenance dredging)	Subtidal soft sediments	40.88 ha
Red channel area in inset 2	C, O	Dredging and deepening of inner port in previously un-dredged areas.	Habitat modification - increase in depth where capital dredging will occur; disturbance by maintenance dredging	Subtidal soft sediments	21.50 ha
Blue channel area	C, O	Deepening of the existing outer channel (previously dredged areas).	Habitat modification - increase in depth; disturbance by maintenance dredging (at similar frequency as existing maintenance dredging)	Subtidal soft sediments	99.23 ha
Red channel area	C, O	Channel widening in previously undredged areas.	Habitat modification - increase in depth; ongoing disturbance by maintenance dredging	Subtidal soft sediments	12.95 ha
Hatched DMPA	C, O	Maintenance dredge material placement at the offshore DMPA.	Temporary habitat modification due to dredged material placement from maintenance dredging	Subtidal soft sediments	269 ha
Direct Habitat Disturbance Associated with Pipeline Alignment					
Orange pipeline	C	Trenching the pipeline at Richters Creek Crossing and shoreline modification	Habitat modification – disturbance to beaches and creek bank at pipeline crossing locations	Intertidal and subtidal soft sediments, river bank habitat	0.12 ha

B7.3.2 Methodology

B7.3.2.a Assessment Approach

A risk-based approach has been used in the marine ecology impact assessment. This is based on the identification of potential impacting processes and characterising the likely level of impact to the existing environment. For the purposes of this Marine Ecology assessment, impacts levels and risks were defined on the basis of the following: and based on the consideration of the following:

- **Consequence of Impact** – made up of assessment of the intensity, scale (geographic extent), duration of impacts and sensitivity of environmental receptors to the impact. Impact consequence ratings take into account the conservation management objectives for protected and threatened species (as outlined in the relevant recovery plans for species listed in **Section B7.2**). (**Table B7-16** is a summary of the categories used to define impact consequence).
- **Duration of impact** - the duration of identified impacts is classified as per **Table B7-17**.
- **Likelihood of Impact** – which assesses the probability of the impact occurring. **Table B7-18** is a summary of the categories used to define impact likelihood.
- **Risk rating** – which assesses the level of risk for key impacting processes. The risk table (**Table B7-19**) adopted is generated from the Consequence and Likelihood scores, based on the overall matrix presented in **Chapter A1** (Introduction).

To determine the most appropriate impact consequences, impact definitions were further defined using assessment methods from elsewhere in this Revised Draft EIS. This includes the ‘zones of impact’ assigned to processes associated with water quality (**Chapter B5** (Marine Water Quality)) and sediment deposition (**Chapter B3** (Coastal Processes)), which take into account the relevant project-specific ecological threshold values applied for this EIS.

The water quality impact predictions (zones of impact) have been derived using percentile exceedance plots, as described in **Chapter B5** (Marine Water Quality). The zones of impact are generally based on dredging environmental assessment guidelines produced by the WA EPA (2016), and include the following:

- Zone of High Impact = water quality impacts resulting in predicted mortality of ecological receptors with recovery time greater than 24 months.
- Zone of Low to Moderate Impact = water quality impacts resulting in predicted sub-lethal impacts to ecological receptors and/or mortality with recovery between 6 months (lower end of range) to 24 months (upper end of range).
- Zone of Influence = extent of potentially detectable [1] plume, but no predicted ecological impacts.

Full details on these zones, their determination, and criteria are provided in **Chapter B5** (Marine Water Quality). Key assumptions and limitations of the impact assessment are outlined in the relevant sections.

[1] Detectable’ plume in terms of detectable above background conditions by instrumentation deployed in the water column

TABLE B7-16 IMPACT CONSEQUENCE CRITERIA (MARINE ECOLOGY)

IMPACT CONSEQUENCE	DEFINITION	HOW DEFINED
Very High	The impact is considered critical to the decision-making process as it would represent a major change to the ecological character of Cairns harbour and/or the immediate surrounds. This level of impact would be indicated by any of the following:	
	Irreversible or long-term (i.e. greater than decades) loss of a unique/rare habitat or community type that is of regional importance	Direct loss of value in the project footprint that is absent elsewhere in the Cairns region
	Irreversible or long-term (i.e. greater than decades) loss or diminishment of important habitats or communities that lead to major flow on effects to biodiversity values and ecosystem functioning at a regional (Cairns wide) scale	Direct loss of value in the project footprint that leads to regional flow-on impacts to the Cairns region
	Severe impacts to populations of Commonwealth or State listed threatened species, such that their capacity to reproduce and recover is significantly affected.	Area supports 'important population' (as per MNES Guidelines 2013), and action is likely to cause impacts to overall population status of the species
High	The impact is considered important to the decision-making process as it would represent a detectable change to the values that underpin the ecological character of the study area (Cairns harbour and surrounds). This level of impact would be indicated by any of the following:	
	>10%, long-term reduction in the total extent of existing seagrass meadows or potential seagrass habitat in the Cairns region	Direct loss of habitat in footprint
	A detectable, medium term (>5 years) change to the structure (diversity, richness, composition, etc.) of high ecological value communities (i.e. reefs, seagrass, high value fisheries species) that lead to significant detectable flow on effects to biodiversity values and ecosystem functioning at a regional (Cairns wide) scale	Zone of High Impact: Deposition/turbidity (percentile + ecological thresholds
	Mortality of a several individuals of internationally/nationally threatened species, but no detectable change to population status or the capacity of populations to recover.	Loss of individuals from study area (from mortality or permanent abandonment, etc.), but unlikely to result in impacts to population (as per MNES Guidelines).
Moderate	While important at a state, regional or local scale, these impacts are not likely to be critical decision making issues. This would be indicated by:	
	Long-term loss or severe modification of important habitat type (particularly seagrass or reefs) including colonisation by invasive marine pests	Direct loss of habitat in project footprint
	A detectable significant change to the structure (diversity, richness, composition, etc.) of a high ecological value community structure (i.e. reef-associated benthos, seagrass, high value fisheries species), but recovery to a state resembling that prior to being impacted within a timeframe of five years or less	Zone of Low to Moderate Impact (seagrass, corals).

IMPACT CONSEQUENCE	DEFINITION	HOW DEFINED
	Loss of several individuals, or temporary loss of life history function for threatened species, or species of high fisheries or otherwise ecological value, but no detectable change in their population status at local (study area and surrounds) spatial scales (e.g. once off interruption of breeding or spawning, not necessarily affecting all of local population).	Loss of individuals from study area (from mortality, long-term or temporary abandonment etc.), but unlikely to result in impacts to any local population (as per MNES Guidelines).
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. This would be indicated by:	
	Changes to sediment type and soft sediment benthic communities at local scale (measured at scale of 10s to 100s of metres)	Any change to soft sediment habitat that is well represented in the Cairns region
	Short term (i.e. duration of dredge campaign, less than one year) changes to the distribution of threatened species or species of high fisheries significance (i.e. avoidance of areas), but no long-term effects to local population status.	No loss of individuals of any threatened species, but temporary avoidance of affected areas possible
Negligible	Minimal change to the existing situation. This could include, for example, impacts that are below levels of detection, impacts that are within the normal bounds of variation, or impacts that are within the margin of forecasting error.	Zone of Influence
Beneficial	Existing marine flora/fauna populations and/or habitat is improved in Trinity Inlet, Trinity Bay and surrounds.	n/a

TABLE B7-17 CLASSIFICATIONS OF THE DURATION OF IDENTIFIED IMPACTS

RELATIVE DURATION OF IMPACTS	
Temporary	Days to months
Short Term	Up to one year
Medium Term	From one to five years
Long Term	From five to 50 years
Permanent / Irreversible	In excess of 50 years

TABLE B7-18 CATEGORIES USED TO DEFINE LIKELIHOOD OF IMPACT

LIKELIHOOD	CATEGORIES
Highly Unlikely/Rare	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction/life of the project but probability well <50%; unlikely but not negligible
Possible	Less probability of occurrence than 'Likely' but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability >50%
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impact period

TABLE B7-19 RISK MATRIX FOR MARINE ECOLOGY

LIKELIHOOD	IMPACT CONSEQUENCE				
	NEGLIGIBLE	MINOR	MODERATE	HIGH	VERY HIGH
Highly Unlikely/ Rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

TABLE B7-20 RISK RATING LEGEND

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact to marine ecology values
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact to marine ecology values
Medium Risk	An issue requiring project specific controls and procedures to manage
Low Risk	Manageable by standard mitigation and similar operating procedures
Negligible Risk	No additional management required

B7.3.2.b Dredging and Tailwater Scenarios

The total duration of the capital dredging campaign is expected to be approximately 12 weeks for the TSHD, with the BHD dredging component expected to take approximately 5-6 weeks within this dredging period. For assessments based on predictive model outputs of dredging scenarios, two scenarios were considered:

- **Scenario 1** - lower end of the expected total dredge material volume (710,000 m^3 of soft material from the channel and 100,000 m^3 of stiff clay material from the inner channel and harbour) and limited overflow from the TSHD (maximum 10 minutes of overflow).
- **Scenario 2** - upper end of the expected total dredge material volume (900,000 m^3 of soft material from the channel and 100,000 m^3 of stiff clay material from the inner channel and harbour) and less-restricted overflow from the TSHD (30 minutes of overflow per cycle).

For assessments of tailwater discharges into the Barron River, predictive modelling was used to assess two possible release locations, both consisting of seawater released with suspended solid concentrations of 100 mg/L (~60 NTU):

- Tailwater discharge point A – located just downstream from the Northern Sands DMPA
- Tailwater discharge point B – located at the Bruce Highway crossing of the Barron River

Modelling of both dredging and tailwater scenarios was undertaken over three different weather periods (representing a range of wind and wave conditions), with the best and worst of the modelling outputs representing the 'likely best case' and 'likely worst case' scenarios presented in this report. Each percentile plot is based around a 30 day modelling window. As such, these scenarios provide lower and upper bounds to expected impacts.

It should be noted that extreme climatic events are not included as part of the worst-case scenarios as dredging and associated discharge would be unlikely to be occurring during these periods.

B7.3.3 Direct Modification of Benthic Habitats and Communities from Dredging, Dredged Material Placement, Wharf Upgrades and Pipeline Trenching

This section describes direct impacts to benthic habitats and communities due to dredging activities, dredged material placement, wharf upgrade works, and pipeline trenching at Richters Creek. Note that indirect impacts associated with water quality effects are considered in **Section B7.3.4**. Impacts from potential spillage during pipeline operation to the underlying seafloor and surrounding ecology are addressed in **Chapter B17** (Hazard and Risk).

B7.3.3.a Dredging of the Channel, Inner Harbour and Swing Basins

Dredging Specifications

Figure B7-46 shows the proposed dredging footprint. For capital works, dredging of the outer channel will widen the existing channel from 90 m to 100 m and deepen the channel from -8.3 m LAT to -8.8 m LAT. Practically, the outer channel will be dredged wider to accommodate channel batters (typically one in four slope), and deeper in some areas to allow for siltation between maintenance dredging campaigns (**Chapter B3** (Coastal Processes)).

The inner channel extends for 2.4 km and has variable widths incorporating bends and swing basins. Capital dredging here will expand the existing Crystal Swing Basin for use by cruise ships, relocate the existing main swing basin further south (to be designated Smiths Creek Swing Basin), and increase the width and depth of the existing inner port channel along its full length.

Based on the anticipated dredge volumes and materials, it is anticipated that the dredging program will take approximately 12 weeks. Future maintenance dredging requirements are expected to be increased by approximately 2-6% (**Chapter B3** (Coastal Processes)).

Benthic Habitat Modification

Dredging will result in the direct removal of soft sediment habitat and biota from within the dredge footprint areas of the existing assessed and approved channel structure. Capital dredging will involve the disturbance of approximately 174.5 ha of soft, unconsolidated sediment, of which 140 ha is already disturbed by the annual maintenance dredging program. Hence, it is proposed that the project will impact approximately 34.5 ha of seafloor that has not previously been dredged, namely the widening of portions of the channel and the small batter slope/ swing basin extensions within the inner port.

It is expected that dredging to widen the outer channel and inner port area will create benthic habitat conditions that are similar to those found within the existing outer channel and previously dredged areas of the inner port. As discussed in the **Section B7.2**, existing benthic habitats and macroinvertebrate assemblages within the outer channel are highly simplified and have low diversity compared to adjacent undredged areas. The existing outer channel and inner port are subject to ongoing disturbance as a result of maintenance dredging.

Water depth will also increase, typically by approximately 0.5 – 2.0 m throughout the existing dredge footprint. The increase in water depth will represent a permanent change in habitat conditions as these depths will be sustained by ongoing maintenance dredging campaigns throughout the operational phase. The following habitat responses are predicted:

- Given the increase in water depth, the seafloor within the dredge footprint is expected to receive slightly lower light levels than present due to light attenuation with depth.
- Localised changes to bed stability on the batter slopes of the dredge footprint (see Chapter B3, Coastal Processes)
- Highly localised and minor changes in the speed and direction of currents after development completion. For example, the highest magnitude changes in tidal current flow velocities are not large (generally ±0.1 m/s, refer **Chapter B3** (Coastal Processes)) and are unlikely to alter local scour or sediment accretion at rates that would affect seagrass or benthic communities.

Effects to Benthic Fauna Communities

Initially, dredging will cause a temporary loss of biota from within the dredge footprint, since benthic communities typically inhabit the surface sediments that will be extracted by dredging. Biota will soon recolonise the dredge footprint but will continue to be regularly subject to similar disturbance through boating propeller wash and the ongoing annual maintenance dredging regime.

While in this modified state, it would be expected that benthic communities within both the existing channel/harbour and proposed new dredge areas (i.e. channel widening/extension area and parts of the inner port that have not previously been dredged) will support similar benthic communities and ecological functions as that currently found in the existing channels.

As discussed in **Section B7.2**, benthic fauna communities within the proposed dredge footprint are largely simplified, with a lower fauna abundance and diversity compared to soft sediment habitats elsewhere in the study area. This relates to both epifauna and infauna communities, and is largely associated with much of the dredge footprint having been exposed to past dredging effects, either directly, or by being located immediately adjacent to previously dredged areas. No reef communities or other features of high fauna biodiversity value occur in the proposed newly dredged areas.

In regards to the proposed dredge pump-out mooring point offshore from Richters Creek, studies undertaken in this area indicated that epibenthos densities varied from bare substrate to low-density benthic communities (**Section B7.2**). Furthermore, habitats along the dredge pump-out alignment from the mooring point to the mouth of Richters Creek do not contain hard substrates or abundant epibenthic communities.

Recolonisation of benthic fauna to a dredged area may occur via several processes including:

- Passive recolonisation, involving the passive settlement of entrained or otherwise resuspended organisms (Morton 1977)
- Larval settlement by planktonic organisms (Skilleter 1998)
- Post-colonisation invasion of the dredged area by adult and juvenile fauna from neighbouring undisturbed areas (noting rates of colonisation dependent on the mobility of the animals present in adjacent areas).

Initial passive recolonisation of dredged areas may occur immediately after dredging, followed shortly by the commencement of recolonisation through larval dispersal or active invasion (within hours to days) (WBM 2004). While commencement of initial recolonisation will occur in a short time frame, 'recovery' (functional recovery in terms of a return to comparable numbers of species and total individuals) for areas that have not previously been dredged would be in the order of months to years but will ultimately be limited by the frequency and timing of maintenance dredging (i.e. maintenance dredging fosters a continuous cycle of disturbance and recovery, such that communities remain in a state of flux). However, such areas are subject to natural disturbances from cyclones and would have significant recovery potential. As such, areas of the dredge footprint that have not previously been dredged can be expected to undergo a shift in community composition, whereby for example, the more tolerant or opportunistic species would contribute proportionately more to total fauna abundances. On the whole, and throughout the longer term operational phase, benthic fauna communities across the dredge footprint will likely reflect those currently inhabiting the existing dredged areas.

Seagrass

The dredge footprint does not presently support seagrass meadows. Approximately 9 ha of the dredge footprint overlaps with seabed areas that have previously supported seagrass and as such, these areas represent potential habitat for seagrass. Of the 9 ha of historic seagrass within the new channel footprint, 6 ha of this falls within the existing footprint, predominantly in areas affected by the widening. Seagrass in the dredge footprint is ephemeral *Halodule uninervis*, with periodic detections during times of favourable conditions with detections in the mid 2000's and again most recently in 2016 (Ports North, pers. com). As discussed in the **Section B7.2**, the seagrass previously recorded here was dominated by *Halodule uninervis*, and at times was also comprised of *Cymodocea serrulata*, similar to other seagrass beds previously mapped on the eastern side of the existing channel (York *et al.* 2016).

The total area of potential seagrass habitat in the footprint is ~ 1% of the cumulative historical extent of seagrass meadows in the Cairns region and ~2% of the meadow extent mapped in 2015.

Secondary (Indirect) Effects

The change in habitat conditions in the dredge channel is predicted to have highly localised secondary effects to marine flora and fauna. Alterations in the composition and abundance of benthic fauna assemblages can be expected within the dredged area immediately after dredging (i.e. prior to recolonisation), resulting in a temporary loss of prey items for fish and invertebrates in the dredge footprint.

Given much of the dredge footprint is already subject to ongoing maintenance dredging, this area does not contain large or dense seagrass areas. Hence, any seagrass present is unlikely to provide a critical foraging function for fish, green turtles, dugongs (or other seagrass dependent marine species) compared to the more extensive seagrass meadows normally occurring elsewhere in Cairns Harbour (i.e. in the vicinity of Cairns Esplanade and Bessie Point).

Overall, modifications to benthic habitats and communities in the proposed channel expansion area are expected to initially result in highly localised reductions in benthic fauna richness and abundance. These communities will begin to recover (possibly commencing immediately after dredging) but will continue to fluctuate in response to maintenance dredging and natural ambient disturbances from extreme weather events, similar to the present situation in maintained dredged areas. Overall, these changes are not expected to cause detectable flow-on effects to other ecosystem components or functions throughout the study area, beyond the dredge footprint.

Note that for marine protected areas, dredging will encroach on the Trinity Inlet FHA and GBR Coast State Marine Park General Use Zone. These effects and corresponding mitigation measures are detailed in Chapter B2, Nature Conservation Areas. No capital dredging will occur within the GBRMP.

B7.3.3.b Wharf Upgrade Works

Marine aspects of the wharf upgrade works focus on the installation of 21 independent dolphin structures between existing bents, together with a new fender system every five bents. Each dolphin has four steel piles (totalling 84 piles during construction), concrete pile caps and mooring bollards. Piles are 900 mm in diameter, and subject to detailed design, equalling a total base area of 53.76 m^2 for all piles combined.

This area (53.76 m^2) represents the area of marine habitat and associated benthic infauna communities that will be permanently displaced through the construction of the wharf upgrade works. All this habitat will be subtidal soft sediment (mud) and represents a small proportion of available soft sediment habitat within the inner port local area (refer sediment class distribution map in **Section B7.2**). This area is already in a modified condition due to existing development, and is a highly mobile fine sediment environment not favourable to establishment of benthic flora or fauna. As such, this loss is not expected to result in detectable flow-on effects to other local fauna components (e.g. fish, large invertebrates) that rely on benthic infauna as a food resource. The loss of benthic habitat and associated assemblages within the wharf upgrade footprint is irreversible and therefore rated as a moderate impact.

The piles will provide additional artificial hard substrata (i.e. 84 piles in approximately 8 m water), which will gradually be colonised by sessile and encrusting biota over time (e.g. algae, attached bivalves, molluscs, bryozoans, etc.), resulting in a benefit in terms of habitat availability for these hard substrate associated communities. It is likely that species richness and biomass of benthic assemblages on the piles will be far greater than on the soft substrate that it replaced. While the piles will act as a fish aggregation device, they are unlikely to increase fisheries productivity except at localised spatial scales.

B7.3.3.c Richters Creek Pipeline Trenching

Approximately 0.12 ha of subtidal river bank will be temporarily modified at the pipeline crossing of Richters Creek. The pipeline will rest on the creek bed and will not restrict fish passage. The disturbance to soft sediment and bank communities is considered to be of minor impact consequence and low environmental risk given the very small scale of the disturbance, its temporary nature, and a lack of sensitive receptors.

Flow-on effects from the potential water quality impacts of this disturbance are considered to be of negligible consequence and mitigation measures are discussed in the **Chapter B5** (Marine Water Quality). Directs impacts to mangrove communities from this crossing and alignment are discussed in **Chapter B8** (Terrestrial Ecology).

B7.3.3.d Habitat Changes due to Altered Hydrodynamics

As discussed in **Chapter B3** (Coastal Processes), the project is predicted to result in minor, highly localised changes to hydrodynamics. Within and immediately adjacent to the dredging footprint, depth-averaged current speeds are predicted to increase/decrease (depending on location) within a range of ±0.1 m/s. Smaller magnitude reductions in peak current speeds (<10 percent) are predicted more broadly within Trinity Bay.

These minor changes in hydrodynamics would not be expected to result in detectable changes to marine habitats and biota.

B7.3.3.e Changes to Habitat and Prey Resources for Species of Economic Significance

Two critical considerations when considering the potential impacts of loss or disturbances to benthic assemblages on the foraging of fishery species are:

(1) The spatial scale of the impact relative to the total area of habitat available

(2) The degree of foraging specialisation exhibited by key fishery species.

With respect to loss or changes in prey resource availability, the level of impact will depend on the whether the animal has a highly specialised diet, and whether the area affected contain critical food resources.

The total area of soft sediment habitat loss proposed (as described above for dredging and piling) is relatively small compared to the total available soft sediment habitat resource in the harbour, Trinity Inlet and the wider study area. Based on habitat assessments and benthic macroinvertebrate community surveys, none of the potentially affected areas are known to support unique benthic macroinvertebrate or benthic habitats, nor are benthic macroinvertebrate communities within these areas considered to be particularly diverse or abundant compared to adjacent areas (consistent with much of the project footprint already having been subject to past/present disturbance).

Fish species occurring in unvegetated soft sediment habitats are generally recognised as being opportunistic benthic foragers (e.g. Hobday *et al.* 1999). This is demonstrated by how rapidly some fish species occurring in these habitats learn to consume introduced invertebrate species such as bivalves and polychaetes (Hobday *et al.* 1999). Similarly, prawns and crabs of economic significance also have a plastic (adaptable) diet (Dall 1992; Wassenberg and Hill, 1987).

Key commercial and recreational fisheries species potentially occurring at and adjacent to areas of disturbance can be broadly classified as broadly opportunistic species which feed on a wide variety of benthic invertebrates and pelagic fish (**Table B7-21**).

TABLE B7-21 PREY OF KEY HARVESTED SPECIES THAT MAY OVERLAP SPATIALLY WITH THE AREA OF HABITAT IMPACTS FOR THE PROJECT

SPECIES	PREY	SOURCE
Eastern king prawn, Tiger prawn, Banana prawn	Benthic invertebrates – crustaceans and polychaetes.	Moriarty (1977)
Blue swimmer crab	Benthic invertebrates - crustaceans, molluscs, echinoderms, polychaetes.	Williams (1982), Wassenberg and Hill (1987)
Mud crab	Benthic invertebrates – molluscs, crustaceans, sedentary or moribund fish.	Williams (1997)
Barramundi	Fish and macrocrustaceans (prawns, crabs, etc.).	Davis (1987)
Threadfin salmon	Demersal and pelagic fish (e.g. ponyfish, flathead, scats, sardines) and macro- crustaceans.	Kailola *et al.* (1993)
Queenfish	A variety of pelagic fish species and cephalopods.	Kailola *et al.* (1993)
Sand whiting	Benthic invertebrates – crustaceans, molluscs, polychaetes.	McKay (1992)

Given the opportunistic behaviour of the benthic foragers listed above, together with the small proportion of habitat lost, it is not expected that permanent loss or modification of habitat would lead to a long-term reduction in populations of species of economic significance. However, it would be expected that demersal fish, crabs and prawns will avoid areas that have depauperate benthic macroinvertebrate assemblages as a result of dredging. This is expected to result in a redistribution of fauna, with animals foraging in other parts of the study area (e.g. adjacent to project footprint) until such times as benthic communities recolonise the disturbed area (i.e. recolonisation will commence immediately in dredged areas, but invertebrates communities in such areas will likely remain in a cyclical state of flux in response to ongoing maintenance disturbance).

Mud crabs, blue swimmer crabs and demersal fish utilise a range of soft sediment habitat types. There is no empirical evidence to suggest that these species have a strong association with a particular sediment type. Some correlative preferences for sediment type (i.e. grain size distributions) have been shown for commercial prawn species (e.g. Somers 1994). However, Somers (1994) suggested that variables other than sediment grain size may be more important, particularly factors such as the availability and extent of food and nursery habitats (e.g. seagrass, mangrove and benthic faunal communities). In the context of this project, this means that longer term changes in habitat conditions (e.g. sediment types, water depths) as a result of dredging, and associated changes to benthic macroinvertebrate communities, the risk of impact is considered to be low for species of economic significance. Further discussion on fisheries impacts specifically relating to the generation of turbid plumes is provided in **Section B7.3.4.a**.

B7.3.4 Increased Suspended Sediment Concentrations and Sedimentation from Dredging

Dredging will generate turbid plumes that will extend over marine areas outside the project footprint. The two key effects of this for consideration in terms of potential impacts to marine ecology relate to:

- water quality effects associated with temporary increases in suspended sediment concentrations (turbidity)
- increased sediment deposition from suspended sediments settling out of the water column (deposition).

These two items are discussed separately below, based primarily on predicted impacts described in the **Chapter B5** (Marine Water Quality) and **Chapter B3** (Coastal Processes) for the various dredging scenarios.

B7.3.4.a Increased Turbidity (Capital Works)

Predicted Turbidity

Turbid plumes generated by dredging will reduce light levels on the seabed, which could affect photosynthetic benthic species requiring light for energy production (e.g. seagrass, algae, and soft coral). The actual impact of turbid plumes on these benthic primary producers will depend on whether critical light requirements are met, and consideration of the magnitude, frequency and duration of low light events.

Numerical modelling of turbid plumes has been carried out for a range of scenarios. Ecological impact assessments in this section are primarily based on this modelling of the best and worst case scenarios, presented as zones of impact in **Figure B7-50**.

Note that both scenarios assume there is overflow from the TSHD and that stiff clays are removed by BHD. Both scenarios assume varying levels of overflow from the TSHD, depending on the type of bed materials encountered and during the worst 30 day period (i.e. taking into consideration both climatic and operational factors). In the context of these outputs, impacts to the 95th percentile turbidity represents the predicted acute water quality effects above background levels over a short- term period (36 hours); while impacts to the 50th percentile turbidity indicate more chronic cumulative water quality effects over a longer (15 day) duration. The extent, location and magnitude of turbidity plumes will ultimately depend on where a dredge vessel is operating at any given time, what type of dredger is operating, and the meteorological/sea conditions at the time of dredging and placement activities.

Ambient turbidity created by wind, waves, and river input is substantial within the study area. For context, percentile contour plots showing modelled ambient turbidity (without dredging) during 50^{th} and 95^{th} percentile conditions are provided on **Figure B7-47**.

Based on the modelled worst case scenario presented here (**Figure B7-48**), it is predicted that median turbidity would increase slightly (in the order of 2-4 NTU) along the northern coastline from near the mouth of Barron River to Yorkeys Knob for portions of time during the dredging campaign (~15 days out of 30). The greatest increase to median turbidity would be near the channel dredging area which would increase to approximately 20 NTU above background. For the likely worst case scenario, under short-term acute (95th percentile) conditions, turbidity is predicted to temporarily increase by approximately 10-20 NTU above background conditions outside of the channel regions, with turbidity approaching 100 NTU within channel in close proximity to the channel dredging area (**Figure B7-49**).

The likely worst case impact plot shows the Zone of Influence (detectable plumes but no ecological impacts) extending from Cape Grafton to beyond Double Island (**Figure B7-50**). The likely best-case scenario shows the zone of influence extending from the channel area to just beyond Double Island. No detectable ecological impact is expected in this zone.

The Zone of High Impact (severe impact, possible mortality) and Zone of Low to Moderate Impact (moderate to low impact, potential sub-lethal effects) represent areas where detectable ecological effects could occur. The Zone of Low to Moderate Impacts is absent in the likely best case scenario, whereas in the likely worst case scenario, it extends from the bend in the channel south into Trinity Inlet (**Figure B7-50**). The Zone of High Impact was restricted to the channel area in both scenarios.

Further details of the predicted turbidity changes at specific locations are provided in Chapter B5, Water Quality.

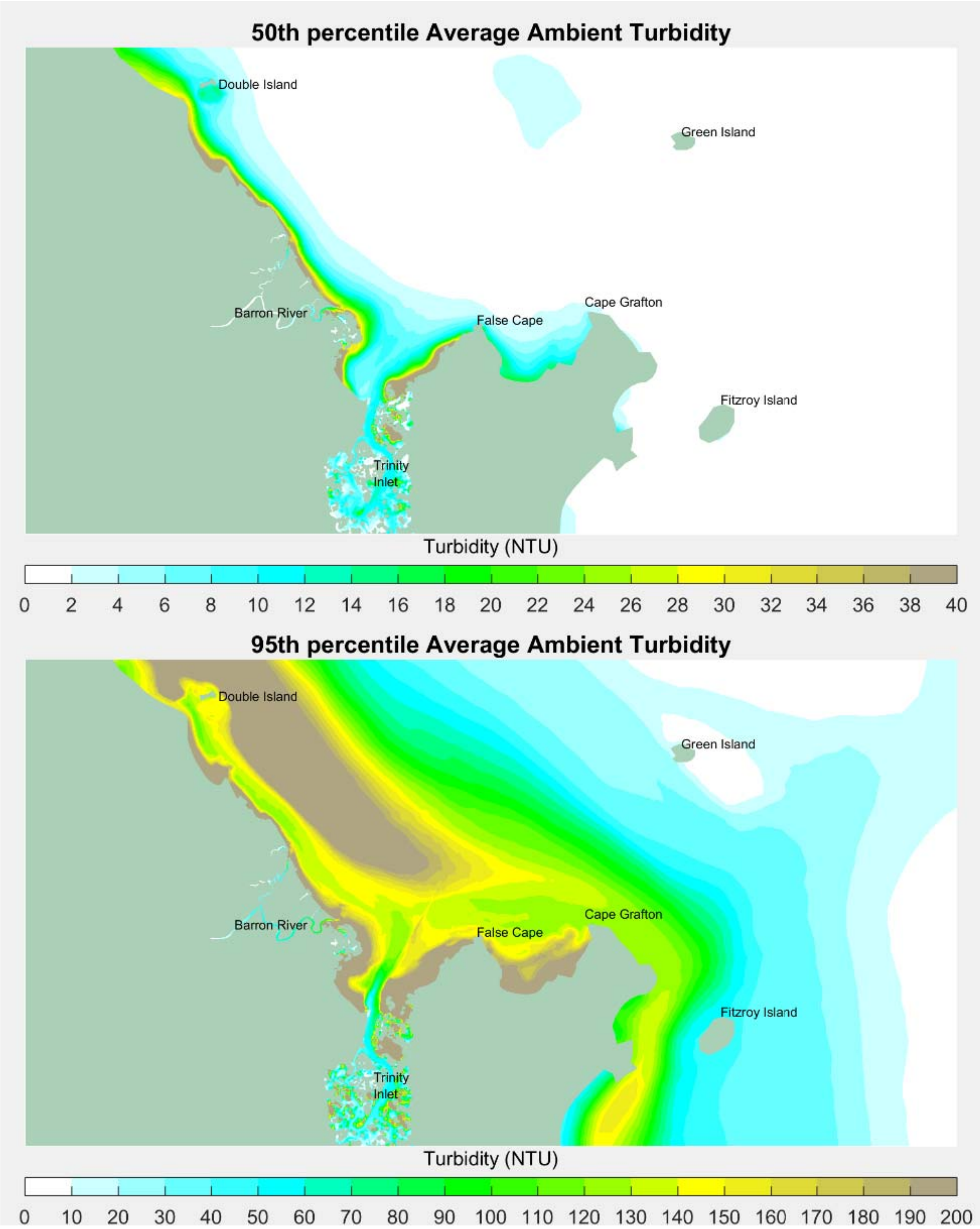


Figure B7-47 Modelled ambient turbidity (without dredging) – 50th percentile (top) and 95th percentile (bottom).

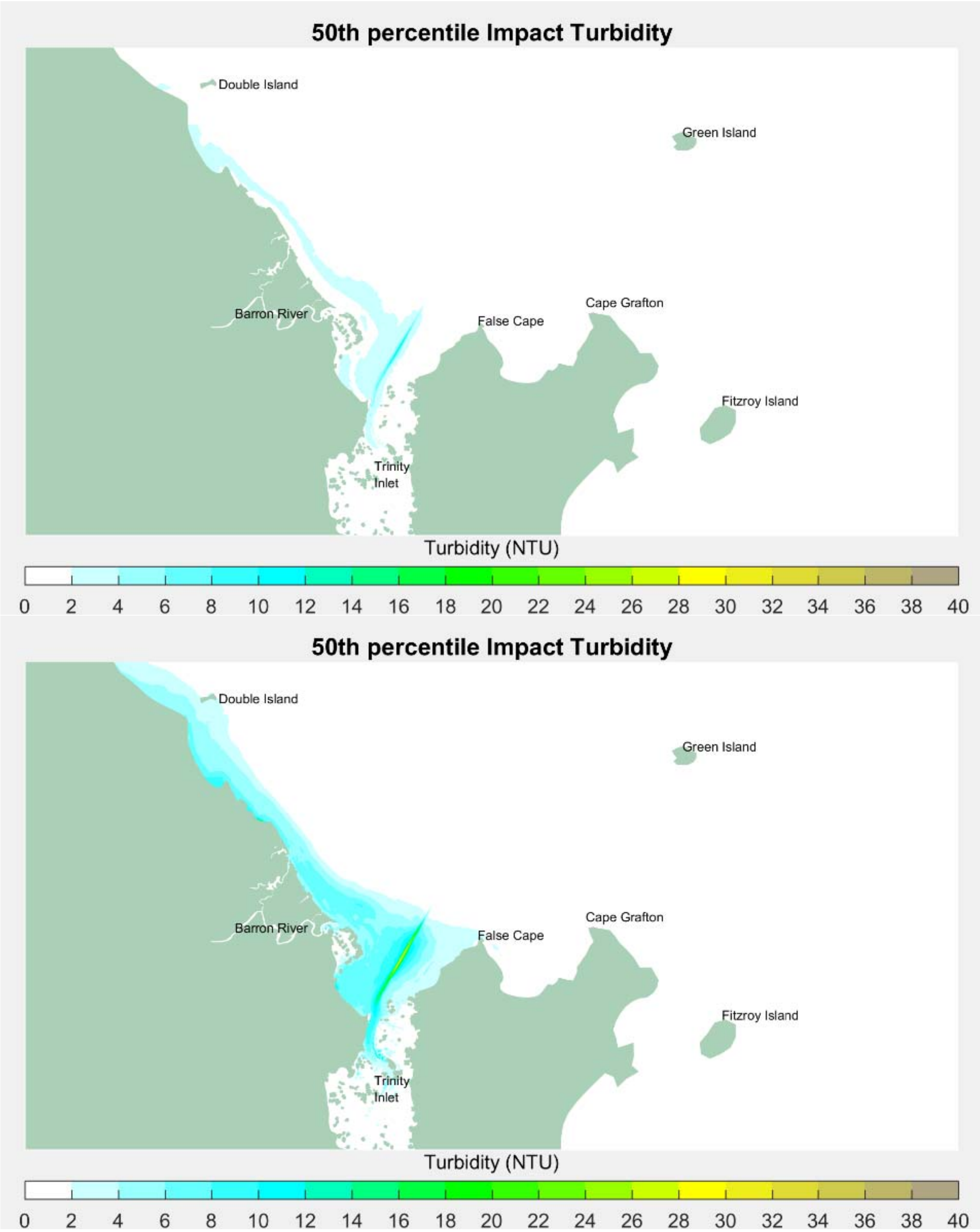


Figure B7-48 Impact of dredging on 50th percentile turbidity under the likely best case scenario (above); and likely worst case scenario (below).

Scale: 2 to 40 NTU.

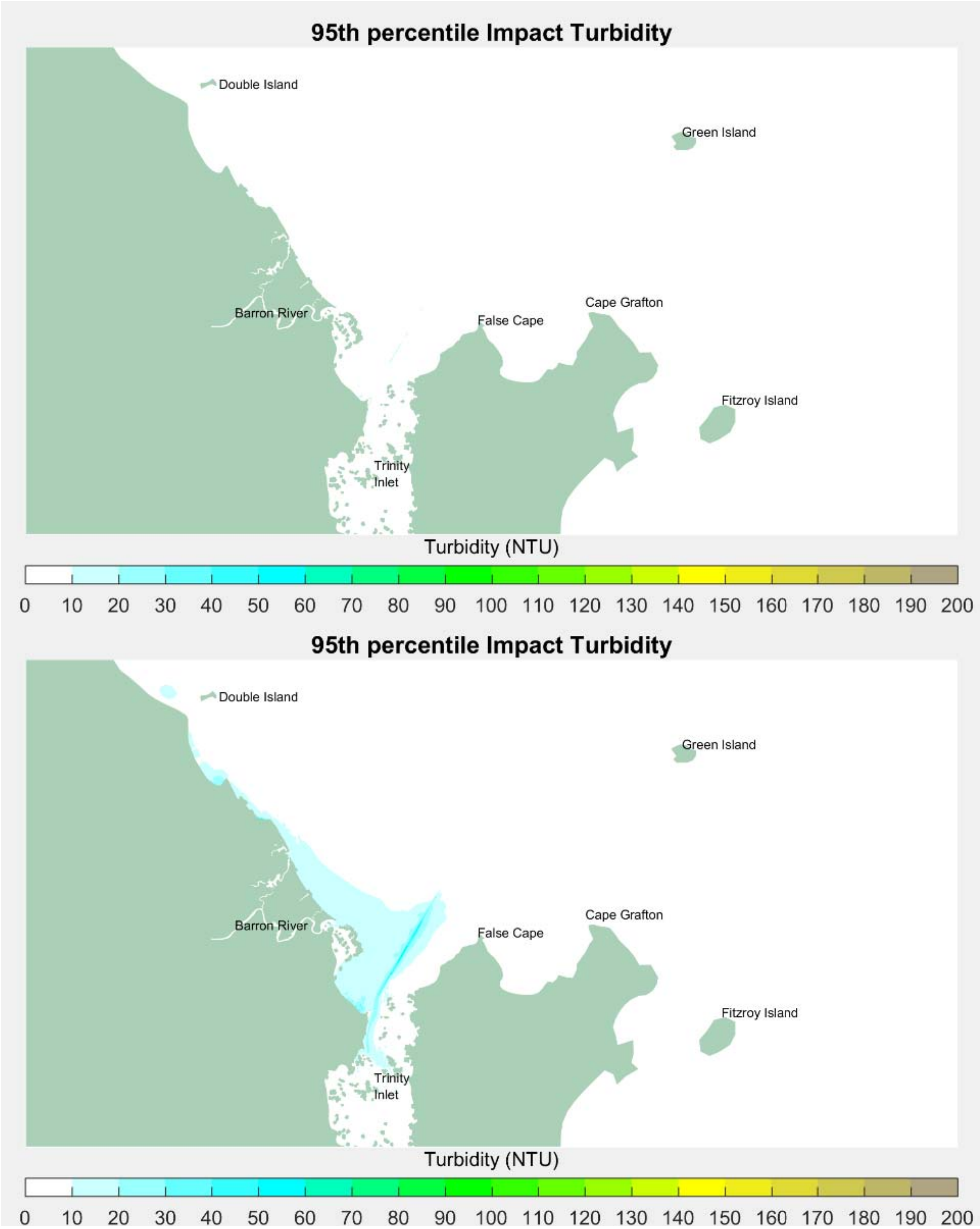


Figure B7-49 Impact of dredging on 95th percentile turbidity under the likely best case scenario (above); and likely best worst scenario (below)

Scale: 10 to 200 NTU.

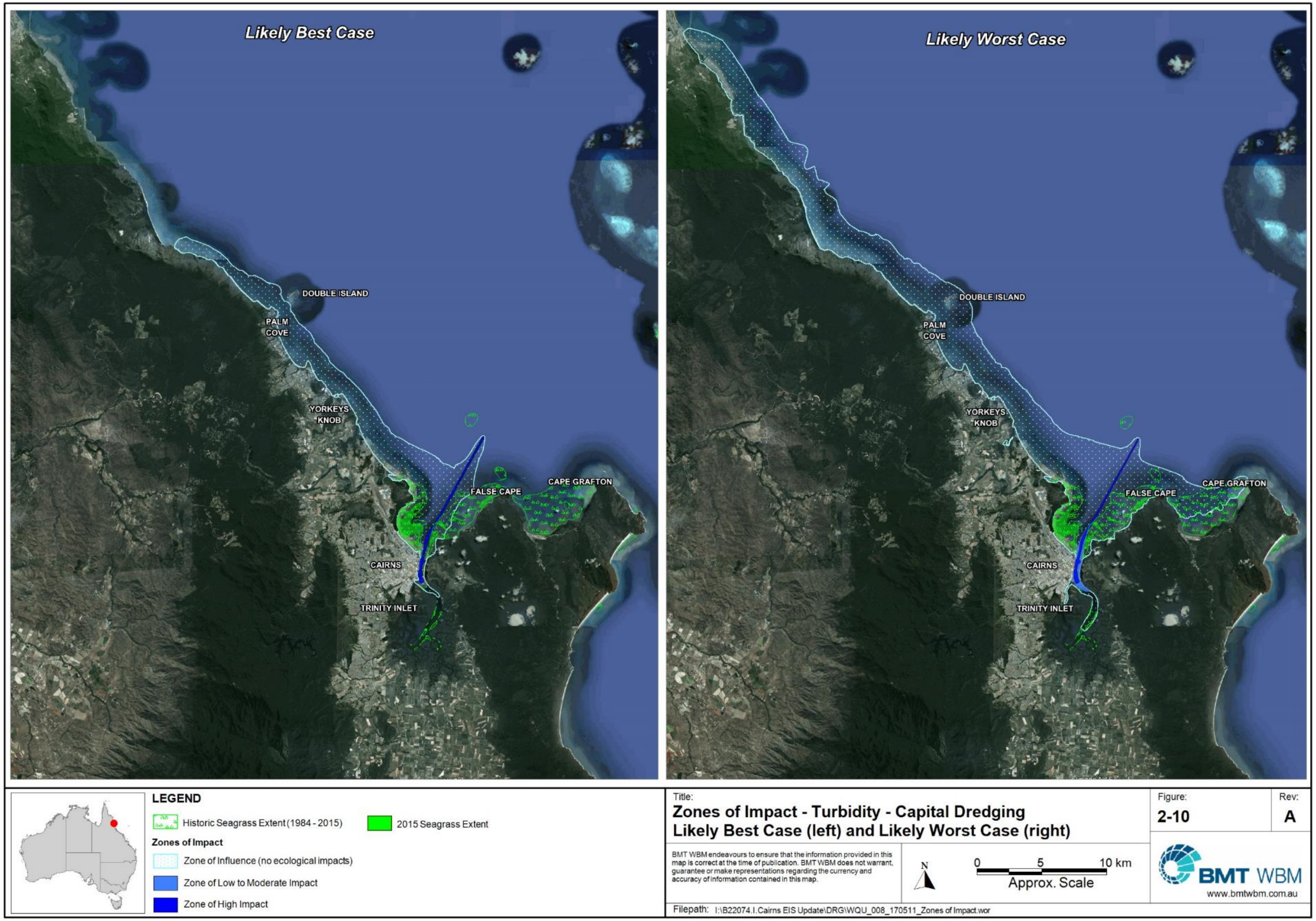


Figure B7-50 Zones of Impact – capital dredging likely best case (left) and likely worst case (right).

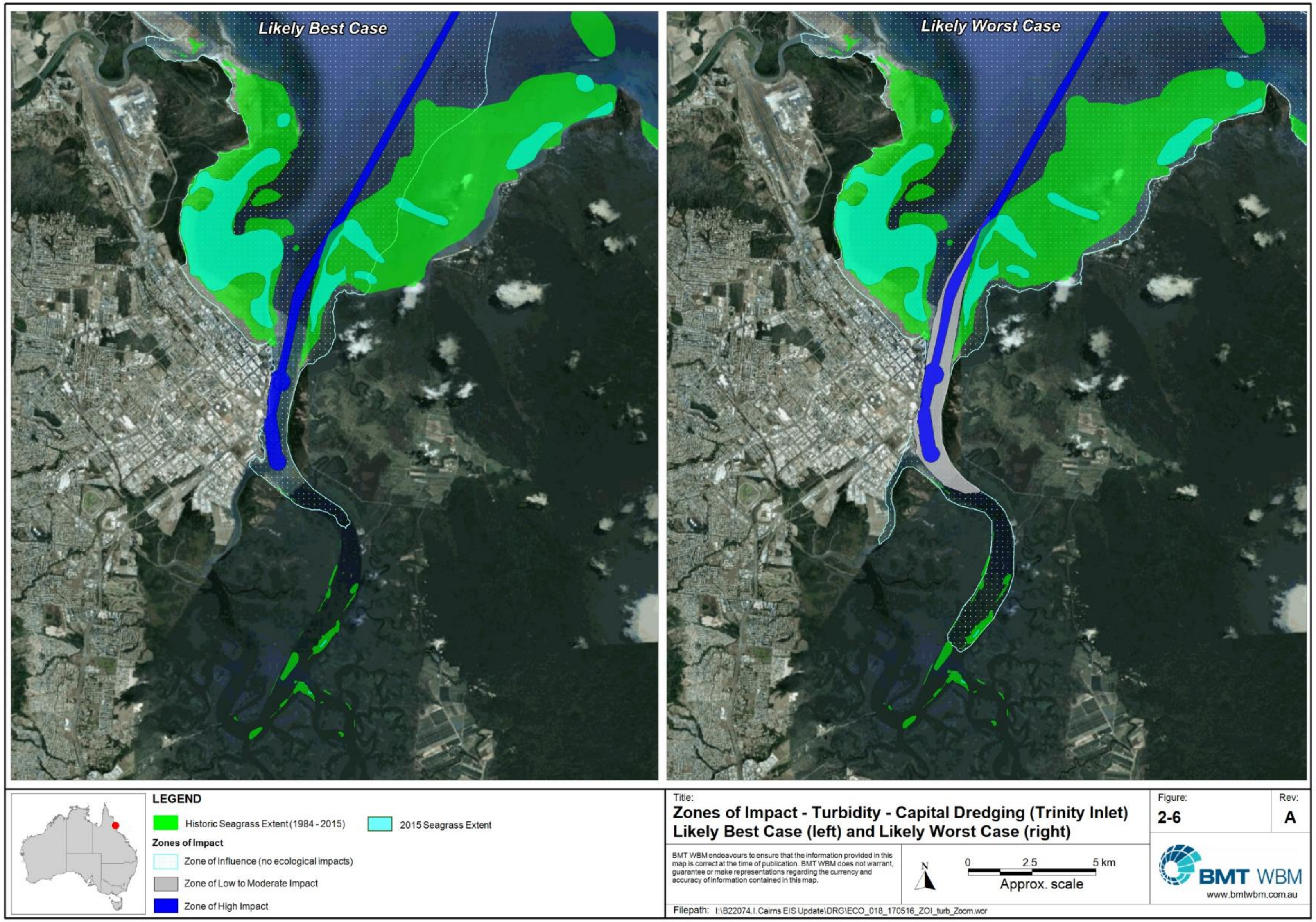


Figure B7-51 Zones of Impact – capital dredging ‑ Trinity Inlet zoom ‑ likely best case (left) and likely worst case (right).

Biotic Effects from Dredge Plumes

Seagrasses and hard corals, as well as other photosynthetic biota (e.g. algae, some soft coral), are considered the key sensitive receptors in terms of turbid plume effects.

The Zone of High Impact is located within the channel, and intersects with areas that have previously supported seagrass. This Zone of High Impact does not intersect areas presently supporting seagrass meadows.

The Zone of Low to Moderate Impact does not coincide with any past or present seagrass distributions, coral reefs or any known high density benthic fauna communities, in the best or worst case scenarios. Localised, temporary effects to soft sediment benthic communities in this zone could occur in this zone as discussed in **Section B7.3.3.a**.

The Zone of Influence (under any modelled dredge scenario) coincides with known (as mapped in 2015) seagrass meadows and coral reefs (e.g. Cairns Harbour, Double Island). By definition, the Zone of Influence includes areas where detectable turbidity changes could occur, but adverse ecological effects are not expected based on known tolerances of sensitive receptors. There are some uncertainties regarding the sensitivities of 'new growth' seagrass (i.e. seagrass that has not been mapped in 2015 but new shoots occur prior to the dredging campaign) and seagrass that is at or near the limits of its tolerance range, and implications are discussed further below.

Seagrass

Seagrass communities in the vicinity of Cairns harbour are usually dominated by *Halodule uninervis, Zostera muelleri*, and to a lesser extent *Halophila ovalis*. Presently the most extensive meadows are dominated by *H. uninervis and Cymodocea serrulata*. In the context of the tolerances of these species to increased turbidity and light attenuation, the following is noted:

- *Z. muelleri* can survive up to a month at low light levels (five percent surface irradiance) but requires 30 percent surface irradiance for long-term survival, as shown in studies undertaken further south at Cleveland Bay (Grice *et al.* 1996). Studies of seagrasses in tropical regions have shown that *Zostera spp.* have significantly greater light requirements (Grice *et al.* 1996, Bach *et al.* 1998, Collier *et al.* 2009) than other species occurring in the study area such as *Halodule uninervis* and *Halophila spp*. (Freeman *et al.* 2008).
- *C. serrulata* withstand (with some shoot loss) complete light deprivation for at least a 14 week period, making it one of the more tolerant species to light deprivation (Collier *et al.* 2016).
- *Halodule spp.* appear to be reasonably tolerant to light deprivation, with *Halodule pinifolia* surviving up to three to four months following complete light attenuation (Longstaff *et al.* 1999). In Townsville under warm conditions, H. uninervis appears also to be relatively tolerant of light deprivation, compared to *Z. muelleri* and *H. ovalis* (Collier *et al.* 2016).
- *Halophila ovalis* is among the most sensitive species to light attenuation (Longstaff *et al.* 1999). This species can show signs of stress after several days of complete light attenuation and mortality within 30 days of complete attenuation (Longstaff *et al.* 1999)
- Some seagrass species are able to tolerate episodic pulses of high turbidity over an extended period. For example, Chartrand *et al.* (2012) conducted shading experiments to determine the effects of short pulses of low light (shading) conditions over eight, 12 and 16 week periods on the seagrass *Zostera mullerii*. Significant declines in seagrass were recorded under light deprivation between three and four weeks, however, cyclic shading (two weeks of shade followed by two weeks of light) resulted in no declines after eight weeks.
- Shading experiments in Townsville using *C. serrulata*, *H. uninervis*, *Z. muelleri*, and *H. ovalis* suggest that *Z. muelleri*, and *H. ovalis* have the highest light requirements and thresholds designed to protect these species will also protect the more tolerant *C. serrulata* and *H. uninervis* (Collier *et al.* 2016).

In consultation with JCU, seagrass tolerance values which may be relevant for Cairns were developed to test water quality thresholds in Chapter B5, Marine Water Quality. These tolerance values included the following:

- **Zone of High Impact** - Total loss of seagrass would likely occur if the light requirement (LR) was not met for more than six weeks for Zostera (LR = 4.5-12 mol/m2/day rolling two week average) and more than 21 days for H. ovalis (LR = 2.8-4.4 mol/m2/day).
- **Zone of Low to Moderate Impact -** Declines in seagrass, with some recovery within a month, would likely occur if the LR was not met for one week (low impact) to six weeks (moderate impact) for Zostera during the growing season (July-Dec). For H. ovalis this equates to one week without the LR (low impact) to three weeks (moderate impact).
- **Zone of Influence** - No predicted impacts to seagrass if light does not fall below LR for H. ovalis and Zostera for more than seven consecutive days.

As discussed above, the Zone of High Impact and Zone of Low to Moderate Impact do not coincide with existing seagrass meadows, indicating that it is unlikely that indirect impacts to existing seagrass would occur. The Zone of High Impact intersects with potential seagrass habitat (i.e. seagrass has been recorded previously) in the dredge channel, however any seagrass present here would be directly impacted (removed) by dredging.

Notwithstanding the above, it is important to note that there is little information on the tolerance of new seagrass growth during periods of recovery. While it is thought that new seagrass regrowth (e.g. new shoots, seedlings) would be less resilient to reduced light levels, there is uncertainty as to what appropriate thresholds would be. In general, (i) new seedlings/shoots have a low energy store so are more dependent on photosynthesis and would be less resilient to periods of low light; and (ii) new seedlings and shoots would have high energy requirements in order to sustain the high rate of growth required to become established (Jarvis *et al.* 2014; pers. comm. M. Rasheed, 2014). As such, this assessment has conservatively assumed that even minor turbidity increases could potentially affect new seagrass growth in recovering areas, particularly in areas directly adjacent to the channel where turbidity generated by dredging will be greatest. On this basis, there is the possibility that impacts to recovering seagrass areas could occur, particularly those directly adjacent to the channel.

Overall, given (i) the minor to moderate scale of predicted impacts; (ii) the current condition and extent of seagrasses; and (iii) the temporary nature of turbid plumes, water quality effects resulting from the project are unlikely to affect the longer-term recovery of seagrass (following large scale declines over the last few years in response to natural disturbance) at the broader Cairns harbour level. Nonetheless, seagrass monitoring will be critical to ensuring that no significant impacts will occur (as listed under mitigation in **Section B7.4.3**). Seagrass surveys will be undertaken before dredging works, in order to define where areas of active seagrass recovery (i.e. new shoots, seedlings) are located at the time of dredging works as well as to confirm any recovery of seagrass within the footprint or Zone of High Impact (although considered unlikely). Further, ongoing monitoring of seagrass condition at both established meadows and recovering areas will form a key component of the reactive monitoring program that will be undertaken during dredging.

In the unlikely event that seagrass mortality occurs as a result of increased turbidity, impacts would be temporary and recovery is expected to occur through a number of mechanisms. Seagrass species found in the study area have adaptations that can allow relatively rapid growth and recovery following disturbance (Duarte *et al.* 1997). Overall, the rate of recovery would depend on factors such as the location, magnitude and extent of disturbance, as well as the time of year and environmental conditions during the recovery period.

Fish and Invertebrates of Commercial Significance

Most fish expected to occur in the study area have a lateral line system, which assists fish to feed in highly turbid waters. Disturbance of the seafloor by dredging will result in mobilisation and entrainment of invertebrates in the water column. This increase in the availability of food resources is expected to lead to an increase in the abundance of fish that feed on invertebrates to the dredging and dredged material placement sites. The increase in small fish could have a localised cascading effect, with piscivorous fish and dolphins also attracted to the dredge sites. Therefore, this could result in localised changes to fish distribution and abundance, and potentially higher rates of predation.

Turbid plumes may also result in physiological effects to fish. Jenkins and McKinnon (2006) suggested that very high suspended solid concentrations (e.g. 4000 mg/L) could cause gill blockage and eventually mortality to fish. There are very few documented cases of fish kills resulting solely from turbid plumes, and in any case, such concentrations would only be expected occur only rarely and at highly localised spatial scale (within the immediate vicinity of the dredger). Blaber and Blaber (1980) also suggested that turbidity gradients may aid fish larvae in locating estuarine nursery grounds. Although empirical data are lacking, it is possible that the creation of a turbidity gradient during the recruitment period of key species may lead to larvae being attracted to a region where settlement and recruitment rates are normally low due to lack of suitable estuarine habitat.

As discussed in the **Section B7.2,** prawns and portunid (mud and sand) crabs represent key species of commercial significance, and utilise both near shore and offshore waters (including parts of the study area) for parts of their life cycle. These species primarily inhabit turbid water environments, and tolerate a wide range of turbidity conditions. Therefore, direct impacts to prawns as a result of high suspended sediment concentrations and sedimentation are not expected and considered to be a negligible impact.

Impacts to key recreational target species (such as mackerel, grunter etc.) are predicted to be low, with some localised short term-impacts predicted, dependant on the timing of dredging along the length of the channel relative to time of year and movement of schools within Trinity Bay.

Further, given photosynthetic epibiota (including seagrass) are sparse within the predicted zones of impact, the epibiota in these areas are not considered to represent a key food resource for species of fisheries significance. Therefore, flow-on effects to fisheries as a result of turbid plumes impacting fish food resources are not expected.

Marine Megafauna

Of the very few species of mega fauna recorded from the study area, dolphins are the most commonly occurring cetacean species occurring in the study area (**Section B7.2**) and are capable of successfully foraging in turbid waters. Dolphins often stir up bed sediments when foraging for benthic prey, resulting in limited to no visibility for prey detection. It is thought that dolphins detect prey using echolocation rather than visual cues (Mustoe 2006, 2008). Dugongs have poorly developed eyesight and rely on bristles on their upper lip, rather than visual cues, to detect seagrass food resources. Therefore, high suspended solid concentrations generated by dredging and dredged material placement are not expected to adversely affect foraging success for cetaceans or dugongs.

Sea turtles generally have good eyesight and rely on visual and olfactory cues to detect prey and other food resources (Swimmer *et al.* 2005). Flatback turtles are known to feed in turbid shallow waters (Robins 1995) and may not be directly affected by turbid plumes generated by dredging and placement. Other species such as green and hawksbill turtle, which feed on seagrass and/or in reef environments, may avoid areas affected by turbid plumes. It is noted, however, that key foraging habitats for these species (i.e. reefs, notable seagrass beds) generally do not coincide with the predicted extent of turbidity impact zones.

Other Receptors

The predicted plumes classified as potentially resulting in ecological effects (i.e. zones of low to moderate and high impacts) do not coincide with the known locations of other sensitive biotic receptors such as coral reef communities. Similarly, the modelled dredge plumes of a level that could cause ecological impacts are not predicted to extend to other habitat types present in the broader study area (i.e. occur in the vicinity of soft sediments or pelagic waters only).

Given the extent and location of potentially impacting plumes within the zones of low to moderate and high impacts, together with the sparseness of photosynthetic epibiota in these offshore areas, detectable flow-on effects to other fauna communities are not anticipated. The sparseness of sensitive receptors (e.g. seagrass, soft corals) suggests they would not be of critical importance as a food source to species of high conservation or fisheries value, and that flow-on effects to additional receptors will be negligible.

Noting that the current proposal does not propose placement of capital dredge material in the Great Barrier Reef Marine Park, significant impacts to marine protected areas are not predicted, refer to **Chapter B2** (

Nature Conservation Areas) for further discussion. This includes the proposal to amend the boundary of the fish habitat area and State Marine Park to accommodate the changes to the channel geometry whilst ensuring no net loss in the area of these protected zones.

Biotic Effects - Increased Sedimentation (from Capital Works)

Changes in sediment deposition due to dredging (i.e. excess sediment) are discussed in Chapter B5, Marine Water Quality. **Figure B7-52** (median, 50^{th} percentile) and **Figure B7-53** (95th percentile) show changes in sediment deposition rates generated by dredging. The plots illustrate the simulated worst and best case 30 day periods during the capital dredging project.

Corals

Thresholds were developed to define the bounds of various impact zones for corals, as described in Chapter B5, Marine Water Quality. The impact zone thresholds were developed from case studies and guideline values based on the tolerances of hard corals to sediment deposition. The adopted thresholds were as follows:

- **Zone of High Impact** – Greater than 20 $mg/cm^2/day$ in the 50^{th} percentile case or more than 200 $mg/cm^2/day$ in the 95^{th} percentile case (over a 9-11 week period period).
- **Zone of Low to Moderate Impact** – Between 1.5 and 20 $mg/cm^2/day$ in the 50^{th} percentile case or between 15 and 200 mg/cm2/day in the 95^{th} percentile case (over a 9-11 week period).
- **Zone of Influence** – Between 0.5 and 1.5 $mg/cm^2/day$ in the 50^{th} percentile case or between 5 and 15 $mg/cm^2/day$ in the 95^{th} percentile case (over a 9-11 week period).

These values are considered conservative, given that the GBRMPA (2010) water quality guidelines establish the following trigger values: a maximum mean annual sedimentation rate of 3 $mg/cm^2/day$, and a daily maximum of 15 $mg/cm^2/day$, which approximate the impact zones described above.

Figure B7-52 shows the location of these zones and reef environments. The Zone of High Impact and Zone of Low to Moderate Impact does not intersect with any known reefs. On this basis, no impacts to reefs are expected.

Seagrass

Soft sediment habitats in the study area represent depositional environment and therefore biota here (i.e. seagrass, soft sediment benthic fauna) have adaptations that allow them to cope with sediment deposition. Erftemeijer *et al.* (2006) reviewed case-studies describing seagrass tolerances to sediment deposition and found the following critical thresholds for seagrass species and genera found in the study area:

- *Cymodocea serrulata* – 130 mm/year (Philippines)
- *Halophila ovalis* – 20 mm/year (Philippines)
- *Zostera noltii* - - 20 mm/year (Spain).

Notwithstanding the above, seagrass responses to sediment deposition are complex. For example, *Halophila ovalis* was found to show an opportunistic growth in plots receiving 40–80 mm of sediment, reaching shoot densities greater than control plots, i.e. increased growth with higher sedimentation (Duarte *et al.* 1997). Burial of *Cymodocea nodosa* with 50 mm of sediment resulted in 90% mortality after 35 days, although some individual shoots were able to survive burial as great as 60 mm (Marba and Duarte 1994 in Erftemeijer *et al.* (2006). Sediment type and ambient light conditions also strongly influence seagrass responses to sediment deposition (Erftemeijer *et al.* 2006).

There is also currently limited data available on sediment deposition thresholds for seagrasses found in turbid depositional environments along the tropical east coast of Australia. Literature values developed by DHI (in Chevron 2010) for a dredging project in north-west Australia were considered in the context of sediment deposition results shown on **Figure B7-52**:

- Zone of High Impact: median (50th percentile) greater than 70 mg/cm^2/day (>25 mm/14 days)[2]
- Zone of Low to Moderate impact: median (50th percentile) 20 – 70 mg/cm^2/day (7-25 mm/14 days)

Sediment deposition rates shown in **Figure B7-52** (median – 50th percentile) are well below the DHI (in Chevron 2010) Zone of High Impact threshold, except in the dredge channel, which does not presently support seagrass. It would be expected that any seagrass that establishes in dredge channel would be directly impacted (removed) by dredging. Seabed areas outside the dredge channel are predicted to have a 50th percentile sediment deposition value <10 mg/cm^2/day, which is less than the threshold for the Zone of Low to Moderate Impact in DHI (in Chevron 2010). Existing seagrass meadows areas outside the channel are predicted to occur within the Zone of Influence.

It should be noted that it is difficult to determine the degree to which sedimentation alone contributes to physiological stress in seagrass. Sedimentation often occurs in areas also (and simultaneously) impacted by elevated turbidity (Erftemeijer *et al.* 2006). This means that when combined with elevated turbidity levels, sediment deposition could result in cumulative stress to seagrasses, particularly during periods when seagrasses are less likely to adapt to sedimentation rates (e.g. autumn-winter). Similar to reduced light levels, this stress could result in localised effects to existing established seagrasses, or a range of other community changes symptomatic of stress (reduced shoot height, above ground biomass, etc.). On this basis, it has been conservatively assumed that localised, measurable effects could potentially occur to existing seagrass meadows close to the channel in response to higher turbidity and sediment deposition.

Soft Sediment Benthos

As discussed in Chapter B3, Coastal Processes, much of the study area is largely a depositional environment. This is particularly true for Trinity Inlet which lacks major fluvial (riverine) flows to drive scour, and is somewhat protected from wave activity. Rather, near shore sediment transport processes throughout the broader study area are largely driven by inputs from the Barron River and associated interactions with wave action along the more exposed coastline to the north of Cairns harbour. Further offshore in the vicinity of the offshore DMPAs, marine beds are stable and exhibit little re-suspension. From an ecological perspective, this indicates that marine habitats are prone to sediment deposition near shore, while offshore sedimentary habitats are generally more stable.

Most benthic infauna species are capable of burrowing at least short distances through sediments, and therefore, have low sensitivity to low levels of sediment deposition. Some highly localised smothering of fauna with limited locomotory capacity could occur directly adjacent to the dredge site. However for most species, the rates of deposition would be minor compared to the ability of fauna to move through sediments, particularly when deposition is considered incrementally over the duration of the anticipated 10 week dredging program.

Low to medium density epifauna communities have been recorded on soft sediment habitats within the predicted moderate to high impact zones (**Section B7.2**). These communities are comprised mainly of filter feeding fauna (e.g. sea pens, feather stars, sponges) and fauna that entrap their prey (some soft corals). At sub-lethal levels of suspended sediment concentrations, some filter-feeders may benefit from the larger amount of suspended organic matter (i.e. food resources) contained within the dredged material, or released from benthic substrates disturbed by the dredger. It is unlikely that suspended sediment concentrations will reach levels that lead to interference or blocking of the respiratory and feeding structures of these animals. For minor, sub-lethal rates of deposition, many filter feeding fauna are also able to actively self-clean parts of their body prone to trapping unwanted non-food particles. If individuals of these sessile epifauna are very small (recently settled juveniles less than the cumulative deposition depth for a given area, say 15 mm in the Zone of High Impact) they could be smothered, which could lead to stress or mortality. As much of the area within the predicted impact zones is considered to be representative of stable to depositional environments, it is expected that most benthic fauna would be well adapted for coping within the sedimentation rates predicted.

[2] 100 mg/cm2 is approximately equivalent to 1-3 mm depth, depending on density of material

The exception to this would be any very small bodied sessile fauna occurring within a Zone of High Impact, which corresponds mostly with the direct impact within the channel footprint.

Based on the predicted low to moderate sedimentation rates over the duration of the dredge program, together with the density and composition of existing benthic communities, sedimentation is expected to result in minor impacts to benthic communities. Most of this impact would be confined to locations within the Zone of High Impact and, to a lesser extent the Zone of Moderate Impact. Note that high sediment deposition is expected to occur in close proximity to areas that already undergo maintenance dredging (existing outer channel), where fauna are already exposed to comparable sedimentation rates from ambient hydrological, coastal process and periodic existing maintenance dredging works.

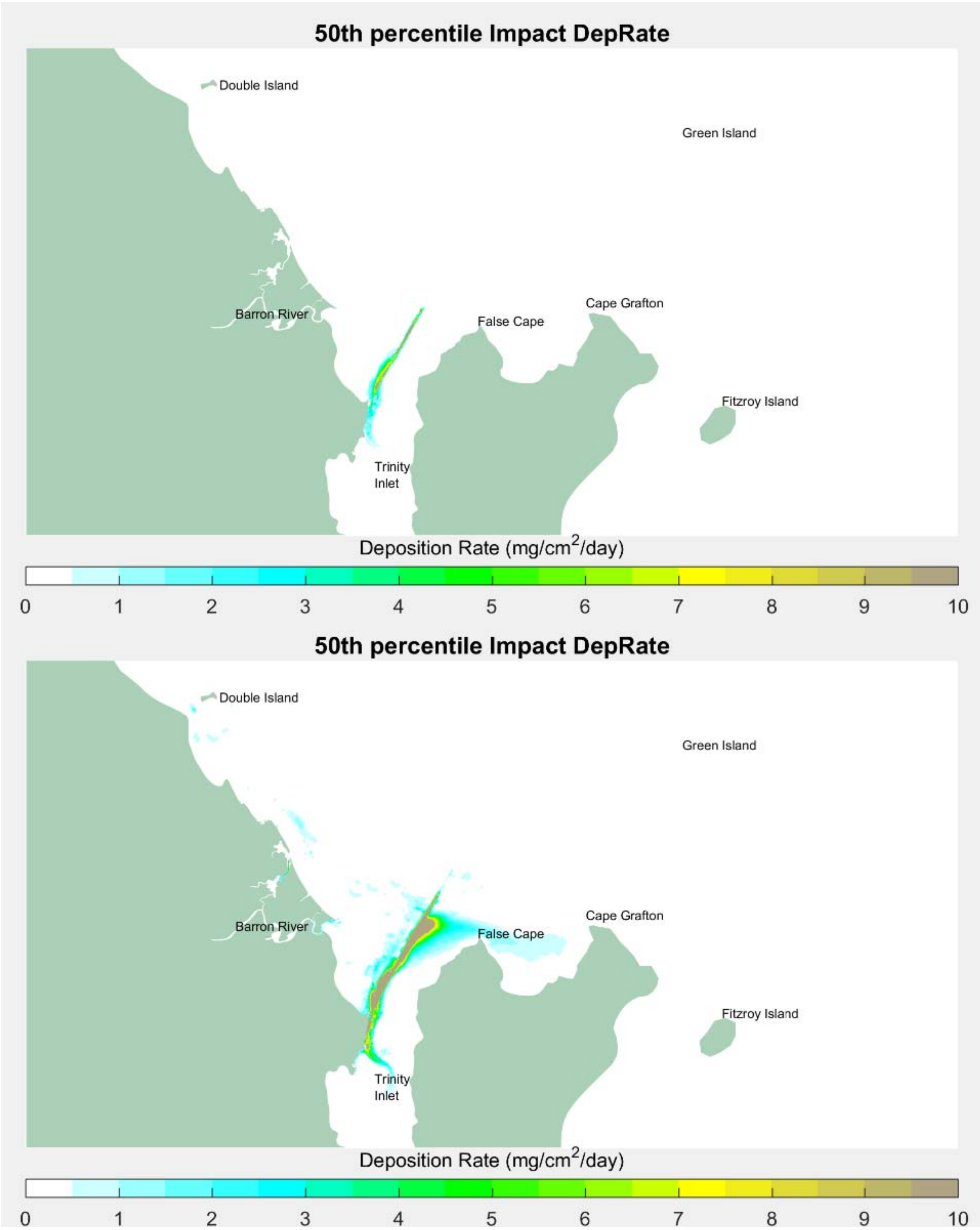


Figure B7-52 Impact of dredging on 50th percentile deposition rate under the likely best case scenario (above); and likely worst case scenario (below).

Scale: 2 to 10 $mg/cm^2/day$

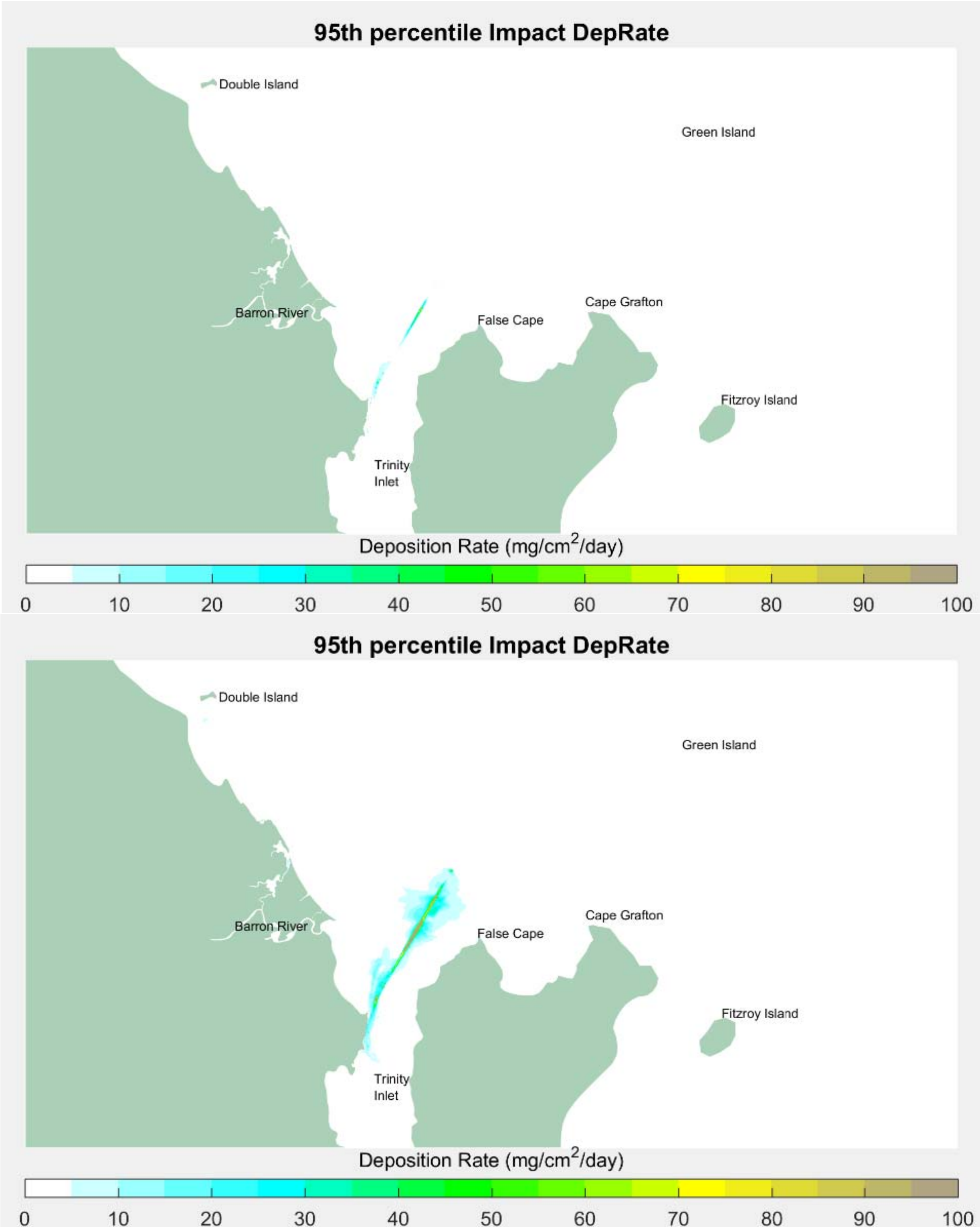


Figure B7-53 Impact of dredging on 95th percentile deposition rate under the likely best case scenario (above); and likely worst case scenario (below).

Scale: 2 to 10 mg/cm^2/day

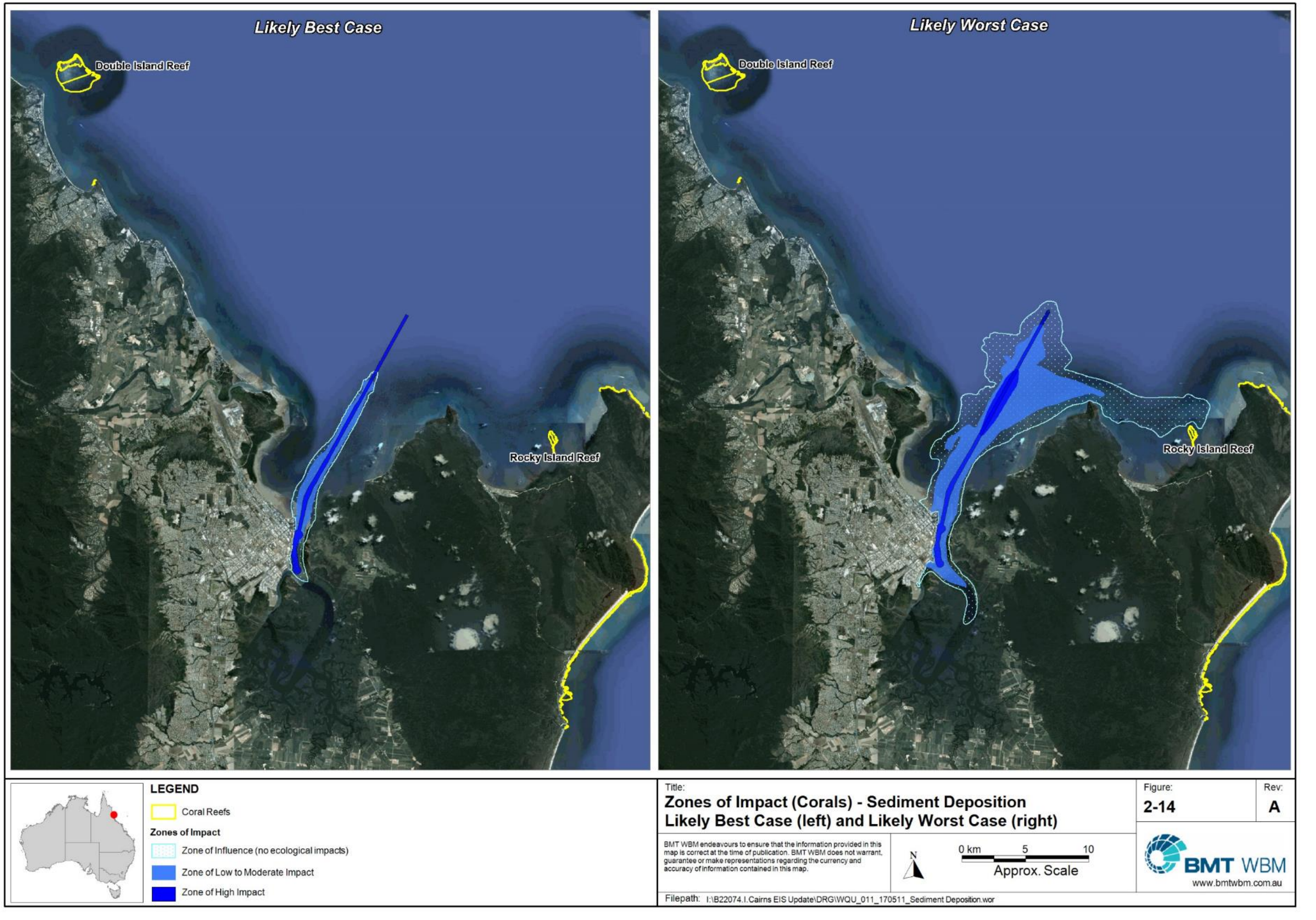


Figure B7-54 Zone of Impact (corals) - sediment deposition - likely best case (left) and likely worse case (right).

B7.3.4.b Maintenance Dredging

As is the current situation, maintenance dredging will be required to ensure that the dredge footprint remains at the required depths for safe navigation of ships. Compared to capital dredging, smaller volumes of material are involved in annual maintenance dredging and the timeframes over which dredging will occur will be shorter.

If the CSDP was approved and constructed, at the outer channel an increase in annual maintenance dredging volume in the order of 2-6% per year is expected, while the existing annual maintenance dredging volume for the inner port is not likely to change significantly (**Chapter B3** (Coastal Processes)). Current channel maintenance dredging campaigns typically occur during the months of July to October and generally take about three-four weeks to complete. In some cases following large wet seasons split campaigns are undertaken with an earlier one-two weeks dredging in May-June. The additional volume associated with the expanded channel will likely extend these campaigns to a period of four-five weeks.

The frequency and duration of turbidity impacts from future maintenance are likely to be similar in nature to those presented above for capital dredging; albeit occurring over a much smaller duration each year, which limits the amount of material available for re-suspension. **Chapter B5** (Marine Water Quality) details potential impacts to water quality from maintenance dredging, utilising actual water quality monitoring data collected over a 12-month period for this Revised Draft EIS (including during annual maintenance dredging in 2013).

Impacts from maintenance dredging are considered to be localised and relatively short term with limited increases in turbidity adjacent to sensitive environments. Furthermore, impacts on sensitive receptors from maintenance dredging has been assessed previously (Environment North 2005 and Worley Parsons 2010) and considered acceptable to regulatory agencies (as outlined in the Ports North 10 year maintenance dredging permit and LTMP).

Based on the assessment presented in **Chapter B5** (Marine Water Quality), turbid plumes from future maintenance dredging are considered to pose a minor impact to marine water quality. Flow on effects to flora, fauna and other marine ecology values, as a result of both water quality and sediment deposition effects, are likewise considered to minor.

Similar to the assessment presented above for capital dredging impacts on benthic habitats in **Section B7.3.4.a**, marine ecology impacts associated with dredged material placement at the existing DMPA will cause a temporary loss of biota from surficial sediments, since benthic communities typically inhabit the top 30 cm of the seabed. However, biota will soon recolonise the dredge footprint (Neil *et al.* 2003, Worley Parsons, 2009) and will continue to be regularly subject to similar disturbance through the ongoing annual maintenance placement regime.

B7.3.5 Tailwater Release from Northern Sands DMPA

B7.3.5.a Physico-chemical Changes

This section examines the potential effects of tailwater release on marine fauna and flora in the Barron River and Richters /Thomatis Creek (henceforth referred to as Richters Creek). The tailwater release simulation consisted of a constant release of turbid seawater (100 mg/L TSS or 60 NTU, at 35 PSU[3]) over 8 weeks of dewatering at 1 m^3 per second. While sedimentation impacts are not expected given these proposed release parameters, the discharge of this water and subsequent changes in water quality have the potential to impact:

- benthic invertebrates and fish communities though turbidity and salinity impacts
- seagrasses through changes in turbidity
- riparian vegetation through increases in salinity.

Water quality data (as shown in **Chapter B5** (Marine Water Quality)) shows that the lower Barron River can fluctuate from a fully saline system approaching 36 PSU to being completely fresh after heavy rainfall and associated flood event. The salinity regime is affected mostly by tides and rainfall with large high tides and low rainfall resulting in the highest salinity, and heavy rainfall induced flood event and neap tides resulting in the

[3] PSU = Practical Salinity Units which is the same as parts per thousand (ppt)

lowest salinities. Moderate rainfall conditions result in a freshwater upper layer, undermined by a salt wedge, which exists beneath the fresher upper layers due to the salt water being heavier (denser). During very high flow conditions, this stratification in salinity breaks down and fresh water occurs through the entire water column.

The modelled increases in median (50th percentile) salinity from tailwater releases (**Figure B7-55**) show that the upstream release point (discharge A) results in up to 3 PSU difference in median surface salinity within 400 m of the release point, and a change of 2 PSU within 2 km upstream of the release point, with very little difference in salinity observed beyond these distances (<1 PSU). The tailwater release point on the Bruce Highway (discharge B) results in up to 2 PSU difference within a kilometre of the release point. The change in salinity appears smaller at the downstream release point because the ambient environment is naturally more saline, being further downstream. The relative changes in percentile salinity are very similar in the 99th percentile case; however, the majority of the changes occur farther upstream (**Figure B7-56**).

Ambient turbidity is also relatively high within the Barron River and Richters Creek (Chapter B5, Marine Water Quality). The respective measured median turbidity for the Barron River and Richters Creek was 18.2 and 19.2 NTU, 80th percentile turbidity was 74.4 and 29.8NTU, and maximum recorded turbidity was 508.9 and 346.2 NTU. The modelled ambient turbidity plots for the Barron River and Richters Creek are shown in Appendix AO (Marine Ecology Impact Assessment), and indicate that the downstream reach is moderately turbid for most of the year and turbidity can reach 50 NTU during major wave-driven resuspension conditions.

Modelled increases in median turbidity (**Figure B7-57**) show that both release points alter ambient turbidity by approximately 5 NTU at the release point, grading down to 2 NTU within several hundred meters of the release point, to decreasing to 0 NTU within a kilometre. The downstream release point TW2 has a greater impact on downstream turbidity, while the upstream TW1 release point shows a greater increase in upstream turbidity. Turbidity plumes from either release point do not reach the mouth of the Barron.

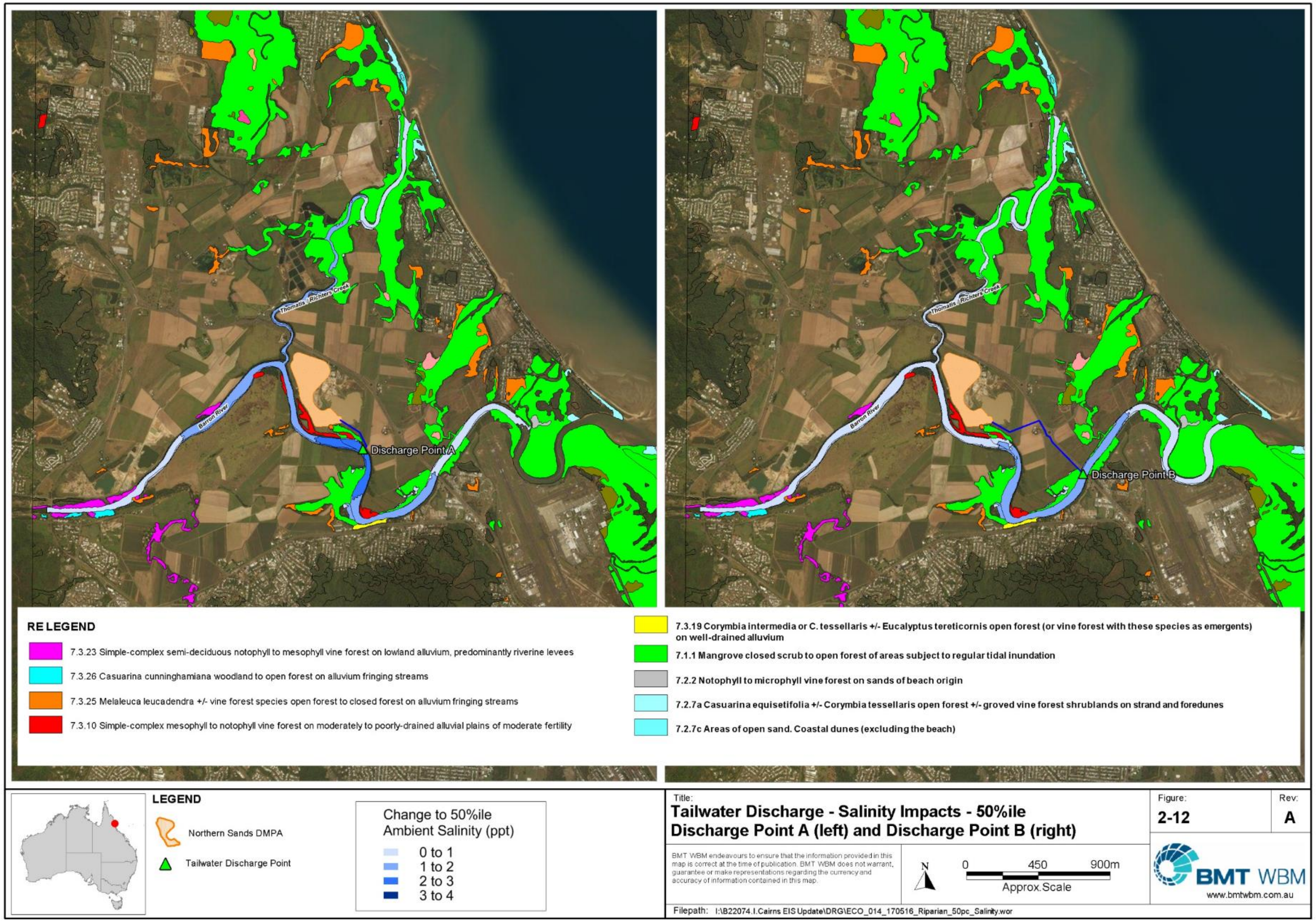


Figure B7-55 Tailwater discharge - salinity impacts - 50%ile Discharge Point A (left) and Discharge Point B (right)

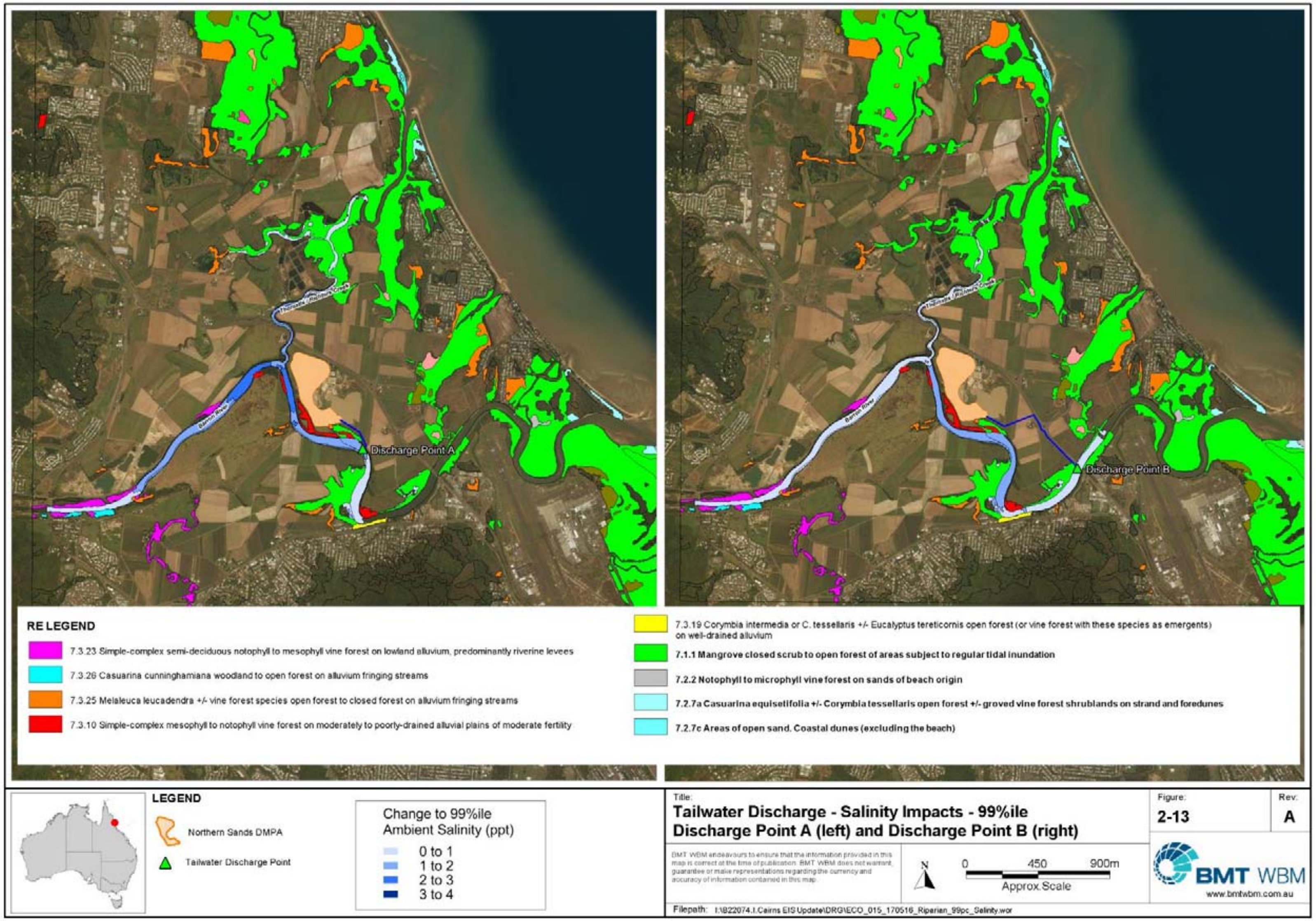
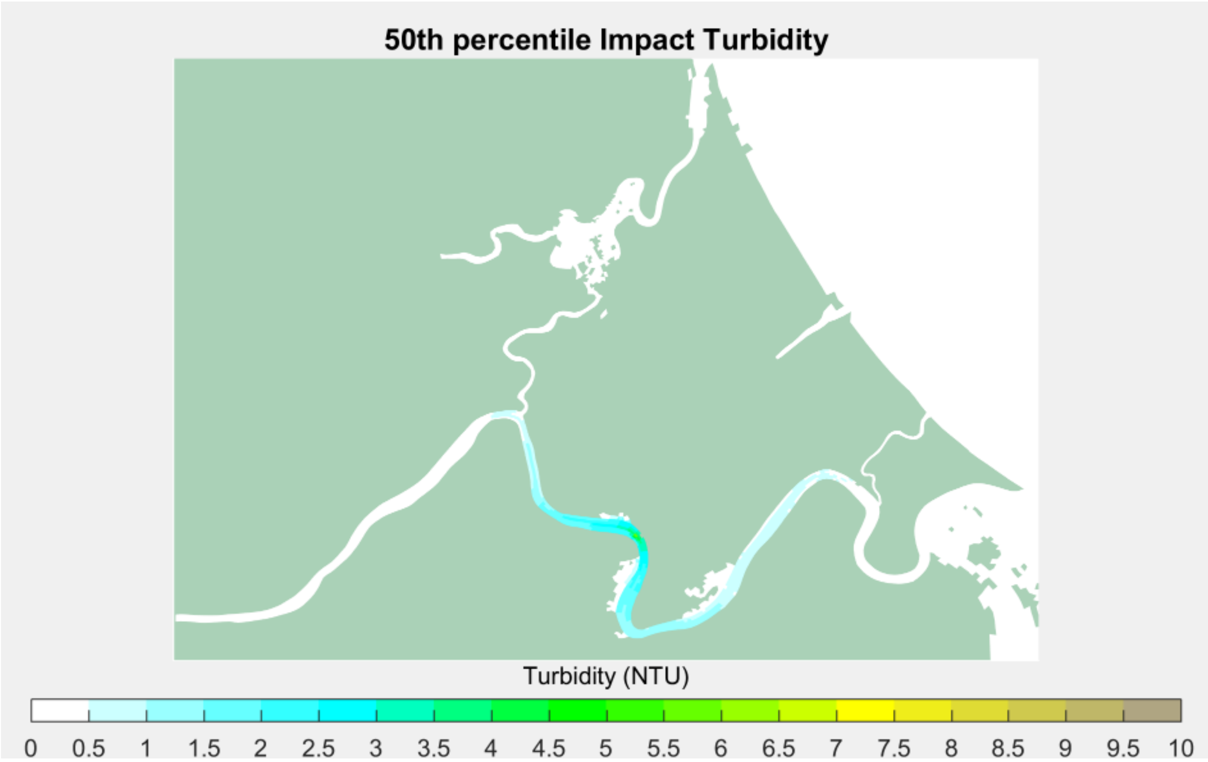


Figure B7-56 Tailwater discharge - salinity impacts - 99%ile Discharge Point A (left) and Discharge Point B (right).



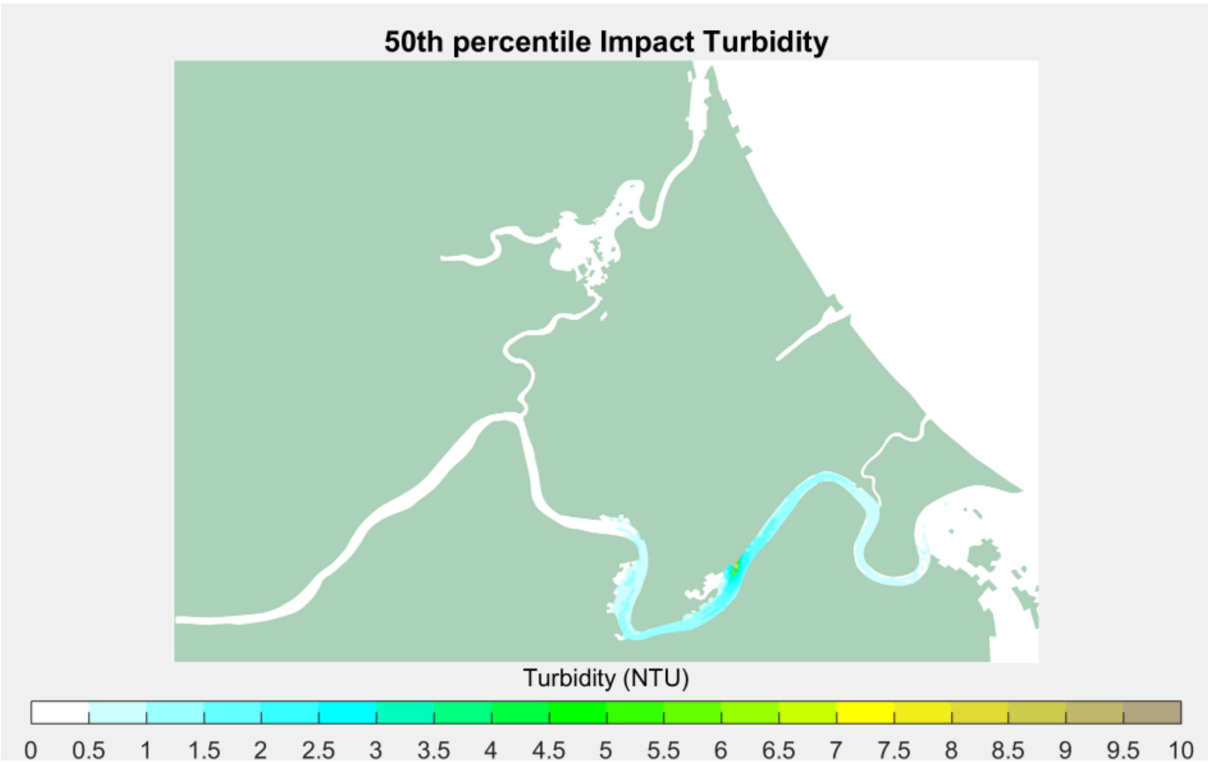


Figure B7-57 50th percentile increase in turbidity at discharge point A (above) and at discharge point B (below).

B7.3.5.b Turbidity Effects to Biota

As discussed in **Section B7.3.4.a**, high concentrations of suspended solids can impact the physiology of fish and invertebrates, and alter the behaviour of many species. The turbidity impact predicted here are well within the range of natural variation observed in the 12 month data set collected for **Chapter B5** (Marine Water Quality). If conducted in the dry season, the impacts of either tailwater discharge point are not expected to push concentrations beyond the Water Quality Objective value of 10 NTU to protect slightly-moderately disturbed ecosystems. The dry season median for the Barron River / Richters Creek confluence was 4.8 NTU (**Chapter B5** (Marine Water Quality)) and additional median turbidity impacts are less than 5 NTU for the all of the Barron except within the immediate vicinity of the discharge. On this basis, significant impacts to benthic marine invertebrates or species of commercial fisheries significance are not expected.

B7.3.5.c Effects of Salinity

Alterations in salinity from tailwater discharges pose a potential threat to riparian communities. This assessment was based on the 2015 Remnant Regional Ecosystem (RE) Mapping (V10) and the information presented in **Chapter B8** (Terrestrial Ecology). RE types that form part of the riparian fringe over these creeks include:

- 7.3.23 Simple-complex semi-deciduous notophyll to mesophyll vine forest on lowland alluvium, predominantly riverine levees (Endangered under the VM Act)
- 7.3.26 *Casuarina cunninghamiana* woodland to open forest on alluvium fringing streams (Endangered under the VM Act)
- 7.3.25 *Melaleuca leucadendra* +/- vine forest species open forest to closed forest on alluvium fringing streams (Of Concern under the VM Act)
- 7.3.10 Simple-complex mesophyll to notophyll vine forest on moderately to poorly-drained alluvial plains of moderate fertility (Of Concern under the VM Act)
- 7.3.19 *Corymbia intermedia* or *C. tessellaris* +/- *Eucalyptus tereticornis* open forest (or vine forest with these species as emergents) on well-drained alluvium (Of Concern under the VM Act)
- 7.1.1 Mangrove closed scrub to open forest of areas subject to regular tidal inundation (Least concern under the VM Act)
- 7.2.2 Notophyll to microphyll vine forest on sands of beach origin (Endangered under the VM Act / Listed as Critically Endangered Littoral rainforest and coastal vine thickets of eastern Australia under the EPBC Act)
- 7.2.7a *Casuarina equisetifolia* +/- *Corymbia tessellaris* open forest +/- groved vine forest shrublands on strand and foredunes (Endangered under the VM Act)
- 7.2.7c Areas of open sand. Coastal dunes (excluding the beach) (Endangered under the VM Act).

RE 7.1.1 (mangroves) is marine adapted vegetation and regularly experiences salinities beyond the likely change resulting from tailwater discharge and is not considered further.

REs 7.2.2, and 7.2.7a, occur on beach ridges and sand dunes and depend on fresh groundwater which will not be impacted by increased salinities in the Barron River and Richters Creek. The ecological values of non-vegetated coastal sand dunes (RE7.2.7c) will not be impacted by salinity levels in these waterways.

The remaining REs occur on the alluvial floodplain and may be sensitive to elevated salinity in available water sources. However, salinity increase within the waterways is not expected to impact these riparian communities which would depend on fresh groundwater and overland flow. The current salinity regime of the water column in the vicinity of these riparian communities approaches seawater (35 PSU) during very dry periods. The expected increase in salinity, in the chronic and the acute cases, will not expose the water column, or riparian communities, to higher salinities than what already occurs. Although the changes in water column salinity associated with tailwater release occur in the vicinity of these remnant patches (**Figure B7-55** and **Figure B7-56**) salinity elevations are minor with a change of only 1-2 PSU expected in the 99th percentile case for the discharge A site, and a change of 0-1 PSU expected from discharge site B, and will not impact on these riparian communities.

In the median (50th percentile) case, a similar magnitude of salinity change is expected with 1-2 PSU expected for the discharge A site around the Richters Creek confluence, and a change of 0-1 PSU expected surrounding discharge site B.

The highest increase in surface salinity concentrations occurs around the confluence with Richters Creek. However, very little of this water enters the Richters Creek system and salinity impacts in this reach are not expected in either scenario. In the 99th percentile case, increasing the salinity of the Barron in the vicinity of the Richters Creek entrance from 33 to 35 PSU is not expected to affect riparian communities.

Based on the existing salinity regime and likely changes to surface salinity, impacts are not expected to riparian communities from saline tailwater discharge. Increases in salinity are not expected to impact benthic fauna communities as they regularly experience full seawater salinity conditions, and increasing richness and abundance with salinity has been observed previously (**Section B7.2**).

Furthermore, as dredging and tailwater discharges are proposed to occur during the dry season when there are less freshwater flows, ambient salinity would be expected to be higher. Tailwater salinity would therefore be likely to have less impact during this period.

B7.3.5.d Effects on Seagrasses

There are currently no seagrass meadows present at the mouth of the Barron River, but meadows have been found there historically (Section B7.2). Neither of simulated release points result in turbid plumes that reach the historical boundary of this seagrass layer. Therefore, impacts to seagrass (which have not been mapped recently but could be in an early colonising state) are not expected from the tailwater operations at either discharge point.

B7.3.6 Interactions between Marine Fauna and Vessels

This section examines the potential for interactions between marine fauna and vessels including dredge plant, and associated ecological effects. While invertebrates and fish are mentioned, discussion focuses on marine megafauna species, particularly threatened or otherwise listed species of conservation significance (MNES).

For capital dredging, it is anticipated that the following dredge plant will be required:

- one medium-sized trailing suction hopper dredge (TSHD)
- backhoe dredger (BHD) and bed leveller
- work boats/survey boat (discussed below in next section).

Interactions between such vessels and marine fauna may arise during capital dredging or maintenance dredging by way of one or more of the following mechanisms:

- direct contact or obstruction of fauna passage
- emissions of artificial noise from the dredger
- entrainment of fauna at the dredge head
- emissions of artificial light during night dredging works and from navigation lighting on the dredge pump-out.

The ongoing operation of the wharf will facilitate an increase in the size and frequency of ship traffic to the CCLT, which will increase the underwater noise and artificial lighting sourced from such vessels, and the potential for direct interactions with marine fauna. Note that such vessels frequent the broader study area but that some of the larger cruise ships are unable to approach the existing port facilities. Rather, large cruise ships currently moor off Yorkeys Knob and ferry passengers by tender to the mainland. This means that impacts relating to interactions between these vessels and marine fauna, essentially relate to a shift in the location of such interactions (i.e. from Yorkeys Knob to the outer channel and inner port), as well as any anticipated increase in cruise ship movements.

Cruise ships (because of their large size and slow speeds) do not present a high risk to marine fauna, except for whales in open sea areas. There will be an increase in cruise ship movements irrespective of the project (noting the new infrastructure only relates to an additional 30 or so ship calls under the high growth scenario). Broader shipping movement in and out of the Reef area is currently being managed under the North-East Shipping Management Plan (AMSA). It is noted that an increase in cruise ships berthing at Trinity Wharves (as opposed to Yorkeys) could increase the risk of interaction with marine fauna, however the shipping channel and inner port are not important habitat for turtles, dolphins and dugong and these large vessels present a low risk to these species.

B7.3.6.a Direct Interactions between Marine Fauna and Vessels or Dredge Plant

When operating any kind of vessel in marine waters, there is a potential risk of fauna vessel strike, primarily for mobile megafauna that swim near the surface and/or frequent the surface to breath, such as whales, dolphins, dugongs and turtles. Interactions may also occur if the presence of a vessel obstructs fauna passage, which may occur if the presence of a vessel deters an animal from continuing along an intended path of passage, or is inclined to detour significantly around a vessel to reach an intended destination (i.e. avoidance behaviour – discussed further below with respect to potential noise effects).

Large vessels currently operate within the study area, including, the TSHD dredger for annual maintenance dredging and large cruise vessels which moor approximately 4 km offshore from Yorkeys Knob. Smaller vessel movements (commercial charters, recreational, small cruise vessels) regularly occur throughout the study area. The large vessels specifically associated with this project would represent a small proportion of the total number of boat movements expected to occur over the duration of capital or operational works. However, while large vessels are slow-moving and provide marine fauna time to evade the approaching vessel, they also typically have large powerful propellers and a lower draft. This means that if an animal does not move out of the vessel path, there is a greater risk of severe injury or mortality. In the event that such interactions occur, they would generally occur at locations within the footprint and associated vessel movement paths.

Given marine megafauna prone to vessel strike (turtles, dugongs, cetaceans) occur within the study area (**Section B7.2**), and that these fauna are afforded a high conservation value (MNES), mitigation measures are proposed in **Section B7.4.5** to reduce the risk of impacts to marine megafauna.

In terms of entrainment, it is possible for the suction at the dredge head to entrain fauna, potentially resulting in fauna injury or mortality. Of the marine megafauna, turtles are the group most likely to be affected by this process. Turtles are highly mobile and will tend to avoid the dredger, typically returning to the surface to breathe every few minutes.

However, they can remain underwater for as long as two hours without breathing when they are resting. Dr Col Limpus suggests that sea turtles can use shipping channels as resting or shelter areas, and that there are recorded incidences of turtles being injured by trailer suction hopper type dredgers. GHD (2005), citing personal communication from Dr Limpus, suggest that the numbers of turtles captured during dredging across all Queensland Ports is decreasing, with an average of 1.7 loggerhead turtles per year. Furthermore, it was suggested that current research indicates the impact of dredging on the overall viability of turtle populations is very low compared to the numbers killed by vessel strikes, trawling, fishing, ingestion of marine debris and indigenous hunting. No incidents between dredgers and turtles have been reported in Cairns for the past 10 years, and the potential for such is considered very low. Maintenance dredging with the TSHD Brisbane over this period has incorporated turtle deflection devices and the exclusion practices noted below.

Given the relatively low numbers of turtles impacted by dredgers compared to other activities, and the use of effective management and operational practices to reduce the potential for turtle capture, it is considered that the proposed dredging will have a negligible consequence on turtle populations in the study area. Other megafauna species (e.g. cetaceans, whales and dugong, etc.) are not considered to be prone to dredge entrainment and will not be impacted by such interactions. Best practice dredging equipment, techniques and management will be used to further reduce risks to turtles (see below).

B7.3.6.b Indirect Interactions between Marine Fauna and Vessels

Lighting

When vessels or navigation lights are operated at night, their on-board lighting systems will generate light emissions to the marine environment. Marine turtles are particularly sensitive to artificial lighting as they may become disorientated during nesting and hatching (Witherington 1992). However, no turtle nesting areas exist in close proximity to the dredge operations or at the inner port, and there is a low incidence of turtle nesting elsewhere in the harbour (i.e. in sight of the outer channel). Further, in the unlikely event that light from project-related vessels or dredge pump-out facilities can be detected by emerging hatchlings during either project construction or operation, the seaward position of such lighting at all times does not pose a risk for guiding hatchlings landward. In this respect, land-derived lighting such as those at the port or throughout Cairns City presents a significantly greater lighting attraction risk for marine fauna. Artificial light is not known to have a major effect on foraging patterns of turtles, dolphins or dugongs.

Mitigation strategies will be implemented to further reduce potential impacts (see below).

Noise

The production and reception of particular sounds are important to many marine fauna species, particularly marine mammals. Both natural and anthropogenic sounds have the potential to interfere with various biological functions. During construction, noise generated by dredging has the potential to adversely affect megafauna as it will form a persistent source of underwater noise that will continue (intermittently) for the duration of dredging works. Such noise may be generated by mechanical means (vessels engines, dredge gear, propellers and other machinery), or by water movements on the vessel hull. While dredger generated noise is normally unlikely to occur at levels that could cause acute hearing damage to marine fauna, it may cause subtle but possibly more widespread increases to ambient noise levels. This may include for example, masking of biologically important sounds (e.g. vocalisations), interfere with dolphin sonar signals or alter fauna behaviour (i.e. noise avoidance). Similar such effects can be expected during the operational phase of the project when large cruise vessels are approaching or docking at port, or during maintenance dredging campaigns.

Additionally, the floating marine booster pump proposed to be located between the offshore dredge pump-out mooring point and the mouth of Richters Creek will potentially produce noise impacts to marine fauna species. Noise from this marine booster pump is expected to be approximately 115 dBA LAeq (15 minute) for approximately 6 hours per day (6 dredge cycles of 1 hour pumping per cycle) while the dredge is moored and pumping material to shore.

In general, the most likely impact of underwater noise from project-associated vessels for marine megafauna is the temporary avoidance of the offending vessels, marine booster pump and their immediate surrounds. The inner port is known to support inshore dolphin species, while the wider harbour area supports sea turtles, dolphins, whales, dugongs and other threatened and/or migratory marine species at various times; depending on temporal factors such as migration seasons, availability of food resources, etc. The likelihood of acoustic impacts to marine fauna occurring would depend on whether these fauna are present at the time of vessel/booster pump operation, the number of animals present and their proximity to the underwater noise source.

If present in or near the dredge footprint during dredge or cruise vessel operation, turtles may exhibit a different response to noise than marine mammals. Turtles often remain stationary for long periods, feeding and resting. GHD (2011) observed turtles exhibiting negligible response in close proximity to marine piling operations and, based on this observation, suggested that it cannot be assumed that turtles will voluntarily move away from adverse vessel/dredge noise effects.

Chapter B10, Noise and Vibration details the ambient underwater noise conditions of the study area and associated impacts predicted to result from construction and operations during the life of the project. While information on the effects of noise on marine fauna in an Australian context is extremely limited, dredging is predicted to have negligible impact on marine mammals and dugongs, primarily restricted to localised behavioural changes within ~100-200 m of the dredge (Chapter B10, Noise and Vibration). Hearing damage would only be expected if animals remain in the vicinity (~10 m of the dredge) for prolonged periods, which is considered extremely unlikely to occur. For underwater noise associated with shipping, effects to marine fauna are expected to be negligible since similar noise sources currently occur in the study area and localised behavioural changes (avoidance) are considered the most likely effect (Chapter B10, Noise and Vibration).

As discussed below, mitigation measures will be implemented to further reduce the risk of vessel related noise effects.

B7.3.7 Acoustic Effects to Marine Fauna from Wharf Upgrade Works

B7.3.7.a Underwater Noise during Wharf Upgrade

Chapter B10, Noise and Vibration describes noise and vibration impacts from the project.

For the wharf upgrade works, underwater noise will result from multiple sources, of which the most chronic will be repeated pulsed inputs from driving the 84 racking steel piles during construction. Noise will also be generated directly from general wharf construction work, as well as through the operation of construction vessels. It is envisaged that the piles will be driven from a barge, by a piling rig with crane and hammer.

Section B7.3.6.b above describes the general impacts that could occur from interactions between marine fauna and anthropogenic underwater noise. Fish deaths have also occasionally been reported in close proximity to piling as physical damage can occur to non-auditory tissue (e.g. vascular tissue) or air-filled cavities such as swim bladders.

As described **Chapter B10** (Noise and Vibration), piling activities during the wharf upgrade works are predicted to result in localised fish mortality within the immediate vicinity (~one-three metres) of the piling rig and behavioural changes (avoidance) expected at distances within one km of the piling rig.

Piling noise is expected to potentially result in hearing damage to marine mammals in the immediate vicinity of the piling rig (up to ~10 m). Although behavioural changes (avoidance) are expected, these are predicted to be limited to within up to ~500 m of the piling rig (**Chapter B10** (Noise and Vibration)). Overall, any piling related noise effects to marine megafauna are considered to be temporary (for the duration of construction works) and minimal in the context of the existing noise regime of the area.

B7.3.8 Other Indirect Interactions between Vessels and Marine Receptors

B7.3.8.a Potential for Marine Pest Introductions

There is a risk that dredging plant (construction stage) and other vessels (operational stage) could translocate introduced marine pests from the port of origin to the Port of Cairns. Few marine pest outbreaks (and eradication operations) have occurred at the Port of Cairns in recent years. While marine pests, if present, could be transported from the dredge or cruise vessels to the local marine environment, the project is not considered to pose a notable risk in terms of the potential of introducing marine pests to the Cairns Harbour and surrounds if appropriate biosecurity inspections and management are employed. This is based on the following:

- The study area is not currently known to support populations of marine pests of concern that could be dispersed by the vessels to waters elsewhere.
- The dredge vessel remaining in the study area for the duration of the dredging campaign.
- As part of the Dredge Management Plan, appropriate measures will be in place during construction to reduce the potential for introducing marine pests from the dredger (e.g. compliance with antifouling, hull cleaning and ballast treatment requirements).
- The study area is already regularly visited by dredge plant and international cruise ships, in addition to other international vessel traffic.
- Cairns is a tropical port and tropical ports are generally less prone to marine pest invasion in comparison to ports in the southern temperate waters of Australia (Hilliard and Raaymakers 1997; Hilliard 1999; Hutchings *et al.* 2002). This is because I) tropical species often have a widespread equatorial distribution, resulting in a higher probability that Cairns is within their natural geographic range; and ii) foreign temperate species used to cooler waters are less likely to survive and establish in warmer tropical waters.

Notwithstanding this, translocation of exotic marine pests into a new environment is potentially an important issue for the Port of Cairns. The environmental and economic impacts due to the introduction of exotic marine pests can be significant. Marine pests, once established, can be difficult to eradicate and can have serious and permanent consequences for the marine environment, marine productivity and public health. While unlikely, the introduction and subsequent establishment of marine pests would be present a moderate consequence from a marine ecology perspective. Marine pest risks will be managed in accordance with standard mitigation procedures discussed in **Section B7.4.6.a**.

B7.3.9 Exposure of Marine Flora and Fauna to Debris, Spills and Dredging-Borne Contaminants

B7.3.9.a Marine Debris

Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. Construction and operational works will generate large quantities of rubbish which could pose a risk to the marine fauna of the study area if not appropriately managed. In particular, plastic bags and packaging could pose a risk to local marine turtles, whales and fish populations.

A variety of waste management strategies will be employed as part of the environmental management plans developed for this project, to reduce waste generation and the quantity of plastic wastes entering the marine environment (**Chapter C1** (Construction Environmental Management Plan) and **Chapter C2** (Dredge Management Plan)).

B7.3.9.b Potential Spills

It is possible that chemical spills would occur on, or from the dredger or other vessels such as cruise vessels, creating the potential for dredge-derived potential contaminants to be introduced to the marine environment. These could include, for example, hydrocarbons or other potential toxicants stored on board. Spills could occur either in the vicinity of the dredge footprint, or while vessels are in port or underway outside the project footprint. In the event that a spill occurs, it may present a toxicity risk to marine flora and fauna. The significance of such an impact is highly variable, depending on factors such as:

- the type of material spilt and its chemical constituents
- the volume and/or load concentration of potential toxicants of concern entering the marine environment
- climate and tidal conditions at the time of event
- the location and timing of a spill, which can dictate the mixing potential (i.e. concentration reduction), extent of water quality effects, and the likelihood of sensitive receptors occurring in the affected area.

Spills of this nature are considered to be unlikely, and no more likely than typical for other large vessels using the wider study area at any given point in time under existing conditions. Given their localised extent or potentially undetectable effects in the event that they do occur, are considered to represent a low level of impact. Mitigation measures outlined in **Chapter B5** (Marine Water Quality), in combination with mitigation measures listed in **Section B7.4.6.d**, will further reduce the likelihood of such occurrences.

B7.3.9.c Potential Toxicants Mobilised by Dredging and Construction

As discussed in **Chapter B4** (Sediment Quality), marine sediments in the proposed dredging and pile driving areas contain potential contaminants at concentrations (95 percent UCL) that are below NAGD screening levels, and therefore do not pose a toxicity threat. As such, impacts to marine biota from mobilisation of contaminants from the dredging process are expected to be negligible.

Potential acid sulfate soils (PASS) will be managed in the Northern Sands DMPA such that tailwater discharges into the Barron River are at a neutral pH with negligible impacts. With appropriate site management, PASS disturbance risk is considered to be negligible.

B7.3.9.d Summary of Impacts to Marine Fauna

Key Impacting Processes Considered for Marine Megafauna

In general, the following conclusions are drawn with respect to marine megafauna impacts:

- Turbid plumes generated by either capital or maintenance dredging and dredged material placement are not expected to result in direct effects to marine megafauna. Some species such as green and hawksbill turtle, which feed on seagrass and/or in reef environments, may avoid areas affected by turbid plumes which will vary in the area affected depending upon dredge operational strategy and climatic conditions. However, it is noted that key foraging habitats for these species (i.e. reefs, notable seagrass beds) do not coincide with the predicted extent of turbidity impact zones.
- Significant flow-on effects resulting from direct loss or disturbance of benthic habitats are considered unlikely, since benthic habitats within the dredge footprint or pile driving footprint are unlikely to provide critical foraging or other habitat functions for green turtles and dugongs (particularly since seagrass in these areas is absent or sparse, relative to elsewhere in the study area). Impacts to other megafauna are likewise considered unlikely as soft sediment habitats, similar to those in the immediate footprint, are widespread throughout the remainder of the study area.
- Vessel fauna strike, or entrainment (at the dredge head) may occur, but this is considered a very low probability and is dependent on highly variable factors such as the species present, the number of individuals present and their condition, at the time of such works/operations. Numerous mitigation measures will be implemented to reduce this risk:
    - Lighting effects to marine megafauna are considered to be negligible, especially near shore in the context of land derived light sources
    - Potential noise effects may be caused by pulsed pile driving works, the more persistent (albeit temporary) dredge and vessel sources, or the marine booster pump. For these noise sources, the most likely effect is expected to be temporary megafauna behavioural changes, by way of avoidance of the noise source and its immediate surrounds. Hearing damage would only be expected if animals remain in close range to the noise source for prolonged periods. This is considered unlikely for most marine megafauna.

B7.4 Recommended Mitigation Measures

B7.4.1 Direct Impacts to Soft Sediment Areas

Habitat removal and physical habitat alteration within the project footprint is an inherent impact of any project that incorporates a marine dredging component. For the project, considerable effort during the design and EIS phases went to the identification and selection of both a dredge footprint and Northern Sands DMPA site that would minimise new direct ecological effects to marine environmental values. The dredge footprint largely aligns with that of the existing outer channel (albeit wider in places) and other areas that are already regularly dredged or influenced by dredging under existing conditions. The revised footprint is designed to minimise the capital dredge footprint as far as practical and reduces the extent of dredging required in greenfield areas.

Chapter C2 (Dredge Management Plan) provides guidance on (i) the mitigation measures that will be adopted to minimise direct impacts to marine flora and fauna; and (ii) monitoring that will be undertaken to validate impact predictions outlined in the EIS. This includes the following relevant strategies and components:

- Seagrass will be surveyed within the channel footprint to determine whether there are any potential direct impacts
- A bathymetry survey of the channel and surrounds will be undertaken progressively and upon completion to minimise over-dredging and confirm final depths at the completion of the capital dredging campaigns

For marine protected areas, note that changes to the boundaries of the areas are proposed to compensate for dredging activities encroaching on these areas (e.g. Trinity Inlet FHA), as detailed in full in Chapter B2, Nature Conservation Areas.

The location and extent of physical habitat alteration and disturbance during construction phase dredging is unlikely to affect high value marine fauna, but the channel footprint coincides with a small area of historic seagrass habitat. Therefore, changes in habitat due to direct modifications are considered to represent an irreversible long-term Low risk, and cannot be practically mitigated (**Table B7-22**).

B7.4.2 Impacts to Commercial Fisheries Species

The residual risk of habitat modification (i.e. expanded channel) on the commercial catch of economically significant species is considered to be long-term and Low (**Table B7-22**). Further discussion on fisheries impacts specifically relating to the generation of turbid plumes is provided in **Section B7.3.4.a**.

B7.4.3 Dredge Plume and Sedimentation Impacts

The project design and **Chapter C2** (Dredge Management Plan) incorporate numerous mitigation measures that will be adopted to reduce the extent and magnitude of turbid plumes in order to minimise impacts to marine flora and fauna. Modelled dredge scenarios included either 10 or 30 minutes of overflow. Limiting overflow is likely to reduce the potential sedimentation impacts predicted for seagrasses in the worst case scenario. Specific relevant strategies and components of the DMP include:

- Capital dredging will not be carried out in late spring and summer (November to February). This coincides, in part, with when seagrasses and other benthic biota may be most likely to be undertaking important life history functions (e.g. seagrass growth, coral spawning, spawning on many commercially significant fisheries species) or coping with seasonal environmental stress (e.g. flood-related effects)
- An environmental valve ('green valve') will be used in overflow pipes of the TSHD to reduce the dispersion of sediments from dredging
- Overflow levels will be raised to the highest allowable point during sailing from the dredge area to the dredge pump-out location to ensure spillage of sediment is minimised
- Sailing routes will be optimised to minimise the generation of propeller wash (noting that propeller wash from the dredger has been taken into account in the modelling as a contributor to sedimentation impacts)

- A reactive water quality monitoring program will be developed and implemented. Dredging activities will be modified or suspended in the event that monitoring detects exceedance/s of trigger values, which will illicit various management responses. Water quality baseline data collected for this project (**Chapter B5** (Marine Water Quality)), together with local photosynthetic active radiation (PAR) data collected by James Cook University, will be used as the basis for establishing these trigger values
- A seagrass monitoring program (and soft sediment benthos monitoring) will be developed and implemented to identify any changes to communities as a result of the dredging program. This will include sampling at multiple times before and dredging at putative impact sites located adjacent to the near shore project footprint, and at suitable control sites.

Reactive water quality and seagrass monitoring, in combination with active management of overflow (informed by the reactive monitoring program), would reduce the risk of impact to a short-term Low risk activity (for turbidity and sediment deposition), in terms of residual risk (**Table B7-22**).

B7.4.4 Impacts of Tailwater Releases on Flora and Fauna

The simulated tailwater releases of 1 m^3/s at 35 PSU and 100 mg/L TSS (~60 NTU) into the Barron River are not likely to result in any observable impacts to benthic invertebrates, commercially significant fisheries species, seagrasses or riparian communities, given the wide range in salinity and turbidity conditions that these communities are regularly exposed to.

Tailwater will need to be managed to ensure that it complies with the release criteria set by the regulator. Other properties of the tailwater, notably dissolved oxygen and pH, will require management to ensure compliance with release criteria. The residual risk rating is short-term and Low (**Table B7-22**).

B7.4.5 Impacts to Megafauna

B7.4.5.a Direct Impacts

Management strategies primarily focus on dredge vessels and dredge plant, and will be implemented throughout the course of the proposed capital and operational dredging works to minimise the risk of interactions with vessels. These management strategies are set out in the Dredge Management Plan (Chapter C2, Dredge Management Plan) and will include:

- Implementation of marine megafauna management strategies.
- Implementation of megafauna exclusion zones (maintaining a given buffer distance between the dredge vessels and megafauna) and associated reactive megafauna monitoring program (regular visual inspections of dredge footprint area and dredge path).
- If visual monitoring for megafauna from the dredge vessels detects megafauna within or headed towards exclusion zones, execute strategies to avoid interactions as required stopping work if megafauna, especially whales, are within or near exclusion zones; halt dredge vessel transit if there is a likelihood the vessel would encroach on observed whales or their anticipated path.
- Operational procedures to minimise the risk of capture of turtles lying on the seabed, especially utilising fauna exclusion devices on the dredge head to reduce fauna entrainment and prevent fauna injury and mortality.
- Ensure dredge suction is not started until the dredge head is lowered and in contact with the seafloor, and stops before lifting the dredge head from the seabed.
- Where it does not conflict with security and safety requirements, lighting on the dredge vessel will aim for low wattage and/or directional light fixtures.

Together, these mitigation strategies will reduce the likelihood of interactions between the dredge vessels and marine megafauna, such that the overall residual impacts to marine megafauna are considered highly unlikely for all related mechanisms (i.e. vessel strike, noise, entrainment and light). The residual risk rating following mitigation is short-term and Low (**Table B7-22**).

In terms of operational phase impacts from increased shipping in Trinity Inlet and Trinity Bay, the potential risk to marine fauna from vessel strike has been assessed as Low (**Table B7-22**) due to the large size and slow speeds of cruise ships. Broader shipping movement in and out of the Reef area is currently being managed under the North-East Shipping Management Plan (AMSA), and is not a port issue. As there are no mitigation measures identified for the operational phase, the residual risk rating is Low (**Table B7-22**).

B7.4.5.b Acoustic Impacts

Recommended mitigation measures to specific to construction phase piling works are covered in Chapter B10 Noise and Vibration. These mitigation measures include:

- Resilient pad (dolly) used where feasible between the pile and hammer head.
- A megafauna observation zone of one km, and exclusion zone of 100 m will be adopted, with piling operation shut down if marine megafauna species are observed within or approaching the exclusion zone.
- A 'soft-start'/'ramp-up' regime will be adopted at each day's commencement of piling works.
- Underwater noise monitoring conducted at the onset of piling to confirm/calibrate the noise predictions, and noise management adapted appropriately.

The residual risk rating following mitigation is short-term and Low (**Table B7-22**).

B7.4.5.c Megafauna Impact Mitigation Summary

Key mitigation strategies specific to minimising potential harm to marine megafauna as a result of the project are primarily focused on reducing interactions (direct or indirect) between megafauna and vessels, dredge plant and pile driving. These include management strategies set out in the Dredge Management Plan (Chapter C2, Dredge Management Plan), and management strategies to be implemented during pile driving works. These measures were developed in line with current best industry practice, and also consider general management strategies outlined in species recovery plans (including the 2003 Recovery Plan for Marine Turtles in Australia). Mitigation measures focusing on protecting megafauna habitats (e.g. seagrass) are provided elsewhere, in the previous sections of this impact assessment.

Overall, implementation of these mitigation strategies, together with best practice construction and waste management methodologies, are expected to result in minor residual impacts for marine megafauna. The residual risk rating following mitigation is short-term and Low (**Table B7-22**).

B7.4.6 Other Marine Vessel Impacts

B7.4.6.a Marine Pests

International and domestic vessels involved in either the construction or operational phases of the project will be required to comply with national and state biofouling and ballast water management guidelines, and other requirements to minimise the risk of introductions of marine pest species. The residual risk rating following mitigation is long-term and Low (**Table B7-22**).

B7.4.6.b Marine Debris

Throughout both the construction and operational phases of the project, ships, dredgers and other vessels associated with the project will need to ensure waste materials are properly managed in accordance with standard protocols and waste management strategies in the respective Management Plans. The Port of Cairns will provide appropriate waste reception facilities for accommodating this, in line with best practice (e.g. Best Practice Guidelines for waste Reception Facilities at Ports, Marinas and Boat Harbours in Australia and New Zealand, IMO Guide to Best Practice for Port Reception Facility Providers and Users). The residual risk rating following mitigation is long-term and Low (**Table B7-22**).

B7.4.6.c Potential Toxicants Mobilised by Dredging or Construction:

It is assumed that the following standard mitigation measures will be employed to ensure associated impacts are negligible:

- Dredging will be undertaken in a manner consistent with the requirements of the NAGD
- A Dredge Management Plan has been developed for the project (Chapter C2, Dredge Management Plan), which will be implemented throughout the duration of the works. A key component of this plan is a water quality monitoring program that will enable reactive and adaptive management of dredging operations in order to minimise water quality effects and, thus, effects to marine flora and fauna
- Dredge material should remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidisation
- Future maintenance dredging during the operational phase of the project is undertaken consistent with the LTDSDMP and in accordance with NAGD or future versions of these guidelines.

The residual risk rating following mitigation is short-term and Negligible (**Table B7-22**).

B7.4.6.d Spills

The following additional mitigation is proposed to reduce the potential impacts associated with spills during project construction and operation:

- Hazardous material handling procedures have been developed for the project as part of the Dredge Management Plan (see Chapter C2, Dredge Management Plan).
- Emergency spill response procedures will be implemented if/when required.
- Relevant staff will be trained to ensure they have an appropriate level of competency for executing the above spills procedures.
- Revise fuel handling and spill response procedures in the port's operational procedures to minimise the potential future risk to sediment quality from refuelling activities associated with the provision of IFO at the port.

With the implementation of the above measures, it is considered highly unlikely that spills, if they occur, will cause adverse impacts to the marine environment. Note that spill and emergency response procedures will be outlined as part of the Dredge Management Plan.

Overall, through the implementation of the above strategies, the residual impact to marine ecological values is considered to be long-term and Low (**Table B7-22**).

B7.4.7 Residual Impacts and Assessment Summary

Table B7-22 summarises the marine ecology issues identified by the impact assessment in the previous sections. This assessment table also includes the significance of each of the identified impacting processes, the likelihood of the impact occurring, and the resulting risk rating.

Most potential impact processes are rated as having a negligible to low risk to marine ecology. The standard and additional mitigation measures discussed in previous sections are also summarised in **Table B7-22**, with a risk rating indicated for the residual impacts after mitigation.

Construction phase residual impacts would be short-term (up to one year) in duration, while operational phase residual impacts (including permanent benthic habitat modification, which are irreversible impacts) would be long-term in duration extending over the life of the project.

TABLE B7-22 ASSESSMENT SUMMARY TABLE – MARINE ECOLOGY

MARINE ECOLOGY	INITIAL ASSESSMENT WITH STANDARD MITIGATION IN PLACE				RESIDUAL ASSESSMENT WITH ADDITIONAL MITIGATION IN PLACE			
PRIMARY IMPACTING PROCESSES	STATUTORY MITIGATION MEASURES REQUIRED	CONSEQUENCE OF IMPACT	LIKELIHOOD OF IMPACT	RISK RATING	ADDITIONAL MITIGATION MEASURES PROPOSED	CONSEQUENCE OF IMPACT	LIKELIHOOD OF IMPACT	RESIDUAL RISK RATING
CONSTRUCTION PHASE								
Direct modification of benthic habitats (subtidal soft sediment habitats, potential seagrass habitat) from capital dredging, and wharf upgrade works. (Seagrass is not currently in the direct impact footprint but may be present at the time of dredging)	Project design minimises area of marine habitat directly lost/ affected by proposal.	Minor	Possible	Low	None Seagrass surveys to confirm presence of unpredicted seagrass. If detected, seagrass impacts resulting in permanent loss will be offset in accordance with Environmental Offsets Act	Minor	Possible	Low
Impacts to commercial fisheries from habitat modification (i.e. expanded channel)	Nil	Minor	Unlikely	Low	Nil	Minor	Unlikely	Low
Increased suspended sediment concentrations from capital dredging (resultant water quality effects) resulting in localised but short-term impacts to seagrass or corals	• Project design minimises the extent (volume) of dredging • Ensure TSHD dredge operates within the approved dredge footprint at all times	Moderate	Possible	Medium	• Implementation of DMP, including: o avoidance of summer months for dredging o sailing routes optimised to minimise propeller wash o implementation of reactive water quality monitoring program	Moderate	Unlikely	Low

MARINE ECOLOGY	INITIAL ASSESSMENT WITH STANDARD MITIGATION IN PLACE				RESIDUAL ASSESSMENT WITH ADDITIONAL MITIGATION IN PLACE			
PRIMARY IMPACTING PROCESSES	**STATUTORY MITIGATION MEASURES REQUIRED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RISK RATING**	**ADDITIONAL MITIGATION MEASURES PROPOSED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RESIDUAL RISK RATING**
	• Overflow dredging by the TSHD is undertaken in accordance with the overflow regime in the Dredge Management Plan. • Dredge hopper compartment is to be kept water tight during all dredging activities. • Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle • No high pressure jets to be used on drag heads outside of dredge footprint Dredge to be fitted with a 'green valve'.				o implementation of soft sediment benthos and seagrass monitoring program.			
Increased sediment deposition from capital dredging resulting in localised but short-term impacts to seagrass or corals	• Project design minimises the extent (volume) of dredging • Ensure TSHD dredge operates within the approved dredge footprint at all times	Moderate	Unlikely	Low	• Implementation of DMP, including: o avoidance of summer months for dredging o sailing routes optimised to minimise propeller wash o implementation of reactive water quality monitoring program	Moderate	Highly Unlikely	Low

MARINE ECOLOGY	INITIAL ASSESSMENT WITH STANDARD MITIGATION IN PLACE				RESIDUAL ASSESSMENT WITH ADDITIONAL MITIGATION IN PLACE			
PRIMARY IMPACTING PROCESSES	**STATUTORY MITIGATION MEASURES REQUIRED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RISK RATING**	**ADDITIONAL MITIGATION MEASURES PROPOSED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RESIDUAL RISK RATING**
	• Overflow dredging by the TSHD is undertaken in accordance with the overflow regime in the Dredge Management Plan. • Dredge hopper compartment is to be kept water tight during all dredging activities. • Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle • No high pressure jets to be used on drag heads outside of dredge footprint • Dredge to be fitted with a 'green valve'.				o implementation of soft sediment benthos and seagrass monitoring program.			
Generation of turbid plumes and increased salinity from tailwater discharges from the Northern Sands DMPA	Tailwater discharges from the Northern Sands DMPA do not exceed specified water quality criteria.	Minor	Possible	Low	Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C)	Minor	Unlikely	Low

MARINE ECOLOGY	INITIAL ASSESSMENT WITH STANDARD MITIGATION IN PLACE				RESIDUAL ASSESSMENT WITH ADDITIONAL MITIGATION IN PLACE			
PRIMARY IMPACTING PROCESSES	**STATUTORY MITIGATION MEASURES REQUIRED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RISK RATING**	**ADDITIONAL MITIGATION MEASURES PROPOSED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RESIDUAL RISK RATING**
Interactions between marine fauna and vessels or dredge plant (i.e. fauna vessel strike, entrainment, indirect artificial noise and lighting effects)	None identified	Moderate	Highly Unlikely	Low	• Implementation of DMP, including: o implementation of marine megafauna management strategies o implementation of megafauna exclusions zones o visual monitoring and implementation of reactive strategies o utilisation of fauna exclusion device(s) to reduced entrainment risk o cease dredge suction prior to lifting dredge head from seabed o minimise lighting utilisation as practicable.	Moderate	Highly Unlikely	Low
Acoustic effects to marine fauna from wharf upgrade works (especially pile driving)	None identified	Minor	Likely	Medium	• Resilient pad (dolly) used where feasible between the pile and hammer head • A megafauna observation zone of one km, and exclusion zone of 100 m will be adopted, with piling operation shut down if marine megafauna species are observed within or approaching the exclusion zone • A 'soft-start'/'ramp-up' regime will be adopted at each day's commencement of piling works	Minor	Possible	Low

MARINE ECOLOGY	INITIAL ASSESSMENT WITH STANDARD MITIGATION IN PLACE				RESIDUAL ASSESSMENT WITH ADDITIONAL MITIGATION IN PLACE			
PRIMARY IMPACTING PROCESSES	**STATUTORY MITIGATION MEASURES REQUIRED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RISK RATING**	**ADDITIONAL MITIGATION MEASURES PROPOSED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RESIDUAL RISK RATING**
					• Underwater noise monitoring conducted at the onset of piling to confirm/calibrate the noise predictions, and noise management adapted appropriately.			
Other indirect interactions from vessels: marine pest introductions	Vessel compliance with national and state biofouling and ballast water management procedures.	Moderate	Unlikely	Low	None identified	Moderate	Unlikely	Low
Introduction of marine debris leading to marine megafauna impacts	• Port of Cairns to provide appropriate waste reception facilities, in line with best practice • All vessels to comply with standard waste management protocols.	Moderate	Unlikely	Low	Implementation of waste management strategies in construction EMP to reduce waste generation and the quantity of plastics entering the marine environment.	Moderate	Highly unlikely	Low
Risk of toxic spills from vessels	None identified	Moderate	Unlikely	Low	• Implement hazardous material handling procedures • Implement emergency spill response procedures as required • Ensure relevant staff trained in above procedures to ensure competency • Revise port fuel handling and emergency response procedures.	Moderate	Highly unlikely	Low

MARINE ECOLOGY	INITIAL ASSESSMENT WITH STANDARD MITIGATION IN PLACE				RESIDUAL ASSESSMENT WITH ADDITIONAL MITIGATION IN PLACE			
PRIMARY IMPACTING PROCESSES	STATUTORY MITIGATION MEASURES REQUIRED	CONSEQUENCE OF IMPACT	LIKELIHOOD OF IMPACT	RISK RATING	ADDITIONAL MITIGATION MEASURES PROPOSED	CONSEQUENCE OF IMPACT	LIKELIHOOD OF IMPACT	RESIDUAL RISK RATING
Potential contaminants mobilised by dredging	Completion of sediment sampling and analysis program (SAP) in line with NAGD guidelines to characterise sediments	Minor	Unlikely	Low	• Implementation of DMP, including reactive water quality monitoring program and relevant adaptive management strategies • Dredged material to remain waterlogged and not to remain in TSHD hopper or dump barge for periods exceeding 24 hours.	Minor	Highly Unlikely	Negligible
Operational Phase								
Future maintenance dredging – mobilisation of contaminants into water column, turbid plumes and sediment deposition	Existing maintenance dredging operations occur in accordance with an approved LTDSDMP which contains management measures to reduce impacts on water quality from dredging and placement	Minor	Possible	Low	Update the LTDSDMP to address the additional volumes and duration of maintenance dredging required by the wider channel	Minor	Possible	Low
Interactions between marine fauna and operational vessels/ship (i.e. fauna vessel strike, entrainment, indirect artificial noise and lighting effects	None identified	Moderate	Highly Unlikely	Low	None identified	Moderate	Highly unlikely	Low
Other indirect interactions from vessels: marine	Vessel compliance with national and state biofouling and ballast	Moderate	Unlikely	Low	None identified	Moderate	Unlikely	Low

MARINE ECOLOGY	INITIAL ASSESSMENT WITH STANDARD MITIGATION IN PLACE				RESIDUAL ASSESSMENT WITH ADDITIONAL MITIGATION IN PLACE			
PRIMARY IMPACTING PROCESSES	**STATUTORY MITIGATION MEASURES REQUIRED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RISK RATING**	**ADDITIONAL MITIGATION MEASURES PROPOSED**	**CONSEQUENCE OF IMPACT**	**LIKELIHOOD OF IMPACT**	**RESIDUAL RISK RATING**
pest introductions	water management procedures.							
Introduction of marine debris	• Port of Cairns to provide appropriate waste reception facilities, in line with best practice • All vessels to comply with standard waste management protocols	Moderate	Highly unlikely	Low	Implementation of waste management strategies in operational EMP to reduce waste generation and the quantity of plastics entering the marine environment.	Moderate	Highly Unlikely	Low
Risk of toxic spills from vessels	None identified	Moderate	Unlikely	Low	• Implement hazardous material handling procedures • Implement emergency spill response procedures as required • Ensure relevant staff trained in above procedures to ensure competency • Revise port fuel handling and emergency response procedures.	Moderate	Highly Unlikely	Low

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