Leekes Creek Estuary and Adjacent Inshore Waters

Habitat Assessment

Prepared for:

Department of National Parks, Sport and Racing

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Summary

This report describes the habitat values and fish communities of the Leekes Creek estuary and adjacent inshore waters (Great Keppel Island, and compliments the initial Fisheries Resource Assessments (FRA) of the Leekes Creek estuary (frc environmental 2014). The study is commissioned by Queensland Parks and Wildlife Services as part of the central Queensland declared Fish Habitat Area (FHA) investigations program, funded by the Gladstone Ports Corporation's (GPC) marine fish habitat offsets program. The program is currently assessing the fisheries values of sections of the Leekes Creek area, Great Keppel Island, to support the possible inclusion of these areas into the FHA network. Further funding provided by GPC through their Biodiversity Offsets Strategy, developed to provide for the long-term conservation of threatened and migratory species, including their habitats, has enabled enhancement of the program through further research, such as this study, of areas proposed for Fish Habitat Area declaration.

At each of 5 locations (Half tide Rocks, Passage Rocks, Northern Leeks Creek, Little Peninsula, and Big Peninsula) timed swims were used as the basis for data collection. Photographs were also taken to support the description of corals and other taxa. Coral Point Count was used to analyse representative photographs for cover. Sediment samples were collected from 3 locations.

At each location, hard corals made up 30 – 40% of cover, and soft corals 2 – 27% of cover of the upper reef slope and platform. Hard coral communities were dominated by branching *Acropora* spp. Minor coral bleaching was observed at Big Peninsula and Passage Rocks.

Large amounts of coral rubble are likely to be attributable to Cyclone Marcia in February 2015.

The most abundant fish species observed were the yellow and barrier reef chromis (*Chromis analis* and *Chromis nitida* respectively), sergeant major, *Abudefduf vaigiensis* and the big-scaled scalyfin, *Parma oligolepis;* wrasses *Halichoeres* sp. and *Thalassoma lunare*; surgeonfish, *Acanthurus* sp.; and reef cod *Epinephelus tauvina* - all species common within the region. Fish recorded were of recreational, commercial and indigenous importance to the area.

At each location, sediments are essentially fine silty sands. For all sites, the concentration of all metals analysed was significantly below the National Assessment Guidelines for Dredging (2009) and ANZECC trigger values. Pesticides were present at levels below the laboratory's Limit of Reporting (thus below the NAGD Screening limits were available). Neither NAGD or ANZECC provide guidelines for nutrients in sediment.

The inshore reefs adjacent to Leekes Creek are likely to contribute to the seascape mosaic of habits critical to the life-cycle of many of the fish species recorded in this survey, and also provide foraging grounds and refuge during low tide, when access to the creek is restricted. Overall, based on the snap-shot survey of benthic habitat and fish, the five sites surveyed would be valuable additions to the proposed Leekes Creek FHA.

1 Introduction and Objectives

This report describes the habitat values and fish communities in the vicinity of Leekes Creek and adjacent inshore waters as part of the declared Fish Habitat Area Investigations Program, Central Queensland (DNPRSR 2015). The study is commissioned by Queensland Parks and Wildlife Services as part of the central Queensland declared Fish Habitat Area (FHA) investigations program, funded by the Gladstone Ports Corporation's (GPC) marine fish habitat offsets program. The program is currently assessing the fisheries values of sections of the Leekes Creek area, Great Keppel Island, to support the possible inclusion of these areas into the FHA network. Further funding provided by GPC through their Biodiversity Offsets Strategy, developed to provide for the long-term conservation of threatened and migratory species, including their habitats, has enabled enhancement of the program through further research, such as this study, of areas proposed for FHA declaration.

This study compliments the initial Fisheries Resource Assessments (FRA) of the Leekes Creek estuary (frc environmental 2014) as well as the seasonal Fisheries Resource Assessments (frc environmental 2015). The study was established to inform the expansion of the proposed Fish Habitat Area to include areas of critical habitat adjacent (and ecologically linked) to the initial area of interest.

Leekes Creek is on Great Keppel Island (23.17°S, 150.955°E) (Table 2.1). The island covers an approximate area of 14.5 km², is within the Great Barrier Reef World Heritage Area, 15 kilometres off the mainland coast. Great Keppel Island experiences a tidal range of approximately 4.0 metres. Leekes Creek is lined with mangrove communities and the channels drain at low tide, with small pools of water remaining. Above tidal waters, the Leekes Creek area has been identified as significant habitat for terrestrial flora and fauna (Chenoweth EPLA 2011).

The objective of this study was to provide a broad-based, 'snap-shot' description of the benthic habitat, and floral and faunal communities, in the vicinity of Leekes Creek and a number of nearby locations: Half Tide Rocks, Passage Rocks, Leekes Point, Little Peninsula, and Big Peninsula. Sediment samples were also collected throughout to provide a broad analysis of sediment quality in the area.

2 Methods

2.1 Habitat, Benthic Communities and Fishes

On-site surveys were undertaken on 4 May 2015 and sediment was collected on 6 May 2015. The weather was fine and sunny with light winds (<5 knots) in the afternoons. Spring tides contributed to a tidal range of 0.70 to 4.10 m (Table 2.1).

Table 2.1 Survey dates, tidal heights and times.

Tide	4 May 2015		6 May 2015	
	Time	Height (m)	Time	Height (m)
low	0317	0.94	0431	1.00
high	0902	3.86	1026	3.50
low	1505	0.74	1618	0.90
high	2127	4.32	2247	4.10

At each of the 5 locations (Map 2.1), timed swims were used as the basis for data collection (Wen et al. 2012). Two scientists on snorkel spent approximately 45 minutes haphazardly exploring each site, taking between 30 to 40 photographs of the benthic habitat (frame size approx. 400 x 400 mm), and counts of fishes. Photographs were also taken to support the description of corals and other taxa (e.g. algae, poriferas, cnidarians).

In the laboratory, 20 photographs were selected randomly for analysis. The percent cover of algae and sessile invertebrates (e.g. barnacles and mussels) was assessed in each photograph (quadrat) using Coral Point Count software (Kohler and Gill 2006). Each quadrat was divided into a 5x5 grid, and two points randomly allocated to each grid. The categories used were:

- hard coral
- soft coral
- macroalgae
- turf algae on coral rubble
- turf algae on rock surface
- coralline algae

- zoanthid
- sponge
- ascidian
- rocky substrate
- coral rubble
- bare sand, and
- other.

The points were used to calculate the percent cover of the habitat type encountered (Edgar & Barrett 1997).

During the timed swims, scientist also assessed coral health looking for signs of coral disease (e.g. bleaching or black band disease). Evidence of coral disease was determined by common visual signs:

- coral bleaching – whitening of corals (Brown 1997)
- black band disease – a consolidated bacterial mat (usually black) migrating from top to bottom that prefers massive corals and leaves behind dead skeletal surfaces (Frias-Lopez et al. 2003)
- white band disease – common on branching corals starting at the base moving outwards (Ritchie & Smith 1998)
- white syndrome – advancing tissue lesions that can result in total coral mortality (Sussman et al. 2008), and
- brown band disease – distinct brown zone of coral derived from ciliates on the surface (Bourne et al. 2007).

2.2 Sediment

Sediment samples were collected from 3 locations (site 1, site 2 and site 3) (Map 2.1) using a van Veen grab. At each site a representative sample of approximately 200 g of sediment was retained for particle size distribution (PSD), metals, pesticides, total organic carbon (TOC), and nutrient analyses in accordance with Buchanan (1984) and Greiser and Faubel (1988). Samples were refrigerated until being transported within recommended holding times to the NATA accredited laboratory (Symbio Alliance) for analysis. All site coordinates were recorded using a GPS.

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Leekes Creek Estuary Habitat Assessment

Map 1.1: Sites surveyed

SOURCES

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LEGEND

Sites surveyed

- Habitat sites
- Sediment sites

N

SCALE

0 100 200 400 600 800

Metres

Scale: 1:15,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2015-06-05

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3 Results

3.1 Half Tide Rocks

Habitat and Benthic Communities

Half Tide Rocks is a shallow, rocky reef (up to 12 m depth) with surrounding sand and silt lying to the North of Great Keppel Island. The upper reef slope is dominated by hard corals (predominantly branching *Acropora* colonies), soft corals and turf algae on coral rubble (Figure 3.1 and Figure 3.2). On the lower reef slope hard corals (predominantly massive forms), soft corals, algae, sand and coral rubble comprise the benthic communities and benthic structure. No coral disease was noted at this site.

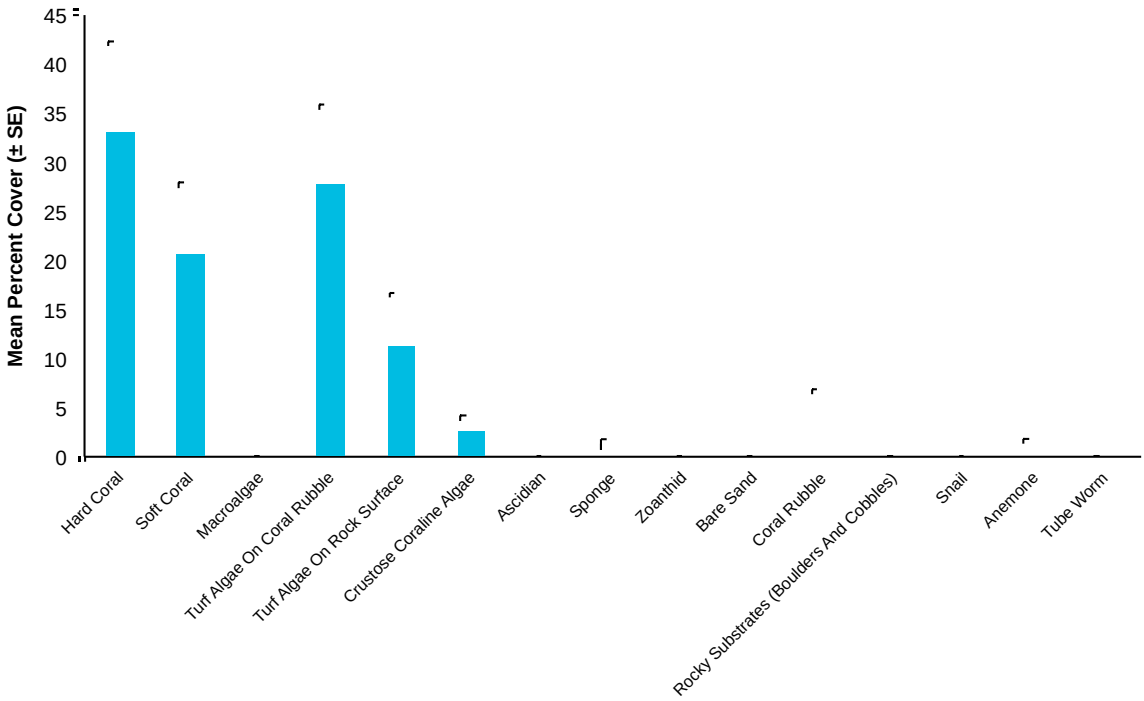
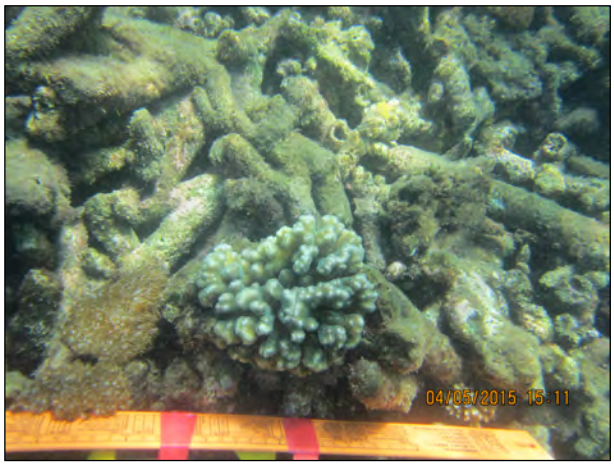


Figure 3.1 Percent cover of benthic community (± SE) at Half Tide Rocks.

Figure 3.2

Turf algae on coral rubble with some hard and soft coral.



Fish

Fish communities were represented by reef fish commonly found on the Great Barrier Reef (Table 3.1). Fish were dominated by large schools of Barrier Reef chromis and anthias (Figure 3.3).

Table 3.1 Fish recorded at Half Tide Rocks.

Family	Species Name	Common Name
Anthiinae	*Pseudanthias* sp.	anthias
Apogonidae	*Apogon* sp.	cardinal fish
Blenniidae	*Salarias fasciatus*	jewelled blenny
Chaetodontidae	*Chaetodon* sp.	butterfly fish
Labridae	*Halichoeres* sp.	wrasse
	Thalassoma lunare	moon wrasse
	Halichoeres margaritaceus	pink-belly wrasse
Pomacentridae	*Abudefduf vaigiensis*	sergeant major
	Amphiprion chrysopterus	tomato anemone fish
	Chromis nitida	Barrier Reef chromis
	Parma oligolepis	big scaled scaly fin
Scaridae	*Scarus frontalis*	reef crest parrotfish
	Scarus sp.	parrotfish

Family	Species Name	Common Name
Serranidae	*Epinephelus tauvina*	reef cod
Sparidae	*Acanthopagrus australis*	yellowfin bream
Tetraodontidae	*Arothron manilensis*	striped puffer
Tripterygiidae	*Helcogramma* sp.	bigmouth triple fin

Figure 3.3

Schooling anthias around a rocky outcrop at Half Tide Rocks.

3.2 Passage Rocks

Habitat and Benthic Communities

Passage Rocks is an elongate reef in 6 – 9 m of water, to the west of Great Keppel Island. The location is subject to strong currents and characterised by two main groups of rocks surrounded by sand. The upper reef is dominated by hard corals, whilst the lower reef is dominated by hard corals, and turf algae on coral rubble and rock surfaces (Figure 3.4). Hard corals on the upper reef were dominated by branching forms, predominantly *Acropora* spp. (Figure 3.5). Minor coral disease was noted with some coral bleaching occurring of *Acropora*.

In previous surveys of Passage Rocks, there was a higher mean percent cover of macroalgae (between 30 and 65%); however, the mean percent cover of hard corals and turf algae was relatively similar (frc environmental 2012).

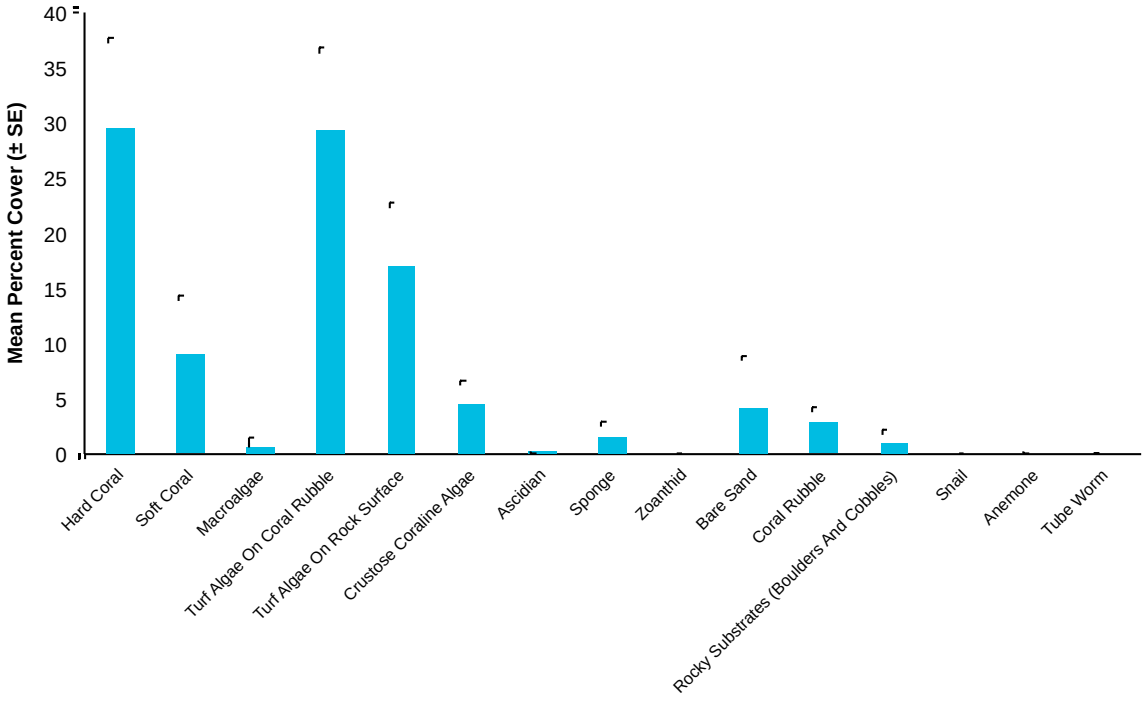


Figure 3.4 Percent cover of benthic community (± SE) at Passage Rocks.

Figure 3.5

Acropora spp. and turf algae on the upper reef at Passage Rocks.

Fish

Fish communities were represented by reef fish commonly found on the Great Barrier Reef (Table 3.2). Fish were sparse and dominated by a few individuals from each species.

Table 3.2 Fish species recorded at Passage Rocks.

Family	Species Name	Common Name
Apogonidae	*Apogon* sp.	cardinal fish
Dasyatidae	*Dasyatis kuhlii*	blue-spotted stingray
Labridae	*Halichoeres* sp.	wrasse
Monocanthidae	*Amanses scopas*	brush-sided leatherjacket
Pomacanthidae	*Chaetodontoplus meredithi*	Queensland yellowtail angelfish
Pomacentridae	*Abudefduf vaigiensis*	sergeant major
	Chromis analis	yellow chromis
	Chromis nitida	Barrier Reef chromis
	Parma oligolepis	big scaled scaly fin
Scaridae	*Scarus* sp.	parrotfish
Serranidae	*Epinephelus tauvina*	reef cod
	Diploprion bifasciatum	yellow emperor
Siganidae	*Siganus lineatus*	golden-lined spinefoot
Sphyraenidae	*Sphyraena flavicauda*	yellowtail barracuda
Tripterygiidae	*Helcogramma* sp.	bigmouth triple fin

3.3 Leekes Point

Habitat and Benthic Communities

Leekes Point is at the headland adjoining the Leekes Creek inlet. The area is characterised by strong tidal runs from the creek. A large amount of coral rubble was noted in the deeper sections of the site. Leekes Point was dominated by turf algae on rock surfaces and soft corals (Figure 3.6). Of the five sites surveyed, this site had the greatest observed proportion of soft corals. No coral disease was noted at this site.

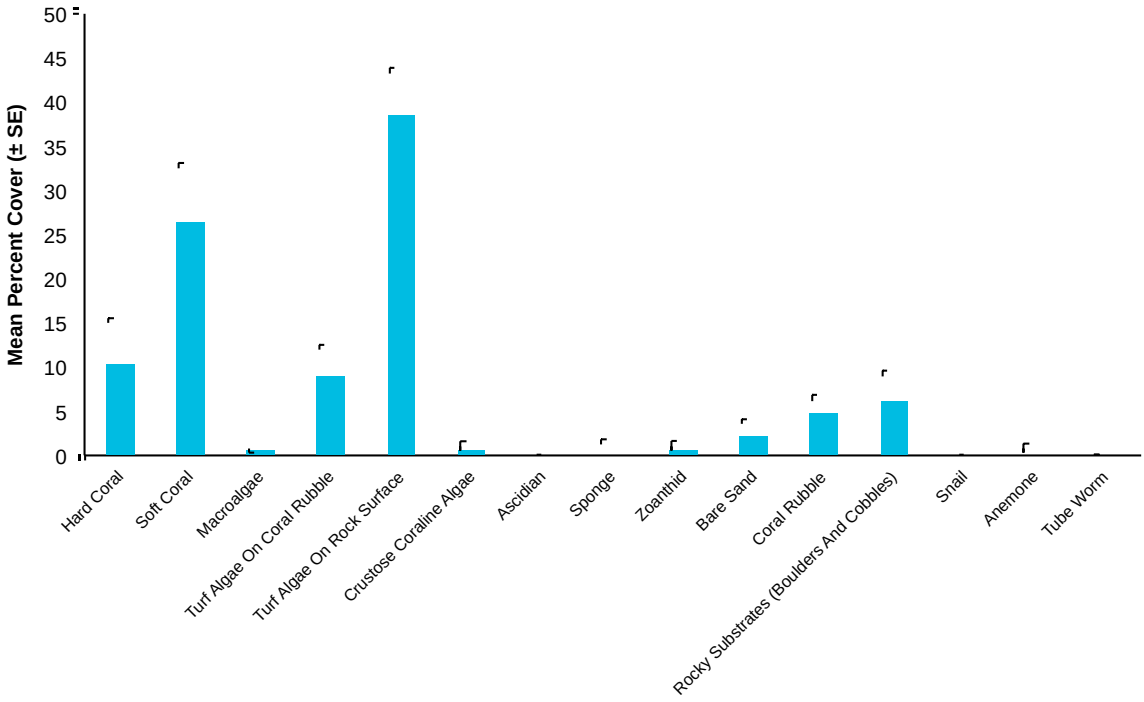


Figure 3.6 Percent cover of benthic community (± SE) at Leekes Point.

Fish

Fish communities were represented by reef fish commonly found on the Great Barrier Reef (Table 3.3). Small schools (5–10 individuals) of wrasse dominated the community.

Table 3.3 Fish species recorded at Leekes Point.

Family	Species Name	Common Name
Acanthuridae	*Acanthurus* sp.	surgeonfish
Apogonidae	*Apogon* sp.	cardinal fish
Balistidae	*Balistidae*	triggerfish
Blenniidae	*Salarias fasciatus*	jewelled blenny
Carangidae	*Gnathanodon speciosus*	golden trevally
Cetorhinidae	*Orectolobus* sp.	wobbegong
Dasyatidae,	*Dasyatis* sp.	stingray
Gerreidae	*Gerres oyena*	silver biddy
Labridae	*Halichoeres* sp.	wrasse
	Thalassoma lunare	moon wrasse
Malacanthidae	*Malacanthus latovittatus*	blue blanquillo
Mullidae	*Upeneus tragula*	freckled goatfish
Pomacentridae	*Abudefduf vaigiensis*	sergeant major
	Chromis analis	yellow chromis
	Chromis nitida	Barrier Reef chromis
	Parma oligolepis	big scaled scaly fin
Serranidae	*Diploprion bifasciatum*	yellow emperor
Siganidae	*Siganus lineatus*	golden-lined spinefoot
Sparidae	*Acanthopagrus australis*	yellowfin bream

3.4 Little Peninsula

Habitat and Benthic Community

Little Peninsula is on the western shore of Great Keppel Island, at the northern end of Svendsons Beach. Shallow fringing reefs slope down to sand at approximately 5 m. The reef was mainly composed of hard corals (*Acropora* sp.) and rocky substrates in the shallower areas and a mixture of corals (hard and soft), turf algae and rocky substrates in the deeper areas (Figure 3.7). No coral disease was noted at this site.

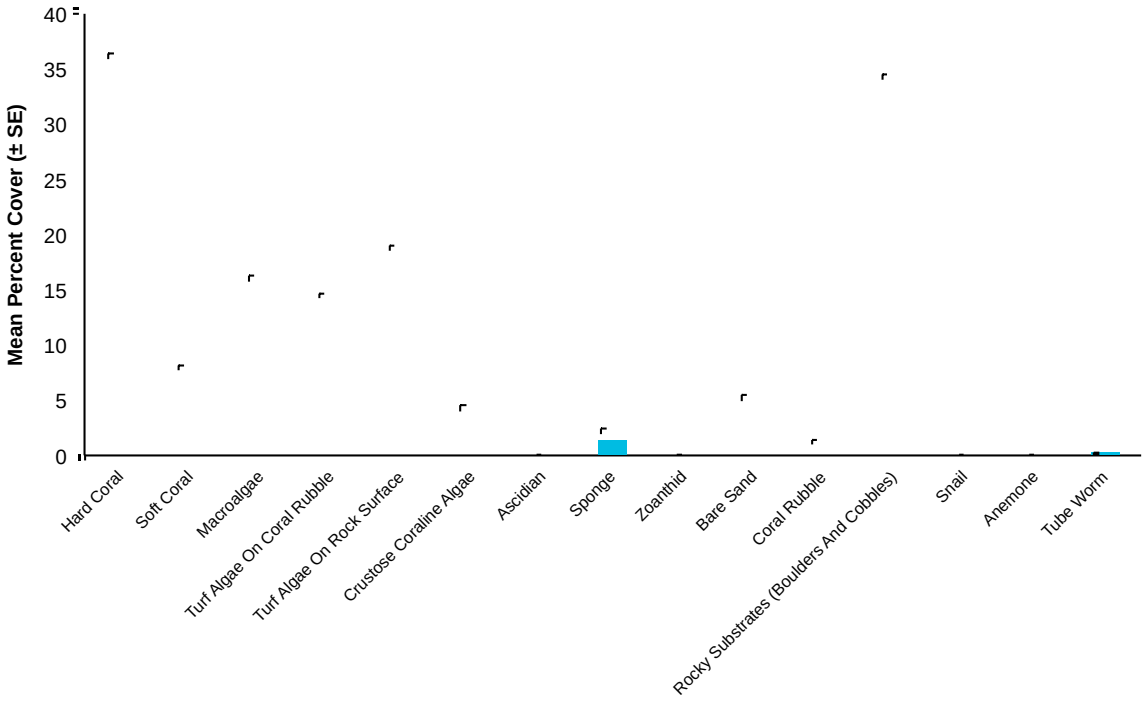


Figure 3.7 Percent cover of benthic community (± SE) at Little Peninsula.

Fish

Fish communities were represented by reef fish commonly found on the Great Barrier Reef (Table 3.4). Fish were sparse and the community was dominated by a few individuals from each species.

Table 3.4 Fish species recorded at Little Peninsula.

Family	Species Name	Common Name
Acanthuridae	*Acanthurus* sp.	surgeonfish
Gerreidae	*Gerres oyena*	silver biddy
Kyphosidae	*Microcanthus strigatus*	stripey
Labridae	*Choerodon jordani*	Jordan's tusk fish
	Halichoeres sp.	wrasse
Lutjanidae	*Lutjanus russelli*	Moses' perch
	Thalassoma lunare	moon wrasse
Mullidae	*Upeneus tragula*	freckled goatfish
Pomacentridae	*Abudefduf vaigiensis*	sergeant major
	Chromis analis	yellow chromis
	Chromis nitida	Barrier Reef chromis
	Parma oligolepis	big scaled scaly fin
Serranidae	*Epinephelus tauvina*	reef cod
Sparidae	*Acanthopagrus australis*	yellowfin bream

3.5 Big Peninsula

Habitat and Benthic Communities

Big Peninsula is on the western side of the headland at the northern end of the island. The location is surrounded by sharply sloping, extensive fringing reefs on the eastern side, and a shallower, 3 m deep platform on the western side, sloping to sand at approximately 12 m. The upper reef was dominated by coral rubble and rocky substrates with some robust encrusting corals, which was likely due to the shallow water and exposure to wave action (Figure 3.8 and Figure 3.9). The deeper areas were dominated by *Acropora* spp. communities. There was minor evidence of coral disease at this site, with some *Acropora* showing signs of recent coral bleaching (Figure 3.10).

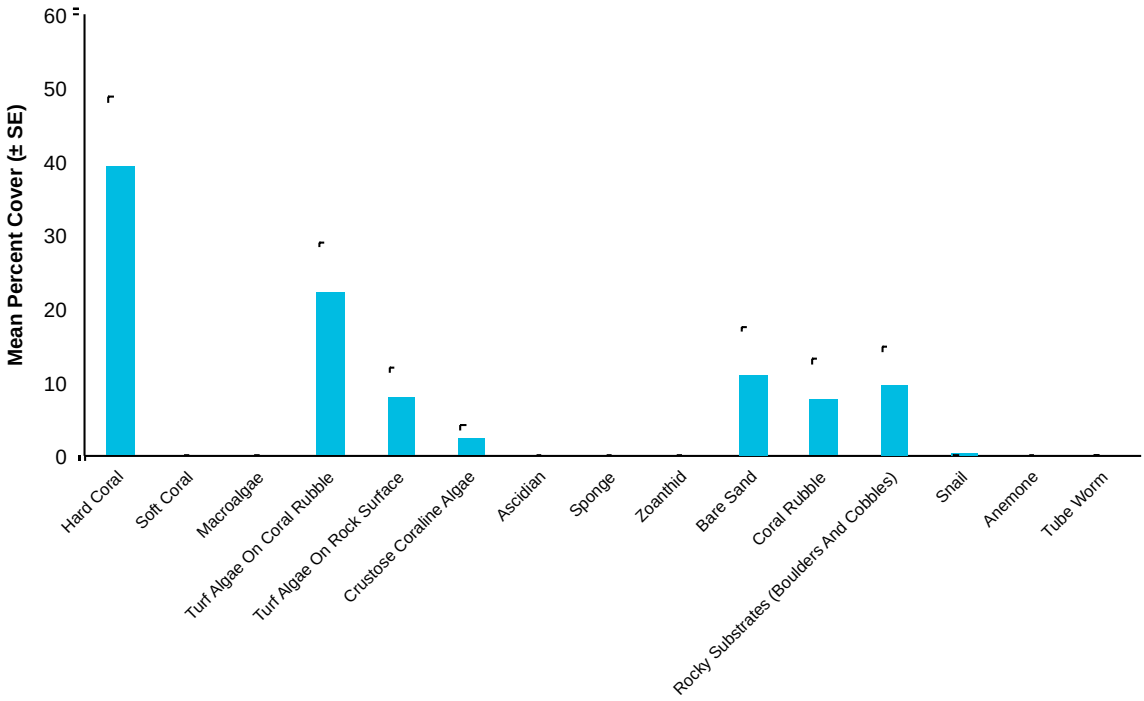


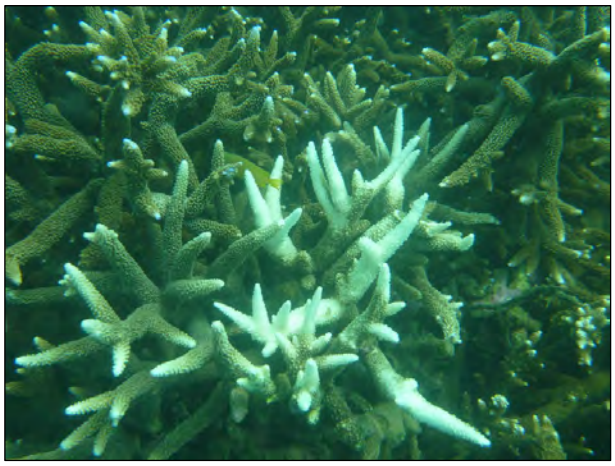
Figure 3.8 Percent cover of benthic community (± SE) at Big Peninsula.

Figure 3.9

Coral rubble and encrusting coral at Big Peninsula.

Figure 3.10

Bleaching of *Acropora* spp. at Big Peninsula.



Fish

Fish communities were represented by reef fish commonly found on the Great Barrier Reef (Table 3.5). There were large schools of yellow chromis and Barrier Reef chromis living amongst the branching coral and several schools of double bar and golden lined spinefoot were swimming throughout the area. This site had the highest relative abundance of fish, which was likely due to the higher mean percent cover of hard corals.

Table 3.5 Fish species recorded at Big Peninsula.

Family	Species Name	Common Name
Acanthuridae	*Acanthurus* sp.	surgeonfish
Blenniidae	*Atrosalarias fuscus*	brown coral blenny
Chaetodontidae	*Chaetodon* sp.	butterfly fish
Gobiidae	*Istigobius decoratus*	decorated goby
Labridae	*Halichoeres chrysus*	golden wrasse
	Halichoeres margaritaceus	pink-belly wrasse
	Labroides dimidiatus	cleaner wrasse
	Thalassoma lunare	moon wrasse
Pinguipedidae	*Parapercis cylindrica*	sharp nose sand perch
Pomacentridae	*Abudefduf vaigiensis*	sergeant major
	Chromis analis	yellow chromis
	Chromis nitida	Barrier Reef chromis
	Chrysiptera glauca	grey damsel
	Pomacentrus amboinensis	neon damsel
Serranidae	*Diploprion bifasciatum*	yellow emperor
	Epinephelus tauvina	reef cod
	Plectropomus leopardus	coral trout
Siganidae	*Siganus doliatus*	double bar spinefoot
	Siganus lineatus	golden-lined spinefoot

3.6 Sediment Quality

At each site, the sediment particle size distribution was dominated by fine sands (Appendix A).

The concentration of all metals was below the National Assessment Guidelines for Dredging (NAGD) (2009) and ANZECC & ARMCANZ Interim Sediment Quality Guidelines low trigger values, where available, at each site. Total petroleum hydrocarbons and pesticides were below the laboratory's Limit of Reporting (thus below the NAGD Screening limits were available) (Appendix A). Neither NAGD or ANZECC & ARMCANZ provide guidelines for nutrients in sediment; however, the concentration of nutrients was relatively low throughout.

Overall, the sediments analysed from the Leekes Creek estuary and adjacent coastal waters are essentially uncontaminated.

4 Conclusions

4.1 Habitat and Fishes

Half Tide Rocks

The benthic community mostly comprised hard and soft corals, and turf algae that supported a variety of fish. There were signs of structural damage from the recent tropical cyclone; however, no coral diseases were observed. Fish recorded included species of recreational, commercial and indigenous importance to the area.

Passage Rocks

The benthic community mostly comprised hard corals and turf algae on coral rubble and rocky surfaces. The corals showed minor evidence of coral disease (i.e. coral bleaching). The cover of macroalgae was lower than previously recorded at this site, which was likely due to the recent tropical cyclone passing through the area. Fish recorded included species of recreational, commercial and indigenous importance to the area. This site was also in close proximity to the Great Barrier Reef Marine Park green zone around Middle Island and would provide connectivity for fish between Middle Island and the Leekes Creek estuary and adjacent bays.

Leekes Point

The benthic communities mostly comprised soft corals and turf algae on rocky surfaces, with a variety of other habitat types (e.g. macroalgae and turf algae). There were no sign of coral disease. Fish recorded included species of recreational, commercial and indigenous importance to the area.

Little Peninsula

The benthic communities mostly comprised hard corals and rocky substrates, and there were no sign of coral disease. Fish recorded included species of recreational, commercial and indigenous importance to the area.

Big Peninsula

The benthic communities comprised a variety of habitats, including hard coral, turf algae, coral rubble and rocky substrates. There were signs of coral bleaching on *Acropora*; however, this was only observed on a few branches and was not widespread over the

area. Fish recorded included species of recreational, commercial and indigenous importance to the area.

4.2 Sediment Quality

Overall, the sediments analysed from the Leekes Creek estuary and adjacent coastal waters are essentially uncontaminated. There was no evidence that run-off from the Fitzroy River were having an impact on the sediment.

4.3 Assessment of Inclusion in Fish Habitat Area

This broad-based survey of habitat in the vicinity of Leekes Creek and adjacent coastal waters confirms the results of earlier studies (Jones et al. 2011a): both hard and soft corals are abundant and hard coral communities are dominated both in terms of percent cover and species richness, by branching forms (*Acropora* spp). Throughout the Keppel Islands, fast-growing, branching *Acropora* corals grow on relatively low relief fringing reef slopes and flats and provide much of the reefs' structural complexity (Diaz-Pulido et al. 2009).

The significant quantity of coral rubble observed in this survey, particularly at sites with higher wave exposure, are likely to reflect the effects of Cyclone Marcia (February 2015). Cyclones are among the most severe physical disturbances to affect coral reefs (Harmelin-Vivien 1994; Lugo-Fernandez & Gravios 2010) and similar local events have been previously recorded (van Woesik & DeVantier 1995; Bostok et al. 2006). Flooding and the change in water quality has contributed to the decline in coral reef condition in the region in 2010, 2011, 2012, and 2013 (Jones et al. 2011b; Thompson et al. 2013). Exposure to low salinity flood waters in 2011 caused a marked reduction in coral cover and juvenile density down to at least two metres depth on reefs inshore of Great Keppel Island (Thompson et al. 2013). Significant loads of suspended sediment and particulate nutrients are similarly discharged in high flow events from erosion and dissolved nutrients from urban and rural areas within the catchment (Devlin et al. 2012).

A decrease in coral cover (as may result from cyclonic weather) can have a direct, negative impact on fish communities (Williamson et al. 2014). Minor coral bleaching was recorded at Passage Rocks and at Big Peninsula, while there was no evidence of bleaching or other diseases at the other three sites. Marine reserves can make a

significant contribution to the replenishment of impacted populations on reefs both within and adjacent to the reserves (Emslie et al. 2015).

From this survey the most abundant fish species observed were the yellow and Barrier Reef chromis (*Chromis analis* and *Chromis nitida* respectively) and wrasses (*Halichoeres* sp. and *Thalassoma lunare*). The most widespread species were the yellow and Barrier Reef chromis, wrasses, sergeant majors (*Abudefduf vaigiensis*), big-scaled scalyfin (*Parma oligolepis*) and surgeonfish (*Acanthurus* sp.), being recorded at most sites. Large carnivorous fish species (e.g. reef cod (*Epinephelus tauvina*) and coral trout (*Plectropomus leopardus*)), were uncommon. Overall, the species recorded were all typical of the region (DAF 2013).

Several species recorded from the five sites have also been recorded in Leekes Creek (frc environmental 2014; 2015). Species recorded in this snap-shot assessment and previously in Leekes Creek were the:

- barracuda
- blue-spotted stingray
- golden trevally
- Moses perch
- spinefoot
- silver biddy, and
- yellowfin bream.

The inshore reefs adjacent to Leekes Creek contribute to the sea-scape mosaic of habitats critical to the life-cycle of many of the species recorded in this survey, as well as providing foraging grounds and refuge during low tide, when access to the creek is restricted. Overall, based on the snap-shot survey of benthic habitat and fish, the five sites surveyed would be valuable additions to the proposed Leekes Creek FHA.

5 References

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Appendix A Sediment Quality Results

Parameter	Units	ANZEC & ARMCANZ ISQG-low Trigger Value	Site 1	Site 2	Site 3
Particle Size Distribution					
gravel	%w/w	–	1	0	3
sand	%w/w	–	94	96	95
silt/clay	%w/w	–	5	4	2
Total Petroleum Hydrocarbon					
C10–C16 fraction	mg/kg	–	<50	<50	<50
C16–C34 fraction	mg/kg	–	<100	<100	<100
C34–C40 fraction	mg/kg	–	<100	<100	<100
Nutrients					
ammonium	mg/kg	–	1.4	0.74	0.66
nitrate	mg/kg	–	0.54	0.58	<0.50
total nitrogen	mg/kg	–	<40	<40	<40
total phosphorous	mg/kg	–	15	20	14
organic carbon	%w/w	–	<0.15	0.37	<0.15
Pesticides	mg/kg	–	*	*	*
Metals and Metalloids					
antimony	mg/kg	2	<1	<1	<1
arsenic	mg/kg	20	1.4	1.6	2.4
cadmium	mg/kg	1.5	<0.5	<0.5	<0.5
chromium	mg/kg	80	4.3	4.5	5.2
cobalt	mg/kg	–	0.6	0.7	0.9
copper	mg/kg	65	1.7	2.1	1.3
lead	mg/kg	50	<1	1	<1
manganese	mg/kg	–	52.4	42.2	83.3
mercury	mg/kg	0.15	<0.5	<0.5	<0.5
molybdenum	mg/kg	–	<0.5	<0.5	<0.5

Parameter	Units	ANZEC & ARMCANZ ISQG-low Trigger Value	Site 1	Site 2	Site 3
nickel	mg/kg	21	1.1	1.1	1.1
selenium	mg/kg	–	<1	<1	<1
tin	mg/kg	–	<1	<1	<1
silver	mg/kg	1	<1	<1	<1
zinc	mg/kg	200	<5	<5	<5

* all pesticides below laboratory limits of reporting