

**Fisheries Resources of Leekes Creek,  
Great Keppel Island**  
Central Queensland  
2014

Prepared by: Queensland Parks and Wildlife Service, Department of National Parks, Sport and Racing

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## List of Acronyms and Abbreviations

CHRIS	Coastal Habitat Resources Information Service
CQRP	Central Queensland Regional Plan
DAFF	Department of Agriculture Fisheries and Forestry (Qld)
DIWA	Directory of Important Wetlands in Australia
FHA	Fish Habitat Area
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
GKI	Great Keppel Island
GVP	Gross value of production
HAT	Highest astronomical tide
NCA	Queensland <i>Nature Conservation Act 1992</i>
NPRSR	Department of National Parks, Recreation, Sport and Racing (Qld)
QPWS	Queensland Parks and Wildlife Service
SPP	Queensland's State Planning Policy
SPRP	Coastal Protection State Planning Regulatory Provision
TUMRA	Traditional Use of Marine Resources Agreement
TV	Trigger value
WQO	Water quality objectives

## Executive summary

This fisheries resource assessment report provides an overview of the fish habitats and fisheries resources of the Leekes Creek study area. It is a compilation of information and data sourced from literature, reports, community knowledge and field surveys. Included is information relating to surrounding land uses, disturbances, administrative and legislative jurisdictions, as well as any other impacts and considerations for fisheries resource management in the area. The findings of this report inform consideration of the Leekes Creek study area for declaration as a Fish Habitat Area (FHA) through the delivery of a thorough and comprehensive overview of the current fisheries values, productivity and habitat status.

One of the main purposes of this report is to assess the suitability of the study area to be incorporated into Queensland's declared Fish Habitat Area (FHA) network. This assessment of suitability is done by assessing the study area against a series of criteria under two categories - fisheries (four criteria) and fish habitat criteria (eight criteria). The presence of any regionally unique fish habitat features is also assessed.

The Leekes Creek study area lies on the continental Great Barrier Reef Island, Great Keppel Island (GKI). GKI is located within the Capricorn Coast, Central Queensland, approximately 48km east of Rockhampton. It is the largest of 16 islands within the Great Barrier Reef Mackay/Capricorn region's Keppel Group and one of only two that are not designated as National Parks under the *Nature Conservation Act 1992*. The study area boundary runs in a direct line from Putney Point on the western border, to Little Peninsula to the north-east and incorporates the entire Leekes Creek estuary along the highest astronomical tide mark (HAT), encompassing approximately 280 hectares (ha).

The Woppaburra people, Traditional Owners of the Keppel Islands, lived on the islands for at least 5000 years until shortly after European settlement when they were forcibly removed (Rowland 2004). Grazing was the primary land use on the island from the 1860's to 1970's and a number of feral goats still inhabit the island. The primary use of GKI since the 1970's has been as a relatively low impact recreation and tourism destination. Construction of a 941ha resort development is scheduled to commence in 2014 which will increase the development footprint and visitor capacity significantly. GKI lies within the Livingstone Shire Council area.

Minimal literature and data relating to Leekes Creek currently exists, therefore additional field surveys were conducted during the compilation of this report to supplement existing data. Field assessments were performed on land and water to identify any previously undocumented habitats and artificial structures. Personal communication with local community members and representatives of local fishing clubs complement published information and provided local knowledge of the study area and its productivity. Fish surveys and a seagrass assessment were conducted to provide an inventory of fish assemblages, abundance and diversity and to map the current extent and nature of known seagrass meadows.

Utilising all available information, the fish habitats of the Leekes Creek study area were assessed against the above criteria and were found to be representative of the level of high quality and diverse fish habitats that the declared FHA network aims to protect. The Leekes Creek study area contains a diverse and abundant range of both inshore and offshore fish species. It supports a popular recreational fishery within its boundaries as well as a productive commercial and recreational fishery in adjacent waters. The Leekes Creek study area contains a significant area of complex, available and diverse fish habitats including fringing reefs, mangrove communities, seagrass meadows, rocky outcrops and intertidal saltmarsh and saltpans. Water quality remains at a high level within the Leekes Creek study area and very few artificial structures have been erected within its boundaries.

The Leekes Creek study area represents a healthy, regionally unique and productive estuarine and near shore environment, which is making a valuable contribution to local fish abundance and diversity. It fulfils all of the four fisheries criteria, all eight of the habitat criteria and the regionally unique feature criteria. It is recommended the Leekes Creek study area be declared an FHA.

The following recommendations are based on the findings of this report.

## Recommendations

1. For the Department of National Parks, Recreation, Sport and Racing (NPRSR) to proceed to public consultation with a view to declare the Leekes Creek study area an FHA under the *Fisheries Act 1994*. (Chapter 11 outlines the suitability of the Leekes Creek study area as compared to the declared FHA selection criteria).
2. To continue close consultation between NPRSR, the Woppaburra people, Local Government, local communities and business owners to ensure culturally significant locations within the study area are highlighted and provide

an avenue to express individual issues and concerns.

3. That the current status of riparian communities be maintained and enhanced where possible and adequate buffer strips be incorporated into future land use within and adjacent to the Leekes Creek study area. This is necessary to support and protect the area's substantial fisheries values.
4. Increased compliance and educational activities be undertaken by the Department of Agriculture, Fisheries and Forestry (DAFF) to prevent further marine plant and fish habitat destruction from unlawful vessel mooring amongst mangroves within Leekes Creek.

## Chapter 1 Introduction

Leekes Creek is an estuarine system on the continental Great Barrier Reef Island, Great Keppel Island (GKI), offshore from the Central Queensland township of Yeppoon. It lies within the Capricorn Coast, approximately 17 kilometres (km) east from the nearest boat ramp which is on the mainland at Rosslyn Harbour and 48km east of the major township of Rockhampton. The Keppel Islands are located directly offshore of the Fitzroy River catchment, which is the largest catchment on the east coast of Australia.

GKI is in the Mackay/Capricorn region of the Great Barrier Reef Marine Park (GBRMP) and is the largest of sixteen islands within the Keppel group, covering an area of approximately 15km<sup>2</sup>. Of the sixteen islands, Great Keppel Island and Pumpkin Island are the only two that are not designated as National Parks under the *Nature Conservation Act 1992*. The GBRMP is a part of the Great Barrier Reef World Heritage Area (GBRWHA), the world's largest World Heritage Area extending 2000km and covering an area of 35 million hectares on the north-east continental shelf of Australia. It is the world's most extensive coral reef system and is one of the world's richest areas in terms of faunal diversity (SEWPC 2013). In addition to coral reefs, the GBRWHA also contains significant areas of seagrass, mangrove, soft bottom communities and island communities (SEWPC 2013).

GKI is a popular tourism destination offering a range of activities such as swimming, diving, snorkelling and bushwalking. It is only accessible by ferry, boat or small light aircraft and there is limited vehicular access throughout the island with transport networks consisting of poorly maintained tracks and trails. On the island there are two backpacker facilities, approximately 20 residential and commercial premises and the Great Keppel Island Resort, which is presently closed and in a dilapidated state. No other major industries exist on the island. The majority of the island is covered by a mix of open forest and woodland, with the remainder a variety of other habitats including wetlands, dwarf shrub land to open heath, mangrove communities and Commonwealth listed critically endangered littoral rainforest and coastal vine thickets of Eastern Australia. Chenoweth (2011) identified the Leekes Creek estuary system as the most important habitat on the island.

GKI has a long history of human habitation. The Woppaburra people, the Traditional Owners of the Keppel Islands, are known to have lived on the islands for at least 5000 years until shortly after European settlement when the last of their people were forcibly removed and sent to Aboriginal missions on the mainland and Fraser Island in 1902 (GBRMPA 2008; Rowland 2004). Archaeological evidence linking the Woppaburra people to the islands include midden sites, burial sites, a bora ring, huts, stone artefacts and campsites. Descendants of the original inhabitants are re-establishing their ties and connections with their traditional homeland and recently have regained ownership and control of 170ha of land on GKI, much of which is adjacent to the Leekes Creek study area.

### 1.1 Fisheries management, fish habitats and fisheries

Commercial, recreational and indigenous fishing is a significant component of Queensland's culture, lifestyle and economy. In the 12 months prior to June 2010, it has been estimated that more than 703 000 Queenslanders went recreational fishing and their economic input from the same period was estimated at over \$73 million (Taylor et al. 2012). The importance of fishing activities is evident in Central Queensland where over 14 340 recreational fishing trips were made in 2007, generating an economic input of over \$5.5 million (frc environmental 2012).

Queensland's commercial fisheries are also significant contributors to the state and national economies and provide vital primary industries for many coastal towns. The annual gross value of production (GVP) for commercial fisheries in Queensland is approximately \$295 million (Williams 2002). Locally, substantial commercial fisheries operate in the greater area around GKI, with almost \$1 million of fish product harvested from the waters directly adjacent to GKI (within a 10Nm radius) in 2011 (DAFF 2013a). An important collection industry for the aquarium trade also exists in the waters around GKI.

A large proportion of fish targeted in Queensland by commercial, indigenous and recreational fishers rely on estuarine habitats for some or all of their lifecycle. Quinn (1992) estimated the number to be as high as 75% in the commercial fishery. Estuaries are amongst the most productive natural habitats in the world (McLusky and Elliott 2004) and their habitats support regional fisheries through the provision of food, shelter, breeding and nursery areas. Despite their importance to local and regional fisheries, human induced impacts such as clearing and land reclamation have resulted in mangrove and salt marsh estuarine habitats to be amongst the most threatened ecological systems globally (Bridgewater and Cresswell 1999). The maintenance and appropriate management of these key fish habitats are vital to ensure the future sustainability of Queensland's fish stocks.

To protect fish stocks and ensure sustainable fishing for future generations, both commercial and recreational fisheries are subject to regulation governing where and when areas may be fished, equipment types that can be utilised and size and possession limits for individual fish species. These measures are complemented by the declared FHA network, which acts to protect appropriate and available fish habitats which are necessary for many fish species to reproduce and/or complete their lifecycle.

## **1.2 Regional fish habitat focus**

Commencing in the late 1960's, FHAs are declared under the *Fisheries Act 1994* and are fundamental to the protection of the state's critical fish habitats. The declared FHA network strategy recognises the complex and interrelated reliance of many species on multiple habitats during their lives and that protecting these habitats and their interconnectivity plays a crucial role in supporting fisheries. The declared FHA concept aims to prevent physical damage from coastal development, whilst still allowing and encouraging community access and use. It has the added benefit of providing a safety net in protecting habitats that are presently poorly understood which may be found to have substantial fisheries values (Baker and Sheppard 2006).

The objective of the FHA concept is to foster a holistic approach to fisheries management by incorporating a wide range of essential habitats. This is considered a much more effective response to protecting fisheries resources than protecting or managing isolated habitats or species. Therefore, expansion of the declared FHA network is fundamental to ensuring a comprehensive, adequate and representative network of key fish habitats are protected for future sustainability.

In 2006, Leekes Creek was nominated by a community member for consideration for declaration as a Fish Habitat Area. For various reasons, including the limited size of the original proposed boundary, this submission was not progressed beyond the initial nomination. As part of the Central Queensland Fish Habitat Area Investigation Program, funded by the Gladstone Ports Corporation's offsets program (GPCL 2012), this area is being revisited, incorporating a larger area to satisfy the minimum criteria as outlined in the FHA selection, assessment, declaration and review policy (NPRSR 2013).

## **1.3 Purpose of report**

This report provides an overview of the Leekes Creek study area and its fish habitat values as they relate to the FHA selection criteria (NPRSR 2013). It provides a summary of available information relevant to the criteria, in addition to management issues, surrounding land uses and other impacts and considerations to the management of fisheries resources in the area. Throughout this report, unless otherwise stated, the term 'fish' refers to finfish, crustaceans, molluscs etc. as defined under the *Fisheries Act 1994*.

## **Chapter 2 Defining the Leekes Creek study area**

### **2.1 *Leekes Creek study area description***

The offshore extent of the Leekes Creek study area is defined by a direct line from Putney Point (23°10'7.18"S, 150°56'5.43"E) to Little Peninsula (23° 9'22.78"S, 150°57'22.41"E) and the inshore boundary extends along the foreshore to highest astronomical tide or cadastral or property boundaries, encompassing the entire Leekes Creek estuarine system (Figure 2.1).

### **2.2 *Local authority boundaries***

Great Keppel Island and the Leekes Creek study area are within the jurisdiction of Livingstone Shire Council. Livingstone Shire Council encompasses 111,776km<sup>2</sup> of land immediately north and east of the city of Rockhampton and includes the main urban centres of Yeppoon, Emu Park, Zilzie and Keppel Sands.

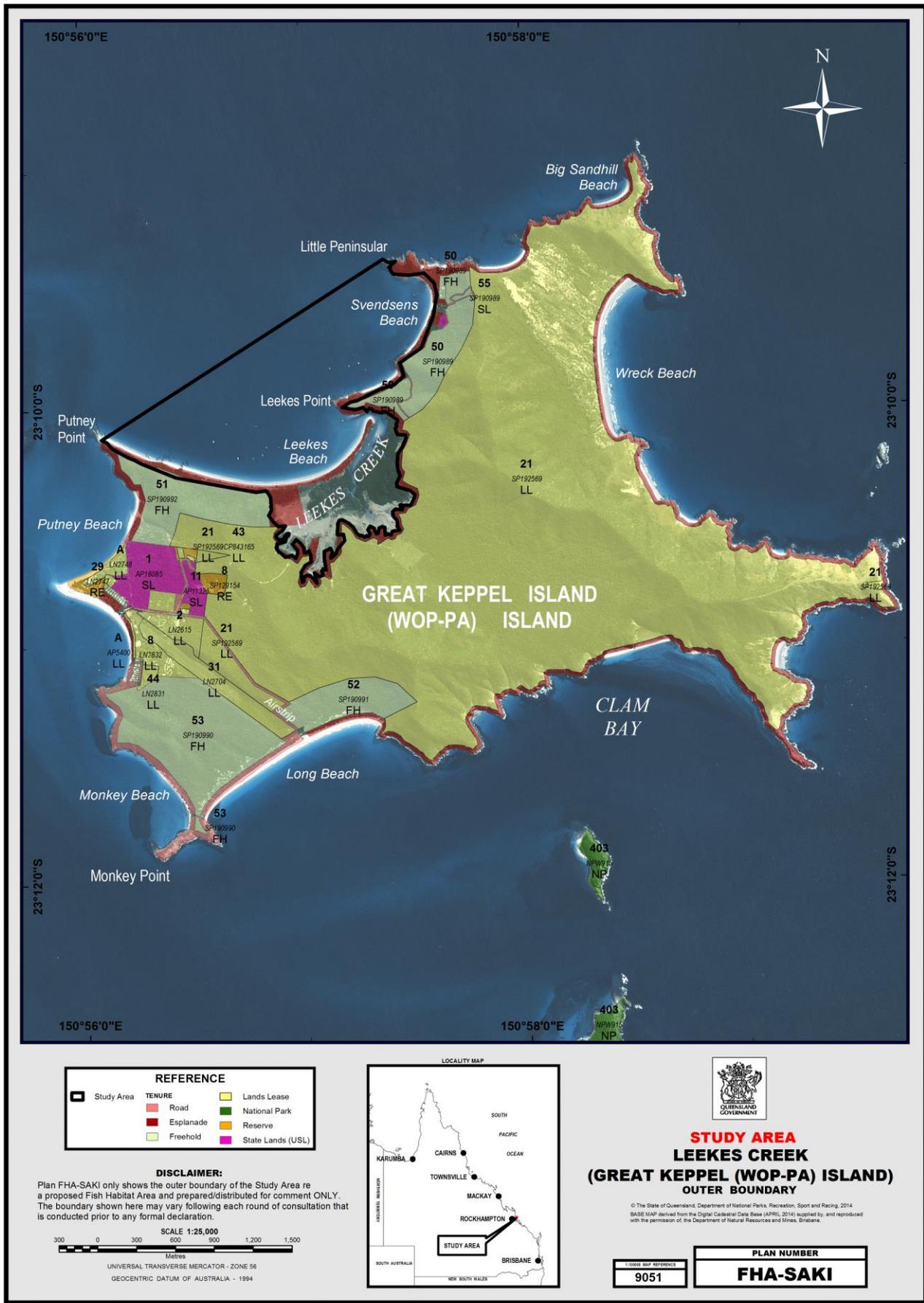


Figure 2.1: Leekes Creek Study Area

## Chapter 3 Faunal communities in the Leekes Creek study area

### Chapter summary

Evidence shows the Leekes Creek study area to be utilised by a diverse range of fish species. In a single three day fish survey, 32 species of fish and 10 species of crab were documented within Leekes Creek. Anecdotal evidence suggests a further 55 fish species and 11 crab species are likely to occur in the area. A large range of these species are of recreational, indigenous or commercial value.

The abundance and diversity of fish identified within the Leekes Creek estuary reflects the range and availability of essential habitats that are contained within the area.

### 3.1 Introduction

Many fish species depend upon estuarine environments for some or all of their lifecycle, therefore a species rich fish community can be a direct indicator of the value of fish habitats in an area. This is reflected in the FHA declaration criteria (NPRSR 2013) which require that for an area to be suitable for FHA declaration, it must contain fish species richness that is comparable to regional benchmark waterways as well as a high diversity and abundance of regionally targeted fish species. The following chapter analyses data and literature gathered relating to the fish species of the study area to determine the fish assemblages, diversity and richness of the Leekes Creek study area.

### 3.2 Data sources

Minimal data has been recorded relating to the fisheries values of the Leekes Creek study area. To expand upon existing data and compile a more comprehensive inventory of fish species found within the area, a fish survey was undertaken in February 2014. This comprised of a single three day survey utilising fyke nets, seine nets, cast nets, crab pots and baited remote underwater videos, with the documentation of fish and crustacean species observed and caught. An assessment of the seagrass meadows in adjacent bays within the study area was conducted during this time, the results of which are documented in chapter 5.2.3.

Further information on faunal communities was sourced from the Great Keppel Island Revitalisation Project's Environmental Impact Study (frc environmental 2012).

### 3.3 Results

Despite the small sampling period during the February 2014 surveys, an impressive diversity of fish and crustacean species were recorded in Leekes Creek (Appendix A). 320 fish were caught and/or recorded, comprising 32 species, from 26 families. Approximately 1180 prawns from the Penaeidae family were caught and 10 different species of crabs were identified. Anecdotal evidence suggests a further 55 fish species and 11 crab species are likely to occur in the study area (Appendix B) and Appendix C provides a full listing of fish species found around the Keppel Islands and fringing reefs.

Of the fish species caught, the majority were adult (61%) with only 8% juvenile. The remainder measured within the intermediate range. The most abundant fish caught were common ponyfish (*Leiognathus equulus*; 23% of total catch) and Endracht hardyhead (*Atherinomorus endrachtensis*; 21.5% of total catch).

The most abundant crab species recorded during the survey was the soldier crab (*Mictyris longicarpus*), with mud crabs (*Scylla serrata*), blue swimmer crabs (*Portunus pelagicus*), hermit crabs (*Diogenidae* spp.) and fiddler crabs (*Uca* spp.) also recorded.

Brown (*Dasyatis fluviatorum*) and blue spotted stingrays (*D. kuhlii*) are known to frequent the creek system in large numbers however only a shovelnose ray (*Aptychotrema* sp.) was recorded during the fish surveys.

In addition to the high fish species diversity found within the Leekes Creek study area, it is also significant to fauna species of conservation significance. Turtle nesting activity has been recorded on Leekes Beach and five of Australia's six species are known to occur in the area, with resident populations of flatback (*Natator depressus*) and green turtles (*Chelonia mydas*) and occurrences of loggerheads (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*). The flatback, green and hawksbill turtles are listed as vulnerable under the *Nature Conservation Act 1992* (NCA) and loggerhead and olive Ridley turtles are listed as endangered.

The wetland area around Leekes Creek and Leekes Beach provide valuable habitat for beach stone curlew (*Esacus magnirostris*), listed as vulnerable under the NCA and rusty monitor (*Varanus semiremex*), listed as a priority species in the Back on Track Actions for Biodiversity, Fitzroy Natural Resource Management region (DERM 2010). Leekes Beach and Leekes Creek have been mapped as Essential Habitat for Beach Stone Curlew by DERM (2012).

## **3.4 Discussion**

### **3.4.1 Species richness**

Despite the small sampling period, an impressive range of fish species were recorded in the Leekes Creek estuary which would indicate a high level of species richness and diversity exists. An ongoing survey regime over a 12 month period would most likely verify this through the documentation of fish species that utilise the area over varying seasons.

A large range of commercial, indigenous and recreationally important fish species were recorded during the survey and many others provide a food source for these fish. A mix of estuarine and reef fish species were amongst those captured and those anecdotally recorded. The most abundant targeted species were yellowfin bream (*Acanthopagrus latus*); sand whiting (*Sillago ciliata*), black bream (*Acanthopagrus palmaris*) and sea mullet (*Mugil cephalus*).

The Leekes Creek study area is offshore from the Cawarral Creek and Fitzroy River declared FHAs which can provide comparison as regional benchmark waterways. A total of 60 fish and 10 crustacean species have been recorded from Cawarral Creek declared FHA and 104 fish species and 16 species of crustacean have been documented in the Fitzroy River declared FHA. The survey data combined with anecdotal evidence from Leekes Creek study area suggests 87 fish species and at least 22 crustacean species are likely to utilise Leekes Creek, which compares extremely favourably with the adjacent declared FHAs and indicates that the Leekes Creek study area is important to local and regional fisheries.

### **3.4.2 Habitat values of Leekes Creek study area**

Many fish and crustacean species utilise a range of habitat types over daily, seasonal and lifecycle timeframes, and have highly specific habitat requirements at certain stages of their lifecycle (e.g. spawning locations). The diversity of fish species recorded in Leekes Creek study area indicates that it contains a wide range of available healthy habitats for utilisation by fish species. The area has sustained very little impact from adjacent land uses and contains minimal in-stream structures.

Additionally, the presence of both adult and juvenile fish species within the estuary suggests that the study area is providing essential habitat throughout the lifecycle of fish species. Examples of essential fish habitats provided by the Leekes Creek study area include salt pans, mangroves, sandy foreshore environments and rocky structures. All of these are important to many targeted fish species for some or all of their lifecycle.

For a comprehensive discussion of habitat values, refer to Chapter 5, Habitat diversity.

### **3.4.3 Introduced marine species**

No introduced marine species have been reported outside of designated ports in the Great Barrier Reef (GBR) (GBRMPA 2011). This was supported by the recent study of the Leekes Creek area (frc environmental 2014), with no introduced species found.

## **3.5 Conclusion**

Results from the February 2014 fish survey supports initial indications that the Leekes Creek estuary contains valuable fish habitats and is utilised by an abundant and diverse range of fish species. Many of the fish and crustacean species documented in the area are of commercial, indigenous and recreational importance. The significance of the large range of fish documented is that a single isolated fish survey is not likely to provide a comprehensive and thorough inventory of fish species. Therefore, the current inventory is likely to only represent a sub-set of the overall fish and crustacean species that utilise the area over varying seasons. Further sampling during autumn, winter and spring would most likely maximise the taxonomic diversity of fish caught and recorded in the Leekes Creek study area.

## Chapter 4 Fisheries of the Leekes Creek study area and surrounds

### Chapter summary

The Central Queensland region supports a range of productive recreational, indigenous and commercial fisheries that are important to the region's economy, culture and lifestyle.

Leekes Creek study area is a popular fishing destination for recreational fishers visiting the island and the adjacent waters support important commercial and recreational fisheries. In a 10Nm radius around GKI, almost \$1 million worth of fish were landed in commercial fisheries in 2011. The surrounding reefs provide a popular destination for recreational fishers with vessel access, as quality reef fish species can be caught without the need to travel great distances offshore. A productive commercial harvest fishery also exists in the waters around GKI.

Many of the fish targeted by recreational, indigenous and commercial fisheries rely on habitats found within estuarine environments for some or all of their lifecycle. The Leekes Creek study area contains an array of essential fish habitats that supports and contributes to the fisheries productivity of adjacent waters.

### 4.1 Introduction

Queensland's commercial, recreational and indigenous fisheries are important to the culture, lifestyle and economy of the state. Within Central Queensland, fishing is an integral part of the culture, a popular pastime and important economic input to local businesses. It contains the Fitzroy River which drains the largest catchment on the east coast of Australia and is widely known as a fishery of regional and state significance (Long and McKinnon 2002). The waters of Keppel Bay support a productive commercial fishery and the Keppel Islands are popular fishing destinations for recreational fishers, providing an opportunity to catch quality reef fish without the requirement to travel great distances offshore.

Many of the fish species targeted by commercial, recreational and indigenous fisheries are estuarine-dependent, which means they spend part of their lifecycle in and rely upon, estuarine habitats (Walker 1997). Robinson and Cully 2013 found that at least 60% of Queensland's recreational catch is sourced from estuaries and Quinn (1992) estimated that 75% of commercial catch landed rely on habitats in estuarine systems for some or all of their lifecycle. For this reason, the productivity of local fisheries is a good indicator of the health and availability of essential fish habitats.

### 4.2 Fishery data sources

Data on fishing output levels was sourced from the DAFF's Coastal Habitat Resources Information System (CHRIS) database (DAFF 2013a). Since 1988, Queensland's commercial fisheries catch statistics have been recorded on CHRIS which stores catch and effort by location through a computer based compulsory commercial fisheries logbook program. Queensland is broken into 30 minute grids for the purposes of recording commercial catch and effort.

Commercial fishing data was obtained for a 10Nm radius around Great Keppel Island (Figure 4.1). The difficulty with such a small grid area is that requirements to ensure confidentiality prohibit data from being released when less than five fishing vessels are operating in an area. This has meant that some data for individual fish species is omitted for several of the years and the following catch figures may underestimate the true value of the fisheries.

Recreational fishing data was sourced from the CHRIS database (DAFF 2013a), which has been recording recreational data since 1997, and the 2010 state wide recreational fishing survey (Taylor et al. 2012). Prayaga et al. (2009) provide information on recreational fishing values and behaviours for the Capricorn Coast, which encompasses the area from Shoalwater Bay in the north to Keppel Sands in the south.

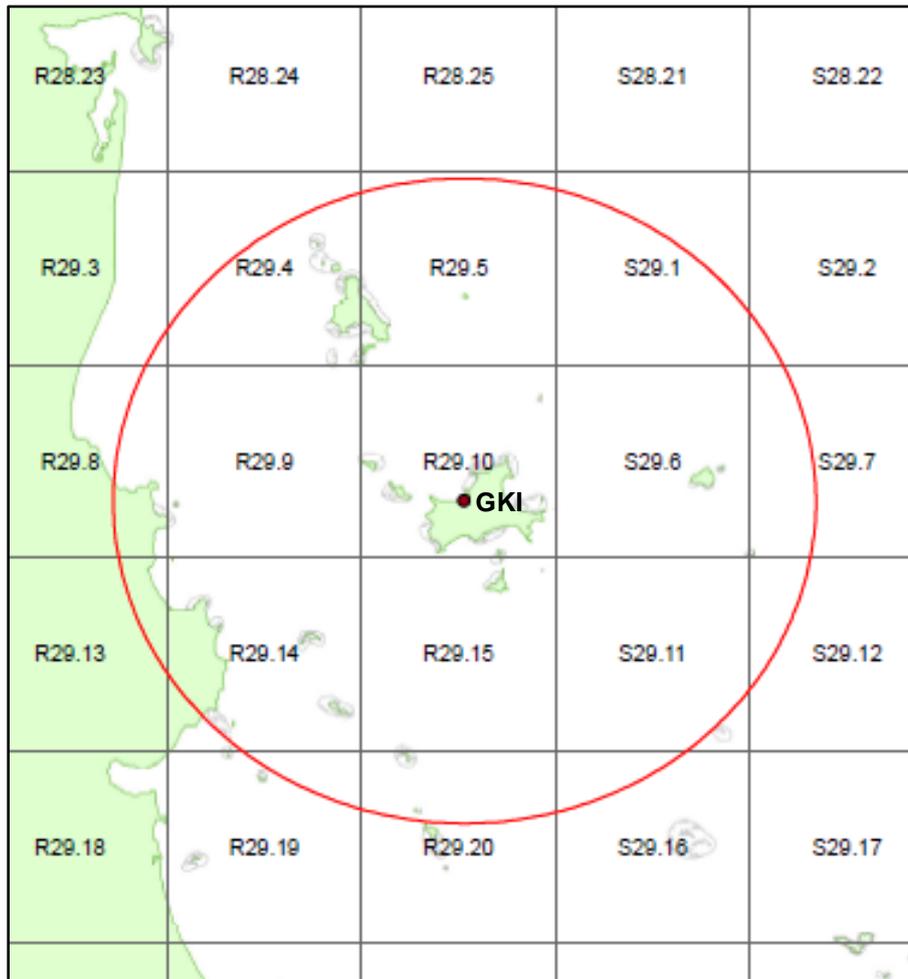


Figure 4.1: 10Nm radius around Great Keppel Island (GKI) used for commercial fishing data extraction

### 4.3 Commercial fishing

Queensland's commercial fisheries are Australia's third largest in value, the eighth most valuable primary producer in Queensland and have an annual GVP of approximately \$295 million (Williams 2002). The trawl fishery is Queensland's largest commercial fishery, with approximately 600 vessels landing up to 10 000 tonnes of product annually (DAFF 2013c).

Central Queensland is a significant contributor to Queensland's commercial fisheries annual GVP. It contains the Fitzroy River declared FHA which plays a critical role in the productivity of important commercial, recreational and indigenous fisheries resources in the region and is widely recognised by recreational and commercial fishers as a fishery of regional and state significance (Long and McKinnon 2002). GKI is offshore (approximately 35km) and to the north-east from the Fitzroy River declared FHA and the habitats contained within the Leekes Creek study area also contribute to local fisheries and increase fish diversity by incorporating additional habitats that can be utilised by different fish species (e.g. fringing reefs and seagrass meadows).

The most significant commercial fisheries within the 10Nm GKI grid are net and otter trawl. Line, pot and collection fishing also occurs, but relatively small numbers of operators utilise the area. Between 2002 and 2011, the average total commercial catch for all fisheries (excluding harvest) was 37.8t, which had a gross value of approximately \$275,000 (ranging from 18.2 t in 2005 to 114.21 t in 2011). The majority of fish caught were penaeid prawns, with banana prawn (*Fenneropenaeus merguensis*) the most targeted species of all fish species recorded.

### 4.3.1 Otter trawl fishery

The otter trawl fishery is the largest commercial fishery in the 10Nm grid around GKI, with penaeid prawns the most targeted fish species. Between 2002 and 2011, the annual average catch for the otter trawl fishery within the 10Nm grid around GKI was 20.34t, which is 53.8% of the average total commercial catch for this area. In 2011 the annual catch rose to 90.61t however effort also rose from an average of 52 days in the previous 9 years, to 281 days fished. Correlation has been made between freshwater flow and increased banana prawn catch rates (Vance et. al. 1985; as cited in Halliday and Robins 2007) which could account for this peak in catch rates (Figure 4.2), which followed significant flood events in 2010-11.

Many species of prawns rely on estuarine habitats such as mangrove lined creeks and seagrass meadows for parts of their lifecycle and without these habitats Queensland's important trawl industry could collapse. Banana prawns (*F. merguensis*) for example, utilise mangrove lined creeks as nursery habitats, moving into coastal waters as they mature, whilst juvenile tiger prawns (*Penaeus* spp.) are mainly found in seagrass meadows and depend on the food and shelter provided in these habitats (GBRMPA 2011).

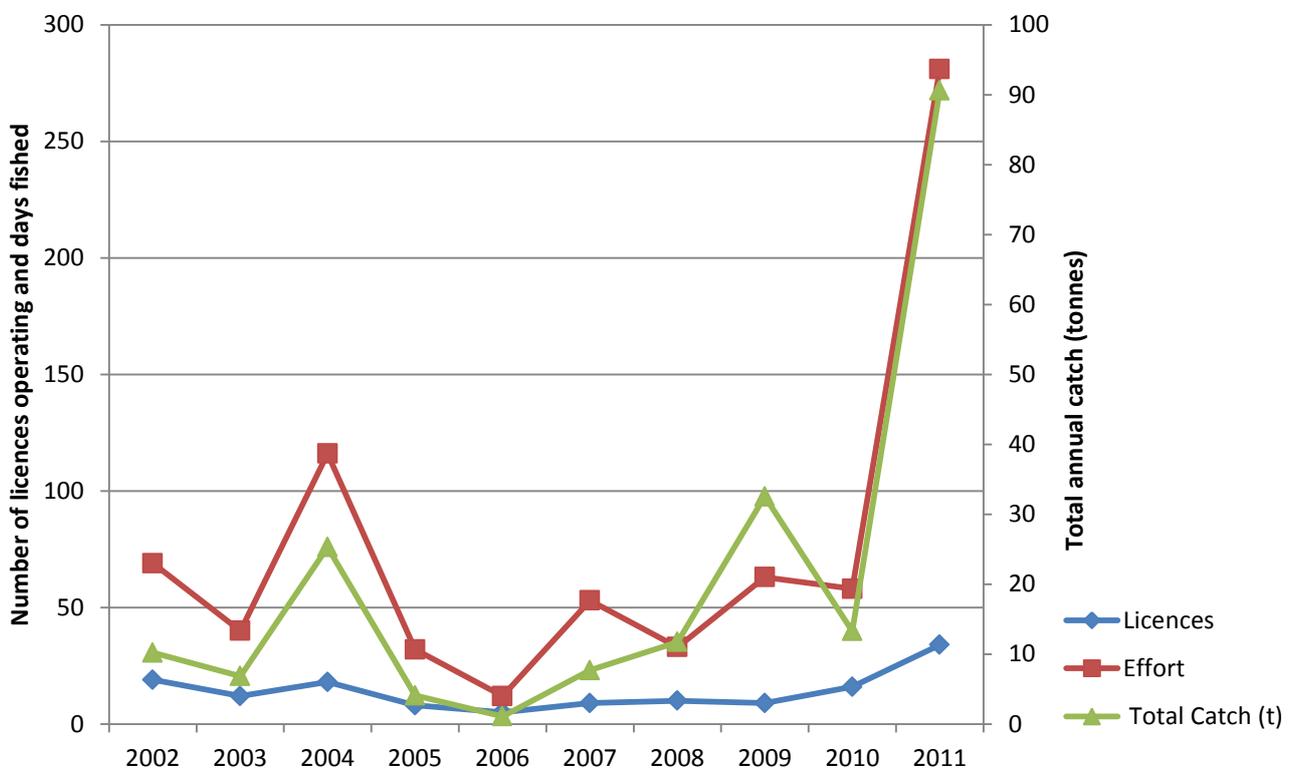


Figure 4.2: Otter trawl fishery catch and effort in the GKI 10Nm grid (data source: DAFF 2013a)

### 4.3.2 Inshore net fishery

The second largest fishery in the Great Keppel Island 10Nm grid is the inshore net fishery. This sector recorded an annual average landing of 14.42t of fish, with shark as the main species targeted (Figure 4.3). Other targeted species include queenfish (*Scomberoides commersonianus*), mullet (*Mugilidae* spp.), threadfin salmon (*Polynemidae* spp.) and mackerel (*Scombridae* spp.). Figure 4.4 shows the total annual catch of the eight most targeted species. Individual species catch numbers are intermittent for some of the years due to the small grid size and the inability to obtain data if less than five fishing vessels are operating in an area.

All of the species targeted in the net fishery around GKI depend upon estuarine habitats such as those found within the Leekes Creek study area for some or all of their lifecycle.

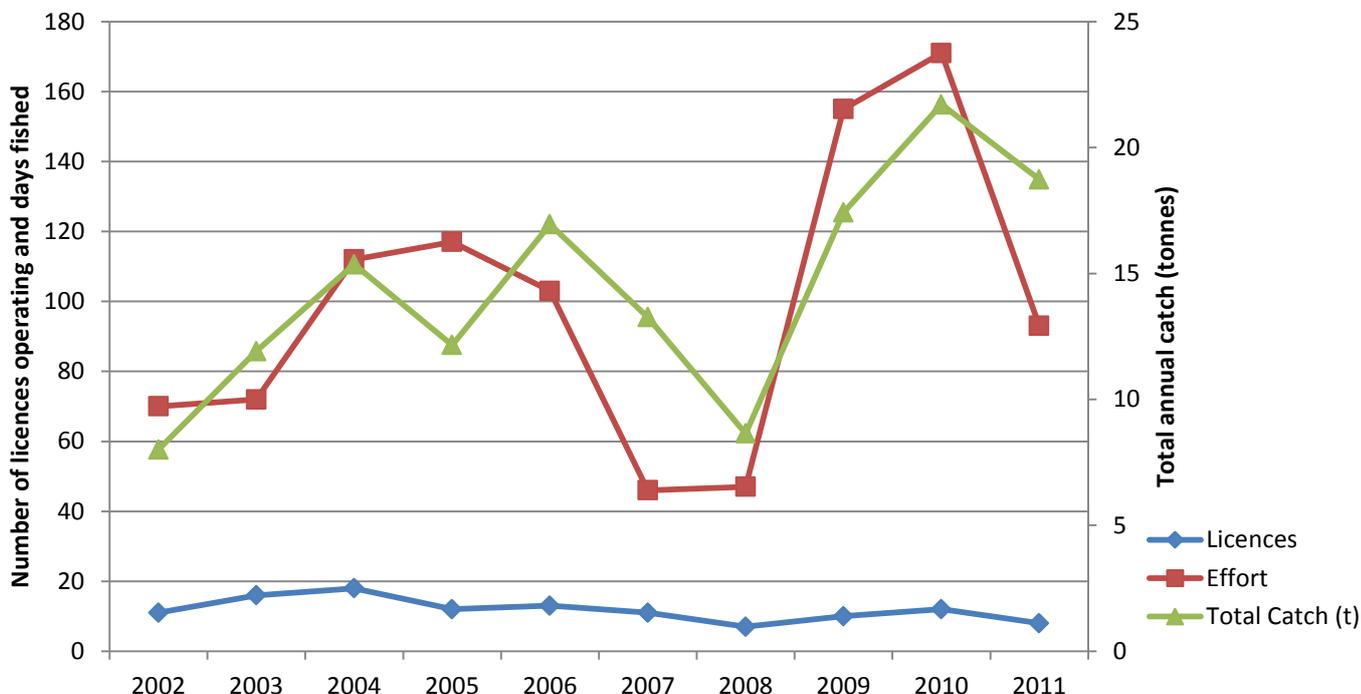


Figure 4.3: Net fishery catch and effort in the GKI 10Nm grid (data source: DAFF 2013a)

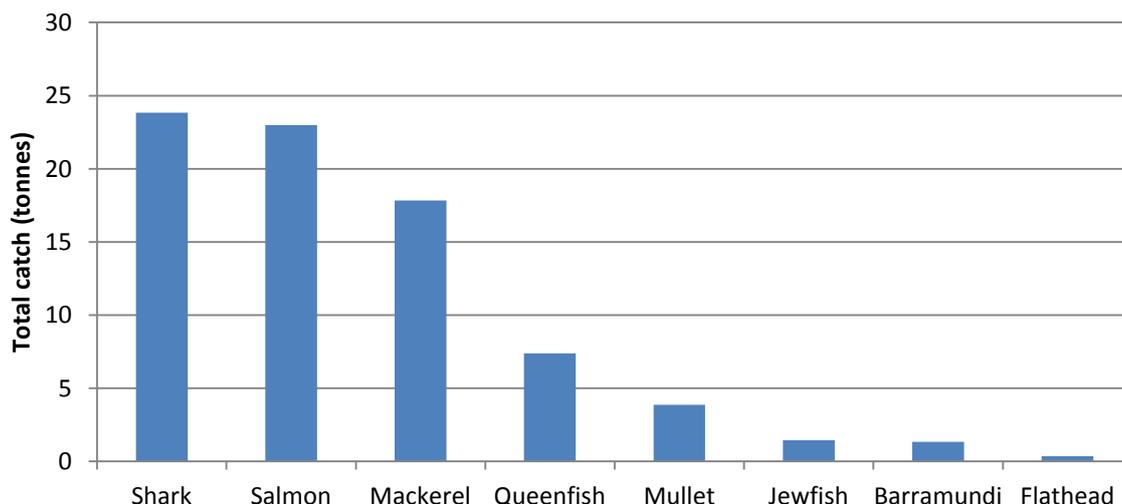


Figure 4.4: Total numbers of fish caught (tonnes) in the inshore net fishery between 2002 - 2011 in the GKI 10Nm grid (data source: DAFF 2013a)

### 4.3.3 Other commercial fisheries

An important marine fish and coral collection fishery exists within the 10Nm grid around GKI, collecting fish and coral for the aquarium trade. The maximum licences operating in any year from 2002 to 2007 were seven and the main fish species targeted were angelfish (*Pomacanthidae* spp.), butterfly fish (*Chaetodontidae* spp.) and dottybacks (*Pseudochromidae* spp.).

Harvesting methods for these fisheries is primarily by hand, utilising underwater breathing apparatus, such as scuba. Harvest fisheries are an important component of Queensland's commercial fisheries, with the economic productivity estimate indicating a combined value of more than \$14.7 million a year (DAFF 2013b). Harvests vary in the 10Nm grid around GKI, ranging between 3 and 17 tonne of coral, which is up to 25% of the total Queensland harvest in some years and 2147 and 5288 fish harvested between 2002 and 2012 (based upon available data).

There are several commercial oyster leases on GKI, one of which is within the Leekes Creek study area. Harvest figures are unavailable for these leases however they are consistently reliable and productive sites (C. Svendsen pers. comm. 2014).

The only available data for the mud crab fishery is for the years 2002 and 2005. Presumably this is because much of the area is open water and the mud crab fishery primarily operates in estuaries and near shore environments, therefore less than 5 vessels may have operated in the fishery in other years. The 2002 catch totalled approximately 3t, valuing \$51,000 and in 2005 just over 1t of crab was landed, to a value of approximately \$13 000.

A similar situation exists for the line fishery. The majority of commercial line fishers target waters further offshore, therefore data is unavailable for several of the years between 2002 and 2011. The average catch for the years 2002, 2004, 2006 and 2010 was approximately 3t of fish a year, to the value of \$19,000.

## 4.4 Indigenous fishing

Traditional fishing activities by Aboriginal and Torres Strait Islander people are a valuable component of their connection with traditional responsibilities of land management and kinship and important for their cultural lifestyle, religion and ceremonial occasions (Henry and Lyle 2003). The right to continue these practices is particularly significant to the Woppaburra, traditional owners of the Keppel Islands, in their goal to renew their cultural and kindred connections to the Islands.

The Commonwealth Government implemented Traditional Use of Marine Resources Agreements (TUMRA) in 2005 to allow for recognition of the rights of Indigenous people to continue their cultural practices and to encourage cooperative management within the GBRMP. A TUMRA describes how Traditional Owners intend to manage their natural resource take and activities within the GBRMP and outlines their chosen level of involvement in preserving the local fisheries and marine resources. The Woppaburra have held a TUMRA with the Australian and Queensland Governments since June 2007 (Figure 4.5) however no subsistence or traditional fishing activities are currently being undertaken by indigenous people within the Keppel Islands. Fishing by Woppaburra people is of a recreational nature and they target similar species to recreational fishers (Chapter 4.5). The Woppaburra TUMRA outlines a commitment to limit green turtle (*Chelonia mydas*) harvest, not to take dugongs (*Dugong dugon*) and prohibit hunting by other indigenous people in the area.

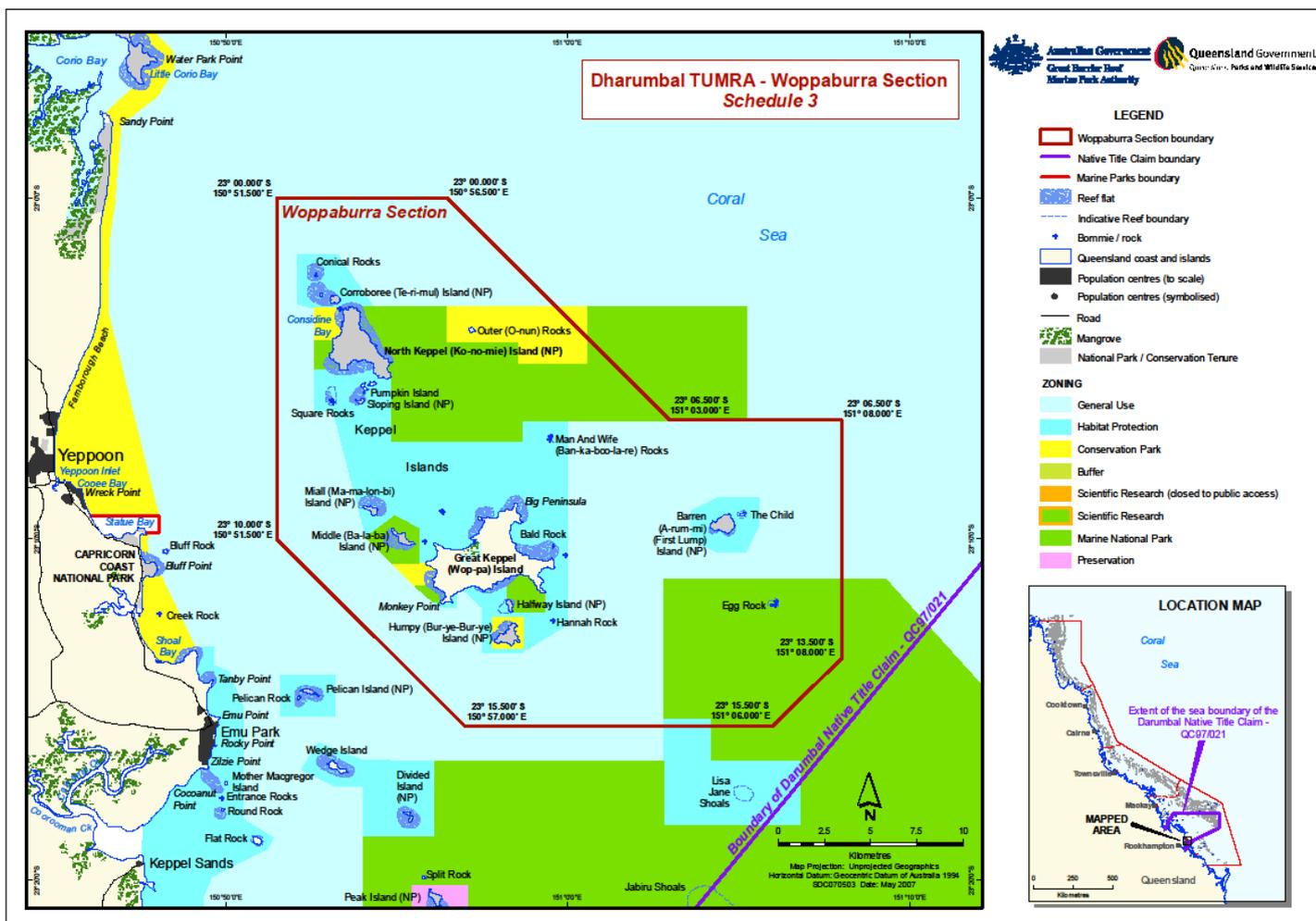


Figure 4.5: Woppaburra section of the Darumbal TUMRA (Source: GBRMPA 2013)

## 4.5 Recreational fishing

Recreational fishing is one of the most popular recreational activities for Queenslanders (Taylor et al. 2012). Between July 2009 and June 2010 approximately 703,000 Queenslanders aged five years and older went recreational fishing within Queensland, which represents 17% of the population (Taylor et al. 2012). This is a significant participation rate and indicates the importance of recreational fishing to Queensland's community and economy.

Recreational fishers contribute to a large proportion of the total annual catch of fish and may exceed commercial figures in some areas and for some species for example, snapper (*Pagrus auratus*), spotted mackerel (*Scomberomorus munroi*) and tailor (*Pomatomus saltatrix*) (SPCC 1984, Henry 1984; as cited in Henry and Lyle 2003; Taylor et al. 2012). For this reason, they have the capacity to have a significant impact on the sustainability of Queensland's fisheries and therefore it is important that fishing trends are monitored and managed accordingly. The recreational fishery is managed and regulated by allowable fishing apparatus, area and season closures and size and in possession limits.

The Capricorn Coast region has a large population of recreational fishers which provides a significant economic flow on effect to other industries and businesses. Based upon surveys conducted by Prayaga et al. (2009), an estimated 14,340 fishing trips occurred in the Capricorn Coast from 2006 to 2007. Direct benefits of this rate of participation can be demonstrated through charter vessel industries, fishing and tackle shops, fishing magazines and boat builders, whereas indirect benefits extend to accommodation providers, fuel suppliers and food outlets (Williams 2002). Prayaga et al. (2009) highlights the value recreational fishers place upon their opportunity to fish within the Capricorn Coast region, estimating the total annual consumer surplus to equate to \$5.53 million. This expenditure makes recreational fishing an important industry to the local economy and small businesses.

Over 3 million fish were captured in the Fitzroy region in 2005, with almost 1.6 million released (DAFF 2013a). The most caught fish within the Fitzroy statistical division is mud crab (*Scylla serrata*), followed by whiting (*Sillaginidae*

spp.), bream (*Sparidae* spp.) and cod (*Serranidae* spp.) (Taylor et al. 2012). Fitzroy residents caught almost 30% of the State's recreational harvest for redthroat emperor (*Lethrinus miniatus*) and jewfish (*Sciaenidae* spp.) and contributed significantly to the total catch of tropical species such as stripey snapper (*Lutjanus carponotatus*) and red emperor (*Lutjanus sebae*) (Taylor et al. 2012).

GKI's offshore location limits its accessibility for many recreational fishers however fishing does occur regularly in Leekes Creek and from Leekes Beach by local residents, day visitors, and overnight visitors to GKI (frc environmental 2011). The foreshore of Leekes Beach is popular for bait collection and the waters and reefs surrounding GKI are frequent destinations for recreational fishers with access to a vessel.

## Chapter 5 Habitat diversity

### Chapter summary

A large proportion of recreational, indigenous and commercially targeted fish species rely on habitats found in estuarine systems for some or all of their lifecycle. Therefore it follows from this that the presence of a diverse range of healthy essential fish habitats is an indication of an estuary's contribution to an area's fish productivity.

Leekes Creek study area contains a diverse array of essential fish habitats such as rocky structure, intertidal flats, coral, mangrove communities and saltmarsh. It has experienced minimal impact from human influences and remains in a relatively pristine condition. Its significance as an estuarine system located offshore, containing a wide variety of fish habitats, would indicate its contribution to local fisheries extends to reef fish species as well as estuarine.

### 5.1 Introduction

Fish habitats contained within estuarine systems are essential to the life cycle of many indigenous, recreational and commercially targeted fish species. These habitats, for example mangroves, saltmarsh, rocky structures and seagrass communities, directly support local inshore and offshore fisheries through provision of food, shelter, breeding and nursery areas. In addition to the direct significance of these habitats to local fish communities, many offshore game fish rely on bait fish that spend a part of their lifecycle in coastal estuarine systems (QDEH 1994). Mangroves and seagrass nursery areas are also important for replenishing fish populations on directly adjacent reefs (Nagelkerken et al. 2012; Mumby et al. 2004, as cited in Roushon et al. 2013; Nagelkerken, Grol and Mumby 2012) which may indicate that the Leekes Creek study area is ecologically significant to local fisheries.

The Leekes Creek estuary is considered relatively large in the context of GBR continental islands, especially in the southern section of the GBRWHA (frc environmental 2012). Fish species generally only found in inshore environments have been recorded in Leekes Creek and two species of anemone fish considered rare in the Keppels have been found in the coral reef adjacent to the creeks' mouth (Jones 2010). This diversity of fish communities indicates that the Leekes Creek study area provides a range of accessible and available habitats for a broad range of fish and their life cycle requirements.

In addition to its fisheries values, the wetland area around Leekes Creek and Leekes Beach provide valuable habitat for beach stone curlew (*Esacus magnirostris*), listed as vulnerable under the Nature Conservation (Wildlife) Regulation 2006 and rusty monitor (*Varanus semiremex*), listed as a priority species in the Back on Track Actions for Biodiversity, Fitzroy Natural Resource Management region (DERM 2010). Leekes Beach and Leekes Creek have been mapped as Essential Habitat for beach stone curlew by the (previous) Department of Environment and Resource Management (DERM 2012).

### 5.2 Habitats of Leekes Creek study area

Leekes Creek study area encompasses an estuarine system and adjacent bays that support a range of essential fish habitats. The creek system is not impeded by artificial structures or barriers and remains in relatively pristine condition.

GKI experiences a tidal range of approximately four metres and the majority of the main channel of Leekes Creek drains at low tide. Some deeper channels and pools remain submerged providing alternate habitat for fish species during low tide.

#### 5.2.1 Marine waters >6m deep

The inshore waters within the Leekes Creek study area are shallow with no permanent marine waters >6m.

#### 5.2.2 Marine waters <6m deep

The waters of the inner bay between Putney Point and Little Peninsula are <6m deep (Patrick 2003). These waters contain a range of habitats, including sandy beaches, seagrass meadows, coral communities and rocky outcrops.

### 5.2.3 Aquatic beds

Seagrass meadows provide nursery grounds for many of Australia's targeted fish and crustacean species (Kirkman 1997). In addition to a large number of important fish species, twenty different prawn species have been recorded utilising the seagrass meadows within the GBRWHA (GBRMPA 2011). For example, as juveniles commercially targeted tiger and endeavour prawns depend upon the food and shelter provided in these habitats (GBRMPA 2011; Kirkman 1997).

The shallow waters of the inner bay between Putney Point and Little Peninsula contain sparse areas of seagrass meadows consisting of *Halophila uninervis* and *Halophila ovalis* with sparse clumps of macroalgae. Currently a seagrass community exists on the northern end of Svendsens Beach with 10% vegetation cover however all other communities identified were small isolated patches with <5% cover.

Seagrass beds naturally vary in area and biomass seasonally and between years (Danaher et al. 2005) and anecdotal evidence suggests a much larger area of seagrass previously existed within the study area (C. Svendsen *pers. comms.* 2013; DAFF 2013a). Anecdotal evidence suggests flooding from the adjacent Fitzroy River may have deposited sediment on the seagrass meadows within Leekes Creek study area in 2011. Seagrasses are marine flowering plants, requiring sunlight to photosynthesise. Sediment loading smothers vegetation and reduces the amount of light that can penetrate to the seagrass, diminishing its ability to grow, respire and regenerate (Kirkman 1997).

### 5.2.4 Coral reefs

Coral reefs consist of a complex mosaic of plants and animals that sustain extremely rich and diverse ecological environments. These habitats support recreational, indigenous and commercial fisheries, provide the coastline with a natural protective barrier from wave action, erosion and storms and generate income through tourism.

A small coral community, approximately 0.5ha in size, exists along Leekes Point outside the mouth of the Leekes Creek estuary. This reef along with others within the Keppel Islands is considered relatively resilient to climate related disturbances, which makes them of high conservation value (Jones 2010).

As a result of extensive flooding in 2011 causing low salinity and increased turbidity, inshore coral reefs within the Keppel Reef system are showing signs of decline from bleaching and disease (Thompson et al. 2011). Therefore, small pockets of highly diverse but resilient coral communities such as those within the study area may be the key to regenerating surrounding reefs impacted by climate change and provide refuge for species that may otherwise disappear from parts of the GBRWHA (Maxmen 2008; as cited in Jones 2010; Jones 2010).

The diversity of coral at this site is relatively high (35 species) which is unusual for its position at the mouth of an estuary as nutrients, sedimentation and turbidity would normally inhibit significant coral growth (Jones 2010). Jones (2010) attributes this to the good quality of water within Leekes Creek. Three species of anemone and three species of anemone fish have been recorded in this coral community, two of which (*Heteractis crispa* and *Cryptodendrum adhaesivum*) are extremely rare in the Keppel Islands and two anemone species have not been found at any other site in the Keppel Islands (Jones 2010).

### 5.2.5 Sand, shingle or pebble beaches

Sandy beaches stretch along the length of the Leekes and Svendsen Beach foreshores (Figure 5.1), with a small beach also inside Leekes Creek mouth.

Communities of algae are supported by these habitats, which provide food sources for zooplankton and filter feeding invertebrates (Zeller 1998). Recreational, indigenous and commercially targeted fish species are attracted to the insects and burrowing animals (small crustacean, worms and molluscs) common to these habitats. The sandy beaches within Leekes Creek study area are utilised by recreational anglers targeting whiting, bream, mullet, flathead and bait fish.



**Figure 5.1: Leekes beach**

### **5.2.6 Estuarine waters**

Estuarine waters, the tidal zones of a waterway, are partially enclosed bodies of water where freshwater from rivers and streams meet and mix with saltwater from the ocean. Estuaries support a wide range of essential fish habitats. Quinn (1992) estimated that 75% of all commercial catch landed in Queensland's commercial fisheries rely on a variety of habitats found in healthy estuaries during some part of their lifecycle. Many of these species are significant to recreational and indigenous fishers as well.

Freshwater inflow is a key factor that defines an estuary and contributes to the biological and physical attributes that create important spawning, nursery and feeding habitats for many commercial, recreational and indigenous targeted species (Halliday and Robins 2007). Leekes Creek drains the largest catchment area on GKI which incorporates a valley formed by two major ridges in the centre of the island. This catchment has a relatively high water flow and provides Leekes Creek with freshwater inflow.

### **5.2.7 Intertidal flats**

The main channel of the Leekes Creek estuary contains large areas of intertidal sand flats. Intertidal flats, forming in sheltered places where water velocity slows, are important sedimentation areas, supporting a highly productive and nutrient rich fish habitat (Figure 5.2). The diverse range of burrowing and surface fauna and interstitial algae produced in these habitats provide direct food source for recreational, indigenous and commercially targeted fish species such as whiting, flathead and bream (Long and McKinnon 2002).



**Figure 5.2: Intertidal flats in Leekes Creek**

### 5.2.8 Intertidal saltmarshes and saltpans

Approximately 19ha of intertidal marshes exist upstream in Leekes Creek, as an interface between the waterway and terrestrial areas (frc environmental 2011; Figure 5.3). These areas are vegetated by a mix of austral seablite (*Suaeda australis*), bead weed (*Sarcocornia quinqueflora*), sea lavender (*Limonium austral*) and marine couch (*Sporobolus virginicus*). Sedge species *Fimbristylis* sp. and *Juncus* sp. are growing adjacent to the mangrove and saltmarsh communities (frc environmental 2012). These areas receive regular inundation enabling utilisation by a variety of fish species.

Although saltmarsh and saltpan environments are tidal for only very short durations, fish venture great distances (up to 400m) onto intertidal marshes during inundation (Thomas and Connolly 2001). Both vegetated and un-vegetated intertidal marshes have been found to provide significant habitat values for many fish species, including economically important species such as bream, whiting and mullet (Thomas and Connolly 2001; Mazumder et al. 2006). Surveys have identified that a large number of fiddler crabs utilise Leekes Creek. Intertidal marshes are significant for the hatching of fiddler crab eggs, which coincides with inundation of saltmarshes allowing for the release of larvae. This has the indirect effect of providing feeding opportunities for itinerant fish species utilising saltmarsh habitats (Mazumder et al. 2006).



Figure 5.3: Intertidal saltpans in Leekes Creek

### 5.2.9 Mangrove communities

Mangroves are flowering shrubs and trees that form distinct communities and often fringe the intertidal zone of estuaries, coastal rivers and bays (Lovelock 1999; Goudcamp and Chin 2006). These communities are among the most productive and biologically diverse ecosystems in the world (Goudcamp and Chin 2006). They are crucial to the biological productivity and food webs of coastal waters, providing critical nursery areas for many indigenous, commercial and recreationally important fish species such as prawns, bream and mackerel, as well as non-commercial species that become food sources for larger species (e.g. billfish and marlin) when they migrate to open waters (Lovelock 1999). Mangrove forests also play a vital role in the protection of the GBR through their role in preventing coastal erosion, trapping sediment and filtering land run-off (Hogarth 1999; Goudcamp and Chin 2006).

The Leekes Creek estuary contains approximately 30ha of a rich, healthy and diverse range of mangrove communities (frc environmental 2011). In general, mangrove distribution is dependent upon environmental factors such as inundation levels and frequency, salinity and wave action (Lovelock 1999; Goudcamp and Chin 2006). Large areas of *Rhizophora* mangroves dominate the communities within Leekes Creek which, as a species, is highly adaptable and tolerant of climate and soil variation (Figure 5.4).



**Figure 5.4: *Rhizophera* dominated mangrove community in Leekes Creek**

#### **5.2.10 Brackish to saline lagoons**

Brackish lagoons are important nursery areas for juvenile fish species. They provide fewer predators, abundant food sources and sheltered areas for juvenile fish species to mature (Brehmer et al. 2013; Verdiell-Cubedo et al. 2013). There are no permanent brackish or saline lagoons within the Leekes Creek study area.

#### **5.2.11 Brackish to freshwater swamps**

Brackish to freshwater swamps provide similar habitat values to juvenile fish as brackish to saline lagoons (Chapter 5.2.10). The Leekes Creek study area boundary only encompasses the tidal and intertidal areas of Leekes Creek and therefore does not contain any freshwater swamps. However upstream of the study area there is a large area of wetland that holds freshwater intermittently. Previous to a fire burning through this area and destroying the thick layer of organic ground material (peat) in the late 1990's, the wetlands held permanent water year round (Carl Svendsen, *pers. comm.* 2014).

This area is on state leasehold land and therefore has not been incorporated into the Leekes Creek study area. However should the study area progress to FHA declaration, it is possible to incorporate this area into the declared FHA upon written permission provided by the leaseholder.

#### **5.2.12 Rocky structures**

Rocky structures provide a hard substrate for the attachment of rich algal flora (which contributes to the primary production of waterways) and immobile invertebrate communities (barnacles, oysters and tube worms) (Zeller 1998). Refuge, feeding opportunities and nursery areas for a wide variety of adult and juvenile fish are also provided by the crevices in these rocky habitats (NSW Fisheries 1999, as cited in Long and McKinnon 2002; Raedemaeker et al. 2010).

Leekes Creek study area encompasses a range of rocky structures. Within Leekes Creek there are several rocky structures which provide sheltered habitat and dispersed along Leekes and Svendsen's beach are large areas of rocky formations supporting barnacles and oysters (Figure 5.5). The rocky substrates around GKI are quite productive, supporting several commercial oyster leases, one of which is within the Leekes Creek study area.



**Figure 5.5: Rocks on Leekes Beach, locally named 'Chocolate Rocks'**

#### **5.2.13 Surf bars**

There are no surf bars in the Leekes Creek study area due to its protection from the prevailing south-east and north-easterly winds.

#### **5.2.14 Overhanging/Undercut river banks**

Overhanging and undercut river banks are generally formed through natural erosion processes and provide substantial shelter and protection for predator and prey fish species. Leekes Creek does not receive highly accelerated water flows through either freshwater flow or tidal influences and its banks have a gradual rise and are protected by dense mangroves, therefore there are no overhanging or undercut river banks in the Leekes Creek study area.

### **5.3 *Unique habitat features***

Leekes Creek study area, being an estuarine system on an offshore continental GBR island, provides a unique opportunity to extend the declared FHA network away from the mainland coast. It attracts a diverse range of fish species, including offshore reef species and fish found inshore. This indicates that it has the capacity to support a wide range of fisheries and contribute to local fisheries productivity.

The coral community that exists outside the mouth of the Leekes Creek estuary may be regionally significant due to its resilience to climate change and high diversity of species (Chapter 5.2.4).

### **5.4 *Conclusions***

Habitat interconnectivity and effective functioning is a fundamental requirement for productive and sustainable fisheries and the importance of protecting all available habitats within an area, such as those in the Leekes Creek study area, is a central focus of the declared FHA concept (NPRSR 2013, Baker and Sheppard 2006).

The diverse range of interconnected fish habitats within the Leekes Creek study area have had minimal impact from human disturbances and are relatively pristine. They provide essential habitat for many recreational, indigenous and commercially targeted fish species at crucial stages of their life cycle, making these habitats important to fish sustainability within the study area and in adjacent waters.

## Chapter 6 Riparian zone

### Chapter summary

Adequate riparian zones are essential to protect and provide a buffer between a waterway and impacts from surrounding land uses. Waterways bordered with well-developed, healthy and intact riparian vegetation are provided a high level of protection from external impacts and generally support higher levels of productivity.

The Leekes Creek study area is bounded by a healthy, relatively pristine riparian zone. It has experienced minimal disturbance or alteration and is functioning effectively. A large portion of the Leekes Creek study area is mapped essential habitat for vulnerable wildlife species and communities of vegetation have been mapped 'Of Concern' under the *Vegetation Management Act 1999*, which affords it a degree of protection.

### 6.1 Introduction

The terrestrial vegetation that grows along the edge of watercourses, the riparian zone, provides significant ecological value and is critical to the protection and maintenance of fisheries resources. Benefits derived from a healthy and functioning riparian buffer zone include:

- flood control
- improvement of water quality through sediment and chemical capture and filtering
- stabilisation of shorelines
- shading
- a buffer from adjacent land uses
- physical habitat
- erosion control through improved bank stability
- protection of fish and wildlife habitats (Bavins et al. 2000; Baker and Sheppard 2006).

It follows from this that the health and extent of coverage of the riparian zone can be an indicator of the impact of surrounding land uses on a waterway. Waterways bordered with well-developed, healthy and intact riparian vegetation are provided much more protection from external impacts and generally support higher levels of productivity than those lacking a vegetative buffer zone (Bavins et al. 2000).

### 6.2 Riparian zones within Leekes Creek study area

The Leekes Creek study area is relatively pristine and un-impacted by human activities. As such, its riparian zone is almost fully intact and healthy. Grazing on GKI appears to have had little impact upon the riparian zone, although Chenoweth (2011) makes several references to altered vegetative states and vegetation damage caused by grazing cattle and goats on the island in general.

Within the riparian zone, there has been an area of approximately 9000m<sup>2</sup> cleared at the northern end of Svendsen's beach for the construction of dwellings and approximately 350m<sup>2</sup> to the south east of Leekes Creek for a now unused shearing shed. In comparison to the size of the remaining riparian zone and the low intensity of land use, this relatively small area of land clearing is not likely to have significantly impacted upon the quality of adjacent waters and fish habitats. The Leekes Homestead shearing shed however, contains a dip site located approximately 5m from the water's edge (23°10'30.489", 150°57'18.8778"), which is currently being monitored by local residents. Arsenic based sheep and cattle dip solutions were used to treat cattle ticks and sheep lice until 1987 (DAFF 2013d). Arsenic is a highly toxic metalloid that persists in the environment, causing poisoning (DAFF 2013d) and remedial action, such as the dip's complete removal, may be necessary to prevent toxic chemicals entering the waterway should erosion or rising seawater levels cause Leekes Creek to begin encroaching upon this site.

The fore-dunes within Leekes Creek study area are vegetated with she-oaks and have a spinifex ground cover. Behind this, eucalypt communities dominate the bushland (Figure 6.1; 6.2). Upstream in the freshwater section, the riparian zone extends 15m on each bank and is dominated by grass and Eucalypt, Melaleuca and Acacia trees (frc environmental 2012). Creighton (1984; as cited in Chenoweth 2011) noted that historically, selective clearing of Melaleuca may have occurred adjacent to the freshwater reaches of Leekes Creek.

Vegetation communities within and adjacent to the Leekes Creek study area have been identified as 'Of Concern' regional ecosystems under the *Vegetation Management Act 1999* and as Essential Habitat for beach stone curlew and are therefore afforded protection from clearing (DNRM 2014).

A full list of vegetation communities within and adjacent to Leekes Creek study area is listed in Appendix D.



**Figure 6.1: Riparian communities behind mangroves in Leekes Creek**

### **6.3 Conclusion**

The Leekes Creek study area is bounded by a healthy and intact riparian zone. The degree of clearing and alteration experienced by adjacent vegetation communities is not likely to have any significant impact upon the fisheries values of the study area. There are some vegetation communities that are considered Of Concern under the *Vegetation Management Act 1999* and Essential Habitat for vulnerable species, which provides a level of protection from future clearing or development.

## Chapter 7 Climate, catchment flows and impoundment structures

### Chapter summary

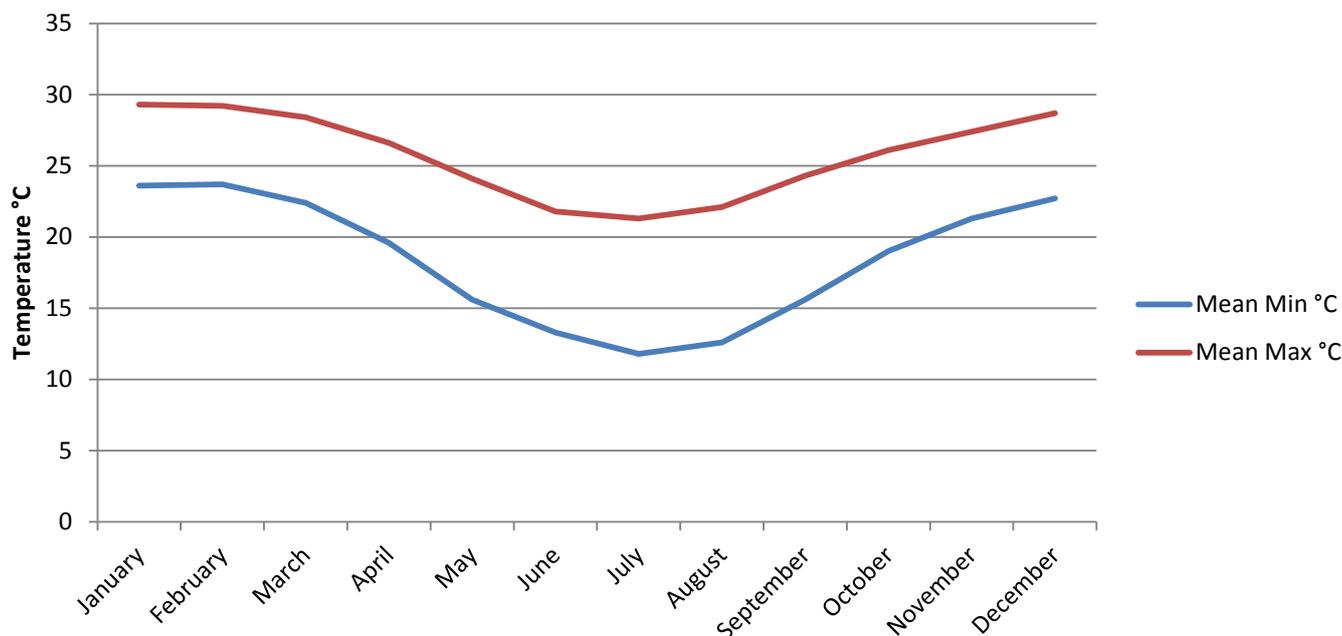
Great Keppel Island has a subtropical climate with an annual average rainfall of almost 990mm. There are no major waterway barriers or impoundments within the Leekes Creek study area. The creek contains limited channel alteration and has a relatively high water flow. A large part of the estuarine section completely drains at low tide with some channels and pools retaining water.

Great Keppel Island experiences a sub-tropical climate with an annual average rainfall of 988.9mm. The highest rainfall typically occurs in February (Figure 7.1c). Mean annual temperatures range from 11.8°C in July and 29.3°C in January (figure 7.1a). Great Keppel Island is within the tropical cyclone zone, with 12 cyclones affecting the island in the 50 years from 1956 to 2006.

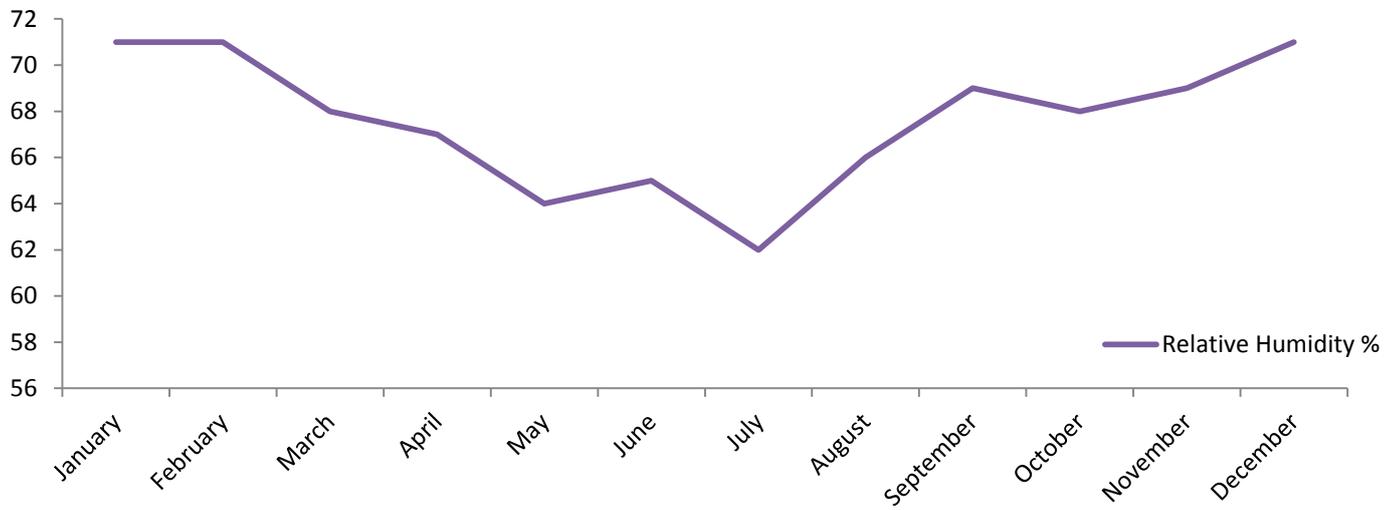
Great Keppel Island's topography is dominated by two ridges aligned in a south-easterly to north westerly direction which extend to the coastline (Tower Holdings 2012). These ridges form a valley area in the centre of the island, falling from an elevation of approximately 65 metres above sea level to sea level at Leekes Beach (Tower Holdings 2012). Leekes Creek and Blackall Creek (a tributary of Leekes Creek) drain these ridges and valley.

Freshwater inflow is a key factor that defines an estuary and contributes to the biological and physical attributes that create important spawning, nursery and feeding habitats for many commercial, recreational and indigenous targeted species (Halliday and Robins 2007). Leekes Creek is not impeded by any artificial barriers that would prevent fish access to all available habitats or restrict freshwater flows. Its upper freshwater section contains limited channel alteration and a relatively high water flow (frc environmental 2012). The majority of the estuarine section completely drains at low tide, with small channels and pools remaining sub-tidal.

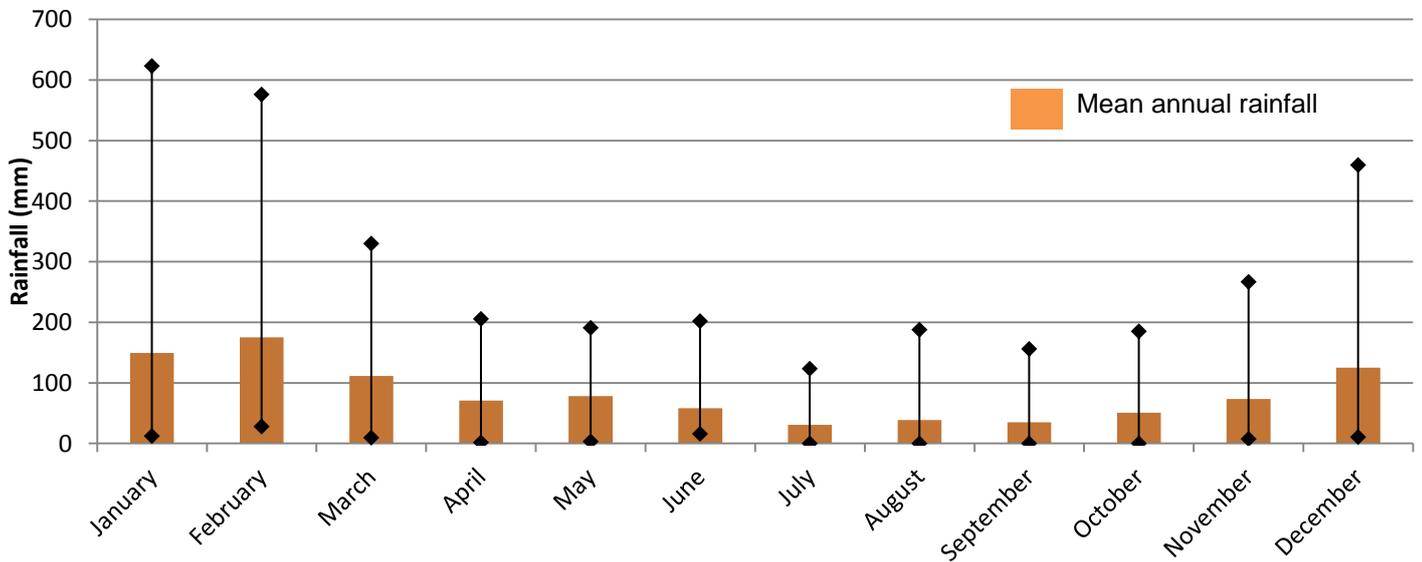
Graph A



**Graph B**



**Graph C**



**Figure 7.1: Great Keppel Island monthly climate averages measured by the Bureau of Meteorology (BoM 2013). (a) Maximum and minimum temperatures (between 1993 and 2013); (b) 3pm relative humidity (between 1993 and 2010); and (c) rainfall. Lines show range (between 1994 and 2013)**

## Chapter 8 Water quality

### Chapter summary

Water quality is fundamental to the health of a waterway, its fish habitats and fish populations. Poor water quality can result in diminishing the values of a waterway, including its recreational, commercial and indigenous fisheries values.

The water quality and sediment data collected from the Leekes Creek study area shows the area to be, on the most part, extremely healthy with contaminant levels significantly below recommended guidelines. The only deviance above the low trigger value was a high concentration of lead identified in sediment sampling in Leekes Creek in one sample period, which may be attributed to increased boating activity in the creek or sampling error.

### 8.1 Introduction

Water quality is fundamental to the value and maintenance of a healthy waterway. It sustains ecological processes that support fish populations, vegetation, wetlands and birdlife. Water quality is closely linked to the surrounding environment and land use and can decline through processes such as land clearing, industrial and urban development, pollution and stream modification (Baker and Sheppard 2006). The impact of these processes diminishes the environmental health of the waterway as well as its commercial and recreational value. Poor water quality can cause fisheries values to decline from introduced disease, degraded habitat values and poor fish health (Baker and Sheppard 2006).

Water quality objectives (WQOs) for coastal and inshore waters in the Central Queensland region are outlined in the Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMP 2010) and the Queensland Water Quality Guidelines (DEHP 2009). These guidelines use the presence of contaminants and the characteristics of water to indicate the quality of water and calculate trigger values (TVs) based on toxicity testing of a range of species. Trigger values provide a measure of the biological significance of the metal concentration through indicating the likelihood of organisms being impacted. Exceeding a TV does not necessarily signify that the water is harmful, but rather it indicates the need for further investigation or action. For parameters not specified in these guidelines, the Australian and New Zealand Environment and Conservation Council's (ANZECC) National Water Quality Management Strategy (ANZECC 2000) is referred to.

### 8.2 Water quality

The waters within Leekes Creek and the adjacent bays were sampled for water quality testing between November 2010 and May 2011 (frc environmental 2012). Physiochemical water quality measurements were recorded *in situ* at the water surface (0.2m) and at depths (ranging between 0.4m and 4.0m in the estuary and 4.0 and 6.0m in marine waters) on both the incoming and outgoing tide. Tests measured water temperature, salinity, pH levels, dissolved oxygen (DO) and the presence of metals. Samples were recorded during the pre-wet (November 2010), wet (January 2011) and post-wet (March - May 2011) seasons. This period coincides with significant flood events on the mainland causing the largest volume of discharge from the Fitzroy River since 1918 (Devlin et al. 2012). Flood plumes from the Fitzroy River entered Keppel Bay and the influence of these plumes was measured as far north as Mackay (Devlin et al. 2012). Therefore the following data may reflect poorer water quality than would normally exist in the study area.

The Leekes' Homestead shearing shed contains a dip site located approximately 5m from the water's edge (23°10'30.489", 150°57'18.8778"), which is currently being monitored by local residents. Arsenic based sheep and cattle dip solutions were used to treat cattle ticks and sheep lice until 1987 (DAFF 2013d). Arsenic is a highly toxic metalloid that persists in the environment, causing poisoning (DAFF 2013d) and remedial action, such as the dip's complete removal, may be necessary to prevent toxic chemicals entering the waterway should erosion or rising seawater levels cause Leekes Creek to begin encroaching upon this site.

#### 8.2.1 pH

pH is the measure of acidity or alkalinity of a waterway. It ranges from 0 (strongly acidic) to 14 (strongly alkaline), with a pH of 7 being neutral. Acidic water can damage the skin and gills of fish, leading to increased susceptibility to fungal and bacterial infection. WQOs recommend a pH level of between 7 and 8.4 for estuarine systems and 8.1

to 8.4 for marine water. Apart from one reading of 6.6 at the surface and 6.9 at a depth of 0.5m, Leekes Creek was consistently within recommended levels at each sample period. Marine waters within Leekes Creek study area ranged between 7.9 and 8.1.

### **8.2.2 Dissolved oxygen concentration**

Dissolved oxygen (DO) is an important measure of the health of a waterway for fish survival, as it is an indication of the available oxygen for fish to respire. Fish kills can occur in waterways with persistent low oxygen concentrations (<50% saturation), and supersaturated levels of oxygen above 100% can be caused by events such as algal blooms. WQOs of 85 - 100% saturation for estuarine waters and 95 - 105% saturation for marine waters are recommended. The majority of samples in Leekes Creek were within recommended guidelines, however high and low extremes were recorded at 103% and 46%. Marine waters occasionally exceeded guidelines, with upper and lower extreme ranges of 114% and 93% respectively.

### **8.2.3 Water temperature**

Water temperature has an impact on fish health and sudden changes to temperature or an extended cold winter can impact fish immunity functions ((former) DERM 2011). There are no trigger values available for water temperature. Temperatures ranged from 22.18°C to 26.51°C in Leekes Creek and 23.53°C to 28.17°C in the marine waters.

### **8.2.4 Metals**

Metals and metalloids dissolve in water and can also be present in suspended particles. They occur naturally in all waterways within Australia and levels tend to peak after heavy rains ((former) DERM 2011). Metals and metalloids are toxicants and high levels can harm aquatic organisms. Concentrations of copper, cadmium, chromium, nickel, lead and mercury were below laboratory detection limits and/or relevant trigger values throughout the sampling period in the Leekes Creek study area. Zinc was slightly elevated during the post-wet season; however it was still within the 95% protection trigger value.

### **8.2.5 Turbidity**

Turbidity provides a measure of sediment in the water column. High levels can stress fish through clogged gills and the declined ability to absorb oxygen. Turbidity trigger levels are at 8.0 NTU for estuarine waters and 1.0 NTU for marine waters. Turbidity levels for Leekes Creek were well within guidelines for the pre-wet and wet seasons (<10 NTU) but elevated to above trigger levels during the post-wet sampling period (1.7 - 204 NTU). The higher readings were recorded in upper Leekes Creek and most likely due to sediment run-off associated with rainfall (frc environmental 2012).

## **8.3 Sediment quality**

Levels of contaminants, such as metals, measured in sediment layers have the capacity to negatively affect fisheries resources. When contaminants dissolve and enter waterways, they tend to bind with suspended sediment particles, which coagulate and sink into the sediment layer. Although these contaminants are generally stable and sediment bound, activities such as dredging, burrowing organisms and natural flood events can destabilise these toxins and have the capacity to adversely affect the surrounding environment and harm fisheries resources. Mangrove sediments tend to contain higher concentrations of contaminants than other shoreline sediment due to aerial roots trapping tidal waters and allowing suspended particles to settle (Vision Environment Qld 2011).

Sediment samples were collected at the Leekes Creek mouth between November 2010 and May 2011 from the top 0.3m of seabed during the pre-wet (November 2010), wet (January 2011) and post-wet (March - May 2011) seasons (frc environmental 2012). With the exception of lead, all metals in the sediment samples recorded at Leekes Creek were significantly below recommended guidelines. Concentrations of lead exceeded the low trigger value during the post-wet survey. This may be attributed to increased boating activity within the creek (frc environmental 2012) or sampling error.

## **8.4 Conclusions**

The water quality and sediment data collected from the Leekes Creek study area shows the waters to be, on the most part, extremely healthy with contaminant levels significantly below recommended guidelines. Slightly elevated levels of lead were identified in the sediment sampling performed in the post wet season which may be attributed to increased boating activity in the creek or sampling error.

Overall, the results of water sampling indicate that the Leekes Creek study area is a healthy waterway with little impact or pollution from surrounding land uses.

## Chapter 9 Land use within and adjacent to Leekes Creek study area

### Chapter summary

Adjacent land uses can have a detrimental impact upon waterways through activities such as land clearing, sediment run off, pollution and alteration of habitats.

Land use impacts on the Leekes Creek study area are minimal. Following subsistence use of the island by the Woppaburra indigenous people, grazing activities were undertaken on Great Keppel Island between the 1860's and 1970's. The island is now primarily a low impact recreation and tourism destination.

The CQ region's economy is supported by a range of production and development industries, the primary two being the resource and agricultural sectors. Tourism and fishing are integral to the economy, particularly in the smaller towns such as Yeppoon and Emu Park. It is anticipated that the economic input from tourism will increase once the GKI Resort is completed

The new GKI resort development, yet to commence construction, is well buffered from the study area and mitigation methods have been incorporated into its design to minimise negative impacts on the surrounding environment. Close monitoring during both the construction and operational phases is recommended to ensure activities associated with construction and increased visitor numbers do not impact upon the fish habitats contained within the Leekes Creek study area.

### 9.1 Introduction

Activities on adjacent land can have a detrimental effect upon waterways and beaches. High intensity use can cause negative effects such as sediment run-off, land clearing, alteration of habitats and pollution of waterways.

The original inhabitants of the Keppel Islands are the Woppaburra people, with evidence of their habitation including midden sites, stone artefacts and campsites, dating back more than approximately 5000 years (GBRMPA 2008). Colonial settlement of GKI began in the 1860's, when a lease was granted to operate a sheep farm on the island. Following settlement by Europeans, Woppaburra numbers declined rapidly until the remaining 17 people were relocated to the mainland and Fraser Island in 1902 (Rowland 2004). Grazing activities ceased on the island in the 1970's and the current primary land use is related to tourism and recreational activities.

Great Keppel Island is adjacent to the coastal town of Yeppoon, which had a population of 6317 in 2011 (ABS 2013). It is within Central Queensland and part of the wider Rockhampton region, which encompasses the urban centres of Yeppoon, Emu Park, Gracemere, Mount Morgan and Rockhampton. Agriculture, forestry and fishing accounted for 13.8% of all businesses registered in the Rockhampton regional council area in 2011-12 (Capricorn Enterprise 2013).

Activities on the mainland adjacent to GKI have the capacity to influence GKI's waterways through sediment run-off and pollution, particularly during major flood events. The Central Queensland (CQ) economy has four major sectors, resources, construction, agriculture and tourism. CQ has experienced rapid economic and investment growth in recent years as a result of investment in the resources sector. Balancing this growth with the equally important agricultural production sector has been a challenge, hence the development of the CQ Regional Plan (chapter 10.2.4).

Tourism and recreational fishing are important economic inputs for the coastal towns of Yeppoon and Emu Park. It is anticipated that the development of the GKI Resort will promote further tourism in the region, facilitating economic growth in this sector (Qld Gov 2013). Declaration of an FHA on GKI will further promote the fisheries values of the area and support tourism and fishing.

In 2009, the region's coastal area supported:

- beef production
- horticulture
- meat processing
- magnesite mining and magnesia production
- salt, silica sand and limestone extraction
- explosives manufacture and storage
- electricity generation, distribution and retail
- defence training and logistics

- retail trade
- education services, health and community services and
- tourism (DETE 2010).

## **9.2 Recreation and tourism**

At present, GKI is a low impact recreation and tourism destination, catering for boating, fishing, diving and snorkelling activities. Visitors and day guests utilise the island which is only accessible by ferry, boat or small light aircraft. There is limited vehicular access throughout the island with transport networks consisting of poorly maintained tracks and trails.

Approximately 20 dwellings have been constructed on the island as residential housing for permanent residents and commercial enterprises with small scale holiday accommodation and facilities. Visitor accommodation ranges from backpacker style dorms and camping to self-contained housing.

## **9.3 Great Keppel Island Resort**

The first resort on GKI, Silver Sands, was established in the 1950's. Over the following 30 years, the name was changed to Great Keppel Island Resort and infrastructure expanded until it had the capacity to accommodate 360 guests by 1982. The resort was purchased by Tower Holdings Pty Ltd in 2007 and closed in February 2008 due to a lack of economic viability.

Tower Holdings Pty Ltd has received approval from the State and Commonwealth governments for the complete redevelopment of GKI Resort and intends to demolish the existing infrastructure and construct a new resort covering an area of 941ha accommodating:

- 250 suites
- 750 eco resort villas and 300 eco resort apartments
- a marina comprising 250 berths, a ferry terminal and yacht club
- an 18 hole golf course
- relocation and extension of the airstrip
- a 575ha environmental park and
- resort worker's accommodation.

In 2009, the original proposal was rejected by the Federal Environment Minister due to unacceptable impacts on the environment and a revised, smaller project was submitted in 2010.

Construction of the new GKI Resort is expected to begin in 2014 and will expand the development footprint on the island significantly (Figure 9.1; 9.2). Once it is completed it will also attract a substantial increase in visitor numbers and boating activity which can lead to degraded coastal areas and inshore marine habitats (Qld Govt 2013). The environmental impact statement (Tower Holdings Pty Ltd 2012) outlines mitigation measures aimed at reducing negative impacts upon the island and the Coordinator General's report on the EIS (Qld Govt 2013) specifies that resort management will be responsible for the ongoing management of tourist and visitor activities. A separation zone has been incorporated into the resort plan to provide a 200 metre buffer between the resort's planned golf fairway and the Leekes Creek estuary.



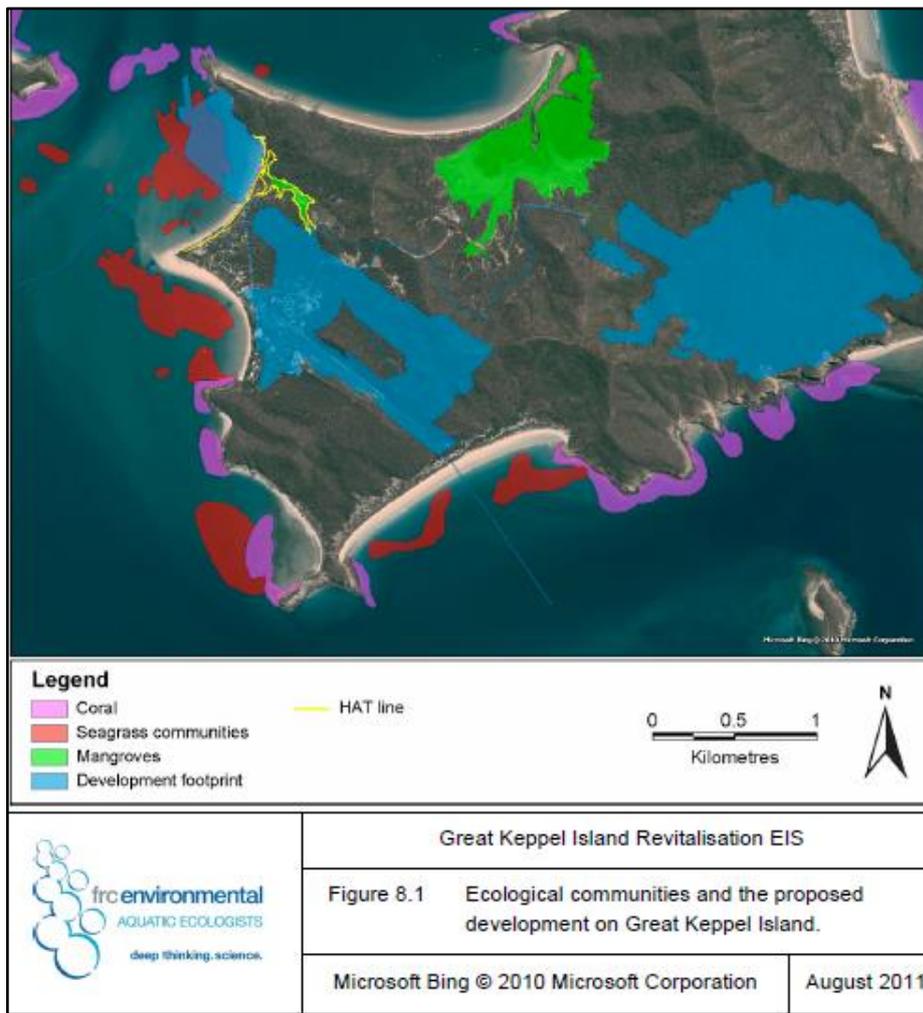


Figure 9.2: Great Keppel Island Resort revitalisation plan development footprint (frc environmental 2011)

## 9.4 Other land uses

Significant grazing activities were undertaken on GKI after European settlement in the 1860's, ceasing in the 1970's. Up to 4000 sheep were grazed at peak operation, with the added introduction of cattle, goats, pigs and other livestock (Tower Holdings Pty Ltd 2012). This has altered some of the natural vegetation through clearing and other disturbances and a feral goat population remains on the island (Tower Holdings Pty Ltd 2012).

The Queensland Government approved the transfer of six parcels of land on GKI to the Woppaburra Land Trust in 2007. This land, approximately 170ha, is enabling descendants of the original Woppaburra people to strengthen, rebuild and renew relationships of connection and continuity with the land, sea and each other through undertaking cultural audits, mapping of land and sea country, conservation planning and engaging in protective land care for areas of cultural significance (Tootell 2007).

## 9.5 Artificial structures

Leekes Creek provides a safe and sheltered harbour for vessels and, as such, is utilised frequently by yachts that often remain in the creek for extended periods of time. Two vessel mooring structures have been erected which have had minimal impact on the waterway (Figures 9.3; 9.4).



**Figure 9.3: Vessel mooring structure within Leekes Creek**



**Figure 9.4: Vessel mooring structure within Leekes Creek**

## **9.6 Conclusion**

Overall, the Leekes Creek study area is a relatively pristine area with minimal impacts from surrounding land use. It has been provided protection from degradation due to the low key activities and minimal development that has occurred on the island.

The incorporation of mitigation methods and buffer zones into the GKI resort development plans are aimed to ease pressures on surrounding areas of ecological significance from the subsequent increased development footprint

and visitor numbers.

## Chapter 10 State and regional planning and management

### Chapter summary

Coastal development has the capacity to cause significant long term or permanent damage to marine waters and their habitats. To address the issue of balancing economic growth in coastal areas against environmental concerns, national, state and local agencies have developed policies and legislation to guide planning decisions concerning these sensitive environments. Key planning mechanisms for the study area include the State Planning Policy, the Central Queensland Regional Plan, the Great Barrier Reef Marine Park zoning plans and the Livingstone Shire Planning Scheme. These mechanisms aid to balance the need for economic growth through coastal development and its impacts upon the marine environment by guiding decision making processes.

### 10.1 Introduction

Balancing the need for economic growth through coastal development against its impacts upon the marine environment is a difficult and often controversial process. Inappropriate development in coastal areas has the capacity to negatively impact upon adjacent habitats, water quality and ecosystems which can be detrimental to the plants and animals that inhabit and depend upon these environments. To protect these sensitive areas, a range of legislative and management provisions are in place to guide planning and development decisions within coastal zones. The following chapter summarises the relevant national, state and regional provisions that are in place to guide coastal development and protection within the Leekes Creek study area.

#### 10.2.1 Great Barrier Reef Marine Park

Great Keppel Island lies within the GBRMP which is declared and managed under the *Great Barrier Reef Marine Park Act 1975*. Australian and Queensland government entities, the Great Barrier Reef Marine Park Authority (GBRMPA) and NPRSR respectively, have a cooperative and integrated management arrangement for the GBR. Additionally, to complement the protection and management intentions of the GBRMP, State Marine Parks have been declared in inshore and tidal areas (Chapter 10.2.2).

The GBRMP is zoned to identify where certain activities are allowed and where some are prohibited. It is a multiple use marine protected area, providing for a range of ecologically sustainable recreational, commercial, indigenous and research activities and opportunities.

#### 10.2.2 Great Barrier Reef Coast Marine Park

Great Keppel Island lies within the Great Barrier Reef Coast Marine Park (GBR Coast MP). The GBR Coast MP is a state marine park that runs the full length of the GBRMP. In some areas it includes waterways and wetlands to high water mark, while in other areas it extends shoreward only to the edge of significant mangrove forests. It protects habitats such as mangroves, seagrass meadows and fringing reefs, all of which play a vital role in supporting and protecting the larger GBRMP. The GBR Coast MP is managed under the *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004* which is administered by the Queensland Parks and Wildlife Service (QPWS), a division within NPRSR.

The GBR Coast MP provides protection for Queensland tidal lands and tidal waters and supports the zoning plan within the GBRMP by adopting complementary zone objectives. The activities that can be carried out in the GBRMP and GBR Coast MP are generally the same however there are some Queensland specific provisions that may apply (NPRSR 2011).

The majority of the tidal areas of GKI, including the Leekes Creek study area, are within a habitat protection zone (Figure 10.1). This zone allows for most lawful activities however a permit is required for activities such as aquaculture, shipping, coastal works, research activities, running a tourism program and harvest fishing for the aquarium trade or for sea cucumber, trochus and tropical rock lobster. Trawling is prohibited in a habitat protection zone.



#### LEGEND



**Figure 10.1: Great Barrier Reef Marine Park Zoning around Great Keppel Island (DAFF 2013a)**

### 10.2.3 State Planning Policy

The Single State Planning Policy (SPP) came into effect on 2 December 2013. This new approach aims to clarify the planning policies previously in place by revoking multiple policies based upon social, economic, environmental and health priorities and replacing them with a consolidated and comprehensive 'one state' planning policy. The SPP outlines matters considered to be of state significance, which include coastal environments, water quality and biodiversity. Local government planning and assessment processes are required to reflect these state interests through appropriate consideration and protection of such things as:

- matters of national and state environmental significance (including declared FHAs)
- strategic offset areas
- protecting species and species habitat, ecosystems and ecosystem services and other natural values to the greatest extent practicable
- and maintaining or enhancing ecological connectivity.

Development decisions relating to GKI will be guided by this policy.

#### **10.2.4 Coastal Management Plan**

The Coastal Management Plan supports the SPP for matters related to planning and development decisions affecting coastal resources on public coastal lands and therefore will also guide development decisions relating to GKI. It is primarily aimed at local government who are responsible for managing areas of public coastal land and beaches however other specialist coastal managers will benefit from the policies and information contained within the plan. The plan provides guidance and direction to achieve the objectives of the *Coastal Protection and Management Act 1995*, which are to:

- provide for the protection, conservation, rehabilitation and management of the coastal zone, including its resources and biological diversity
- have regard to the goal, core objectives and guiding principles of the National Strategy for Ecologically Sustainable Development in the use of the coastal zone
- ensure decisions about land use and development safeguard life and property from the threat of coastal hazards, and
- encourage the enhancement of knowledge of coastal resources and the effect of human activities on the coastal zone.

#### **10.2.5 Regional and local government plans**

Under the *Sustainable Planning Act 2009*, local councils are obligated to prepare planning schemes for their area. Planning schemes support the local government when assessing development applications and identifying future land uses through the provision of a detailed direction for the area that integrates and balances the economic, social and environmental needs and aspirations of the local community whilst focusing on land use, development, infrastructure and valuable features of an area to drive decisions on land use and change (SDIP 2013). GKI falls within the planning scheme of Livingstone Shire Council and is within a comprehensive development zone. All areas within the Comprehensive Development Zone are subject to a detailed structure map, which allocates the island into the following specific land use precincts:

- accommodation and associated facilities
- village commercial
- conservation
- aquifer.

The entire Leekes Creek study area is designated a conservation precinct. For this area, Livingstone Shire Council have identified triggers to optimise the need to maximise nature conservation and consequential detrimental effects with the need for a practical and efficient development assessment system.

The *Sustainable Planning Act 2009* emphasises the delivery of sustainable planning outcomes by encouraging the incorporation of:

- preparation of a strategic land-use plan;
- increased emphasis on community engagement - to ensure all of the community's needs are reflected in the final plan;
- greater flexibility - to cater for unexpected changes; and
- new streamlined ways for local governments to amend their planning scheme to reflect these changed circumstances (SDIP 2013).

To assist and provide guidance to local councils in their planning and policy making, the Central Queensland Regional Plan (CQRP) is in place. The CQRP focuses on mining and agriculture and aims to effectively manage the high level of growth of these industries in the Central Queensland area by incorporating the key state interest matters addressed in the SPP with a regional focus. The focus of the plan is to:

- protect the region's priority agricultural land uses from incompatible resource development by mapping priority agricultural areas and identifying assessment criteria that will apply to resource activities undertaken in a priority agricultural area
- protect the future of towns in the region by mapping priority living areas and initiating legislative amendments that will allow local governments to determine whether or not resource activities can be located within a priority living area
- identify infrastructure opportunities for the region, and
- provide regional direction in relation to other state interests.

It therefore does little to support the fisheries values of coastal regions in Central Queensland.

### **10.2.6 Declared Fish Habitat Areas**

Declared FHAs are estuarine and inshore environments along the Queensland coast that are protected against physical disturbance from coastal development whilst still allowing for community access for boating, fishing and recreational activities. They are declared under the *Fisheries Act 1994* and are a critical management tool for the sustainability of Queensland fisheries. Expansion of the declared FHA network to ensure a comprehensive, adequate and representative state-wide network is essential to cater for the reliance of many fish species on multiple habitats during their lives and to protect these habitats and their interconnectivity.

Presently the nearest declared FHAs to Leekes Creek are the Cawarral Creek, Fitzroy River and Corio Bay declared FHAs. These three management 'A' areas are recognised as highly productive fishery areas and major contributors to the sustainability of the region's fisheries.

### **10.2.7 Significant wetlands**

First published in 1993, The Directory of Important Wetlands in Australia (DIWA) is a cooperative project involving Australian, state and territory governments. In addition to identifying nationally important wetlands, DIWA provides information on wetlands, their ecology and their social and cultural values. It does not uphold any legislative jurisdiction but guides management decisions by highlighting the ecological significance of listed areas.

To be considered nationally important, a wetland must meet at least one of the six criteria:

- biogeographic representativeness
- important ecological or hydrological functions
- provision of animal habitat during times of vulnerability or adverse conditions
- support for more than 1% of the national population of any taxa
- support for threatened taxa or communities and
- hold historical or cultural significance.

The most recent edition of the Directory published in 2001, listed 904 nationally important wetland sites across the nation, covering an area of 57, 904 254ha. The nearest DIWA listed wetland to Leekes Creek is the Fitzroy River delta, approximately 35km south west of Leekes Creek study area.

Ramsar wetlands are sites that are recognised under the Convention on Wetlands of International Importance (Ramsar convention) as being of international significance in terms of hydrology, ecology, botany, zoology or limnology (SEWPC 2011). The *Environmental Protection and Biodiversity Conservation Act 1999* enhances the management and protection of Australia's Ramsar wetlands by regulating activities that will or are likely to have a significant impact upon the site. There are two Ramsar wetlands in Central Queensland, these are Shoalwater and Corio Bays approximately 70km and 30km from Leekes Creek study area respectively.

## **10.3 Conclusion**

The Leekes Creek study area is afforded a degree of protection through various local, state and federal management and legislative provisions. These provisions guide management and development decisions and aim to ensure the significant ecological values of an area are not lost to inappropriate development activities. The declaration of Leekes Creek study area as an FHA would provide this important fisheries area a much more comprehensive level of protection from disturbance caused by coastal development.

## Chapter 11 Suitability of Leekes Creek study area for FHA declaration

### Chapter summary

The Leekes Creek study area meets all of the four fisheries criteria and the eight habitat criteria outlined in the FHA assessment criteria. Its location on an offshore continental GBR island, regionally significant coral communities and provision of nursery areas for juvenile fish supports the additional 'regionally unique feature' criteria.

The Leekes Creek study area would be an important addition to the declared FHA network, which currently lacks representation from any areas with similar characteristics. The close proximity of reef and estuary plays a special role in the ecology of the local area and allows utilisation by both inshore and offshore fish species. These special qualities indicate that the area should be afforded a high level of protection. It is therefore recommended that the Leekes Creek study area progress to public consultation with the view to declaring it a management 'A' FHA.

### 11.1 Introduction

The Declared FHA network began in the late 1960's as a response to coastal development pressures on fish habitats within Moreton Bay and the Gold Coast. Since then the network has expanded to include 70 declared FHAs along the Queensland coast, protecting more than 1.1 million ha of high quality fish habitats. The declared FHA concept recognises that many fish species have a complex and interrelated reliance on multiple habitats during their lives and that expansion of the network has the added benefit of providing linkages between these habitats and protected areas.

In order to appropriately and consistently assess candidate areas for declaration as an FHA, the FHA selection, assessment, declaration and review operational policy (NPRSR 2013) has been developed. This document provides a set of criteria to guide decisions as to whether an area is suitable for declaration as an FHA (Appendix E). This chapter summarises the findings of this report in relation to the FHA selection criteria.

Assessment against the FHA selection criteria is a vital component of the eventual declaration of an FHA, however it is only the first step in the process. Community support is a critical factor for the long term integrity of declared FHAs and therefore, candidate areas that are assessed as meeting the requirements of the FHA selection criteria are subject to extensive public consultation to gauge community and stakeholder support.

### 11.2 Assessment of Leekes Creek study area in relation to the FHA selection criteria

The aim of this Fisheries Resource Assessment is to assess the suitability of the Leekes Creek study area for declaration as an FHA. A brief summary of the assessment of the Leekes Creek study area against each of the criteria (Appendix E) is provided below.

#### Fisheries Criteria

##### 1. High fish species richness

The fish species inventory documented for the Leekes Creek study area exceeds that of the adjacent Cawarral Creek declared FHA and compares favourably with that of the Fitzroy River declared FHA.

- *Fish species richness similar to that of comparable regional 'benchmark' waterways (Chapter 3) - compatible with FHA*

##### 2. High diversity and abundance of regionally targeted fish species

Fish surveys identified 13 regionally targeted fish species within Leekes Creek and anecdotal evidence increases this number significantly.

- *>15 regionally targeted fish species highly abundant (Chapter 3) - compatible with management 'A' area*

### 3. Supports existing fisheries

The Leekes Creek study area is utilised by recreational fishers for bait collection, mud crabbing and angling and contains a commercial oyster lease.

- *Regular use of the area by recreational and commercial fishers (Chapter 4) - compatible with management 'B' area*

### 4. Supports external/regional fisheries

The area within a 10Nm radius around GKI supports significant commercial and recreational fisheries. This small area produced almost \$1 million in commercial fish product in 2011 and supports an important commercial harvest fishery. A productive and highly frequented recreational fishery exists in the waters surrounding GKI.

- *Major commercial and recreational fisheries occur in the adjoining area and adjacent offshore waters; with species targeted directly linked to the area (Chapter 4) - compatible with management 'A' area*

## **Fish Habitat criteria**

### 1. Large in size

The Leekes Creek study area is approximately 280ha in size.

- *>100 ha (Chapter 2) - compatible with management 'B' area*

### 2. Diverse habitat types

10 of the 14 habitat types outlined in the NPRSR FHA selection criteria (NPRSR 2013) are contained within the Leekes Creek study area.

- *>7 habitat types represented (Chapter 5) - compatible with management 'A' area*

### 3. Presence of a functioning riparian buffer zone

The riparian zone bounding the Leekes Creek study area is fully intact and in near pristine condition.

- *>80% of the length of the riparian zone is adequately vegetated and functioning effectively (Chapter 6) - compatible with management 'A' area*

### 4. Limited disturbance from artificial in-stream structures

There are two relatively insignificant in-stream structures within the Leekes Creek study area that are not impacting upon the quality of the estuary including its fish habitats

- *Minimal disturbance from artificial structures. Average separation between structures >400m and <5% of the riverbank is altered by artificial structures (Chapter 9) - compatible with management 'A' area*

### 5. Good water quality

- *Water quality within the Leekes Creek study area is of a high standard and well within ANZECC guidelines (Chapter 8) - compatible with FHA*

### 6. Limited disturbance from, or ongoing reduction of impacts from, water impoundment structures

There are no water impoundments in the Leekes Creek system.

- *No water impoundments are present on the main stream or/and any major tributary of the main stream (Chapter 7) - compatible with FHA*

### 7. Limited interaction with development of major significance to the state

The new Great Keppel Island resort was declared a coordinated project by the Coordinator-General and is planned to commence construction in 2014. The closest infrastructure, the golf fairway, will be located approximately 200

metres from the Leekes Creek study area, to provide a buffer zone; and mitigation methods will be in place to minimise and prevent impacts upon the creek system.

- *Adjoining developments are in a location and can be appropriately buffered to ensure that they will have no existing or future impacts on the area (Chapter 9) - compatible with FHA*

## **8. Compatible with adjacent land and aquatic planning**

Great Keppel Island is a tourist destination, with a small number of permanent residents. The study area is located within the Great Barrier Reef Marine Park's habitat protection zone and the Livingstone Shire Council Planning Scheme's conservation zone.

- *Adjacent land and aquatic planning compatible with the intent of the strict management 'A' area (Chapter 9) - compatible with management 'A' area*

### **Regionally unique features**

Leekes Creek study area would provide a unique addition to the declared FHA network, being an estuarine system on a GBR continental island. A diverse and abundant range of fish species utilise the area and its range of habitats indicates that it holds the capacity to support both inshore fish and offshore reef species.

A coral community within the study area may be regionally significant due to its resilience to climate change, high diversity of species and the presence of fish and anemone species that are rare in the Keppel Island region.

- *Presence of regionally unique natural fish habitat features (Chapter 5) - compatible with FHA.*

## **11.3 Conclusion**

The Leekes Creek study area is a relatively pristine estuarine system, containing productive fish habitats that support an important recreational and commercial fishery. The Leekes Creek study area clearly meets all requirements to be suitable for declaration as an FHA.

As an estuarine system on an offshore continental GBR island, Leekes Creek study area provides a unique opportunity to extend the declared FHA network. The mix of reef and estuary, in such close proximity, plays a special role in the ecology of the local area and enables utilisation by both inshore and offshore fish species. The declared FHA network does not currently include a system similar to the Leekes Creek study area. The inclusion of areas such as this is important for connectivity and to ensure a comprehensive and representative range of fish habitats are incorporated into the network.

These features of Leekes Creek study area indicate it would be an important addition to the declared FHA network and its suitability as a management A area outweighs the suggested management level based solely on the minimum size criteria. It would be an important addition to the declared FHA network, and therefore it is recommended that Leekes Creek study area progress to public consultation with the view to declaring it a management A FHA.

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## Appendix A: Species of fish and crustacean documented in the Leekes Creek study area

List source: frc environmental 2012, Leekes Creek Estuary Fish and Seagrass Assessment (frc Environmental 2014)

### Family

Species	Common name
<b>Fish</b>	
Atherinidae (Hardyheads and Silversides)	
<i>Atherinomorus endrachtensis</i>	Endracht hardyhead
Caesionidae (Fusiliers)	
<i>Caesio caerulea</i>	Blue and gold fusilier
Carangidae (Jacks and Scads)	
<i>Gnathanodon speciosus</i>	Golden trevally
Carcharhinidae (Requiem sharks)	
<i>Negaprion acutidens</i>	Lemon shark
Clupeidae (Herrings)	
<i>Herklotsichthys koningsbergeri</i>	Koningsberger's herring
<i>Sardinella albella</i>	White sardine
Cynoglossidae (Tonguefish)	
<i>Paraplagusia bilineata</i>	Patterned tongue sole
Dasyatidae (Stingrays)	
<i>Pastinachus sephen</i>	Cowtail stingray
<i>Dasyatis fluviatorum</i>	Brown Stingray
<i>Taeniura lymma</i>	Bluespotted Stingray
Drepaneidae (Sicklefish)	
<i>Drepane punctata</i>	Sicklefish
Gerreidae (Mojarras)	
<i>Gerres subfasciatus</i>	Common silverbidy
<i>G. filamentosus</i>	Thread-finned silver bidy
<i>G. oyena</i>	Common silver bidy
Gobiidae (Gobies)	
<i>Favonigobius exquisitus</i>	Exquisite sand goby
<i>Periophthalmus argentilineatus</i>	Mudskipper

Haemulidae (Grunts) <i>Pomadasys kaakan</i>	Spotted javelinfinch
Leiognathidae (Ponyfish) <i>Leiognathus equulus</i>	Common ponyfish
Lutjanidae (Snappers) <i>Lutjanus russelli</i>	Moses perch
Mugilidae (Mulletts) <i>Mugil cephalus</i>	Sea mullet
Mullidae (Goatfish) <i>Parupeneus barberinus</i>	Dash-dot goatfish
Platycephalidae (Flatheads) <i>Platycephalus endrachtensis</i> <i>P. fuscus</i>	Bar-tailed flathead Dusky flathead
Pseudomugilidae (Blue eyes) <i>Pseudomugil signifer</i>	Pacific blue-eye
Rhinobatidae (Guitarfish) <i>Aptychotrema</i> sp.	Shovelnose ray
Scatophagidae (Scats) <i>Selenotoca multifasciata</i>	Striped butterflyfish
Serranidae (Rockcods and Groupers) <i>Ephinephelus coioides</i>	Estuary cod
Siganidae (Rabbitfish) <i>Siganus canaliculatus</i>	White-spotted spinefoot
Sillaginidae (Whitings) <i>Sillago ciliata</i>	Sand whiting
Sparidae (Seabream and porgies) <i>Acanthopgrus latus</i> <i>A. palmaris</i>	Yellowfin bream Black bream
Terapontidae (Grunters) <i>Terapon jarbua</i>	Crescent perch
Tetraodontidae (Pufferfish) <i>Arothron immaculatus</i> <i>A. manilensis</i>	Immaculate pufferfish Striped pufferfish
Unknown	Unidentifiable juvenile

## **Crustaceans**

### Calappidae

*Ashtoret granulosa*

Armed crab

### Diogenidae (Hermit crabs)

Various

Hermit crab

### Dotillidae

*Scopimera inflata*

Sand bubbler crab

### Grapsidae (Marsh, shore and talon crabs)

*Goniopsis cruentata*

Red mangrove crab

### Mictyridae

*Mictyris longicarpus*

Soldier crab

### Ocypodidae (Ghost and fiddler crabs)

*Ocypode ceratophthalma*

Horn-eyed ghost crab

*Ucca* spp.

Fiddler crab

### Penaeidae

Unidentified

Prawn

### Portunidae (Swimming crabs)

*Portunus pelagicus*

Blue swimmer crab

*Scylla serrata*

Mud crab

*Thalamita crenata*

Mangrove swimming crab



## Appendix B: Species of fish and crustacean anecdotally recorded in the Leekes Creek study area

List source: Leekes Creek Estuary Fish and Seagrass Assessment (frc environmental, 2014)

### Family

Species	Common name
<b>Fish</b>	
Albulidae (Bonefishes)	
<i>Albula vulpes</i>	Bonefish
Atherinidae (Hardyheads and silversides)	
<i>Pranesus ogilbyi</i>	Ogilby's hardyhead
Belonidae (Needlefish)	
Various	Longtom
Brachaeluridae (Blind sharks)	
<i>Brachaelurus waddi</i>	Blind shark
Carangidae (Jacks and scads)	
<i>Alectis indica</i>	Indian threadfin
<i>Caranx sexfasciatus</i>	Bigeye trevally
<i>Seriola lalandi</i>	Yellowtail amberjack
<i>Trachinotus blochi</i>	Snubnose pompano
<i>T. russelli</i>	Large-spot dart
Carcharhinidae (Requiem sharks)	
<i>Carcharhinus macrurus</i>	Dusky shark
<i>C. spallanzani</i>	Spot-tail shark
<i>Galeocerdo cuvieri</i>	Tiger shark
Chanidae (Milkfish)	
<i>Chanos chanos</i>	Milkfish
Chirocentridae (Wolf herring)	
<i>Chirocentrus dorab</i>	Dorab wolf-herring
Dasyatidae (Wolf herring)	
<i>Taeniura lymna</i>	Ribbontail stingray
Ephippidae (Spadefish)	

<i>Platax pinnatus</i>	Dusky batfish
Haemulidae (Grunts) <i>Plectorhincus gibbosus</i> <i>Pomadasys argenteus</i>	Harry hotlips Silver grunt
Hemiramphidae (Halfbeaks) <i>Hyporhamphus australis</i> <i>Hemiramphus robustus</i>	Eastern sea garfish Three-by-two garfish
Hemiscylliidae (Longtail carpet and bamboo sharks) <i>Hemiscyllium ocellatum</i>	Epaulette shark
Latidae (Perches) <i>Lates calcarifer</i>	Barramundi
Lethrinidae (Emperors) <i>Lethrinus fletus</i>	Grass emperor
Lutjanidae (Snappers) <i>Lutjanus argentimaculatus</i> <i>L. carponotatus</i>	Mangrove red snapper Spanish flag snapper
Monodactylidae (Silver batfishes) <i>Monodactylus argenteus</i>	Silver moony
Mugilidae (Mulletts) <i>Liza</i> sp. <i>Myxus elongatus</i>	Mullet Sand grey mullet
Myliobatidae (Eagle rays) <i>Aetobatus narinari</i> <i>Manta alfredi</i>	Spotted eagle ray Manta ray
Orectolobidae (Wobbegongs) <i>Orectolobus ornatus</i>	Ornate wobbegong
Paralichthyidae (Large-tooth flounders) <i>Pseudorhombus arsius</i>	Large-tooth flounder
Plotosidae (Eel-tail catfish) <i>Plotosus anguillaris</i>	Striped eel catfish
Rachycentridae (Cobia) <i>Rachycentron canadum</i>	Cobia
Rhinobatidae (Guitarfish) <i>Rhynchobatus djiddensis</i>	Giant guitarfish

*Glaucostegus typus*

Giant shovelnose ray

Scombridae (Mackerels, tunas and bonitos)

*Cybiosarda elegans*

*Cybium commersoni*

*Euthynnus alletteratus*

*Indocybium semifasciatum*

*Sawara nipponia*

*Scomberoides lysan*

*Scomberomorus queenslandicus*

Leaping bonito

Narrow-barred Spanish mackerel

Little tunny

Broad-barred king mackerel

Japanese Spanish mackerel

Double spotted queenfish

Queensland school mackerel

Serranidae (Rock cods and groupers)

*Epinephelus merra*

*E. tauvina*

*Plectropoma maculatus*

Honeycomb grouper

Greasy grouper

Spotted coral grouper

Sillaginidae (Whitings)

*Sillago maculata*

Trumpeter whiting

Sphyraenidae (Barracudas)

*Agrioposphyraena barracuda*

*Sphyraena obtusata*

Great barracuda

Obtuse barracuda

Sphyrnidae (Hammerhead sharks)

*Sphyrna lewini*

Scalloped hammerhead

Stegostomatidae (Zebra sharks)

*Stegastoma fasciatum*

Zebra shark

Synanceiidae (Ray-finned fish)

*Synanceia trachynis*

Estuarine stonefish

Terapontidae (Grunters)

*Pelates quadrilineatus*

Fourlined terapon

Tetraodontidae (Pufferfish)

*Tetractenos hamiltoni*

Toadfish

Uranoscopidae (Stargazers)

*Ichthyscopus lebeck*

Long nosed stargazer

### **Crustaceans**

Callianassidae (Ghost shrimps)

*Callianassa australiensis*

Ghost shrimp

Grapsidae (Marsh, shore and talon crabs)

*Grapsus albolineatus*

*Metopograpsus frontalis*

Tropical rocky shore crab

Mangrove crab

Ocypodidae (Ghost and fiddler crabs) <i>Ocypode cordimana</i>	Ghost crab
Palinuridae (Spiny lobsters) <i>Panuliris ornatus</i>	Ornate rock lobster
Penaeidae <i>Penaeus esculentus</i> <i>P. plebejus</i>	Brown tiger prawn Eastern king prawn
Portunidae (Swimming crabs) <i>Portunus sanguinolentus</i>	Flower crab
Raninidae (Frog crabs) <i>Ranina ranina</i>	Spanner crab
Squillidae (Mantis shrimps) <i>Squilla granti</i>	Mantis shrimp
Thalassinidae (Mud lobsters) <i>Thalassina squamifera</i>	Mud lobster

## Appendix C: Fish species list for the Keppel Islands fringing reefs

List source: Williamson, unpublished

### Family

Species	Common name
<b>Fish</b>	
Acanthuridae (Surgeonfishes)	
<i>Acanthurus blochii</i>	Ringtail surgeonfish
<i>A. dussumieri</i>	Eyestripe surgeonfish
<i>A. grammoptilus</i>	Finelined surgeonfish
<i>A. lineatus</i>	Lined surgeonfish
<i>A. nigricauda</i>	Epaulette surgeonfish
<i>A. nigrofuscus</i>	Brown surgeonfish
<i>A. xanthopterus</i>	Yellowfin surgeonfish
<i>Ctenochaetus binotatus</i>	Two-spot bristletooth
<i>C. striatus</i>	Striated surgeonfish
<i>Naso annulatus</i>	Ringtail unicornfish
<i>N. brevirostris</i>	Spotted unicornfish
<i>N. lituratus</i>	Orange spine unicornfish
<i>N. tuberosus</i>	Humpnose unicornfish
<i>N. unicornis</i>	Bluespine unicornfish
<i>Prionurus microlepidotus</i>	Australian sawtail
<i>Zebrasoma scopas</i>	Twotone tang
<i>Z. veliferum</i>	Sailfin tang
Chaetodontidae	
<i>Chaetodon aureofasciatus</i>	Golden butterfly fish
<i>C. auriga</i>	Threadfin butterfly fish
<i>C. baronessa</i>	Eastern triangular butterfly fish
<i>C. bennetti</i>	Bluelashed butterfly fish
<i>C. citrinellus</i>	Speckled butterfly fish
<i>C. ephippium</i>	Saddle butterfly fish
<i>C. flavirostris</i>	Dusky butterfly fish
<i>C. lineolatus</i>	Lined butterfly fish
<i>C. lunula</i>	Raccoon butterfly fish
<i>C. lunulatus</i>	Pinstripe butterfly fish
<i>C. melannotus</i>	Black back butterfly fish
<i>C. ornatissimus</i>	Ornate butterfly fish
<i>C. plebeius</i>	Blue spot butterfly fish
<i>C. rafflesi</i>	Latticed butterfly fish
<i>C. rainfordi</i>	Rainford's butterfly fish
<i>C. speculum</i>	Oval spot butterfly fish
<i>C. trifascialis</i>	Chevroned butterfly fish
<i>C. ulietensis</i>	Double saddle butterfly fish
<i>C. vagabundus</i>	Vagabond butterfly fish
<i>Chelmon rostratus</i>	Beaked coralfish
<i>Coradion altivelis</i>	Highfin coralfish
<i>C. chrysostomus</i>	
<i>H. acuminatus</i>	Longfin bannerfish
<i>H. monoceros</i>	Masked bannerfish
<i>H. varius</i>	Horned bannerfish
<i>Parachaetodon ocellatus</i>	Ocellate butterfly fish

## Ephippidae

*Platax orbicularis*  
*P. teira*  
*P. pinnatus*

Orbiculate batfish  
Roundface batfish  
Longfin batfish

## Haemulidae

*Diagramma pictum*  
*Plectorhinchus chaetodontoides*  
*P. flavomaculatus*  
*P. gibbosus*  
*P. lessonii*  
*P. unicolor*

Painted sweetlips  
Spotted sweetlips  
Goldspotted sweetlips  
Brown sweetlips  
Lesson's thicklip

## Kyphosidae

*Kyphosus* spp.  
*Microcanthus strigatus*

Stripey

## Labridae

*Anampses geographicus*  
*A. neoguinaicus*  
*Bodianus axillaris*  
*B. loxozonus*  
*B. mesothorax*  
*Cheilinus chlorurus*  
*C. fasciatus*  
*C. trilobatus*  
*C. undulatus*  
*Choerodon anchorago*  
*C. cyanodus*  
*C. fasciatus*  
*C. graphicus*  
*C. monostigma*  
*C. schoenleinii*  
*C. vitta*  
*Epibulus insidiator*  
*Gomphosus varius*  
*Halichoeres melanurus*  
*Hemigymnus fasciatus*  
*H. melapterus*  
*Labrichthys unilineatus*  
*Labroides bicolor*  
*L. dimidiatus*  
*Labropsis australis*  
*Oxycheilinus diagramma*  
*Pseudolabrus guentheri*  
*Stethojulis bandanensis*  
*S. strigiventer*  
*Thalossoma hardwicke*  
*T. janseni*  
*T. lunare*  
*T. lutescens*

Scribbled wrasse  
Black backed wrasse  
Axilspot hogfish  
Blackfin pigfish  
Split level hogfish  
Floral maori wrasse  
Redbreast maori wrasse  
Tripletail maori wrasse  
Humphead maori wrasse  
Orange dotted tuskfish  
Blue tuskfish  
Harlequin tuskfish  
Graphic tuskfish  
Dark spot tuskfish  
Blackspot tuskfish  
Redstripe tuskfish  
Slingjaw wrasse  
Birdnose wrasse  
Tail-spot wrasse  
Fiveband wrasse  
Blackeye thicklip  
Tubelip wrasse  
Bicolor cleaner wrasse  
Blue streak cleaner wrasse  
Southern tubelip  
Cheeklined wrasse  
Gunther's wrasse  
Red shoulder wrasse  
Three-ribbon wrasse  
Sixbar wrasse  
Jansen's wrasse  
Moon wrasse  
Green moon wrasse

## Lethrinidae

<i>Gymnocranius</i> spp.	
<i>Lethrinus atkinsoni</i>	Pacific yellowtail emperor
<i>L. laticaudis</i>	Grass emperor
<i>L. lentjan</i>	Pink ear emperor
<i>L. miniatus</i>	Redthroat emperor
<i>L. nebulosus</i>	Spangled emperor
<i>L. obsoletus</i>	Yellow striped emperor
<i>L. ornatus</i>	Ornate emperor
<i>Monotaxis grandoculis</i>	Bigeye seabream

## Lutjanidae

<i>Lutjanus argentimaculatus</i>	Mangrove jack
<i>L. carponotatus</i>	Stripey snapper
<i>L. fulviflamma</i>	Blackspot snapper
<i>L. fulvus</i>	Blacktail snapper
<i>L. lemniscatus</i>	Yellow streaked snapper
<i>L. lutjanus</i>	Bigeye snapper
<i>L. monostigma</i>	One-spot snapper
<i>L. quinquelineatus</i>	Fiveline snapper
<i>L. russelli</i>	Mosses' snapper
<i>L. sebae</i>	Emperor red snapper
<i>L. vitta</i>	Brown stripe red snapper
<i>Symphorus nematophorus</i>	Chinaman fish

## Mullidae

<i>Parupeneus barberinus</i>	Dash-and-dot goatfish
<i>P. bifasciatus</i>	Five-barred goatfish
<i>P. ciliatus</i>	Diamond scale goatfish
<i>P. indicus</i>	Yellow spot goatfish

## Muraenidae

<i>Echidna nebulosa</i>	Snowflake moray
<i>Gymnothorax favagineus</i>	Tessellate moray
<i>G. javanicus</i>	Giant moray
<i>G. meleagris</i>	Whitemouth moray
<i>G. undulatus</i>	Undulated moray

## Nemipteridae

<i>Scolopsis bilineatus</i>	Two-lined monocle bream
<i>S. margaritifer</i>	Pearly monocle bream
<i>S. monogramma</i>	Rainbow monocle bream

## Pomacanthidae

<i>Centropyge bicolor</i>	Bicolor angelfish
<i>C. bispinosus</i>	Two-spine angelfish
<i>C. nox</i>	Midnight angelfish
<i>C. tibicen</i>	Keyhole angelfish
<i>C. vrolikii</i>	Pearlscale angelfish
<i>Chaetodontoplus duboulayi</i>	Scribbled angelfish
<i>C. meredithi</i>	Queensland yellowtail angelfish
<i>Pomacanthus imperator</i>	Emperor angelfish
<i>P. semicirculatus</i>	Blue angelfish
<i>P. sexstriatus</i>	Six-banded angelfish
<i>P. xanthometapon</i>	Blue face angelfish
<i>Pygoplites diacanthus</i>	Regal angelfish

Pomacentridae

<i>Abudefduf bengalensis</i>	Bengal sergeant
<i>A. sexfasciatus</i>	Scissortail sergeant
<i>A. vaigiensis</i>	Indo-pacific sergeant
<i>A. whitleyi</i>	Whitley's sergeant
<i>Acanthochromis polyacanthus</i>	Spiny puller
<i>Amblyglyphidodon aureus</i>	Golden damsel
<i>A. curacao</i>	Staghorn damsel
<i>A. leucogaster</i>	White belly damsel
<i>Amphiprion akindynos</i>	Barrier reef anemonefish
<i>A. chrysopterus</i>	Orange-fin anemonefish
<i>A. clarkii</i>	Clark's anemonefish
<i>A. melanopus</i>	Red and black anemonefish
<i>A. perideraion</i>	Pink anemonefish
<i>Chromis amboinensis</i>	Black-fin puller
<i>C. atripectoralis</i>	Blackaxil puller
<i>C. atripes</i>	Darkfin puller
<i>C. nitida</i>	Yellowback puller
<i>C. retrofasciatus</i>	Black bar chromis
<i>C. ternatensis</i>	Ternate chromis
<i>C. weberi</i>	Weber's chromis
<i>Chrysiptera rex</i>	King demoiselle
<i>C. rollandi</i>	Rolland's demoiselle
<i>C. talboti</i>	Talbot's demoiselle
<i>Dascyllus aruanus</i>	Banded humbug
<i>D. melanurus</i>	Blacktail humbug
<i>D. trimaculatus</i>	Threespot humbug
<i>D. reticulatus</i>	Headband humbug
<i>Dischistodus melanotus</i>	Black-vent damsel
<i>D. perspicillatus</i>	White damsel
<i>D. prosopotaenia</i>	Honeyhead damsel
<i>D. pseudochrysopoecilus</i>	Monarch damsel
<i>Hemiglyphidodon plagiometapon</i>	Lagoon damselfish
<i>Neoglyphidodon melas</i>	Black damsel
<i>N. nigroris</i>	Black and gold chromis
<i>Plectroglyphidodon dickii</i>	Dick's damsel
<i>P. lacrymatus</i>	Jewel damsel
<i>Pomacentrus adelus</i>	Obscure damsel
<i>P. amboinensis</i>	Ambon damsel
<i>P. australis</i>	Australian damsel
<i>P. bankanensis</i>	Speckled damsel
<i>P. brachialis</i>	Charcoal damsel
<i>P. chrysurus</i>	Whitetail damsel
<i>P. coelestis</i>	Neon damsel
<i>P. lepidogenys</i>	Scaly damsel
<i>P. moluccensis</i>	Lemon damsel
<i>P. nagasakiensis</i>	Nagasaki damsel
<i>P. vaiuli</i>	Ocellate damsel
<i>P. wardi</i>	Ward's damsel
<i>Stegastes apicalis</i>	Australian gregory
<i>S. fasciolatus</i>	Pacific gregory

Scaridae

<i>Bolbometopon muricatum</i>	Bumphead parrotfish
<i>Cetoscarus bicolor</i>	Bicolor parrotfish
<i>Chlorurus bleekeri</i>	Bleeker's parrotfish
<i>C. microrhinus</i>	Steephead parrotfish
<i>C. sordidus</i>	Greenfin parrotfish
<i>Hipposcarus longiceps</i>	Pacific longnose parrotfish
<i>Scarus altipinnis</i>	Mini-fin parrotfish
<i>S. chameleon</i>	Chameleon parrotfish
<i>S. dimidiatus</i>	Yellowbarred parrotfish
<i>S. flavipectoralis</i>	Yellowfin parrotfish
<i>S. frenatus</i>	Sixband parrotfish
<i>S. ghobban</i>	Bluebarred parrotfish
<i>S. globiceps</i>	Globehead parrotfish
<i>S. niger</i>	Swarthy parrotfish
<i>S. psittacus</i>	Common parrotfish
<i>S. rivulatus</i>	Surf parrotfish
<i>S. rubroviolaceus</i>	Ember parrotfish
<i>S. schlegeli</i>	Yellowband parrotfish
<i>S. spinus</i>	Greensnout parrotfish
<i>S. tricolor</i>	Tricolor parrotfish

Serranidae

<i>Aethaloperca rogaa</i>	Redmouth grouper
<i>Anyperodon leucogrammicus</i>	Whiteline rockcod
<i>Cephalopholis boenak</i>	Brown-banded cod
<i>C. cyanostigma</i>	Blue-spotted rockcod
<i>C. microprion</i>	Dot-head cod
<i>Cromileptes altivelis</i>	Humpback grouper
<i>Diploprion bifasciatus</i>	Yellow emperor
<i>Epinephelus caeruleopunctatus</i>	White spotted grouper
<i>E. corallicola</i>	Coral grouper
<i>E. fasciatus</i>	Blacktip rockcod
<i>E. fuscoguttatus</i>	Flowery rockcod
<i>E. hexagonatus</i>	Wirenet rockcod
<i>E. lanceolatus</i>	Queensland grouper
<i>E. merra</i>	Birdwire rockcod
<i>E. ongus</i>	Speckle-finned cod
<i>E. quoyanus</i>	Long-finned cod
<i>Plectropomus laevis</i>	Bluespotted coral trout
<i>P. leopardus</i>	Common coral trout
<i>P. maculatus</i>	Bar-cheeked trout

Siganidae

<i>Siganus argenteus</i>	Streamlined spinefoot
<i>S. corralinus</i>	Coral rabbitfish
<i>S. doliatus</i>	Barred spinefoot
<i>S. fuscescens</i>	Black rabbitfish
<i>S. javas</i>	Streaked spinefoot
<i>S. lineatus</i>	Goldlined rabbitfish
<i>S. puellus</i>	Masked rabbitfish
<i>S. punctatus</i>	Spotted rabbitfish
<i>S. spinus</i>	Scribbled rabbitfish
<i>S. vulpinus</i>	Foxface

Zanclidae

<i>Zanclus cornutus</i>	Moorish idol
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## Appendix D: Regional ecosystems within and adjacent to Leekes Creek study area

((former) DERM 2012)

Regional eco-system	Description	Vegetation Management Act 1999 status	Biodiversity Status
8.1.1	Mangrove vegetation of marine clay plains and estuaries. Estuarine wetland	Least concern	Not of concern at present
8.1.2	Samphire open forbland to isolated clumps of forbs on saltpans and plains adjacent to mangroves	Least concern	Of concern
8.2.1	Casuarina equisetifolia open forest to woodland with Ipomoea pes-caprae and Spinifex sericeus dominated ground layer on foredunes	Of concern	Of concern
8.2.6	Corymbia tessellaris +/- Acacia leptocarpa +/- Allocasuarina littoralis +/- Banksia integrifolia +/- rainforest species open forest on parallel dunes	Of concern	Of concern
8.2.9	Tussock grassland on coastal dunes	Of concern	Endangered
8.3.5	Eucalyptus platyphylla and/or Lophostemon suaveolens and/or Corymbia clarksoniana woodland on alluvial plains	Of concern	Endangered
8.11.8	Corymbia citriodora or Eucalyptus moluccana woodland on metamorphosed sediments (subregion 4)	Least concern	No concern at present
8.11.10	Lophostemon spp. and/or Acacia spp. and/or Melaleuca viridiflora and/or Allocasuarina littoralis +/- Eucalyptus spp. +/- Corymbia spp. tall open shrubland on exposed hill slopes of islands and headlands, on metamorphosed sediments	Of concern	Of concern
8.11.12	Eucalyptus crebra and/or E. drepanophylla and/or E. exserta and/or Corymbia clarksoniana and/or C. xanthope and/or Lophostemon confertus low woodland on metamorphics on islands and headlands	Of concern	Of concern

## Appendix E: Declared Fish Habitat Area assessment criteria

(NPRSR 2013)

<b>Fisheries criteria</b>	<b>Compatible with management 'B' area</b>	<b>Compatible with management 'A' area</b>
High fish species richness	Fish species richness similar to that of comparable regional 'benchmark' waterways.	
High diversity and abundance of regionally targeted fish species (adult or juvenile)	>10 regionally targeted fish species highly abundant.	> 15 regionally targeted fish species highly abundant.
Supports existing fisheries	Regular use of area by commercial, recreational or traditional fishers.	Major commercial and/or recreational and/or traditional fishery within area.
Supports external / regional fisheries	Commercial, recreational or traditional fishing occurs adjoining the area or in adjacent offshore waters, targeting species that are directly linked to the area.	Major commercial, recreational or traditional fisheries occurs adjoining the area or in adjacent offshore waters, targeting species that are directly linked to the area.

<b>Fish habitat criteria</b>	<b>Compatible with management 'B' area</b>	<b>Compatible with management 'A' area</b>
Large in size	> 100ha	> 500ha
Diverse habitat types	> 4 habitat types represented	> 7 habitat types represented
Presence of a functioning riparian buffer zone	> 50% of the length of the riparian zone is adequately vegetated and functioning effectively.	> 80% of the length of the riparian zone is adequately vegetated and functioning effectively.
Limited disturbance from artificial in-stream structures	Minimal disturbance from artificial structures (e.g. jetties, boat ramps, revetments). Average separation between structures 100 – 400m and / or < 5% of the riverbank altered by artificial structures.	Nil to minimal disturbances from artificial structures (e.g. jetties, boat ramps, revetments). Average separation between structures > 400m and / or < 5% of the riverbank altered by artificial structures.
Good water quality	Water quality standard meets the Queensland Water Quality Guidelines ((former) DERM 2009) or water quality objectives under the Environmental Protection (Water) Policy 2009 where applicable, for the protection of aquatic ecosystems; or Documented water quality improvement program is in place to enable the area to meet the Queensland Water Quality Guideline or water quality objectives within 5 years or less.	

<p>Limited disturbance from, or ongoing reduction of impacts from, water impoundment structures</p>	<p>1. No water impoundment structures are present on the main stream and any major tributary of the main stream; or</p> <p>2. The main stream and any major tributaries of the main stream only have water impoundment structures that:</p> <p>allow for &gt; 75% of flows to overtop the structure or are managed to release adequate (from a fisheries perspective) environmental flows; and</p> <p>drown out regularly enough to allow for adequate fish passage or have a functional fishway; or</p> <p>3. Fish passage and environmental flows in the main stream and any major tributaries will be maintained and a proposed program of water management activities will ensure a net improvement in fish passage and / or environmental flows within a 10 year timeframe.</p>	
<p>Limited interaction with developments of major significance to the state</p>	<p>No developments of major significance to the state are present within or adjoining the area; or</p> <p>Any adjoining developments of major significance to the state are in a location and can be appropriately buffered to ensure that they will have no existing or future impacts on the area.</p>	
<p>Compatible adjacent land and aquatic planning</p>	<p>Adjacent land and aquatic planning compatible with intent of management 'B' area.</p>	<p>Adjacent land and aquatic planning compatible with intent of the strict management 'A' area.</p>
	<p>No reduction in habitat values through inappropriate public or a proliferation of private structures or impacts from development.</p>	

<b>Regionally unique features</b>	<b>Compatible with management 'B' area</b>	<b>Compatible with management 'A' area</b>
<p>Presence of regionally unique natural fish habitat features</p>	<p>Contains one or more regionally unique features, e.g. habitat type, spawning ground, nursery location or habitat assemblage.</p>	