Toondah Harbour

Marine Ecology
EPBC Referral

Prepared for:

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Background

Toondah Harbour is located at Cleveland, within the Redland City Local Government Areas (LGA), approximately 30 km from Brisbane in south-east Queensland. In June 2013, at the request of Redland City Council (RCC), Toondah Harbour was declared a priority development area (PDA) by the State Government under the *Economic Development Act 2012.* In June 2015, Walker Group Holdings Pty Ltd (Walker) was selected as the preferred developer and is now responsible for designing, financing and constructing the project. The proposed master plan includes a new ferry and tourism precinct, marina, increased residential living with a diversity of housing types, and a retail, entertainment and dining precinct integrated with parks, plazas, boardwalks and recreational facilities.

frc environmental was commissioned to undertake environmental assessment services to inform a referral under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) with respect to marine (including estuarine) ecology. Specifically, this report describes the existing marine habitats and communities in and adjacent to the PDA, describes and assesses the likely occurrence of marine Matters of National Environmental Significance (MNES) protected under the EPBC Act, identifies potential impacts to the marine environment as a result of the construction and operation of the proposed project, and suggests mitigation measures.

Marine Habitats

The PDA and adjacent areas supports a diversity of intertidal and shallow subtidal habitat, including saltmarsh, intertidal mangrove forest, intertidal and subtidal seagrass meadows, coral and rubble assemblages, and intertidal and subtidal mudflats and sand-banks. These habitats have a high to very high ecological value and were surveyed in the PDA area in 2014 (Table 1.1 and Map 1).

Marine plant communities, including saltmarsh, mangrove and seagrass, are an important fish habitat and are of high ecological value. Coral communities in the area are unique in that they are likely to represent the marginal range of several species and are of high ecological value. Similarly, mudflat and sandbank habitats support a relatively diverse and abundant invertebrate assemblage, providing an important source of food for fish and other invertebrates and are of moderate ecological value. Each of these habitat types extends beyond the PDA; and each is extensively distributed throughout western Moreton Bay.

Table 1.1 Habitats of the PDA and adjacent areas.

Description	Biota Observed	Ecological Value
Shellfish Reefs Historically dominated the area, currently functionally extinct. Remnant oysters likely to be restricted to intertidal areas.	Not surveyed	**Not Applicable** Shellfish reefs are currently functionally extinct
Saltmarsh There are approximately 1.2 ha of saltmarsh south of (and none within) the PDA (Map 1). The saltmarsh is in the upper most intertidal zone with the mangroves offshore. The saltmarsh is highly disturbed by the developed areas along the foreshore. The saltmarsh receives run-off from developed areas and rubbish was found throughout.	**Plants** Grey mangrove, river mangrove, sea rush, seablite, samphire, couch, benthic algae	**High – important fisheries value** Diversity of flora was low and patchy. Some of the saltmarsh area is listed as a vulnerable threatened ecological communities under the EPBC Act.
Intertidal Mangrove Forests There are approximately 5.3 ha of mangroves within the PDA (Map 1). The mangrove forests are along the upper intertidal zone and are bordered by mud and sand flats. The mangrove forests along the foreshore are highly disturbed by the developed areas. These mangrove forests receive run-off from developed areas. There was rubbish within the mangrove roots and along the shoreline throughout the PDA.	**Plants:** Grey mangrove, river mangrove, stilted mangrove, yellow mangrove, algae **Invertebrates** Hercules mud whelks, barnacles, periwinkles, nerites, estuarine slugs, hermit crabs, sand bubblers, fiddler crabs, mangrove crabs, polychaetes	**High – important fisheries value and high diversity of fauna** Diversity of flora was low, but cover was high. The diversity of fauna was high, but abundances were low.
Intertidal and Subtidal Seagrass There are approximately 32.7 ha of seagrass within the PDA (Map 1). The seagrass meadows are predominantly in the intertidal and shallow subtidal zone between the foreshore and island of mangroves offshore within the PDA. There are also some sparse seagrass meadows in the lower intertidal zone adjacent to the subtidal areas. There has been some disturbance of the seagrass meadows by recreational boat traffic and wash from ferries on the southern section adjacent to the channel.	**Plants** Seagrass, macroalgae **Invertebrates** Hermit crabs, sea cucumbers, anemones, swimmer crabs, polychaetes, soft corals, jellyfish, prawns, mussel, clams **Vertebrates** Fish, stingrays.	**Very High – important fisheries value, potential foraging area for threatened species (turtles and dugong)** There was moderate diversity and abundance of flora and fauna. The area is likely to be used by several fish species of commercial importance. The area potentially provides significant habitat and foraging ground for marine turtles and dugongs.
Coral and Rubble Assemblage There are scattered corals to the north and east of Cassim Island and there may also be some coral within and to the south of Fison Channel. There are areas of soft coral and hard coral reef to the east of Cassim Island, outside the PDA.	Not surveyed	**High – supports distinctive species** Marginal range of several species, unique communities
intertidal and Subtidal Mudflats and Sand-banks This zone includes the current dredged channel for boat and ferry access to Moreton Bay, and shallow unvegetated intertidal flats (Map 1). The area around the channel is extremely disturbed by the frequent boat and ferry traffic, with wash affecting exposed areas at low tide. The rest of the area is moderately disturbed, with run-off from developed areas and some recreational use.	**Plants** Benthic algae **Invertebrates** Hercules mud whelks, hermit crabs, fiddler crabs, mangrove crabs, polychaetes **Vertebrates** Fish, stingrays	**High – important fisheries value** Invertebrate fauna was relatively diverse and abundant.

Toondah Harbour Marine Ecology
EPBC Referral

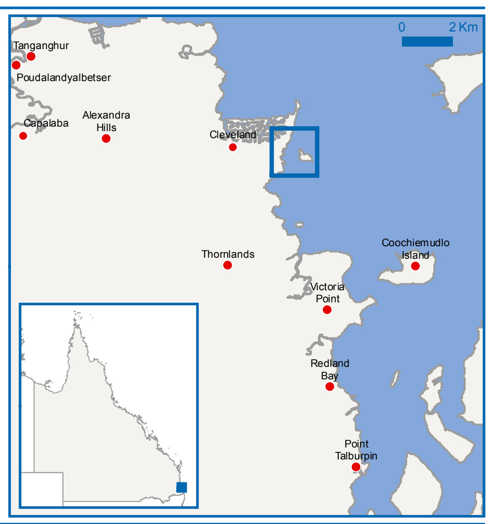
Map 1:
Marine habitats of Toondah Harbour and the PDA

LEGEND

Toondah Harbour PDA

Dominant Marine Habitats

- *Avicennia marina*
- *Rhizophora stylosa*
- *Aegiceras corniculatum*
- *Ceriops tagal var. australis*
- Saltpan / Saltmarsh
- *Juncus kraussii*
- Seagrass
- Rubble
- Sand / Mud



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Matters of National Environmental Significance

The proposed project is within the Moreton Bay Ramsar wetland boundary, which is a wetland of national importance. Threatened and migratory loggerhead turtles and green turtles are highly likely, and hawksbill turtles are moderately likely to intermittently occur in the potential area of impact While these species are unlikely to nest in the vicinity of the PDA, they are likely to use the area as a foraging ground. Migratory Indo-Pacific humpback dolphins and dugong are also highly likely to intermittently occur in the potential area of impact. Both these species tend to occur in estuarine and shallow coastal areas and may use the area for feeding.

Loggerhead turtles, green turtles, hawksbill turtles Indo-Pacific humpback dolphins and dugong also occur within the wider Moreton Bay and along the east coast of Queensland. The area in the immediate vicinity of the proposed works is unlikely to provide critical significant habitat for these species.

Potential Impacts

Potential Impacts from the proposed project include:

- direct loss of habitat directly under the footprint of the proposed project
- gain of habitat in some of these areas
- marine fauna trapped or injured in wet excavation areas
- disturbance of sediments and soil (potentially increasing turbidity, suspended solids, sedimentation, nutrients and/or contaminants and disturbing potential acid sulfate soils)
- spills of hydrocarbons and other contaminants
- increased stormwater runoff (with greater non-permeable surfaces on the subject site) and associated contaminants and foreshore erosion
- altered hydrodynamics
- increased site access and boating activity
- spread of weeds and pests
- increased litter, and
- long-term improvement in water quality around the Fison Channel.

A number of industry standard measures could be put in place to mitigate these impacts, including:

- designing the project to minimise the area of disturbance (project footprint); the volume of sediment and / or soils disturbed; and, any changes to hydrodynamics
- using the project footprint for any temporary construction and storage
- incorporating structures that provide valuable habitat for fish in the design
- identifing and managing acid sulfate soils and other contaminants
- using temporary enclosures (e.g. complete enclosures such as sheet piles) to reduce the intensity and spatial distribution of turbid plumes during construction
- installing any temporary enclosures at low tide to minimise the number of marine vertebrates caught in the area
- catching any animals that are trapped in the enclosures and releasing them in appropriate habitat outside the area
- using trained marine mammal and turtle spotters prior to commencement of excavation and dredging activities and appropriate management tools to avoid impacts to them (e.g. triggers for cessation of excavation or dredging works)
- developing turbidity and suspended solids thresholds and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction
- avoiding disturbance of sediment and / or soils during important periods of reproduction for coral and seagrass (e.g. late spring and summer) and / or during low
- minimising litter, waste and the use of hydrocarbons and other chemicals
- following national and international best practice standards, including Australian standards relating to antifouling paints and contaminants, Nature Conservation (Wildlife Management) Regulation 2006, vessel and vehicle management and site management strategies and fuel storage and handling activities outlined in AS1940
- implementing environmental management plans, including a Marine Fauna Management Plan, Stormwater Management Plan, Sediment and Erosion Management Plan, Waste Management Plan, Weed Management Plan and Spill Management Plan
- monitoring changes in seagrass and coral communities to determine any potential impacts.

With the use of appropriate mitigation measures, potential impacts to aquatic habitats and communities are likely to be of low significance, other than the direct impacts to marine plants and soft sediment within the footprint, and changes to water quality and soft sediment communities within the dredging and reclamation area.

1 Background

Toondah Harbour is located at Cleveland, within the Redland City Local Government Areas (LGA), approximately 30 km from Brisbane in south-east Queensland. Toondah Harbour is an existing marina area that serves as the base for water taxi, passenger and vehicular ferry services between the mainland and North Stradbroke Island.

In June 2013, at the request of Redland City Council (RCC), Toondah Harbour was declared a priority development area (PDA) by the State Government under the *Economic Development Act 2012*. The PDA was declared to provide opportunities for mixed use and medium density residential development in addition to tourism and retail based development, ferry terminals, open space and a marina. In June 2015, Walker Group Holdings Pty Ltd (Walker) was selected as the preferred developer and is now responsible for designing, financing and constructing the project. Economic Development Queensland (EDQ) and Redland City Council (RCC) are the landowners and will work closely with Walker to implement the shared vision for the project over the next 15 to 20 years.

The PDA has a total area of 68.4 hectares, encompassing 17.9 hectares of existing land and 50.5 hectares of marine and tidal environments. Much of the landward portion of the PDA was previously reclaimed from the 1960s onwards.

The proposed master plan includes a new ferry and tourism precinct, marina, increased residential living with a diversity of housing types, an a retail, entertainment and dining precinct integrated with parks, plazas, boardwalks and recreational facilities.

1.1 Scope of Work

frc environmental was commissioned to undertake environmental assessment services to inform a referral under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) with respect to marine [1] ecology. Specifically, frc environmental was requested to:

- describe the existing marine habitats and communities, based on field surveys (done in 2014), available data on the spatial distribution of habitats, and on a review of recent literature
- describe the marine Matters of National Environmental Significance (MNES) protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in and adjacent to the PDA

[1] With the definition of 'marine' ecology including estuarine ecology.

- assess the likely occurrence of listed marine MNES in the PDA
- assess potential impacts and risk to the marine environment as a result of the construction and operation of the proposed project, and
- identify mitigation measures that may avoid, reduce or remedy potential impacts.

2 Marine Habitats and Communities

2.1 Overview

The PDA and adjacent areas supports a diversity of intertidal and shallow subtidal habitat, notably:

- saltmarsh
- intertidal mangrove forest
- intertidal and subtidal seagrass meadows
- coral and rubble assemblages, and
- intertidal and subtidal mudflats and sand-banks.

These habitats were surveyed and mapped for the PDA area in 2014 (refer to Map 1 and Table 1.1 in the Summary and to Appendix A for methods). Each of these habitat types extends beyond the PDA; and each is extensively distributed throughout western Moreton Bay (Map 2). Prior to European settlement, shellfish reefs were also extremely abundant in coastal bays and estuaries of southern Queensland, including Moreton Bay. Subtidal shellfish reefs are now likely to be functionally extinct in the area (Diggles 2015).

Estuarine systems are a 'seascape' of interconnected patches of habitat (including seagrasses, mangroves, saltmarshes, oyster or coral reefs and rubble banks, and un-vegetated sand-banks and mudflats), linked actively through the movement of organisms and passively through the waterborne transport of primary production (Irlandi & Crawford 1997; Loneragan et al. 1997; Micheli & Peterson 1999; Rapoza & Oviatt 2000; Connolly & Guest 2002; Skilleter & Loneragan 2003; Skilleter et al. 2005). These habitats provide a range of ecological values and are important for the maintenance of fisheries resource, biodiversity and ecosystem services, and often support a high abundance and diversity of fish and invertebrates (Beck et al. 2001; Table 1.1). In addition to sustaining adult populations, which are harvested by inshore fisheries, many habitats are widely recognised for their role as 'nurseries' for juvenile fish, crabs and prawns, and their contribution to the productivity of offshore fisheries (Coles & Lee-Long 1985; Connolly 1994; Laegdsgaard & Johnson 1995; Halliday & Young 1996; West & King 1996; Blaber 1997; Butler et al. 1999; Beck et al. 2001; Chargulaf et al. 2011).

A description of each habitat in or adjacent to the PDA and in the Moreton Bay region, as well as a summary of the ecological significance of each habitat, is provided below. Information has been sourced from a field survey in 2014 (refer to Appendix A for field and laboratory methods) as well as a review of available data and literature.

2.2 Shellfish Reefs

Historical Extent

Shellfish (oyster) reef habitat was presumed to dominate southern Moreton Bay (including the PDA) prior to European settlement (Figure 2.1; Diggles 2015). Today, subtidal shellfish reefs are functionally extinct throughout most of southern Queensland (Beck et al. 2011; Diggles 2013). Shellfish reefs have also declined worldwide, with an estimated 85% of reefs lost globally (Beck et al. 2011). Shellfish reefs remaining in Moreton Bay are likely to be restricted to low numbers (individuals or clumps), mainly in the intertidal. In southern Moreton Bay the decline of shellfish reefs has resulted from a combination of events including overfishing, disease, increased sediment loads and declining water quality (Smith 1981; Diggles 2013).

Subtidal shellfish reefs in southern Queensland are unlikely to be restored by natural recruitment, thus active intervention to identify successful locations and to determine the most effective methods for restoration of shellfish reefs is underway. Current projects in Pumicestone Passage (north east Moreton Bay) as well as in several other locations around Australia are aimed at restoring shellfish habitat (TropWATER 2017).

Ecological Significance

Shellfish reefs have several important ecological functions, including providing structure and food, filtering sediments and nutrients, and stabilising the shoreline.

Oysters provide the basis of entire ecosystems, providing hard structure (in predominantly soft sediment environments) by the constant adhesion of new larvae to existing shells. Fouling and encrusting flora and fauna attach to, and grow on oyster reefs including algae, sponges, hydroids, bryozoans, gastropods and other bivalves. The shell matrices and crevices provide refuge, and the reef ecosystem provides food for many species, including polychaetes, crustaceans, gastropods and fish. Several species of fish also use the reefs for laying eggs, as a nursery (NOAA 2017) and as a corridor between shelter and foraging grounds (Grabowski & Peterson 2007). Intertidal shellfish reefs in Australia are also likely to provide foraging habitat for migratory shore birds protected under bilateral migratory bird agreements such as CAMBA and JAMBA (TropWATER 2017).

Being filter feeders, oysters filter detritus and phytoplankton from the water column. Consumed organic matter is used for growth, some of which is consumed by predators or degraded by bacteria and other organisms when the oysters die (NOAA 2017). Forming calcium carbonate shells, oysters remove carbon from the water column and act as a carbon sink (Grabowski & Peterson 2007). Waste material is excreted as faeces and inorganic nutrients, either directly from the oyster or via predators and other reef and benthic organisms. Deposit feeder and other organisms in the sediment use some of the excreted material as food. Inorganic nutrients are used by primary producers. In systems with high ratios of oyster biomass to water volume, the removal of suspended organic particles controls nutrient flow, and therefore the amount of phytoplankton, zooplankton, and other components of the ecosystem. Thus, the loss of large areas of shellfish reef can result in a shift from a benthic-pelagic system to a planktonic-microbial system (NOAA 2017). Shellfish reefs promote the health of other estuarine habitats, such as seagrass, by increasing light penetration and minimising negative effects of eutrophication (Grabowski & Peterson 2007).

Shellfish reefs also create a physical barrier and enhance deposition (Borsje et al. 2011). They attenuate wave energy and reduce shoreline erosion, effectively protecting other estuarine habitats such as saltmarsh (Grabowski & Peterson 2007).

Figure 2.1 Presumed extent of biogenetic reef forming shellfish resources in south east Queensland prior to European settlement (grey)(Diggles 2015).

2.3 Saltmarsh

Adjacent to the PDA

There is an area of saltmarsh south of the PDA that extends from the landward edge of the mangrove zone up to the terrestrial zone (Figure 2.2, Map 3). The saltmarsh community is dominated by marine couch (*Sporobolus virginicus*) with patches of common samphire (*Sarcocornia quinqueflora*) (Figure 2.3) and seablite (*Suaeda australis*). Along the upper most portion of the saltmarsh, there is a dense zone of sea rush (*Juncus kraussii*) (Figure 2.4).

There are approximately 1.2 ha of saltmarsh south of the PDA, and none within it (as mapped in 2014 on Map 1; **Error! Reference source not found.**).

Figure 2.2

Saltmarsh south of the PDA.

Figure 2.3

Common samphire.

Figure 2.4

Sea rush.

Saltmarsh of the Region

Claypan habitats in Moreton Bay are commonly unvegetated, but may also be dominated samphires or grasslands (Map 3; (Dowling & Stephens 2001). Samphire communities are dominated by samphire (*Sarcocornia* spp.) and seablite (*Suaeda* sp.). Grassland communities are dominated by marine couch (*Sporobolus virginicus*), saltwater couch (*Paspalum vaginatum*) and patches of rush, such as *Juncus kraussii* (Dowling & Stephens 2001).

Within Moreton Bay, there are approximately 368 ha of samphire and 2 034 ha of claypan habitat (Beumer et al. 2012). The eastern side of Moreton Bay is typically dominated by the rush *Juncus kraussii* due to abundant freshwater in the intertidal zone, while the western side of Moreton Bay is dominated by chenopod species of *Sarcocornia* and *Suaeda* due to the hypersaline intertidal sand flats (Lovelock et al. 2014).

Subtropical and temperate coastal saltmarsh is listed as vulnerable under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999*. The listed coastal saltmarsh community consists of dense to patchy areas of mainly salt-tolerant vegetation that is generally less than 0.5 m high and bare sediment (clay). This habitat occurs throughout Moreton Bay, including south of the PDA (Map 3).

Ecological Significance of Saltmarsh

Saltmarsh areas provide permanent habitat for a number of animals, including crabs, mosquitoes and other insects. Large clutches of crab larvae are produced in saltmarsh areas during the spring tides when the marsh is inundated. The highest concentration of zooplankton in estuaries are found in spring tides in saltmarshes (Saintilan & Mazumder 2004). This concentrated release of plankton into the water column can be an important food source for other organisms, such as fish, including some commercially important species (Saintilan & Mazumder 2004; Mazumder et al. 2006). As well as providing prey for shore birds and other animals, crabs bioturbate the sediment and contribute to cycling nutrients in the estuary.

Saltmarshes stabilise bare mud flats, act as fish habitats during inundation, re-mineralise terrestrial and marine debris, contribute to the nutrient cycling of estuaries, and may buffer the water bodies from excess terrestrial nutrient run-off (Adam 1990). They may also reduce erosion in the upper intertidal zone (van Erdt 1985, cited in Adam 1990). Recent studies indicate saltmarshes sequester carbon and that the carbon in these sediments may help mitigate increases of carbon dioxide in the atmosphere (Lovelock et al. 2014). Within the Tweed Moreton Bioregion in south-east Queensland, only 84 km^2 of saltmarsh communities remain (Dixon et al. 2011).

While our understanding of the direct use of saltmarshes by finfish and nektonic crustaceans is comparatively poor (Connolly 1999), some studies have indicated that fish of commercial and recreational importance rarely use upper littoral saltmarsh habitat (Morton et al. 1987; Connolly et al. 1997), while others have found widespread use of saltmarshes by a range of common and commercially important fish species (Thomas & Connolly 2001). Fish communities found using saltmarshes are typically dominated by smaller fish families (e.g. Ambassidae and Gobiidae) but also include whiting, flathead and prawns (Saintilan & Rogers 2013).

Vertebrate animals are also commonly found using the resources located in saltmarshes, as it provides foraging habitats for shore birds, bats, the water mouse and on occasion kangaroos and reptiles (e.g. snakes and goannas) (Saintilan & Rogers 2013). Thirteen insectivorous bats have been recorded using saltmarshes as a foraging ground with some species preferring to forage over saltmarsh vegetation where mosquitoes were in high abundance (Gonsalves 2012).

2.4 Intertidal Mangrove Forests

Mangroves of the PDA

The mangrove forest along the shoreline of the PDA is dominated by the grey mangrove (*Avicennia marina*) and the stilted mangrove (*Rhizophora stylosa*), with sparse river mangroves (*Aegiceras corniculatum*) and yellow mangroves (*Ceriops australis*) in the upper intertidal zone. The grey mangrove dominates the lower and upper intertidal zones, while the stilted mangrove dominates the middle intertidal zone (Figure 2.5). In the 2014 field survey there was evidence of insect damage (Figure 2.6) throughout the PDA, and some yellowing of leaves (Figure 2.7), which is likely to be due to stress such as low rainfall and high salinity in the sediment. There were few dead mangrove trees, however in some area up to 20% of the branches were dead. The density of seedlings was low with most seedlings recorded in the mangrove forest north of the current ferry terminal.

Mangrove communities offshore, east of the PDA, are dominated by the grey mangrove, with some stilted mangrove in the middle of the island (as mapped in 2014 on Map 1). In 2014, the condition of these mangroves was similar to those along the shoreline, with some dead branches and insect damage.

Epifauna of the mangroves was dominated by various mollusc species. Whelks and periwinkles were common on mangrove branches and roots (Figure 2.8), while Hercules mud whelks (*Pyrazus ebeninus*) were common on the substrate. Nerites (*Nerita* spp.) were also recorded on mangrove branches and roots (Figure 2.9). Maroon mangrove crabs (*Perisesarma messa*) were caught in pitfall traps, while broad-fronted mangrove crabs (*Metopograpsus frontalis*) (Figure 2.10) were recorded using crab holes around pneumatophores.

Mangrove communities of the PDA were typical of south-east Queensland being low in diversity and dominated by the grey mangrove. There are approximately 5.3 ha of mangroves within the PDA that are likely to be of good fisheries and aquatic ecological value (as mapped in 2014 on Map 1).

Figure 2.5

Dense *Rhizophora stylosa* south of the current ferry terminal within the PDA.

Figure 2.6

Insect damage on grey mangrove leaves.

Figure 2.7

Yellowing leaves of stilted mangroves.

Figure 2.8

Mangrove whelk (*Batillaria australis*) on mangrove trunk.

Figure 2.9

Nerite on stilted mangrove prop root.

Figure 2.10

Broad-fronted mangrove crab.

Mangroves of the Region

The mangroves of Queensland have been divided into three broad communities: high rainfall forest communities; low rainfall claypan communities; and subtropical communities (Dowling & McDonald 1982). Within the Toondah Harbour PDA, mangroves are typical of the subtropical communities. Subtropical mangrove communities are floristically less diverse than the other two community types, primarily because they are at the southern limit of many species ranges (Dowling & McDonald 1982).

There are seven species of mangrove in Moreton Bay (and in the Moreton Bay Marine Park); grey mangroves (*Avicennia marina)* river mangroves (*Aegiceras corniculatum*), large-leaved mangroves (*Bruguiera gymnorrhiza*), yellow mangroves (*Ceriops australis*), milky mangroves (*Excoecaria agallocha*), white flowered black mangroves (*Lumnitzera* *racemosa*), and stilted mangroves (*Rhizophora stylosa*). The mangrove fern, *Acrostichum speciosum*, is also common (Dowling 1979; 1986; Hyland & Butler 1988; Dowling & Stephens 2001). In the Moreton Bay Marine Park there are approximately 140 km^2 of mangroves, with the largest communities in Pumicestone Passage and the southern bay islands, south of Jacobs Well (DERM 2010a).

Ecological Significance of Mangroves

Mangroves help protect coastlines from recession by dampening wave energy (Alongi 2008), can moderate the impact of extreme events (i.e. tropical storms) (Zhang et al. 2012) and can act as a buffer between the land and sea (Dahdouh-Guebas & Jayatissa 2009). Mangrove forests are also important nursery grounds for many species of juvenile fishes, including commercially important species (Robertson & Blaber 1992; Laegdsgaard & Johnson 1995; Halliday & Young 1996; Blaber 1997) (e.g. sea mullet, Figure 2.11). Juveniles of seven of the ten commercially harvested fish species in Moreton Bay are most abundant in mangroves (Laegdsgaard & Johnson 1995). Further, Morton (1990) reported that 46% by species and 94% by weight, of fishes associated with an *A. marina* forest in Moreton Bay were of direct commercial significance.

Mangrove lined creeks support a variety of fish species that have habitat-specific distributions according to individual species requirements for food and shelter (Zeller 1998). Mangrove forests can act as carbon sources for estuarine, inshore, and offshore waters, through the export of leaf and fruit material (Lee 1995). Decomposing mangrove material provides both soluble nutrients and detrital fragments that are eaten by crustaceans, such as prawns and crabs, and some fish. Decaying plant and animal matter are consumed by juvenile and adult greasy back prawns, and juvenile banana prawns, both of which are obligate residents of mud banks adjacent to mangroves (Staples & Vance 1985). Adult banana prawns eat both small benthic invertebrates feeding on detritus in channels draining mangroves, and benthic algae on adjacent mud flats (Newell et al. 1995). Mangroves also trap, accumulate and release nutrients (and in some cases pollutants) and particulate matter (silt) from surrounding land, thus acting as a buffer to the direct effects of run-off. They also protect the shoreline from erosion from the water (e.g. waves and boat wash) or the land (run-off), and contribute to the establishment of islands and the extension of shorelines (Blamey 1992). Similar to saltmarshes, mangroves also play a major role in carbon sequestration (Lovelock et al. 2014).

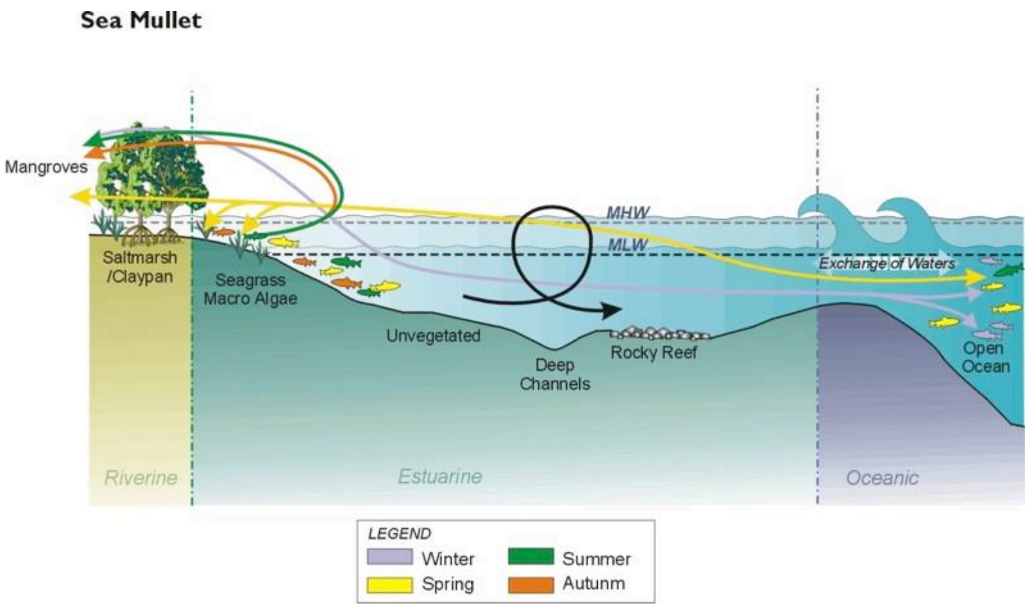

Figure 2.11 Mangroves provide critical habitat for young sea mullet.

2.5 Intertidal and Subtidal Seagrass

Seagrass in and in the Vicinity of the PDA

There are approximately 32.7 ha of seagrass in the PDA, primarily in the lower intertidal and subtidal area in the eastern section of the PDA (as mapped in 2014 on Map 1). The seagrass meadows are dominated by *Zostera muelleri* with some *Halophila ovalis* (Figure 2.12), and *Halophila spinulosa* (Figure 2.13). The percent cover of seagrass in the PDA ranges from 1% to 85%, with an average percent cover of 33% (Healthy Land and Water and Science Under Sail 2015).

There are extensive beds of seagrass to the north and south of the PDA, these beds are dominated by *Zostera muelleri* with some *Halophila ovalis*. In surveys in 2011 seagrass patches within the PDA and to the south of the existing channel were recorded as being between 1 and 25% cover, with patches of up to 50% cover to the north of the channel and offshore (Roelfsema et al 2013). More recent surveys (2015 and 2016) indicate there are patches of *Halophila spinulosa* offshore (Healthy Land and Water and Science Under Sail 2015) (Map 4).

In the 2014 survey of seagrass in the PDA, density was highest in the low intertidal and subtidal zone between the current ferry terminal and Cassim Island (Figure 2.14), and sparser in the higher intertidal area adjacent to the mud and sand flats.

In the survey in 2014, seagrass meadows were in good condition; however, there were some patches of seagrass that were covered in filamentous algae. Within the seagrass meadows there were several species of macroalgae, including:

- sargassum (*Sargassum flavicans*)
- *Padina gymnospora*
- oyster thief (*Colpomenia sinuosa*), and
- *Halimeda* spp.

Stingrays were observed foraging in the seagrass at low tide, and several species of fish were observed entering the seagrass meadow on the incoming tide

Epifauna of the seagrass beds in this survey was sparse, with low numbers of individuals recorded. At low tide, Hercules mud whelks were in the seagrass near the more exposed areas (Figure 2.15), while blue swimmer crabs (*Portunus armatus*) were present in the subtidal areas (Figure 2.16). Two bivalves were recorded: the strawberry cockle (*Fragum unedo*) (Figure 2.17) and the razor clam (*Pinna bicolor*). Several anemone species and some small colonies of soft corals were also recorded. One sea cucumber was found under a rock in the seagrass beds; however, no other sea cucumbers were observed on the seagrass in the intertidal or subtidal zone.

Benthic infauna was dominated by polychaetes and crustaceans, with some bivalves and gastropods. Polychaete communities comprised several families including Capitellidae, Cirratulidae, Syllidae and Spionidae. Crustacean communities comprised Gammarid amphipods, snapping shrimp (family Alpheidae) and hermit crabs (family Diogenidae). Brittle stars (class Ophiuroidea) were recorded at one site in the shallower subtidal area. The abundance and taxonomic richness of benthic infauna was highest at this site (Table 2.1), despite the other seagrass site being deeper and less exposed at low tide.

Table 2.1 Mean abundance of benthic infauna per square metre and total taxonomic richness of benthic infauna at each site.

Site	**Mean Abundance (± SE)**	**Total Taxonomic Richness**
Seagrass 1	333 (± 17)	13
Seagrass 2	1583 (± 246)	24

Figure 2.12

Seagrass meadow comprising *Zostera meulleri* and *Halophila ovalis* in the PDA.

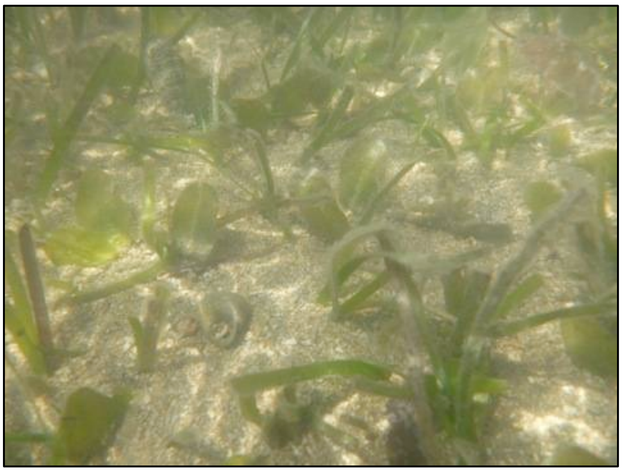

Figure 2.13

Halophila spinulosa.

Figure 2.14

Dense seagrass in the lower intertidal zone.

Figure 2.15

Hercules mud whelk in shallow seagrass.

Figure 2.16

Blue swimmer crab in the seagrass.

Figure 2.17

Cockle exposed at low tide.

Seagrass of the Region

There are seven species of seagrass in Moreton Bay (and in Moreton Bay Marine Park): *Cymodocea serrulata, Halophila ovalis, Halophila spinulosa, Halophila decipiens, Halodule uninervis, Syringodium isoetifolium*, and *Z. muelleri*. *Z. muelleri* is the dominant species in terms of area. Most seagrass in Moreton Bay is intertidal, with subtidal seagrass generally found in water less than 3 m deep at low tide (Hyland et al. 1989). Over 280 species of macroalgae have been recorded from Moreton Bay (Tibbetts et al. 1998). An algae, *Caulerpa taxifolia,* is also commonly found in Moreton Bay in the same shallow, soft sediment niche as seagrass (Phillips & Price 2002; Thomas 2003).

Moreton Bay supports 189 km^2 of seagrass (Roelfsema et al. 2009). The largest and most dense seagrass meadows are in the eastern bay surrounding South Passage between Moreton and Stradbroke islands; though there are also substantial meadows in the southern and western parts of the bay. With increasing urbanisation and industrial development, seagrass meadows within western Moreton Bay have been lost over the past decades. While some meadows have been lost as a direct result of infilling, a far greater area of seagrass has been lost as a result of changes in water quality (EHMP 2006).

Seagrass meadows occur in areas of Moreton Bay with poor water quality, providing some evidence of the resistance to these impacts (Gibbes et al. 2014). This resilience is likely a result of the uptake of nutrients from the water column reducing nutrient available for algal growth, the trapping of sediments from the water column improving water clarity, and the harbouring of grazers minimising the growth of epiphytic algae. Evidence of resilience has been shown after flood events in Moreton Bay, where seagrass biomass remained constant throughout the year in meadows close to flood plumes (high in suspended sediments and nutrients) compared to meadows in less impacted areas. Meadows in flood impacted areas had longer and wider leaves, and higher concentrations of chlorophyll *a*, allowing greater absorption of light and sediment baffling than meadows in less impacted areas (Gibbes et al. 2014). Large-scale loss of seagrass has historically occurred in some areas of Moreton Bay (e.g. Bramble Bay and southern Deception Bay) (Dennison & Abal 1999). Recovery in these area can be limited by sediments that are more easily resuspended, nutrients released into the water column available for algal growth and reduced grazing rates of algae. However, recent surveys in Moreton Bay show recovery in areas where seagrass was previously completely lost (Gibbes et al. 2014). Both *H. ovalis* and *H. spinulosa* are opportunistic species, producing large quantities of seeds and with relatively high growth rates. This enables them to quickly colonise areas when conditions are suitable; however, they also rapidly disappear when conditions deteriorate.

Ecological Significance of Seagrass

Seagrasses are primary producers (Hillman et al. 1989) that are recognised as playing a critical role in coastal marine ecosystems (Poiner & Roberts 1986; Hyland et al. 1989; Pollard 1984). They provide shelter and refuge for resident and transient adult and juvenile finfish, crustaceans and cephalopods, many of which are of commercial and recreational importance, others of which are the preferred foods of these species (Dredge et al. 1977; Hutchings 1982; McNeill et al. 1992; Coles et al. 1993; Edgar & Shaw 1995; Gray et al. 1996; Connolly 1997) (Figure 2.18). They also have a number of other ecological functions including providing large amounts of substrate for encrusting animals and plants (Harlin 1975; Klumpp et al. 1989) and trapping detritus and dissolved organic matter, increasing local nutrient cycling (Moriarty et al. 1984).

Whilst the abundances of juveniles of many fish and crustacean species are commonly higher in seagrass habitats than over bare sand or mud, there are also significant differences in abundance between seagrass meadows (e.g. Gray et al. 1996). Some sites have consistently higher recruitment (McNeill et al. 1992), whilst other sites may periodically or temporarily have higher abundances (Gray et al. 1996; Connolly 1999). This may be due to a variety of factors including structural complexity of the seagrass meadows; location of the seagrass meadows with respect to currents and the dispersal of larvae; and natural fluctuations (patchiness) in population sizes (Gray et al. 1996; Connolly 1999). To date the importance or fisheries values of seagrass has largely been measured by the absolute abundance of fauna found in it. However, seagrass habitat may also provide important linkages and refuges between different habitat types (e.g. mangroves and seagrass), and between up and downstream communities. Thus, whilst a seagrass meadow may not support high abundances of fish or crustaceans at any one time, over a period of time many individuals may use it as they pass through to other areas. In Moreton Bay, marine reserves and connectivity influenced the abundance of fish in seagrass meadows, with effects likely to vary between different species (Henderson et al. 2017).

Seagrass distribution is most affected by light intensity, desiccation, and nutrient levels. Other factors, such as currents, substrate suitability, prior patterns of distribution, dispersion of propagules, grazing by turtles and dugongs, and episodic events (including cyclones and floods) also play roles in determining the distribution of seagrass.

Of these factors, light availability is often the most important in determining the distribution of seagrass. The amount of light reaching a seagrass meadow is the combination of the light intensity at the surface, the depth at which the seagrass is growing, the turbidity of the water, and the presence or absence of epiphytes on the seagrass. Light availability, or specifically the duration of light intensity exceeding the photosynthetic light saturation point controls the depth distribution of seagrass (Dennison & Alberte 1985; Dennison

1987; Abal & Dennison 1996). For example, on average 30% of surface light; a light attenuation co-efficient of less than 1.4 m^{-1} and median total suspended solids of less than 10 mg/L are required for the survival of *Z. muelleri* (Abal & Dennison 1996; Longstaff et al. 1998). *H. ovalis*, on the other hand, has a particularly low tolerance to light deprivation caused by pulsed turbidity, such as floods and dredging (Longstaff et al. 1998).

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

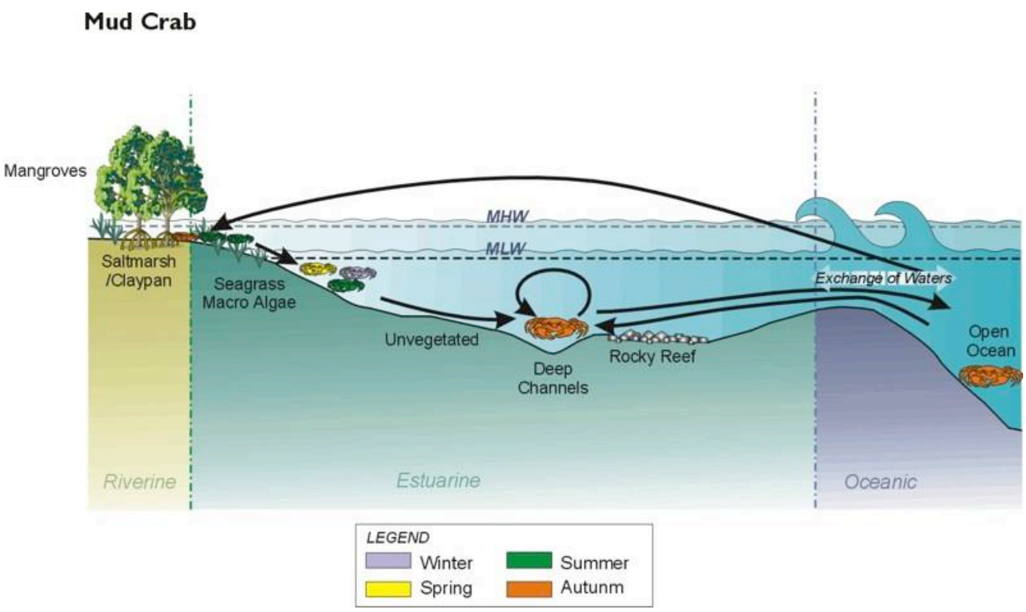

Figure 2.18 Seagrass meadows provide important shelter for juvenile mud crabs.

2.6 Coral and Rubble Assemblages

Coral and Rubble adjacent to the PDA

No significant areas of live corals were recorded in the PDA during the 2014 survey (as mapped in 2014 on Map 1). Scattered isolated hard coral individuals on sand or rubble as well as rubble and rock supporting algae, soft coral and sponges have recently been observed to the north and east of Cassim Island (Figure 2.19 and Figure 2.20; frc environmental, pers. obs.). Areas of algae (approximately >25% cover) on un-consolidated surface (e.g. sand or rubble) where patchy coral may be present were also recently mapped north and east of Cassim Island as well as within and to the south of

Fison Channel (Roelfsema et al. 2017) (Figure 2.21, Map 5). There were also areas of soft coral (approximately > 25% cover) on un-consolidated surface and hard coral (approximately > 20% cover) on consolidated surface (e.g. reef matrix or rock) east of Cassim Island (Roelfsema et al. 2017) (Figure 2.21).

Figure 2.19

Isolated hard coral on sand and rubble east of Cassim Island.

Figure 2.20

Rocky assemblages supporting algae, soft coral and sponges east of Cassim Island.

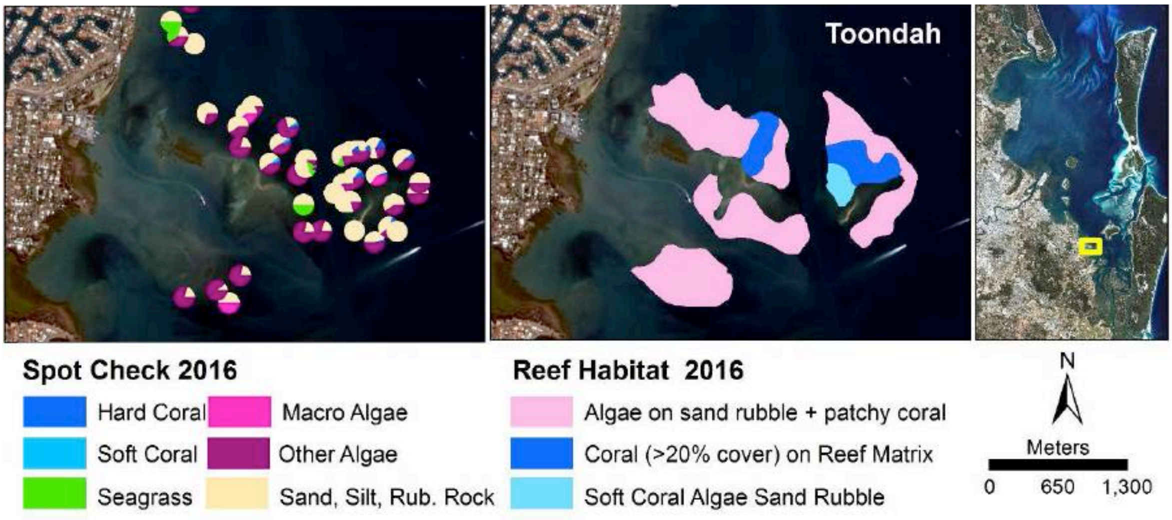

Figure 2.21 Reefal areas around Toondah Harbour. Spot-check survey sites with charts indicating benthic composition (right) and mapped reef habitat area (left). Source: (Roelfsema et al. 2009).

Coral and Rocky Reefs of the Region

Coral habitats in Moreton Bay are mainly distributed in shallow (> 3 m LAT), inshore areas and are characterised by a mixture of soft and hard corals and algae (Roelfsema et al. 2009). Fringing reefs occur around many of the inshore islands, including Peel, Mud, Saint Helena, King, Green, King, Macleay and Goat, North Stradbroke, Coochiemudlo islands (Figure 2.22). There is approximately 13.5 km^2 of coral in Moreton Bay (Gibbes et al. 2014).

Moreton Bay hosts marginal reefs of coral communities that are unique in that they are in a transitional area where tropical, sub-tropical and temperate species co-exist (Beger et al. 2014; Perry & Larcombe 2003). Coral communities in Moreton Bay comprise:

- 64 scleractinian coral species (from 26 genera and 13 families) in the inner bay, and
- 125 species (from 35 genera) in the outer bay (Wallace et al. 2009).

Coral communities on high-latitude coastal reefs of eastern Australia are typically widely distributed, generalist and stress-tolerant species with massive and horizontal morphologies (Sommer et al. 2014). In Moreton Bay substantial living coral assemblages remain, and they are currently at their highest recorded living diversity (Wallace et al. 2009). The corals of inshore Moreton Bay show a remarkable persistence through time

(78% are also recorded in the Holocene fossil record) and space (72% occur in outer Moreton Bay and 59% in New South Wales), indicating an inbuilt resilience (Wallace et al. 2009). This may be a result of a naturally dynamic system, where intermittent loss of species due to severe natural impacts is mitigated by external recruitment (Wallace et al. 2009). Coral reefs in marine reserves of Moreton Bay resisted impacts of major floods compared to other areas (that were fished), which may reflect a greater ecological resilience due to a greater biomass of herbivores influencing herbivory on macroalgae and coral recruitment dynamics (Olds et al. 2014).

Herbivorous fish in reef habitats of Moreton Bay include pencil surgeonfish (*Acanthurus dussumieri*), black rabbitfish (*Siganus fuscescens*), Australian sawtail (*Prionurus microlepidotus*), parrotfish (*Scarus ghobban*) and Bengal sergeant fish (*Abudefduf bengalensis*), unicornfish (*Naso unicornis* and *N. bankieri*), white-bar anthias (*Pseudanthias leucozonus*), stripey (*Microcanthus strigatus*), angelfish (*Pomacanthus semicirculatus* and *Centropyge tibicen*) and striped trumpeter (*Pelates octolineatus*) (Yabsley et al. 2016). Reef habitat in reserve areas of Moreton Bay supported a greater biomass of herbivorous fishes and had greater grazing of turf algae (Yabsley et al. 2016).

Historically, reef growth in Moreton Bay has been episodic, responding to natural environmental variation throughout the Holocene (Lybolt et al. 2011). The only significant change in coral species composition occurred between approximately 200 and 50 years ago, following anthropogenic alterations of the Moreton Bay and its catchments (Lybolt et al. 2011). Moreton Bay was dominated by *Acropora* species, but nutrient enrichment and sediment inputs following European settlement was likely to have resulted in the shift to massive corals (e.g. *Cyphastrea*, *Favia* and *Goniopora* species), which now dominate communities (Wallace et al. 2009; Zann et al. 2012).

In 2015, the reefs of the inshore Moreton Bay region had an average hard coral cover of 20% and experienced the highest average bleaching relative to other regions (i.e. Sunshine Coast, Outer Moreton Bay and the Gold Coast in 2015) (Pentti et al. 2016). In Moreton Bay, coral growth is limited by environmental factors (e.g. light penetration and water chemistry) (Fellegara & Harrison 2008; Kleypas et al. 1999) and in particular by eutrophication (Gibbes et al. 2014), sedimentation and fishing pressure (Roelfsema et al. 2017). Nonetheless, Moreton Bay coral communities have persisted with communities fluctuating with water quality and freshwater flooding after heavy rainfall (Queensland Museum 2017). Coral populations of Moreton Bay have the potential to be self-sustaining, however, isolated reef areas may be slow to recover from disturbance (Fellegara et al. 2013).

Overall, inner Moreton Bay corals are naturally subject to large fluctuations in salinity, temperature, turbidity and nutrients (Dennison & Abal 1999). The project area is unlikely to contain complex carbonate reefs, but may contain scattered corals on rubble. These coral assemblages are likely to provide an important contribution to carbonate sediment production (Dennison & Abal 1999). Reproduction is likely to occur in late spring and summer (Fellegara et al. 2013).

Ecological Significance of Coral and Rocky Reefs

Coral and rocky reefs have several important ecological functions including:

- physical structure (e.g. protection of shorelines from waves and storms reducing beach erosion)
- biotic (e.g. spawning, nursery, breeding and foraging grounds for marine life)
- biogeochemical (e.g. nitrogen fixation)
- information (e.g. reef organisms used as monitoring and pollution records), and
- social / cultural (e.g. recreational and aesthetic values) (Maragos et al. 1996; Moberg & Folke 1999).

Reefs are also highly connected to other marine and freshwater habitats, such as mangroves, seagrass and estuaries, with many marine organisms utilising a variety of these habitats throughout their lifecycles. For example, adult mangrove jacks live on coral reefs, but use freshwater rivers and creeks as juveniles (GBRMPA 2017).

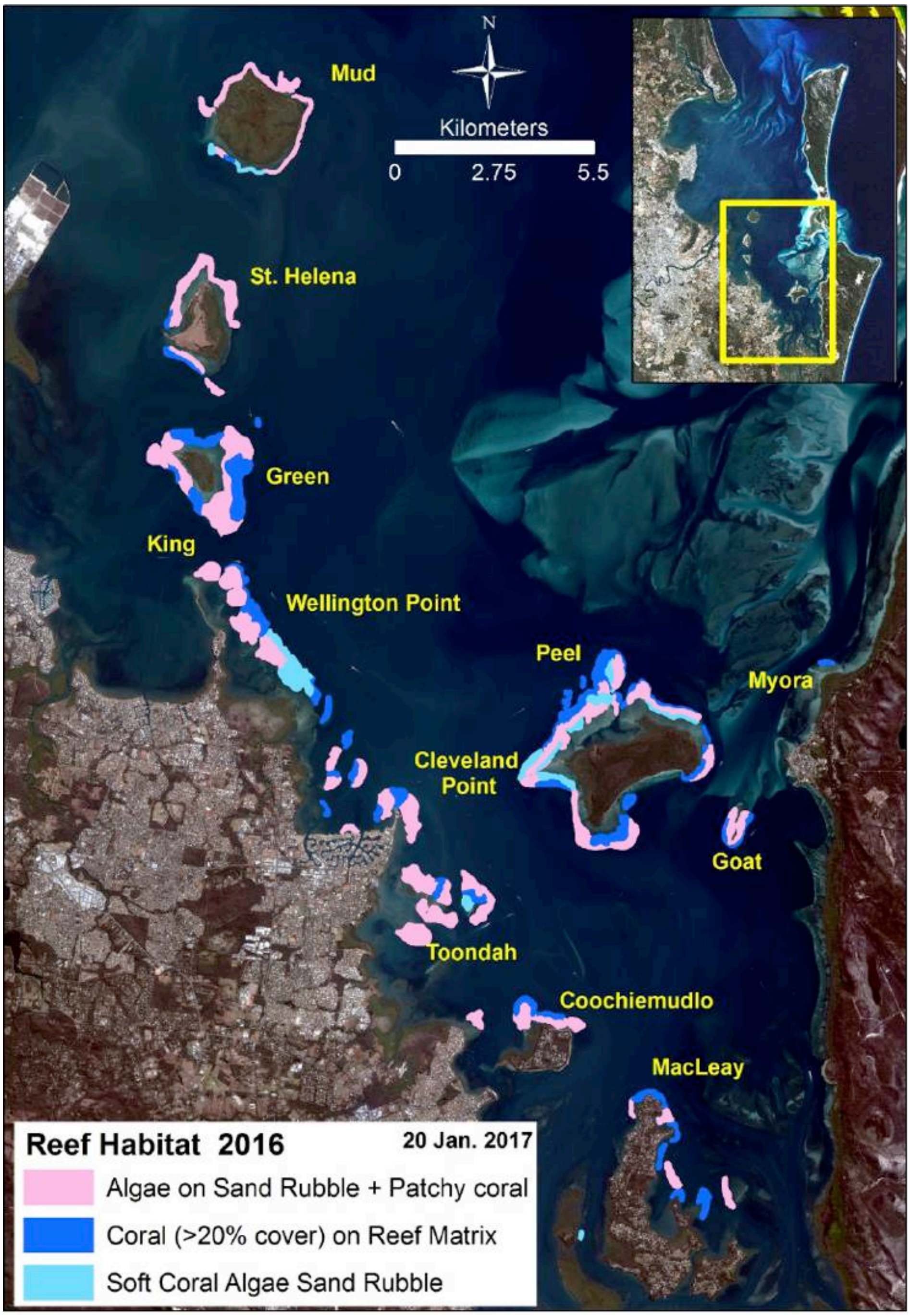

Figure 2.22 Inshore Moreton Bay reefal areas. Source: Roelfsema et al 2017.

2.7 Intertidal and Subtidal Mudflats and Sand-banks

Mudflats and Sandbanks of the PDA

The sediments within and adjacent to the PDA are bioturbated muds and sands, with sparse areas of exposed rubble (comprising rocky material and shell fragments). There is a layer of rubble that is below the muds and sands throughout the PDA ranging from 0.1 to 0.6 m below the surface. in the 2014 survey, the area of muds and sands typically extended from the mangroves into the existing channel or to seagrass beds north of the channel. The muds and sands were not compacted, and were easily dispersed. There were numerous holes created by burrowing fauna (i.e. crabs and polychaetes) (Figure 2.23).

Epifauna of the intertidal mudflats and sandbanks was dominated by Hercules mud whelks. There were also fiddler crabs (*Uca* spp.) and sand bubbler crabs (along with evidence of their foraging) on the mudflats.

Benthic infauna on the intertidal mudflats and sandbanks were dominated by polychaetes with some crustaceans, bivalves and gastropods. Polychaetes were dominated by individuals from the family Capitellidae, which are considered to be indicators of organic pollution (Beesley et al. 2000; Dean 2008). Benthic communities of the intertidal mudflats have been sampled at two sites in the PDA, with mean abundance varied between 267 ± 109 and 967 ± 303 per square meter between the sites. Taxonomic richness was similar between sites (9 to 10 species). Benthic communities of the intertidal sandflats have also been sampled at two sites in the PDA, with mean abundance varying between 83 ± 67 and 200 ± 0 per square meter between the sites and taxonomic richness relatively similar between sites (3 to 6 species).

The mud and sand habitats were similar to those found throughout Moreton Bay (e.g. Godwin Beach, Manly and Nudgee Beach) although the sediment is less compacted.

In 2014, benthic communities of subtidal mud of the channel were sampled at two sites, which were both dominated by polychaetes, with some crustaceans. Polychaete communities were dominated by the families Magelonidae and Cossuridae, while crustaceans were dominated by the family Tanaidacea. The abundance (550 ± 144 to 700 ± 200 per square metre) and taxonomic richness (8 to 11 species) in the channel were similar between sites.

Figure 2.23

Mudflat substrate and associated fauna burrows within the PDA.

Mudflats and Sandbanks the Region

Bioturbated mud and sand is the dominant habitat of western Moreton Bay, with over 422 km^2 of subtidal un-vegetated habitat and 75 km^2 of intertidal flats in Moreton Bay (Ozcoasts 2009) (Figure 2.24).

Sand from the Brisbane River has been deposited in a river delta protruding into the bay, some of this material has been transported by waves to form tidal flats, predominantly to the north. A belt of river-derived mud (up to 5 m thick) has been deposited along the western side of the bay, extending to about 10 – 15 m water depth (Maxwell 1970; Hekel et al. 1979; Jones & Stephens 1981).

Marine sand has been deposited between Bribie Island and Moreton Island, and between Moreton Island and North Stradbroke Island. The central, deeper part of the bay receives no sand and very little mud.

There are two relatively diverse bioregions for invertebrate communities within Moreton Bay: the western bay – dominated by estuarine species; and the eastern bay – dominated by marine species (Davie 1998). Diversity in the western bay is largely attributable to infaunal communities (living within the sediment), while communities in the eastern bay comprise a large number of infaunal and epibenthic (on the surface) invertebrates such as corals and ascidians.

Communities in the western bay are characterised by infaunal or mobile epibenthic species tolerant of high turbidity and sedimentation levels, such as crustaceans, worms and echinoderms (Davie 1998).

Diversity in the western bay is highest near the mouth of the Brisbane River and declines steadily to the north (Davie 1998). Some unvegetated sandbanks are exceptionally species poor, while others throughout Moreton Bay support diverse assemblages of finfish and decapod crustaceans (Lasiak 1986; Brown & McLachan 1990; Kailola et al. 1993; Morrison 1996). Bare sand and mud flats support different communities to vegetated areas, and are particularly important for some species of whiting and prawn.

The structure of benthic macroinvertebrates communities is influenced by a suite of factors including nutrient loads, sediment grain size and turbidity. As they are largely immobile, and quickly respond to changes in these factors, changes in their community structure can be used as a tool to assess the ecological health of waterways, and to identify characteristics of pressures acting on those waterways. With the use of control sites, and temporally replicated baseline monitoring, they can also be used to assess the impacts of a development.

Increases in sediment organic and nutrient loads often leads to a reduction in community diversity and species richness, which is associated with a shift in community composition and trophic group structure (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999; Coleman & Cook 2003; Rossi 2003). Changes in sedimentation rates lead to shifts in trophic groups, with the abundance of suspension feeders decreasing in more turbid waters.

Following nutrient enrichment, the population density of opportunistic deposit feeders usually increases dramatically, and macroinvertebrate communities typically become dominated by polychaetes (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999). These worms are characterised by their ability to respond rapidly to environmental change and are widely recognised as useful indicators of environmental health (Pearson & Rosenberg 1978; ANZECC & ARMCANZ 2000).

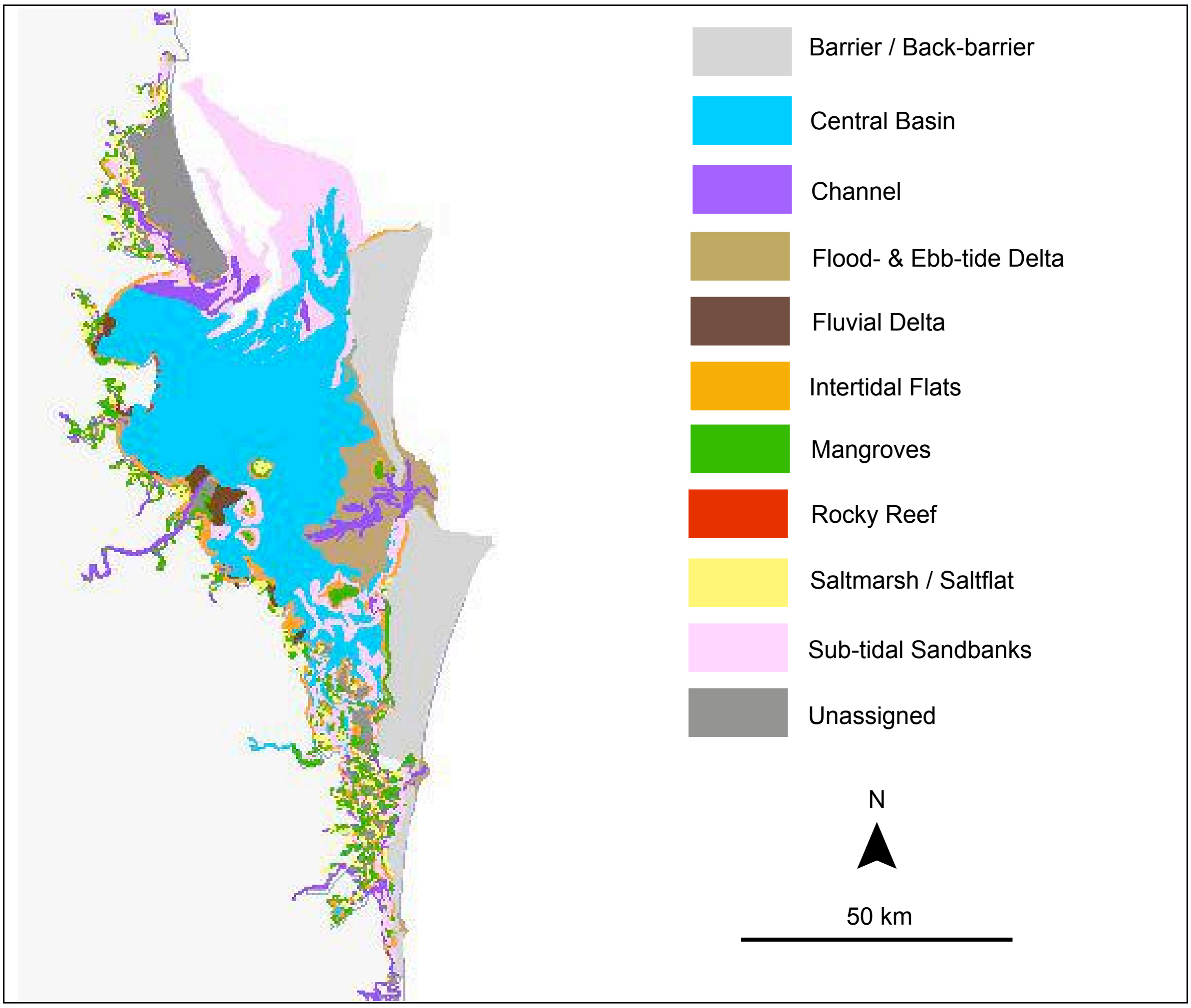

Figure 2.24 Geomorphic Habitats in Moreton Bay.

Ecological Significance of Mudflats and Sandbanks

Areas of sandy and muddy sediment, whilst commonly considered to be not as productive as areas supporting seagrass, are also important to the ecosystem. Where sediments are stable, microalgae communities become established within both the intertidal and shallow subtidal. The microalgae support an associated community of small benthic invertebrates (e.g. polychaete and nematode worms, cumaceans, copepods and soldier crabs), which in turn are an important source of food for fishes, such as bream and whiting (Weng 1983). Soft sediment tidepools are formed at low tide, which support a variety of fishes and can serve as a nursery for juveniles, such as whiting (Chargulaf et al. 2011). Laegdsgaard and Johnson (1995) suggest mudflat habitats may be transitional zones between juvenile and adult habitats. Bare substrates in shallow waters may also provide shelter from larger predators, with whiting, flathead and flounder commonly associated with bare substrate habitat.

Intertidal and shallow subtidal sand flats support a variety of fish species. Fish, such as whiting and flathead, feed in sandy areas; whereas fish, such as bream and mullet, prefer the fauna associated with muddy areas (Figure 2.25). In southern Moreton Bay, the yellowfin bream is perhaps the best known example of a species that migrates to surf bars to spawn (Pollock et al. 1983). Shallow surf bars are also the spawning grounds for whiting, flathead, luderick, tailor and mullet.

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

Bare and soft sediment areas are typically dominated by burrowing faunal species (Barnes & Hamylton 2013) and the fauna associated with soft sediment habitats are typically determined by the character of the sediment: its grain size and stability; and with the presence or absence (Poiner 1980; Humphries et al. 1992), or proximity of seagrass (Ferrell & Bell 1991). Grain size influences the ability of organisms to burrow, and the stability of 'permanent' burrows. Unstable sediments support less diverse benthic communities than those that are relatively stable. Bare sediments within 10 m of seagrass meadows supported a similar total abundance of fishes, but a reduced diversity of species compared with nearby *Zostera* seagrass meadows; whereas bare substrate 100 m distant from the seagrass meadows supported significantly fewer individuals and species (Ferrell & Bell 1991). In partial contrast, studies of bare substrate and nearby *Ruppia* meadows showed finfish diversity to be higher over bare substrate, but abundance and biomass highest in the seagrass meadows (Humphries et al. 1992).

Shallow water, bare sediment communities are characterised by widely fluctuating abundances, species richness and diversity. These fluctuations are correlated with severe abiotic disturbances (e.g. wind and wave activity). During calmer months, shallow bare sand developed similar communities to deep-water bare sand habitats (Poiner 1980).

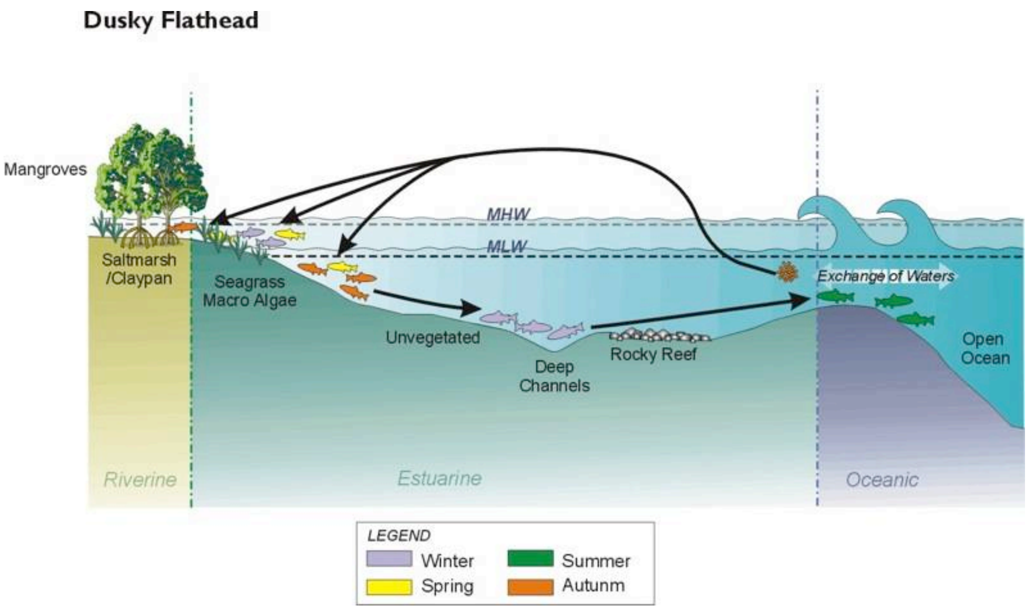

Figure 2.25 Un-vegetated sand and mud substrates are a preferred habitat of dusky flathead.

3 Matters of National Environmental Significance

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as Matters of National Environmental Significance (MNES) (DoTE 2014a).

The nine MNES to which the EPBC Act applies are:

- world heritage properties
- national heritage places
- wetlands of international importance (Ramsar wetlands)
- nationally threatened species and ecological communities
- migratory species
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions, and
- a water resource in relation to coal seam gas development and large coal mining development.

In addition, the EPBC Act confers jurisdiction over actions that have a significant impact on the environment where the actions affect, or are taken on, Commonwealth land, or are carried out by a Commonwealth agency (even if that significant impact is not on one of the nine MNES).

3.1 Protected Matters Search

The Protected Matters Search Tool was used to assist in determining whether marine MNES were likely to occur in or near the area potentially impacted by the proposed Toondah Harbour development. The search area included the subject site and a 5 km buffer zone. This search area was considered to include all marine areas that are within the likely extent of impact, in order to adequately identify all marine MNES that could potentially be impacted by the proposed project.

The following MNES relevant to marine ecology (excluding avian fauna) were listed in this search:

- World Heritage Properties – none
- National Heritage Places – none
- Wetlands of International Importance – 1
- Great Barrier Reef Marine Park – none
- Commonwealth Marine Areas – none
- Listed Threatened Ecological Communities – 1
- Listed Threatened Species – 14
- Listed Migratory Species – 21

There are no World Heritage Properties, National Heritage Places, Commonwealth Lands, Commonwealth Heritage Places, Commonwealth reserves or critical habitats in the vicinity of the Project Area. Likewise, the Great Barrier Reef Marine Park is approximately 350 km north of the proposed project and will not be affected. The Temperate East Marine Bioregional Plan (Commonwealth of Australia 2012) has been prepared under section 176 of the EPBC Act for Commonwealth Marine Area (which extend from 3 to 200 nautical miles from the coastline). The Commonwealth Marine Area is approximately 25 km east of the proposed project, and will not be affected by the proposed project.

Other matters listed in the search results included 43 listed marine species (excluding avian fauna) and 14 whales and other cetaceans. Listed 'marine species' and 'whales and other cetaceans' are protected in Commonwealth Marine Areas under the EPBC Act. The closest Commonwealth Marine Area is approximately 25 km east of the proposed project. The Project will not have a significant impact on Commonwealth Marine Areas and thus listed 'marine species' and species listed only as 'marine species' or 'whales and other cetaceans' are not considered further in this report. However, species that are also listed as 'migratory' or 'threatened' are also protected in state waters (i.e. coastal waters to three nautical miles and other waters under Queensland jurisdiction) under the EPBC Act.

Under section 34 of the EPBC Act, threatened ecological communities listed as vulnerable are not protected under Part 3 'Requirements for Environmental Approvals' of the Act. The listed threatened ecological community in the vicinity of the proposed project is the Subtropical and Temperate Coastal Saltmarsh, which is listed as 'vulnerable', and is consequently not considered further in this report.

'Wetlands of international importance', 'threatened species' and 'migratory species' are discussed in the following sections.

Results of the EPBC Act Protected Matters Search for within 5 km of the subject site are provided in Appendix B. These results are indicative only. Further assessment is required (DoTE 2014b), and is provided in the remainder of this Chapter.

3.2 Wetlands of International Importance (Ramsar Wetlands)

The proposed project is within the Moreton Bay Ramsar wetland boundary (Map 6). This wetland is approximately 113,314 ha in its entirety, and comprises:

- Moreton Island
- parts of North Stradbroke Island
- parts of South Stradbroke Island
- parts of Bribie Island
- some of the Southern Bay Islands
- waters and tributaries of Pumicestone Passage
- intertidal and subtidal areas of the western bay, southern bay and sandy channels of the Broadwater region
- marine areas and sand banks within the central and northern bay, and
- beach habitats (DoTE 2014c).

Aquatic habitats within the Moreton Bay Ramsar wetland include seagrass and shoals, tidal flats, mangroves, saltmarshes, coral communities, freshwater wetlands, peat land habitats, ocean beach and foredunes.

Moreton Bay Ramsar wetland was declared as it:

- is one of the largest estuarine bays in Australia which is enclosed by a barrier island of vegetated sand dunes
- plays a substantial role in the natural functioning of a major coastal system through its protection from oceanic swells providing habitat for wetland development, receiving and channelling the flow of all rivers and creeks east of the Great Dividing Range from the McPherson Range in the south to the north of the D'Aguilar Range

- supports over 355 species of marine invertebrates, at least 43 species of shorebirds, 55 species of algae associated with mangroves, seven species of mangrove and seven species of seagrass
- is a significant feeding ground for green turtles and is a feeding and breeding ground for dugong. Moreton Bay also has the most significant concentration of young and mature loggerhead turtles in Australia, and is ranked among the top ten dugong habitats in Queensland
- supports more than 50,000 wintering and staging shorebirds during the non-breeding season. At least 43 species of shorebirds use intertidal habitats in the Bay, including 30 migratory species listed by JAMBA and CAMBA, and
- is particularly significant for the population of wintering Eastern curlews (3,000 to 5,000) and the Grey-tailed tattler (more than 10,000).

3.3 Listed Threatened Marine Species

Fourteen threatened (endangered or vulnerable) marine species were listed as potentially occurring within 5 km of the proposed project using the protected matters search tool. The likelihood that these species are present in the area potentially impacted by the proposed Toondah Harbour project, was assessed using the criteria in Table 3.1.

Table 3.1 Criteria used to assess the likelihood of occurrence of species.

Likelihood of Occurrence	Definition
low	The species is considered to have a low likelihood of occurring in the area potentially impacted by the Project, or occurrence is infrequent and transient. Existing database records are considered historic, invalid or based on predictive habitat modelling. The habitat does not exist for the species, or the species is considered locally extinct. Despite a low likelihood based on the above criteria, the species cannot be totally ruled out of occurring in the potentially impacted area.
moderate	There is habitat for the species; however, it is either marginal or not particularly abundant. The species is known from the wider region.
high	The species is known to occur in the potentially impacted area, and there is core habitat in this area.

Ecological information used in the assessment of the likelihood of occurrence of each threatened marine species included:

- the results of literature search
- the results of field surveys, and
- professional experience.

The likelihood of occurrence of each species was supported by evidence of their habitat preferences, and the availability and distribution of critical habitats close to the proposed project and of the wider region. Habitats of particular importance to Commonwealth listed marine and estuarine species (i.e. critical habitats) include their preferred / key:

- nesting / breeding areas
- feeding habitats, and
- migration corridors (Reeves 2008; Stern 2009).

It also includes areas where the species may not presently occur, which are critical if the species is to recover from its currently threatened state (Gibson & Wellbelove 2010). The presence and condition of these key areas / habitats, and other habitats that are vital for the day-to-day survival of listed species, can assist in determining whether a species is likely to occur within a particular area. The likelihood of occurrence of a species within an area will in turn influence the extent of likely impacts on the population from any proposed project.

The 'potential area of impact' for the purposes of this assessment comprised shallow inshore waters of Moreton Bay within and adjacent to Toondah Harbour, including Fison Channel. Of the listed threatened species, loggerhead turtles and green turtles are highly likely and hawksbill turtles are moderately likely to occur in the potential area of impact (Table 3.2).

3.4 Listed Migratory Marine Species

Twenty-one migratory marine species were listed as potentially occurring within 5 km of the proposed project using the protected matters search tool. Of these listed migratory species, 12 species are also listed as threatened species.

The 'potential area of impact' for the purposes of this assessment comprised shallow inshore waters of Moreton Bay within and adjacent to Toondah Harbour, including Fison Channel. Of the listed migratory species, loggerhead turtles, green turtles, Indo-Pacific humpback dolphins and dugong are highly likely and hawksbill turtles are moderately likely to occur in the potential area of impact (Table 3.3).

Table 3.2 Threatened marine species listed as potentially occurring within 5 km of subject site on the online Protected Matters search tool, and their likelihood of occurrence in the area potentially impacted by the Toondah Harbour project.

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
Mammals				
Balaenoptera musculus	blue whale	E	While the blue whale may occur in coastal and continental shelf waters off eastern Australia, they are typically found around the southern coastline off Western Australia and South Australia, where there are a number of known coastal aggregation sites associated with migratory routes (DSEWPAC 2012b). Blue whales are considered to be occasional visitors to the Moreton Bay region, with 1 stranding recorded from Moreton Island, 1 sighting reported from North Stradbroke Island and 1 animal whaled at the Tangalooma whaling station when in operation (Chilvers et al. 2005). *Feeding Areas* Blue whales feed at the ocean surface and at depth (Gill & Morrice 2003; McCauley et al. 2004). Within Australian waters, there are two known major feeding areas; off the South Australian; and, Western Australian coastlines. The blue whale feeds primarily on krill, but will also consume fish and squid (Kawamura 1980). The distribution of the primary krill prey extends into Eastern Australian waters (Blackburn 1980); however, feeding areas within this region are unknown. *Breeding Areas* Blue whales calve in deep waters off tropical island shelfs outside of Australian waters (DoTE 2016b). *Migration Routes* The blue whale migrates from Antarctic and sub-Antarctic waters in the summer into Western Australian waters en route to Indonesian Archipelago waters for breeding (Double et al. 2012; Double et al. 2014). In Australia, they primarily use western and southern coastal waters during migration (DEWHA 2008). *Key Threats* Key threats include whaling, climate change, noise interference and vessel disturbance (DoTE 2016b). ***Summary*** **Moreton Bay is not considered to be core habitat for this species, and the area is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that blue whales will occur in marine habitats within and adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	low
Eubalaena australis	southern right whale	E	Southern right whale sightings in Australian waters are seasonal, typically occurring between May and November (DoTE 2016j). They are primarily found around the southern coastline off southern Western Australia and far west as South Australia, where there are a number of known coastal aggregation sites (DoTE 2016j). Sightings in Queensland waters are rare, but this species has been observed off Moreton Island, North Stradbroke Island and in Moreton Bay (Noad 2000). *Feeding Areas* Southern right whales are thought to feed in deep, offshore waters. Australian populations of southern right whales are likely to forage between 40°S and 65°S, generally south of Australia. The species typically consumes copepods in the northern part of these waters, while at higher latitudes (south of 50°S), krill is the main prey item (DoTE 2016j). *Breeding Areas* Southern right whales calve very close to the coast in Australia, usually in waters <10 m deep, primarily in Western Australia and South Australia (DSEWPAC 2012b). Nursery grounds are occupied from May to October (DoTE 2016j). *Migration Routes* The migratory paths between calving and feeding areas are not well understood. However, there is substantial movement along the coast, indicating that	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			connectivity of coastal habitats is important (DoTE 2016j). *Key Threats* Key threats include whaling, climate change, vessel disturbance, competition with fisheries for prey, noise interference and habitat degradation (DoTE 2016j). ***Summary*** **While they may migrate along the coast, inshore coastal waters have no particular significance to southern right whales. Moreton Bay is not considered to be core habitat, unlikely to support important populations, or offer habitat critical to the survival of this species. There is a low likelihood that southern right whales will occur in marine habitats within and adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	
Megaptera novaeangliae	humpback whale	V	Humpback whales occur in two separate populations within Australian waters, the west coast and the east coast populations. Sightings along the coastlines are highly seasonal and linked to the northerly and southerly migration routes to breeding areas in tropical waters (DoTE 2016p). The migratory pathway of humpback whales is on the eastern side of the large sand islands that separate Moreton Bay and the Pacific Ocean. Moreton Bay is an important resting area for humpback whales during migration, particularly during the southward migration in September and October (Chilvers et al. 2005). *Feeding Areas* Eastern Australian humpback whales are likely to forage at higher latitudes, south of 55°S, and will only feed opportunistically upon arrival into coastal Australian waters (DoTE 2016p). *Breeding Areas* Calving takes place during winter in tropical waters at low latitudes (15°S to 20°S) (Chittleborough 1965; W.H. 1966). The breeding area for the eastern population of the humpback whale is presumed to be off the coast between central and northern Queensland (Smith et al. 2012). *Migration Routes* During summer, humpback whales feed in high latitudes and during winter move north to tropical waters for calving, using close, coastal waters (DoTE 2016p). During migration, resting is undertaken around the Hervey Bay region (Chaloupka et al. 1999; Paterson et al. 2001; Double et al. 2010) and around Moreton Bay (DEH 2005b). *Key Threats* Key threats include whaling, climate change, competition with fisheries for prey, noise interference and habitat degradation (DoTE 2016p). ***Summary*** **While some areas in the north of Moreton Bay are important resting areas for humpback whales, the area potentially impacted by the proposed Toondah Harbour project is not considered to be core habitat and is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that humpback whales will occur in marine habitats within and adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	low
Reptiles				
Caretta caretta	Loggerhead Turtle	E	Loggerhead turtles are primarily found around coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia (Limpus et al. 1992; Prince 1994; Limpus 1995a). Moreton Bay is an important foraging ground for the loggerhead turtle (DoTE 2013a) and loggerhead turtle have been reported in the vicinity of the project (ALA 2017). *Feeding Areas* The loggerhead turtle forages in a wide range of intertidal and subtidal habitats, including coral and rocky reefs, seagrass meadows, and non-vegetated sand or mud areas (Limpus 2008b). They tend to maintain small home ranges within their foraging grounds (within approximately 10 to 15 km of coastline).	high

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Moreton Bay is an important foraging ground for the loggerhead turtle (DoTE 2013a). *Breeding Areas* Loggerhead turtles nest on open, sandy beaches (Spotila 2004). The three major nesting areas for loggerhead turtles in Queensland are in the Great Barrier Reef, and include: · the Capricorn Bunker Island Groups, especially Wreck, Tryon and Erskine islands · Mon Repos and adjacent beaches of the Woongarra Coast and Wreck Rock Beach, together with · the islands of the Swain Reefs, especially Pryce Island and Frigate, Bylund, Thomas and Bacchi cays. A small number of loggerhead turtles nest on the local sand islands of Bribie, Moreton, and North and South Stradbroke (DNPRSR 2007). *Migration Routes* Loggerhead turtles show fidelity to both their feeding and breeding areas, and can make reproductive migrations between foraging and nesting areas of over 2,600 km (Limpus et al. 1992). *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016e). ***Summary*** **While there is unlikely to be any nesting loggerhead turtles in the vicinity of the PDA, Moreton Bay supports a significant loggerhead turtle feeding population. Loggerhead turtles are highly likely to occur in marine habitats within and adjacent to the Toondah Harbour project, particularly in the seagrass beds and coral or rubble areas, which they may use as feeding habitats.**	
Chelonia mydas	green turtle	V	The green turtle is globally distributed in tropical and sub-tropical waters, and is usually associated with shallow marine habitats that support seagrass and algal communities (DoTE 2013b). Green turtles are known to feed on the seagrass in Moreton Bay (DNPRSR 2007) and have been observed during fortnightly water quality surveys in the vicinity of the PDA (frc environmental, pers. obs.). *Feeding Areas* Immature green turtles are carnivorous (Brand-Gardner et al. 1999), while adults are generally herbivorous, feeding mostly on algae and seagrass. Adults will occasionally eat other items such as mangrove fruit, sponges and jellyfish (Pendoley & Fitzpatrick 1999; Forbes 1994). Adult green turtles typically forage in shallow benthic habitats, such as tidal and subtidal coral and rocky reefs and inshore seagrass beds and algae mats (Musick & Limpus 1997; Poiner & Harris 1996; Robins et al. 2002). Green turtles are known to feed on the seagrass in Moreton Bay (DNPRSR 2007). *Breeding Areas* Green turtles nest on sandy beaches. In Queensland, southern green turtle populations typically nest around the Capricorn-Bunker Groups and adjacent islands in the southern Great Barrier Reef (Limpus et al. 2003), but also nest on islands of the outer edge of the reef (DoTE 2013b). There are no key nesting areas in Moreton Bay; however, some turtles nest on the sandy beaches of the outer islands. *Migration Routes* Green turtles can migrate more than 2,600 km between their feeding and nesting grounds. *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016f).	high

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Summary **While there are unlikely to be any nesting green turtles in the vicinity of the PDA, Moreton Bay supports a significant feeding populations of green turtles. Green turtles are frequently observed in the seagrass beds adjacent to the proposed project (frc environmental, pers. obs. during fortnightly water quality surveys). Green turtles are highly likely to occur in marine habitats within and adjacent to the Toondah Harbour, particularly in the seagrass beds, which they may use as feeding habitat.**	
Dermochelys coriacea	leatherback turtle	E	The leatherback turtle is a pelagic species in tropical, subtropical and temperate waters. On the Australian east coast, leatherback turtles typically occur from south-east Queensland to central New South Wales. As the most pelagic of all marine turtles, the leatherback turtle spends much of its time in the open ocean and venturing close to shore, mainly during the nesting season (Lutz & Musick 1996; Benson et al. 2007; GBRMPA 2011). There is no known resident population of leatherback turtles in Moreton Bay (DNPRSR 2007). *Feeding Areas* The leatherback turtle is a pelagic feeder, primarily consuming gelatinous organisms such as jellyfish and salps (Bjorndal 1997; Kaplan 1995). Their distribution reflects the distribution of their food, and can be explained by 'hot spots' of jellyfish abundance (Leary 1957; Lazell 1980). Foraging leatherbacks have been recorded as far south as Bass Strait and through the Gulf of Carpentaria (GBRMPA 2011). *Breeding Areas* Leatherback turtles require sandy beaches to nest. There are no large leatherback turtle rookeries in Australia; however, leatherback turtles occasionally nest within the Great Barrier Reef, with nesting recorded at Wreck Rock and adjacent beaches near Bundaberg (one to three nests per annum) (GBRMPA 2011). Sporadic nesting has been recorded at other widely scattered sites in Queensland; however, there is a strong likelihood that leatherback turtles have not nested in Queensland since 1996 (Hamman et al. 2006; GBRMPA 2011). *Migration Routes* The leatherback turtle spends much of its time in the open ocean and may traverse thousands of kilometres over its lifetime from feeding areas to nesting beaches (Lutz & Musick 1996; Benson et al. 2007). Leatherback turtles are known to migrate from Australia to rookeries in Indonesia, Papua New Guinea and Solomon Islands (Hamman et al. 2006; Limpus 1995b). *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016g). ***Summary*** **Given that there is no known population in Moreton Bay, there are no key nesting habitats and it's largely pelagic existence, there is a low likelihood that leatherback turtles occur in marine habitats within and adjacent to Toondah Harbour.**	low
Eretmochelys imbricata	hawksbill turtle	V	The hawksbill turtle is globally distributed in tropical, sub-tropical and temperate waters (GBRMPA 2013c). There is a small resident population of hawksbill turtles in Moreton Bay. *Feeding Areas* Hawksbill turtles are heavily reliant on coral reef and rocky habitats, where they forage mainly on sponges but also seagrass, algae, squid, gastropods, sea cucumbers, soft corals and jellyfish (GBRMPA 2013c). As juveniles, they eat plankton (Meylan 1984). Feeding areas occur throughout eastern Queensland, from Torres Straight to Julian Rocks in northern New South Wales. *Breeding Areas* Hawksbill turtles nest on sandy beaches in the northern Great Barrier Reef and the Torres Strait. In Australia, the key nesting and inter-nesting areas include:	moderate

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			· Milman Island and the inner Great Barrier Reef Cays north from Cape Grenville Central · Torres Strait islands · Crab Island · Murray Islands · Darnley Island · Woody Island · Red Wallis and Woody Wallis Islands · Bramble Cay and Johnson Islet (Torres Strait), and · Western Cape York Peninsula (DEHP 2005). *Migration Routes* Hawksbill turtles that nest or forage on the east coast of Australia migrate to Indonesia, Papua New Guinea, the Solomon Islands, and Vanuatu (GBRMPA 2013c). *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016i). ***Summary*** **Despite not providing critical habitat, there is a small resident population of hawksbill turtles in Moreton Bay, and they may feed in, or traverse, the proposed project area. There is a moderate likelihood that hawksbill turtles occur in marine habitats within and adjacent to the Toondah Harbour project.**	
Lepidochelys olivacea	olive ridley turtle	E	Olive ridley turtles occur in tropical and sub-tropical regions of the Pacific and Indian oceans. In Australia, they are found in soft-bottomed, shallow, protected waters from the Joseph Bonaparte Gulf in Western Australia to southern Queensland (GBRMPA 2013d). They are typically not associated with coral reef habitat or shallow inshore seagrass flats (Limpus 2008a). Very few individuals have been recorded in Moreton Bay (e.g. only 3 reported captures by fishers in trawl nets; Robins & Mayer 1998). *Feeding Areas* Olive Ridley turtles feed in continental shelf waters on crabs, echinoderms, shellfish and gastropods (GBRMPA 2013d). A substantial part of the immature and adult population forage over shallow benthic habitats (Harris 1994 cited in Limpus 2008a); however, large juvenile and adult olive ridley turtles have been recorded in both benthic and pelagic foraging habitats (Musick & Limpus 1997). Foraging habitat can range from depths of several metres (Conway 1994) to over 100 m (Whiting et al. 2005). *Breeding Areas* There are two main breeding areas for olive ridley turtles in Australia, one in the Northern Territory with about 1,000 nesting females per year, and the other in the Gulf of Carpentaria with less than 100 nesting females per year (GBRMPA 2013d). There are no records of nesting from the east coast of Australia. *Migration Routes* Studies in the eastern Pacific and Atlantic Ocean show long distance reproductive migratory behaviour for olive ridley turtles, which is similar to other sea turtle species (Meylan 1982). *Key Threats*	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016m). ***Summary*** **Moreton Bay does not provide critical habitat and is unlikely to support important populations or offer habitat critical to the survival of this species. Further, very few individuals have been recorded in Moreton Bay. There is a low likelihood that olive ridley turtles occur in marine habitats within and adjacent to the Toondah Harbour project.**	
Natator depressus	flatback turtle	V	Unlike other marine turtles, the flatback turtle lacks an oceanic phase and remain in the surface waters of the continental shelf throughout its life. Little is known about their foraging habits and habitat, although juvenile and adult turtles seem to occupy similar habitats and both forage on soft-bodied (mostly benthic) organisms (Limpus et al. 1994). *Feeding Areas* The flatback turtle tends to forage in shallow continental shelf waters with soft substrates, feeding on a variety of soft-bodied animals, including soft corals, sea pens, sea cucumbers and jellyfish (Limpus 2007). Catch records from trawlers (as bycatch) indicate that the flatback turtle also feeds in turbid, shallow (depth of 10 m to 40 m) inshore waters. The foraging distribution for the eastern Australian stock encompasses from Hervey Bay to Torres Strait and possibly into the Gulf of Papua (Limpus 2007). *Breeding Areas* Flatback turtle nesting habitat includes sandy beaches in the tropics and subtropics, with all recorded nesting beaches in Australia (Limpus et al. 1989). In eastern Queensland, flatback turtles nest between Bundaberg in the south to the Torres Strait in the north. The main nesting sites in the southern Great Barrier Reef are: · Curtis Island · Peak Island · Facing Island · Hummock Hill Island, and · Wild Duck islands (Limpus 1971; Limpus et al. 1983). Scattered aperiodic nesting occurs along the mainland and on inshore islands between Townsville and the Torres Strait (Limpus et al. 1994). Nesting activity is greatest between late November and early December ceasing sometime in late January. *Migration Routes* Flatback Turtles make long reproductive migrations similar to other species of sea turtles, although most of these movements are restricted to the continental shelf (DoTE 2013c). Migrations have been recorded between Australia and Indonesia, Papua New Guinea, Solomon Islands and Vanuatu (GBRMPA 2013a). *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016q). ***Summary*** **Moreton Bay is not considered to be core habitat and is unlikely to support important populations or offer habitat critical to the survival of this species. Further, very few individuals have been recorded in Moreton Bay. There is a low likelihood that flatback turtles occur in marine habitats within and adjacent to the Toondah Harbour project.**	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
Fish and Sharks				
Epinephelus daemelii	black rockcod	V	The black rockcod occurs in warm temperate and subtropical waters of the south-western Pacific, including south-eastern Australia and parts of New Zealand (DSEWPaC 2012a). Black rockcod generally inhabit near-shore rocky and offshore coral reefs at depths down to 50 m, but are occasionally recorded from deeper waters. In coastal waters adult black rockcod are found in rock caves, rock gutters and on rock reefs. Recently settled juveniles are often found in coastal rock pools, while older juveniles can be found in estuaries (DSEWPaC 2012a). *Feeding Areas* Black rockcod are a large, opportunistic carnivore that preys on smaller fishes and crustaceans (McCulloch 1922; Pogonoski et al. 2002a). It is likely that they feed in and around rocky or coral reef habitats. *Breeding Areas* Little is known about their reproductive behaviour, but they are known to aggregate during spawning (Malcolm & Harasti 2010). *Key Threats* Current threats to black rockcod are incidental by-catch by commercial and recreational fishers, and illegal fishing activities (DSEWPaC 2012a). Modification of estuarine habitat is considered a potential threat to juvenile black cod (DSEWPaC 2012a). ***Summary*** **Given the banks are predominantly lined by mangroves with sandy or muddy substrates, there is a low likelihood that black rockcod occur in marine habitats within and adjacent to the Toondah Harbour project.**	low
Carcharias taurus	grey nurse shark	CE	The grey nurse shark occurs in two distinct populations on the east and west coast of Australia. The eastern coastal species is distributed from southern Queensland to southern New South Wales, with sharks primarily aggregating within inshore rocky reefs and islands (DoTE 2016c). Critical habitat for the shark includes those sites used for aggregation and several of these are noted within the Moreton Bay Marine Park (Environment Australia 2014). *Feeding Areas* Grey nurse sharks may work cooperatively to feed (Compagno 1984; Ireland 1984) and feed on a variety of smaller vertebrate, squids and crustaceans (Compagno 1984). It is likely that feeding takes place around aggregate areas. *Breeding Areas* Little data is present on the breeding areas of the grey nurse shark; however, the females may give birth at select pupping grounds (DoTE 2016c). Within pregnant grey nurse sharks of eastern Australia, a southerly migration is noted to pupping grounds from northerly mating and gestation aggregation sites (Bansemer & Bennett 2008). *Migration Routes* North to south migration between key critical habitats in grey nurse sharks occurs between aggregation sites for both male and female sharks (Bansemer and Bennett 2008). *Key Threats* Key threats include commercial fisheries bycatch and tourism (DoTE 2016c). ***Summary*** **As the area of the subject site does not meet key habitat requirements for this species, there is a low likelihood that this species would occur in marine habitats within or adjacent to the Toondah Harbour project.**	low
Carcharodon	great white	V	Great white sharks are found in most coastal waters of Australia, with the exception of the Northern Territory. The shark generally inhabits both inshore	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
carcharias	shark		coastal and continental habitats (Pogonoski et al. 2002 in DEWHA 2009); however, within Australian waters, the great white shark primarily inhabits those areas from the coast to 100 metres (DoTE 2016d). There are few records of great white sharks in Moreton Bay (Karczmarski et al. 1997). *Feeding Areas* Juvenile individuals selectively hunt smaller prey classes (e.g. fish and other sharks), while larger individuals appear to selectively hunt marine mammals (Estrada et al. 2006; Malcolm et al. 2001). Seasonal site fidelity appears to occur (CMAR 2007). *Migration Routes* Seasonal migration is apparent in both juvenile and adult great white sharks and display highly directional, coastal migration up the eastern coast with through interconnected habitat areas during autumn to winter (Bruce et al. 2006). *Breeding Areas* Limited data is available for particular breeding areas, however it is expected to occur from spring through to summer in temperate areas (Francis 1996; Uchida et al. 1996). *Key Threats* Key threats include commercial fisheries bycatch and human protective measures (DoTE 2016d). ***Summary*** **There is a low likelihood that great white sharks occur in marine habitats within or adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	
Pristis zijsron	green sawfish	V	In Australian waters, green sawfish have historically been recorded in the coastal waters off Broome, Western Australia, around northern Australia and down the east coast as far as Jervis Bay in New South Wales (Stevens et al. 2005). However, there have been no records of this species south of Cairns since the 1960s (Stevens et al. 2005). The green sawfish inhabits inshore marine waters, estuaries and river mouths with both sandy and muddy bottom habitats (Allen 1997; Peverell et al. 2004; Stevens et al. 2005). It has been recorded in very shallow water (<1 m) to offshore trawl grounds in over 70 m of water (Stevens et al. 2005). *Feeding Areas* Sawfish feed on fishes and benthic invertebrates. They are relatively active on the mud and sand flats on a moving tide, presumably feeding (GBRMPA 2012). *Breeding Areas* Estuarine habitats are used as nurseries with juveniles migrating into marine waters (Thorburn et al. 2007). *Key Threats* Key threats include fisheries pressure and habitat degradation (DoTE 2016t). ***Summary*** **The green sawfish has not been recorded south of Cairns since the 1960s. There is an extremely low likelihood for the species to be in marine or freshwater habitats within or adjacent to the Toondah Harbour project.**	low
Rhincodon typus	whale shark	V	The whale shark is found in all oceanic and coastal waters around Australia; however, is more common in those of northern Western Australia, the Northern Territory and Queensland (Compagno 1984; Last & Stevens 1994). Whale sharks prefer warmer surface waters with cold-water upwellings (Pogonoski et al. 2002b). It is noted as a pelagic shark, but will also come into coastal waters (DoTE 2016u). *Feeding Areas* Whale sharks primarily feed on planktonic and nektonic prey using a suction filter feeding technique (Compagno 1984). The shark appears to aggregate	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			seasonally in response to a pulse surge in prey in the areas around: · Ningaloo Reef (DoTE 2016u) · Christmas Island (DEH 2005b) · Coral Sea (DEH 2005b) Overall feeding appears typically to occur near or at the water surface (Compagno 1984). *Breeding Areas* Data on sexual activity of the whale shark is limited, and no evidence of pupping has yet been recorded (Rowat & Brooks 2012). As no observations have occurred off the highly populated coastline of Eastern Australia, it would presume to only occur, in remote areas offshore. *Key Threats* Key threats include predation, habitat degradation, competition with fisheries and tourism (DoTE 2016u). ***Summary*** **As the adjacent area does not meet habitat requirements of this species, there is an extremely low likelihood for whale sharks to occur in marine habitats within or adjacent to the Toondah Harbour project.**	

Source: (DoTE 2014b)

CE Critically Endangered; E endangered; V vulnerable

Table 3.3 Migratory marine species listed as potentially occurring within 5 km of the subject site, on the online Protected Matters search tool, and their likelihood of occurrence in the area potentially impacted by the Toondah Harbour project.

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
Mammals				
Balaenoptera edeni	Bryde's whale	-	Bryde's whales occur within all Australian waters except Northern Territory, and, are found in both inshore and offshore waters (Bannister et al. 1996). There are a limited number of sightings in Australia. Bryde's whale is an occasional visitor to the Moreton Bay region, with two sightings recorded from Moreton and North Stradbroke islands (Chilvers et al. 2005). *Feeding Areas* Bryde's whales feed on a variety of prey items (Kato 2002; Martin 1990) and are broken into two key 'forms' (Best 1977). The coastal whale will consume schooling fishes while the offshore whale ingest crustaceans and cephalopods (Best 1960; 1977; Kawamura 1980; Nemoto & Kawamura 1977; Ohsumi 1977). No specific feeding areas are known for Bryde's whale; however, it appears that the whale may follow local movements of prey (DoTE 2016a). Limited dive times have led to the whale being considered as pelagic (DoTE 2016a). *Breeding Areas* There are no known breeding areas for Bryde's whale; however, the offshore form does travel northerly to tropical waters during winter and may be for breeding and calving (Kato 2002). *Migration Routes* Limited migration occurs for Bryde's whale. The inshore form appears to display limited movement while the offshore form migrates from subtropical to tropical waters, presumably for reproductive purposes. *Key Threats* Key threats include competition with fisheries and oceanic pollution (DoTE 2016a). ***Summary*** **Moreton Bay is not considered to be core habitat for this species, and the area is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that Bryde's whales occur in marine habitats within or adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	low
Balaenoptera musculus	blue whale	E	See Table 3.2.	low
Eubalaena australis	southern right whale	E	See Table 3.2.	low
Megaptera novaeangliae	humpback whale	V	See Table 3.2.	low
Orcaella heinsohni (previously known as *Orcaella brevirostris)*	Australian snubfin dolphin	–	This species is listed as *Orcaella brevirostris* (Irrawaddy dolphin) in the EPBC search results. However, in 2005, genetic analysis showed the dolphin described as the Irrawaddy dolphin in Australia was actually a different species, now described as the Australian snubfin dolphin, *Orcaella heinsohni* (Beasley et al. 2005). While Irrawaddy dolphins occur across southern Asia and the Gulf of Papua New Guinea, in both coastal and freshwater systems (Culik 2010), the Australian snubfin dolphin occur only in waters off the northern half of Australia and is Australia's only endemic dolphin species. The Australian snubfin dolphin occurs from approximately Broome on the west coast to the Brisbane River on the east coast, of which the latter was considered outside the normal range (Parra et al. 2002). There appears to be 'hotspots' of higher densities along the Queensland coast (Parra et al. 2002) and preliminary data suggest that they occur in small, localised populations (Stacey & Arnold 1999). They appear to inhabit shallow waters <15 m deep within 10 km of the coast and up to 20 km of a river mouth, often in proximity to seagrass meadows (GBRMPA 2013b). It is doubtful that they venture very far upstream in river systems, although occasional vagrants may venture upstream	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			(Parra et al. 2002). *Feeding Areas* Like the Irrawaddy dolphin the Australian snubfin dolphin is assumed to be an opportunistic-generalist feeder, taking food from the bottom and water column. Diet consists primarily of fish, but includes cephalopods (squid and octopus) and crustaceans (prawns and crabs). Feeding may occur in a variety of habitats, from mangroves to sandy bottom estuaries and embayments, to rock and / or coral reefs. Feeding primarily occurs in shallow waters (less than 20 m) close to river mouths and creeks (DoTE 2016r). *Breeding Areas* There is limited information on the breeding and calving areas of the Australian snubfin dolphin; however, mating is likely to occur year round (DoTE 2016r). *Migration Routes* Limited information exists on their migration routes; however, home ranges and territories for appear to be large (DoTE 2016r). *Key Threats* Key threats include competition with fisheries, incidental capture in nets, habitat destruction and degradation, pollution and interaction with vessels (DoTE 2016r). ***Summary*** **The Brisbane River is considered the southern-most extent of the Australia snubfin dolphin range, and even so tenuously. Therefore, there is a low likelihood that Irrawaddy dolphin or Australian snubfin dolphins occur in marine habitats within or adjacent to the Toondah Harbour project, which is south of the Brisbane River.**	
Sousa chinensis	Indo-Pacific humpback dolphin	–	The distribution of Indo-Pacific humpback dolphins appears to be continuous along the east coast of Queensland (Corkeron et al. 1997). The Indo-Pacific humpback dolphin usually inhabits shallow coastal waters in association with rivers or creeks, estuaries, enclosed bays and coastal lagoons (Hale et al. 1998; Parra 2006). Recent surveys conducted in the far northern section of the Great Barrier Reef Marine Park showed that most sightings of Indo-Pacific humpback dolphins occurred in waters less than 5 km from land, 20 km from the nearest river mouth, and in waters less than 15 m deep (Parra et al. 2006b). Moreton Bay is one of the southernmost bay systems with a resident Indo-Pacific humpback dolphin population and is estimated to have approximately 100 and 163 individuals, predominantly in the western side of the bay (Chilvers et al. 2005; Parra et al. 2006a). *Feeding Areas* Indo-Pacific humpback dolphins have only been recorded feeding in shallow waters. They feed in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and / or coral reefs (DSEWPC 2013; DEHP 2013). They are opportunist-generalist feeders, consuming a wide variety of coastal and estuarine fishes, but also reef, littoral and demersal fishes, and some cephalopods and crustaceans (Parra 2005). *Breeding Areas* No key calving areas are known in Australian waters (Bannister et al. 1996). *Migration Routes* Indo-Pacific humpback dolphins are considered to be migratory, with evidence of migration across international boundaries (Culik 2003). In Queensland, there is evidence to indicate possible seasonality between different habitats (DEHP 2013). Home ranges appear to be large. *Key Threats* Key threats include habitat destruction and degradation, bycatch in gillnets and shark nets, illegal sport killing, overfishing of prey species, pollution and human interaction threats arising from tourism and transport (DoTE 2016v). ***Summary***	high

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Given their known population in Moreton Bay and preference for shallow coastal and estuarine areas, the Indo-Pacific humpback dolphin are highly likely to feed in or traverse within marine habitats of the Toondah Harbour project area.	
Dugong dugon	dugong	-	Dugong occur in all northern coastal waters from Broome in Western Australia to Moreton Bay in Queensland (Marsh et al. 2002; Marsh et al. 2011). The population of dugongs in Moreton Bay has been estimated to range between approximately 503 to 1019 individuals. The eastern banks of Moreton Bay supported 80–98% of the dugong population at any one time. In this area, there are several dugong 'hot spots' generally associated with seagrass communities (Lanyon 2003; Chilvers et al. 2005). *Feeding Areas* Dugongs feed almost exclusively on seagrass, particularly H. uninervis, H. ovalis and H. spinulosa, and principally inhabit seagrass meadows of shallow, protected bays and mangrove channels (Preen 1992; Preen et al. 1995; Lanyon & Morris 1997; Marsh et al. 2011). Their dependence on seagrass for food generally limits them to waters within 20 km of the coast, although individuals have been sighted further from the coast during aerial surveys (e.g. Marsh & Lawler 2002) and they have been observed feeding in deep-water (water depth of more than 20 m) seagrass (Lee Long et al. 1997). *Breeding Areas* Limited data suggests that dugong utilise tidal sandbanks and estuaries for calving (Marsh et al. 1984; Marsh et al. 2011). Mating herds have been observed in Moreton Bay (Marsh et al. 2011). *Migration Routes* Dugongs prefer shallow and protected areas with seagrass meadows, however they can be highly migratory due to their search for suitable seagrass or warmer waters (Marsh et al. 2002) and are known to travel several hundred kilometres. Dugongs have evolved to cope with the inherently unpredictable and patchy nature of seagrass meadows by moving to alternative areas known to support seagrass in the past. *Key Threats* Key threats include habitat degradation, pollution, anthropogenic noise and interaction with fisheries (DoTE 2016h). ***Summary*** **Moreton Bay supports feeding and breeding populations of dugong. Dugong have been observed near Toondah Harbour (frc environmental, pers. obs.) and are highly likely to occur within the marine habitats of the Toondah Harbour project area, particularly in the seagrass beds.**	high
Lagenorhynchus obscurus	dusky dolphin	-	Dusky dolphins mostly occur in temperate and sub-Antarctic, inshore waters (Ross 2006; DoTE 2016k). There are only thirteen records of the dusky dolphin in Australian waters (Bannister et al. 1996; Gill et al. 2000; Ross 2006). *Feeding Areas* Dusky dolphins are considered to be surface feeders (DoTE 2016k). Limited evidence suggests they feeds offshore during the night and rests inshore during the day (Sekiguchi et al. 1992; Bannister et al. 1996; Würsig et al. 1997). No Australia-specific feeding information is available; however, it would be expected that Australian populations of the dusky dolphin exhibit similar behaviour. *Breeding Areas* No breeding or calving areas are identified in Australian waters (DoTE 2016k). *Migration Routes* Limited information is available for seasonal movement patterns in Australia, but movement patterns may be linked to the position of the Subtropical Convergence and / or ENSO events (DoTE 2016k). *Key Threats*	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Key threats include pollution and interaction with fisheries. ***Summary*** **Moreton Bay is not considered to be core habitat for this species, and the area is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that dusky dolphins will occur in marine habitats within or adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	
Orcinus orca	killer whale	-	Killer whales are found throughout Australian state, continental and oceanic waters. Within these waters, killer whales are predominantly found in southern state waters (Ling 1991; Chatto & Warneke 2000). *Feeding Areas* Killer whales feed on an abundance of prey types including fish, invertebrates, birds and marine mammals (Bannister et al. 1996; Saulitis et al. 2000). In Australia, foraging generally occurs in coastal or oceanic waters (DoTE 2016s). Therefore, foraging by killer whales within Moreton Bay would be highly unlikely. *Breeding Areas* No calving areas are known in Australian waters (DoTE 2016s). *Migration Routes* Killer whales are noted to probably follow migratory routes (DoTE 2016s); however, these migratory routes would generally occur along typical habitats; oceanic or continental shelf waters. *Key Threats* Key threats include pollution, targeted hunting and illegal killing, and interactions with fisheries, including the potential for incidental capture (DoTE 2016s). ***Summary*** **Moreton Bay is not considered to be core habitat for this species, and the area is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that killer whales will occur in marine habitats within or adjacent to the Toondah Harbour project.**	low
Reptiles				
Caretta caretta	loggerhead turtle	E	See Table 3.2.	high
Chelonia mydas	green turtle	V	See Table 3.2.	high
Dermochelys coriacea	leatherback turtle	E	See Table 3.2.	low
Eretmochelys imbricata	hawksbill turtle	V	See Table 3.2.	moderate
Lepidochelys olivacea	olive ridley turtle	E	See Table 3.2.	low
Natator depressus	flatback turtle	V	See Table 3.2.	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
Fish and Sharks				
Pristis zijsron	green sawfish	V	See Table 3.2.	low
Rhincodon typus	whale shark	V	See Table 3.2.	low
Carcharodon carcharias	great white shark	V	See Table 3.2.	low
Lamna nasus	mackerel shark	–	The mackerel shark is a wide ranging coastal and oceanic species found in temperate and cold-temperate waters worldwide, preferring water temperatures below 18°C (Stevens et al. 2006). In Australia, this species occurs from southern Queensland to south-west Australia (Last & Stevens 2009). They typically occur in oceanic waters off the continental shelf, although they occasionally enter coastal waters (Francis et al. 2002). *Feeding Areas* Mackerel sharks are thought to be reasonably flexible in the types of habitat used for foraging (Pade et al. 2009). The mackerel shark feeds on pelagic fish and cephalopods, with elasmobranchs forming a small part of their diet (Joyce et al. 2002). *Breeding Areas* Mackerel sharks in the southern hemisphere are thought to give birth off New Zealand and Australia in winter (Francis & Stevens 2000); however, little is known of their key pupping areas. *Migration Routes* The mackerel shark is known to undertake seasonal migrations, although the timing and details of these migratory movements are not well-understood (Saunders et al. 2011). *Key Threats* The key threat to this species is overfishing (DoTE 2016l). ***Summary*** **Mackerel sharks typically occur in waters off the continental shelf. While they may venture into the coastal area of Moreton Bay, the marine habitats within or adjacent to the Toondah Harbour project are unlikely to provide significant habitat for them.**	low
Rays				
Manta birostris	giant manta ray	–	The taxonomy of mantra rays has recently been revised and the genus *Manta* now includes two distinct species: · *Manta birostris* a more oceanic species that migrates large distances in cooler waters, and · *Manta alfredi* more common on the continental shelf, around tropical and subtropical coral and rocky reefs, islands and along coastlines (Marshall 2008; Marshall et al. 2009; Couturier et al. 2011; see below). *Feeding Areas* The manta rays feeds on plankton, and can be encountered in large numbers along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts (Marshall et al. 2011). They can also be encountered on shallow reefs while being cleaned or feeding at the surface inshore and offshore. In inshore areas, they can occasionally be observed in sandy bottom areas and seagrass beds (Marshall et al. 2011). *Breeding Areas* There is little information on the reproductive biology of the giant manta ray (Marshall et al. 2011).	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Migration Routes While the manta rays is widely distributed and appears to be a migratory species, regional populations appear to be small considering the scale of their habitat (Marshall et al. 2011). *Key Threats* No threat data is available (DoTE 2016o). ***Summary*** **The area adjacent to the Toondah Harbour project does not provide critical habitat for *M. birostris*, and there is a low likelihood they will occur in marine habitats within or adjacent to the project area.**	
Manta alfredi	Reef Manta Ray		As above, the taxonomy of mantra rays has recently been revised and the genus *Manta* now includes two distinct species: · *Manta birostris* a more oceanic species that migrates large distances in cooler waters (see above), and · *Manta alfredi* more common on the continental shelf, around tropical and subtropical coral and rocky reefs, islands and along coastlines (Marshall 2008; Marshall et al. 2009; Couturier et al. 2011). Of the two giant manta ray species, the most likely species to occur near the coastline is *M. alfredi*. This species shows high site affinity that is likely to be related to feeding areas, cleaning stations, reproductive sites and migratory landmarks (Couturier et al. 2011). *Feeding Areas* The manta rays feeds on plankton, and can be encountered in large numbers along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts (Marshall et al. 2011). They can also be encountered on shallow reefs while being cleaned or feeding at the surface inshore and offshore. In inshore areas, they can occasionally be observed in sandy bottom areas and seagrass beds (Marshall et al. 2011). *Breeding Areas* There is little information on the reproductive biology of the manta rays (Marshall et al. 2011). *Migration Routes* While the manta rays is widely distributed and appears to be a migratory species, regional populations appear to be small considering the scale of their habitat (Marshall et al. 2011). *Key Threats* No threat data is available (DoTE 2016n). ***Summary*** **While the area adjacent to the Toondah Harbour project may provide some habitat requirements for vagrant *M. alfredi*, there is an extremely low likelihood that they will occur in marine habitats within or adjacent to the area.**	low

Source: (DoTE 2014b)

E endangered; V vulnerable

4 Assessment of Potential Impacts and Mitigation Measures

The discussion of potential impacts presented here is preliminary, and based on a combination of professional experience gained working on similar projects and the preliminary master plan. As detailed design and construction methods are yet to be finalised, the discussion of potential impacts is generic, and subject to further design information.

Potential direct impacts include:

- loss of habitat directly under the footprint of the proposed project
- gain of habitat in some of the footprint area
- marine fauna becoming trapped or injured in wet excavation areas.

Indirect impacts to the marine ecosystem may include:

- disturbance of sediments and soil (increasing turbidity, suspended solids, sedimentation, nutrients, contaminants and potential acid sulfate soils)
- spills of hydrocarbons and other contaminants
- increased stormwater runoff (with greater non-permeable surfaces on the subject site) and associated contaminants and foreshore erosion
- altered hydrodynamics
- increased site access and boating
- spread of weeds and pests, and
- increased litter.

Following dredging of Fison Channel, water quality is likely to improve around the channel as deepening the channel will reduce the current disturbance of bottom sediments from boating activities (particularly large passenger and vehicle ferries).

4.1 Loss of Habitat

Direct impacts that may result from the construction of the proposed project are the physical removal of, and damage to aquatic habitats.

The proposed project will result in the direct loss of aquatic habitat under the project footprint. While the design of the footprint is yet to be finalised, it is likely to include at least a portion of the PDA area, and thus result in a loss of habitat in the PDA, which includes:

- approximately 5.3 ha of mangroves
- approximately 32.7 ha of seagrass (ranging in cover from 1% to 85%)
- isolated and clumps of algae and potentially coral growing on bare sediments and rocks
- non-vegetated[2] soft sediments and the associated macrobenthos.

Other habitats along the foreshore including natural and artificial rock, pylons and concrete walls will also be either removed or incorporated into the project design.

The risk of direct disturbance to aquatic habitats during construction can be minimised by limiting the area of disturbance, for example by using areas within the project footprint for any temporary construction and storage, and by marking any marine plants that are to be retained and avoiding their disturbance.

4.2 Gain of Habitat

The installation of the pylons and other structures will provide hard-substrate that will likely be colonised by algae and invertebrates such as oysters and barnacles, and shelter for a range of fishes and mobile invertebrates (such as prawns).

Artificial structures such as the proposed pylons provide valuable habitat for fish as they:

- provide protection from predators
- feeding opportunities
- shelter from currents
- shade, which is also important in attracting many fish species (de la Moriniere et al. 2004; Verweii et al. 2006), and
- extra settlement habitat for recruitment (Derbyshire 2006).

[2] Devoid of macroscopic flora; benthic microalgae are expected to be associated with the surface sediments

The characteristics of artificial structures and the organisms growing on those structures influences the type of fish and other fauna that it is likely to support. Studies of natural and artificial habitat indicate that each support a fish fauna of similar species richness, yet of different, but often overlapping, assemblages (Fujita et al. 1996; Clark & Edwards 1999).

Fish-friendly structures should be incorporated into the design where possible. The Fisheries Guideline for Fish-Friendly Structures outlines several general and specific fish-friendly design features intended for developments that require aquatic infrastructure (Section 4.2 in Derbyshire 2006). Design options that may be considered for the structures associated with the upgrade may include:

- incorporating artificial habitat modules under piers and other supporting structures of the marina
- use of revetments constructed from different sized pieces of rock that offer more habitat than walls made out of smooth concrete
- gently sloping revetments rather than vertical revetments, and
- not using materials such as polystyrene, tyres, treated wood and uncured concrete.

4.3 Marine Fauna Trapped in Excavation Areas

Fish, turtles and marine mammals may become trapped in excavation areas during excavation, dredging and reclamation works. Impact to these marine fauna will depend on the time taken to excavate and the turbidity of the water during excavation, with higher turbidity and longer periods more likely to negatively impact marine fauna.

A management plan for minimising the risk of impacting marine vertebrates should be formulated prior to in- or on-water construction activities. Mitigation options to be considered include:

- installing sheet piles, silt curtains or other temporary barriers at low tide to minimise the number of marine vertebrates caught in the area
- capturing fish within the area confined by the sheet piles, silt curtains or other temporary barriers and releasing them outside the area
- visual observations by a trained marine mammal and turtle spotter prior to commencement of excavation and dredging activities

- cessation of excavation or dredging if a dolphin, dugong or turtle is observed within the area, until the animal can be removed from the area being excavated, and
- using mechanical noise to drive marine mammals away from an area prior to completion of the installation of sheet piles, silt curtains or other temporary barriers.

4.4 Disturbance of Sediments and Soils

Disturbance of sediment and / or soils may lead to:

- changes in benthic community structures
- increases in turbidity, sediment suspension and smothering
- nutrient enrichment of surrounding waters
- release of contaminants, and
- exposure of acid sulfate soils (ASS).

Sediments may be disturbed by construction activities such as clearing and earthworks, dredging and reclamation, and pile placement. The risk and severity of these potential impacts will be related to the intensity, duration, spatial extent and frequency of exposure that results from the construction works. Potential impacts to each habitat type are outlined in the remainder of this section. Communities that are most sensitive to disturbances of sediment and / or soils in the area are seagrass meadows and scattered corals on rubble. Measures to reduce potential impacts to these communities include:

- designing the project to minimise the area of sediment and / or soils being disturbed
- using temporary enclosures (complete enclosures such as sheet piles or alternate enclosures such as silt curtains) to reduce the intensity and spatial distribution of potential impacts
- isolate the disturbance areas, for example by using sheet piles, silt curtains, oil spill booms, bunding, trenching and / or similar technologies
- identification and management of acid sulfate soils and other contaminants, through a sediment sampling and analyses plan (SAP)
- developing thresholds for turbidity and suspended solids, and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction, and

- monitoring changes in seagrass and coral communities post-construction to determine any potential impacts.

Measures such as avoiding disturbance of sediment and / or soils during important periods of reproduction for coral and seagrass (e.g. late spring and summer) or during low tide when water is shallower and dredge plumes may be more concentrated may also reduced potential impacts. Further, given corals in the area are isolated individuals on rubble (rather than reef complexes), a coral translocation and replantation program, where coral are moved to nearby area/s during construction and returned to the area post construction would also reduce impacts to coral assemblages.

A complete enclosure (e.g. by installing temporary sheet piles) of areas where sediments and soils are to be disturbed, including the marina and reclamation areas, would isolate increases in turbidity, suspended sediment (and hence smothering), nutrient enrichment, contaminants and acid sulphate soils to the adjacent marine environment. Temporary sheet piles have been used successfully in other reclamation and marina project in Queensland and are likely to be the best practice method for minimising impacts of disturbances of sediment and soils. The design and application of comprehensive Erosion and Sediment Control Management Plans and an Acid Sulfate Management Plan will also minimise and manage potential impacts of disturbing sediment and soil in the marina and reclamation areas.

The development and application of thresholds for turbidity and suspended solids over seagrass and corals would also contribute to minimising impacts. Such thresholds would include maximum allowable exceedances above ambient levels and limits to the duration of plumes, along with appropriate management responses (e.g. triggering cessation of works). Thresholds should be site specific, and take into account the variability in local ambient levels and the sensitivities of local species (Erftemeijer & Robin Lewis 2006; Erftemeijer et al. 2012).

Impacts to Benthic Communities

Excavating or dredging soft sediment habitats in the proposed marina as well as dredging Fison Channel may impact macroinvertebrate communities. Impacts to soft-sediment benthic macroinvertebrate communities are likely to be temporary (recovering in a few months), although where the freshly exposed substrate is physically or chemically different from the removed sediment, community structure may change. Community structure may also change due to increases in depth, decreases in light penetration associated with a deeper environment, and with changes in currents in the water column.

Soft sediment communities within the marina and channel are likely to be deeper and in some areas of the marina will receive shade from the structures, leading to reduced benthic microalgal (BMA) biomass. Due to the relatively small area that will be disturbed, any shifts in benthic macroinvertebrate community structure are unlikely to significantly impact fisheries productivity on a local or regional scale.

Increased Turbidity, Suspended solids and Sedimentation

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

Seagrass and Macroalgae Communities

The temporary increase in turbidity associated with excavation and spoil handling typically reduces or alters the penetration of light through the water column (McMahon et al. 2017). Light availability, or specifically the duration of light intensity exceeding the photosynthetic light saturation point, controls the depth distribution of seagrasses (Dennison & Alberte 1985; Dennison 1987; Abal & Dennison 1996). For example, on average 30% of surface light; a light attenuation co-efficient of less than $1.4 m^{-1}$ and total suspended solids of less than 10 mg/L are required for the survival of *Zostera muelleri* in Moreton Bay (Longstaff et al. 1998; Abal & Dennison 1996). *H. ovalis* another common species in the area, has a particularly low tolerance to light deprivation caused by pulsed turbidity such as floods and dredging (Longstaff et al. 1998). However, *H. ovalis* can quickly recolonise areas due to its high growth rate and high seed production.

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

When suspended solids settle on seagrass communities, the burial can result in increased seed germination, decrease in shoot density and productivity, changes in growth (e.g. increase vertical and rhizome growth) and mortality (Cabaço et al. 2008).

The sensitivity of seagrass to turbidity and sedimentation varies within and between species and life histories (Erftemeijer & Robin Lewis 2006). Local conditions influence the sensitivity of seagrass species, with areas experiencing large fluctuations in background turbidity often displaying greater resilience (Erftemeijer & Robin Lewis 2006). Further, the deepest edge of meadows are often more susceptible to changes in light levels (Ralph et al. 2007). Thus, increases in turbidity and sedimentation are likely to result in adverse environmental effects when the turbidity generated (by dredging for example) is significantly larger than the ambient (or baseline) variation of turbidity and sedimentation rates in the area (Erftemeijer & Robin Lewis 2006).

Coral and Rubble Assemblages

Most coral are host to symbiotic zooxanthellae (algae) that can produce the majority of the corals energy requirements through photosynthesis. Turbidity and suspended sediments (which can result from dredging, excavation and reclamation works) reduce light levels and hence the ability of the zooxanthellae to photosynthesise (Erftemeijer et al. 2012). Sediment settling on coral can also clog filtering and feeding apparatus, smother coral and / or further reduce the light available for photosynthesis by shading symbiotic zooxanthellae. Energy is expended on clearance of settling sediments, such as the production of mucus (Erftemeijer et al. 2012; Bessell-Browne et al. 2017a). With the production of mucous sheets and effective bioindictor of sediment related exposure for massive Porites corals (Russell-Browne et al. 2017). Embryo and larval stages of coral tolerate higher sediment loads and are less sediment-sensitive than other life-history pelagic stages (Ricardo et al. 2016).

Suspended sediments can also effect reproduction and recruitment processes which underlie the maintenance of communities and their resilience to disturbance. Never the less, light limitation is thought to have a greater impact on coral health than suspended sediments (Bessell-Browne et al. 2017b).

Overall impacts to corals from increased turbidity, suspended sediment and smothering include reduced growth, lower calcification rates and reduced productivity, bleaching, increased susceptibility to diseases, physical damage, reduced regeneration and mortality (Erftemeijer et al. 2012). This can result in changes in community structure, decrease in density and diversity of coral and loss of reef habitat if sediment disturbances are severe and long-lasting (Erftemeijer et al. 2012). Fine sediments tend to have a greater impact on corals than coarser sediment (Erftemeijer et al. 2012).

Soft Sediment Benthos

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

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

Fish and Marine Megafauna

Although some fish and marine megafauna (e.g. dolphins, turtles and dugongs) may avoid areas of high turbidity and suspended solids, areas of high turbidity and suspended solids may also be attractive to a range of fish, particularly juveniles, as it confers a greater degree of protection from predators (Blaber & Blaber 1980). Reduced visibility can also change the behaviour of mobile marine fauna. Suspended sediment in the water column can cause physiological effects to fish, such as clog gills or influence reproduction (e.g. fertilisation, or survival of eggs or larvae). Although, there is evidence that levels high enough to directly affect fish physiology are limited to the immediate vicinity of the dredging and disposal operations (McCook et al. 2015 and references herein). Fish and marine megafauna may be indirectly impacted by the loss or degradation of habitats, and effects on food webs, connectivity, and changes in ecosystem processes.

Nutrient Enrichment of Surrounding Waters

The proposed development may result in an increase in nutrients in the surrounding water, for example by disturbance of the sediment. Such increases are likely to be minor where development is controlled by an appropriate Environmental Management Plan. Never the less potential impacts of an increase are nutrients are discussed below.

Mangroves and Saltmarsh

Increased nutrients can have positive impacts on the productivity of mangrove communities; commonly there is an increase in growth and productivity associated with low levels of nutrient enrichment (e.g. Onuf et al. 1977; Clough et al. 1983; Dunstan 1990; McLaughlin 1987). Available data suggests that nitrogen availability is limiting mangrove growth in south east Queensland waters, such as Moreton Bay (Dennison et al. 1998). However, as there was no increase in leaf turnover rates, the capacity of mangroves in Moreton Bay to convert dissolved nutrients to particulate nutrients via litter fall may be limited (Dennison et al. 1998). That is, increasing nutrients may lead to an initial increase in biomass of mangroves; however, this uptake may not be sustained. In northern Australia, leaf production increased with nitrogen fertilisation (Boto & Wellington 1983). It has been suggested that the response of mangrove forest to nutrient enrichment could be in two stages, with an initial increase in leaf production followed by an increased foliar nutrient concentration (Dennison et al. 1998).

Seagrass

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

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

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

Macroalgae and Phytoplankton

Elevated nutrients can rapidly be taken up and stored by macroalgae and phytoplankton during pulsed discharge events (Furnas 2003). Phytoplankton is very abundant in coastal waterways and has high nutrient uptake rates. As a result, phytoplankton is commonly the principal flora assimilating nitrogen and phosphorus within coastal estuaries of southern Queensland.

Nutrients exported to or released within the coastal zone can significantly increase the productivity and competitive potential of some macroalgal species (Schaffelke & Klumpp 1998a; Schaffelke & Klumpp 1998b), with macroalgal cover often being significantly correlated with distance from rivers mouths and positively correlated with turbidity, chlorophyll-*a* and current speed (van Woesik et al. 1999).

Phytoplankton communities are sensitive indicators of nutrient enrichment. Increased nutrient availability has been linked with not only increased phytoplankton biomass, but also with a shift in the community composition of the phytoplankton. Whilst correlations between increased water column nutrient levels and increased phytoplankton abundance are common, phytoplankton assemblages can incorporate nutrients so rapidly that there is no apparent increase in nutrients in the water column. Phytoplankton has the ability to uptake nutrients in various forms, such as ammonium (the preferred form of N), nitrate, urea and phosphate (Dennison & Abal 1999).

The diatom-cyanobacteria fraction of the phytoplankton community is often the first to respond to increased nutrient availability (Parsons et al. 1978, cited in Hallegraeff 1996), consequently diatoms are typically associated with algal blooms in tropical and sub-tropical coastal waters. However, chronic elevations in available nutrients can result in pronounced shifts from high biomass microplankton communities dominated by diatoms, to highly productive pico-nanoplankton communities (Harding 1994).

Phytoplankton growth is primarily limited by light, nutrients (principally phosphorous and nitrogen) and temperature. However, other macronutrients such as silicate and micronutrients (vitamins, trace elements and chelators) are also important in controlling growth and community composition (Hallegraeff 1996).

The Ecosystem Health Monitoring Program administered by the Healthy Waterways Partnership investigated factors limiting phytoplankton growth in Moreton Bay and the surrounding river estuaries. Phytoplankton growth responses are substantially lower in Moreton Bay than in the river estuaries, due to a lower abundance of phytoplankton in the bay. Throughout Moreton Bay and the river estuaries nitrogen is the major nutrient limiting growth.

Coral and Rubble Assemblage

Nutrient enrichment can reduce coral calcification and fertilization rates and exacerbate coral disease (Fabricius 2005). Macroalgae abundance can also be enhanced (Fabricius 2005), which may compete with coral in some areas.

Soft Sediment Benthos

Benthic microalgae play an important role in sediment nutrient processes, and are hypothesised to be highly efficient at denitrification and the absorption of nutrients (Dennison et al. 1998).

However, turbidity limits benthic microalgae productivity – for example, in the turbid reaches of the Brisbane River, benthic microalgae concentrations are 0 – 20 mg/m^2, compared to concentrations of around 50 mg/m2 at some sites in Moreton Bay, where there is low turbidity and growth is not nutrient-limited (e.g. southern Pumicestone Passage) (Dennison & Abal 1999).

Increases in sediment organic and nutrient loads often lead to a reduction in community diversity and species richness, which is associated with a shift in community composition and trophic group structure (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999; Rossi 2003).

Population densities of opportunistic deposit feeders characteristically increase in areas impacted by organic enrichment and macro-invertebrate communities typically become dominated by polychaetes (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999). These worms are characterised by their ability to respond rapidly to environmental change and are widely recognised as useful indicators of environmental health (Pearson & Rosenberg 1978; ANZECC & ARMCANZ 2000). In particular the polychaete families Capitellidae and Spionidae have been identified as indicators that are sensitive to organic enrichment (Tsutsumi 1990; ANZECC & ARMCANZ 2000). The densities of capitellid polychaetes in environments with high nutrient and organic loads typically exceed 1000 individuals per m^2 (Tsutsumi 1990; Hutchings et al. 1993). Such densities are generally indicative of organic enrichment and are used as the trigger levels for ANZECC & ARMCANZ guidelines.

Many benthic macro-invertebrate species are metal sensitive and increased concentrations have been shown to affect benthic invertebrates at the population and community level (Morrisey et al. 1996; Ward & Hutchings 1996; Reish & Gerlinger 1997). Increases in the concentration of trace metals in estuarine sediments remove metal sensitive species and facilitates the explosion of polychaete populations, which can selectively exploit metal contaminated conditions (Ward & Hutchings 1996). Changes in community structure are usually accompanied by a reduction in the richness and diversity of benthic macro-invertebrate communities.

Nutrient enrichment increases the cycling of sulphur through the sediment. Under normal aerobic conditions, hydrogen sulphide (H_2S) and sulphuric acid (H_2SO_4) produced during sulphate (SO_4) reduction rapidly convert back to SO_4 and have little impact on macroinvertebrate communities (Edgar 2001). Similarly, H_2S is not usually a problem in most anaerobic sediments, because it is quickly bound to Fe to form pyrite and iron mono-sulphides. However, H_2S may become a problem when the Fe scavenging capacity of the sediments is exceeded, that is, where there are very high organic loadings. In heavily organically enriched environments with low dissolved oxygen, H_2S and H_2SO_4 concentrations can increase dramatically (Coleman & Cook 2003), and allow these poisonous compounds to build up in the sediment, and potentially negatively impact macro-invertebrate communities (Coleman & Cook 2003).

Marine Fauna

Nutrient enrichment can result in localised eutrophication and depletion of oxygen in the water column. Many species of fish become stressed when DO concentrations drop below 4 mg/L, and levels of < 2 mg/L are fatal to most species. Similarly, invertebrates of the bed and bank are impacted by low DO concentrations.

Conditions of low DO, high H_2S and low redox potentials usually occur simultaneously and their impacts on macroinvertebrate populations are difficult to separate in their effect on community structure (Wu 2002). Under these conditions there is often a reduction in the richness and diversity of macroinvertebrate communities, which is associated with a trophic shift toward deposit feeding taxa (Wu 2002; Coleman & Cook 2003).

Release of Contaminants

The absorption of heavy metals from solution occurs in plants and animals by passive diffusion across gradients created by adsorption at the surface, and by binding by constituents of the surface cells, body fluids, etc. An alternative pathway for animals is when metals are adsorbed onto or are present in food, and by the collection of particulate or colloidal metal by food gathering mechanisms. Depending upon the types and concentrations of heavy metals release, impacts could range from the reduction of reproductive capacity of some species to the mortality of aquatic flora and fauna. The effect of chronic heavy metal pollution is still largely unresolved, and effects depend on the interrelationships of many physical and chemical factors. Threshold concentrations of toxicants to ensure the protection of aquatic ecosystems have been developed by the Australian and New Zealand Environment and Conservation Council (ANZECC & ARMCANZ 2000). With the implementation of an appropriate Environmental Management Plan, there are unlikely to be any significant impacts from the release of contaminants.

Disturbance of Acid Sulfate Soils

Sediments from Toondah Harbour have potential acidity (frc environmental 2010). Disturbance of intertidal and marine sediments may expose acid sulfate soils to oxidising (acidifying) conditions. Acid sulfate materials are formed when pyrite in sediments is exposed to oxidation. Pyrite (FeS_2) is unstable in the presence of specialised bacteria and atmospheric oxygen, decomposing to the form ferrous iron and sulfuric acid.

The effects of acidification can be chronic or acute. The effects of chronic acidification on Australian estuarine biota, including fishes, is poorly understood; however, sudden acidification has been responsible for fish-kills, disease and other disturbances (Sammut et al. 1993). Chronic low-level acidity may reduce vigour and predispose marine biota to other diseases. Historical fluctuations in commercial finfish and prawn catches may be partially attributable to periods of increased acidity in estuarine waters (Leadbitter 1993).

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

With the implementation of an appropriate Environmental Management Plan, there are unlikely to be any significant impacts from acid sulfate sediments.

4.5 Spills of Hydrocarbons and Other Contaminants

Hydrocarbon spills from machinery during construction activities can negatively affect aquatic flora and fauna. It is possible that hydrocarbon spills could occur during the transportation of fuel or during equipment refuelling in the construction phase of the project. Concentrations of dissolved oil fractions below 0.01 ppm have not been shown to have adverse effects on any aquatic organism either in the short or long term, at any stage of development or at a cellular or sub-cellular level. Between 0.01 ppm and

0.1 ppm, some adult animals show sub-lethal behaviour and physiological disturbance, while developmental stages may show retarded growth or increased abnormalities. In general, the developmental stages of a species are far more susceptible than are adults, frequently by one or two orders of magnitude (Brown 1985).

Whilst acute (or at least a one off) contamination may result in severe ecological consequences, recovery is in most cases inevitable. In contrast, chronic contamination can result in the permanent (or at least for the duration of contamination) morbidity or localised extinction of flora and fauna. Chronic small spills, though probably influencing a lesser area, effectively prevent recovery and lead to cumulative impacts. Frequent spills from diffuse locations within a waterway can result in an enduring impact over a very wide area.

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

Floral communities and sessile faunal communities are most at risk from chronic hydrocarbon pollution. As these communities often form a critical component of habitat (providing structural complexity, shelter and often food), a permanent impact to these communities may have a consequentially widespread impact on the mobile components of the faunal community including fishes and crustaceans. Both petroleum and petroleum by-products are harmful to mangroves (Odum & Johannes 1975) causing mechanical damage by blocking the pores in the pneumatophores and effecting respiration, photosynthesis and translocation (Mackey & Smail 1995). Hydrocarbons are also known to cause reproductive disorders, immune deficiencies, tumours and cyst development in marine mammals and reptiles, especially when they are stressed (Schaffelke et al. 2001).

Low levels of petroleum hydrocarbons in the aquatic environment are adsorbed onto, or incorporated into, the sediments, where they may persist for years (Voudrias & Smith 1986; Pelletier et al. 1991). A large number of small-scale oil spills may lead to a significant increase in hydrocarbons over time, in effect resulting in a permanent impact. Mangrove sediments in particular may serve as long-term reservoirs for chronic contamination holding hydrocarbons for periods in excess of 5 years (Burns et al. 1994).

Where fuel storage and handling activities are undertaken in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols), the risk of impacts to aquatic flora and fauna due to chronic and acute fuel spills is considered minor.

4.6 Increased Stormwater Runoff

Contaminants and nutrients may enter the aquatic environment from stormwater run-off from the proposed development site. The release of toxicants to the marina and surrounding waters will be minimised by treating stormwater (with water sensitive urban design techniques) to comply with local water quality criteria (Hyder 2010). Further, the sediment and erosion control plan is developed to minimise the release of sediment-bound nutrients and toxicants to the water. A storm water management plan is developed that complies with the most recent version of the *Urban Stormwater Quality Planning Guidelines* (DERM 2010b). With these in place, it is unlikely that suspended sediments and toxins become critically elevated in the waters of, and adjoining, the marina due to storm water runoff, and are therefore unlikely to cause an adverse ecological impact.

4.7 Altered Hydrodynamics

Changes in water velocity around the proposed development may alter (increase or decrease) the suitability of habitat for marine plants as well as change the composition of benthic macroinvertebrates. Marine plants may be influenced by changes in velocity resulting in removal of sediment, changes in sediment composition and chemistry, as well as changes in turbidity levels. Benthic macroinvertebrate communities are also likely to change with any changes to water velocity: in low flow environments predators exert more influence on benthic community structure than in high flow environments (Leonard et al. 1998). Any changes to sediment grain size would also alter the composition of benthic macroinvertebrate communities.

Reduced velocities may result in an accumulation of fine sediment and may also result in changes to sediment chemistry and water turbidity. Marine plants are unlikely to be negatively impacted by reduced flows and may even show a positive response. The composition of benthic macroinvertebrates is likely to change due to lower water velocities in this area.

4.8 Increased Human Activity

Increased human activity during construction, including changes in underwater noise levels, may affect the behaviour of fauna, particularly marine mammals

Underwater noise and other loud sounds may affect marine mammals by interfering with their use of sounds in communication, especially in relation to navigation and reproduction (Weilgard 2007; Wright & Burgin 2007). Marine mammals cease feeding, resting or social interaction at the onset of acoustic disturbance and to initiate alertness or avoidance behaviours (Richardson et al. 1995). Marine mammals in the vicinity of frequent, high intensity noise are likely to be highly stressed or even physically harmed and consequently, are likely to stay well away from continuously operating acoustic disturbance (Smith 1997). Therefore, any Indo-Pacific humpback dolphins, bottlenose dolphins or dugongs in the vicinity of the proposed development may vacate the area on commencement of the proposed in-water works such as wet excavation. Noise from on-land works is unlikely to disturb marine mammals. Any avoidance behaviour is likely to cease following completion of the work

Turtles have relatively poor hearing and are far less likely to be impacted by underwater acoustic disturbance. In the unlikely event that in- and underwater construction does audibly disturb turtles, they may temporarily leave the area. Similarly, underwater construction noise may disturb some local fish, which may vacate the area for a short time.

The risk of impacts to marine fauna as a result of noise will be reduced further by preparing a Fauna Management Plan. Measures to minimise potential impacts to marine fauna may include:

- where dredging or pile driving activities are occurring, every morning before works begin, or after works have ceased for more than two hours and prior to it beginning again, appropriately trained Marine Fauna Observers (MFOs) inspect the area around all pile driving activities for 30 minutes
- all vessel crew maintaining a look out for marine mammals and turtles during all operations
- if prior to works, a marine mammal or turtle is identified within 150 metres, then pile driving does not commence until the animal has passed
- if after works have commenced (including a soft start phase), a marine mammal or sea turtle is observed within 100 m of the noise emitting source, then pile driving ceases until the animal has passed

- if a marine mammal or turtle are sighted in the pre-defined observation and exclusion zones, project vessels operating in the area are notified and piling ceases until the animal has passed
- have a 'soft-start' for all pile driving, slowly increasing intensity of the driving hammer power
- site inductions for all vessel crew covering procedures to minimise disturbance to marine fauna
- training of all vessel crew in the identification of marine mammals and turtles
- routine maintenance and inspection of all noise-generating equipment (including vessel engines, drill and piling equipment) to reduce unnecessary increases in noise levels from the equipment
- where practical, engines, thrusters and auxiliary plant are no left on standby or running mode
- adherence to speed limits of all vessels involved in construction
- movement restrictions including:
  - if a vessel in transit approaches a marine mammal or turtle (or vice versa), the vessel will take all care to avoid collisions, including stopping, slowing down, and/ or steering away
  - vessels will not intercept the path of travel, either behind or ahead of the animal, or approach head on, and will not pursue marine mammals or turtles
  - vessels will keep clear of the no approach zone (Figure 4.1)
  - vessels will have a maximum speed of 5 knots in the caution zone (Figure 4.1)
  - vessels will not change speed or course suddenly in the caution zone (Figure 4.1)
  - vessels will not enter the caution zone if animals are stranded, entangled or in distress, and
  - vessels will avoid separation of adult and young marine mammals.

It is also recommended that daily logbooks are kept of all marine mammal and turtle sightings and interactions, and any management actions taken to avoid damage to them.

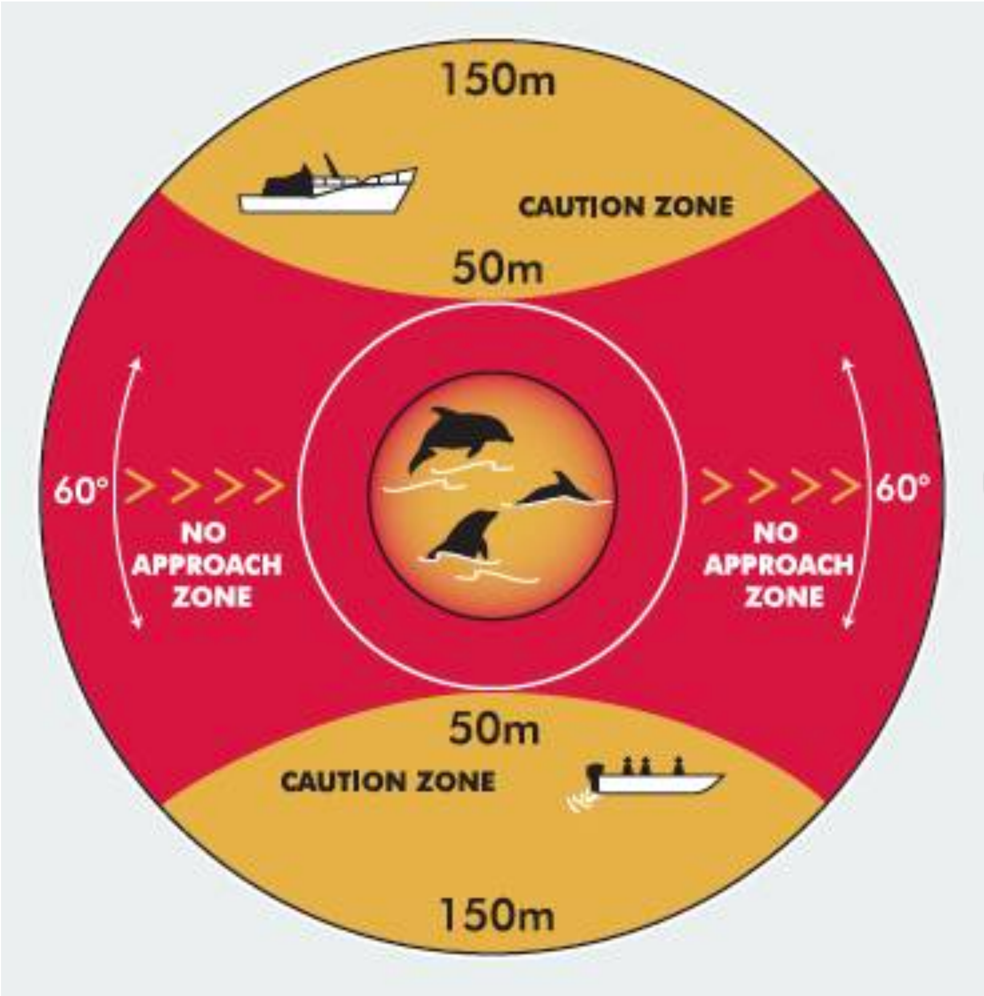

Figure 4.1 Caution and no approach zones for dolphins and turtles (DEH 2005a).

Any distressed or damaged marine mammals or turtles should be reported to RSPCA QLD on 1300 284625 (the designated call centre for Queensland National Parks and Wildlife Service for marine mammal and turtles strandings).

4.9 Increased Boat Activity and Access

Antifouling paints used on the exterior of boats often contain heavy metals, particularly copper, that can build up in marine organisms. In south-east Queensland, many anchorages have exceeded the ANZECC/ARMCANZ trigger values for copper, with copper concentrations in the water column correlated with vessel numbers (Warnken et al. 2004). The proposed development may increase the concentration of heavy metals, particularly copper in the water. This risk is reduced where International and Australian standards relating to antifouling paints are followed (National Heritage Trust 2007).

Increased boat traffic may increase the chance of collisions between boats and marine vertebrates, particularly turtles, both in the immediate vicinity of the proposed development and in the broader environs of the Marine Park.

Boat strikes are responsible for the largest proportion of all human-related turtle strandings or mortalities (Greenland et al. 2004). In general, the shallower the area and the larger the boat, the greater the risk of a boat strike to turtles. Turtles feed on the intertidal flats at high and mid tides, and drop into deeper waters (which can include the waters of navigation channels) at low tide, where they can be struck by passing traffic. This habit of moving into navigation channels increases the risk of boat strike. Exclusion devices for marine megafauna (e.g. dolphins, turtles and dugongs) are used in Queensland to reduce the risk of being caught in dredges (McCook et al. 2015).

Dolphins are likely to be able to avoid approaching boats; however, at least nine dolphins were killed in Queensland by boat strike in a period of 8 years (Greenland & Limpus 2007b). Dugong will also avoid approaching boats; however, they are slower than dolphins and more vulnerable to vessel strike. Since dugongs were included in the Marine Wildlife Stranding and Mortality Database in 1996, between 2 and 7 individuals have died each year due to boat strike (Greenland & Limpus 2007a). The majority of these boat strikes occurred in Moreton Bay due to the high amount of boat traffic. The vulnerability of dugongs (with slow breeding rates and slow maturity) means that any dugong deaths may contribute to a population decline.

Go slow areas in Moreton Bay Marine Park limit speed in areas that are recognised as particularly significant for dugongs and turtles. Exclusion devices for marine megafauna (e.g. dolphins, turtles and dugongs) are used in Queensland to reduce the risk of being caught in dredges (McCook et al. 2015). The Nature Conservation (Wildlife Management) Regulation 2006 also outlines measures to protect marine mammals including marine mammal approach distances for vessels and aircraft.

4.10 Spread of Weeds and Pests

Marine pest species can be introduced via ballast water and hull fouling. While this risk is predominantly from vessels that have been in international waters, there is also a risk of boats spreading pests established in other ports. The introduction and spread of marine pest species can be minimised by following protocols of the National System for the Prevention and Management of Marine Pest Incursions, which aims to prevent new marine pests from arriving in Australia, and minimize the spread of pests within Australian waters. To reduce the risk of inadvertently spreading marine biofouling pests, vessel operators need to minimise the amount of biofouling on their vessels (Australian Government 2010).

Increased usage of the shoreline may lead to an increase in weed cover in mangrove and saltmarshes. This may be a result of dumping of garden refuse, by seeds and propagules being inadvertently spread along access tracks and paths by vehicles or on foot, and by the air and water borne spread of seeds and propagules from gardens and landscaped areas.

A weed management plan, and a strategy for the maintenance of native plant areas on the proposed site would reduce this risk of introduced plant pests.

4.11 Increased Litter

Seven turtles in Moreton Bay were found to have ingested synthetic materials in 2001, and nine turtles in 2002 (Greenland et al. 2004). Of these, most had ingested fishing line, and only two animals were released alive (Greenland et al. 2004). In 2001 and 2002, entanglement in fishing ropes / lines, bags and ghost nets accounted for 21-35% of the annual human-induced turtle stranding or deaths (Greenland et al. 2004).

Dugongs have also been stranded / killed by ingesting fishing line or hooks (e.g. 2 individuals in Moreton Bay in 2003), or becoming entangled in ropes, fishing line and crab pots etc. (0-2 individual each year) (Greenland & Limpus 2005).

A waste management plan will reduce impacts from increased litter. Measures may include:

- complete removal from site of all construction waste
- waste storage facilities secured to avoid removal of waste either unintentionally or through vandalism
- reduction of waste at the source, reuse and recycling as well as recovery of materials or conversion of waste into useable materials
- educational signage, explicitly stating the risk to wildlife of disposing rubbish in the water

4.12 Improve Water Quality

Water quality in Fison Channel is currently impacted by the disturbance and re-suspension of sediment from boats, particularly to large vehicle and passenger ferries. Plumes of turbid water are created from the movement of these boats, particularly at low tide when water is relatively shallow in the channel. While dredging the channel will create short-term sediment plumes (refer to potential impacts in Section 4.4), following dredging there is likely to be a long term improvement in water quality as the water level will be deeper and thus turbid plumes from boating will be reduced.

5 Risk Assessment

A risk assessment of potential impacts has been undertaken (Table 5.1), and a summary of potential and residual risk is presented in Table 5.2. 'Best practice' assessment and practices will be employed to minimise the impacts associated with both construction and operation of the proposed Project. Table 5.2 provides a summary of mitigation measures and the associated residual risk.

Table 5.1 Risk assessment matrix.

	Consequence				
Probability	Catastrophic Irreversible Permanent (5)	Major Long Term (4)	Moderate Medium Term (3)	Minor Short Term Manageable (2)	Insignificant Manageable (1)
Almost Certain (5)	(25) Extreme	(20) Extreme	(15) High	(10) Medium	(5) Medium
Likely (4)	(20) Extreme	(16) High	(10) Medium	(8) Medium	(4) Low
Possible (3)	(15) High	(12) High	(9) Medium	(6) Medium	(3) Low
Unlikely (2)	(10) Medium	(8) Medium	(6) Medium	(4) Low	(2) Low
Rare (1)	(5) Medium	(4) Low	(3) Low	(2) Low	(1) Low

Table 5.2 Preliminary analyses of potential impacts.

Design	Construction	Operation	Potential Impact	Extent of Impacts	Potential Mitigation Measure	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
●	●		Direct impacts to marine plants, and soft sediment under the footprint	Long-term, predictable and irreversible	Limiting the area of disturbance (project footprint) where possible Using the project footprint for any temporary construction and storage	Water quality (1) Low Sediment quality (1) Low Saltmarsh and Mangroves (15) High Seagrass and macroalgae (15) High Coral and rocky communities (12) High Soft sediment communities (15) High Mobile biota (2) Low Listed species (2) Low	Water quality (1) Low Sediment quality (1) Low Saltmarsh and Mangroves (15) High Seagrass and macroalgae (15) High Coral and rocky communities (12) High Soft sediment communities (15) High Mobile biota (2) Low Listed species (2) Low
●	●		Direct gain of habitat	Long-term, predictable and irreversible	Design fish-friendly structures Build artificial structure that provide valuable habitat for fish	Not applicable – beneficial potential impact	Not applicable – beneficial potential impact
●	●		Trapping or injuring of marine fauna during wet excavation	Short-term, predictable and reversible	Install the sheet piles, silt curtains or other temporary barriers at low tide to minimise the number of marine vertebrates caught in the area Capture fish within the area confined by the sheet piles, silt curtains or other temporary barriers and release outside the area Visual observations by a trained marine mammal and turtle spotter prior to commencement of excavation and dredging activities Cessation of excavation or dredging if a dolphin, dugong or turtle is observed within the area, until the animal can be removed from the area being excavated, and Drive fauna away from an area prior to completion of the installation of sheet piles, silt curtains or other temporary barriers by mechanical noise, such as banging an iron pipe underwater	Water quality (1) Low Sediment quality (1) Low Saltmarsh and Mangroves (1) Low Seagrass and macroalgae (1) Low Coral and rocky communities (1) Low Soft sediment communities (1) Low Mobile biota (9) Medium Listed species (9) Medium	Water quality (1) Low Sediment quality (1) Low Saltmarsh and Mangroves (1) Low Seagrass and macroalgae (1) Low Coral and rocky communities (1) Low Soft sediment communities (1) Low Mobile biota (3) Low Listed species (4) Low
●	●		Disturbance of sediments and soils	Short-term, predict table	Design the project to minimise the area of sediment and / or soils being disturbed Use temporary enclosures (complete enclosures such as sheet piles or alternate enclosures such as silt curtains) to reduce the intensity and spatial distribution of potential impacts Isolate the disturbance areas, for example by using sheet piles, silt curtains, oil spill booms, bunding, trenching and / or similar technologies Identify and manage acid sulfate soils and other contaminants, through a sediment sampling and analyses plan (SAP) Developing turbidity and suspended solids thresholds and appropriate management (e.g. triggers for ceasing works)	Water quality (15) High Sediment quality (3) Low Saltmarsh and Mangroves (3) Low Seagrass and macroalgae (15) High Coral and rocky communities (15) High Soft sediment communities (10) Medium Mobile biota (3) Low Listed species (3) Low	Water quality (8) Medium Sediment quality (1) Low Saltmarsh and Mangroves (2) Low Seagrass and macroalgae (4) Low Coral and rocky communities (4) Low Soft sediment communities (8) Medium Mobile biota (1) Low Listed species (1) Low

Design	Construction	Operation	Potential Impact	Extent of Impacts	Potential Mitigation Measure	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
					for seagrass and corals and monitoring water quality during construction Monitoring changes in seagrass and coral communities post-construction to determine any potential impacts. Avoiding disturbance of sediment and / or soils during important periods of reproduction for coral and seagrass (e.g. late spring and summer) and / or during low Coral translocation and replantation program		
●	●	●	Spills of hydrocarbons and other contaminants	Short-term, predictable and irreversible	Minimise the use of hydrocarbons and chemical where possible Best-practice vessel and vehicle management and site management Fuel storage and handling activities will be in accordance with AS1940 Spill kits, training of personnel and a Hazardous Materials Register, a register of Materials Safety Data Sheets Any fuel, oil or chemical spills are contained and cleaned up immediately Spill Management Plan (EMP)	Water quality (15) High Sediment quality (10) Medium Saltmarsh and Mangroves (10) Medium Seagrass and macroalgae (10) Medium Coral and rocky communities (10) Medium Soft sediment communities (10) Medium Mobile biota (10) Medium Listed species (10) Medium	Water quality (4) Low Sediment quality (4) Low Saltmarsh and Mangroves (4) Low Seagrass and macroalgae (4) Low Coral and rocky communities (4) Low Soft sediment communities (4) Low Mobile biota (4) Low Listed species (4) Low
●	●		Increased stormwater runoff	Long-term, predictable and irreversible	Sediment and Erosion Management Plan (EMP) Stormwater Management Plan	Water quality (15) High Sediment quality (3) Low Saltmarsh and Mangroves (3) Low Seagrass and macroalgae (15) High Coral and rocky communities (15) High Soft sediment communities (10) Medium Mobile biota (3) Low Listed species (3) Low	Water quality (4) Low Sediment quality (1) Low Saltmarsh and Mangroves (2) Low Seagrass and macroalgae (4) Low Coral and rocky communities (4) Low Soft sediment communities (4) Low Mobile biota (1) Low Listed species (1) Low
●		●	Altered hydrodynamics	long-term, predictable and irreversible	Design project to minimise changes to hydrodynamics	Water quality (4) Low Sediment quality (1) Low Saltmarsh and Mangroves (1) Low Seagrass and macroalgae (4) Low Coral and rocky communities (4) Low Soft sediment communities (4) Low Mobile biota (1) Low Listed species (1) Low	Water quality (3) Low Sediment quality (1) Low Saltmarsh and Mangroves (1) Low Seagrass and macroalgae (3) Low Coral and rocky communities (3) Low Soft sediment communities (3) Low Mobile biota (1) Low Listed species (1) Low
●	●	●	Increased boat activity and access	long term, predictable, reversible	Follow international and Australian standards relating to antifouling paints and contaminants Marine Fauna Management Plan, including Go slow areas Follow the Nature Conservation (Wildlife Management)	Water quality (8) Medium Sediment quality (8) Medium Saltmarsh and Mangroves (1) Low Seagrass and macroalgae (1) Low	Water quality (3) Low Sediment quality (3) Low Saltmarsh and Mangroves (1) Low Seagrass and macroalgae (1) Low

Design	Construction	Operation	Potential Impact	Extent of Impacts	Potential Mitigation Measure	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
					Regulation 2006	Coral and rocky communities (4) Low Soft sediment communities (1) Low Mobile biota (3) Low Listed species (8) Medium	Coral and rocky communities (1) Low Soft sediment communities (1) Low Mobile biota (1) Low Listed species (3) Low
●	●	●	Spread of pest species	long term, predictable, reversible	Weed Management Plan	Water quality (1) Low Sediment quality (1) Low Saltmarsh and Mangroves (8) Medium Seagrass and macroalgae (8) Medium Coral and rocky communities (8) Medium Soft sediment communities (8) Medium Mobile biota (3) Low Listed species (3) Low	Water quality (1) Low Sediment quality (1) Low Saltmarsh and Mangroves (3) Low Seagrass and macroalgae (3) Low Coral and rocky communities (3) Low Soft sediment communities (3) Low Mobile biota (3) Low Listed species (3) Low
●	●	●	Litter and waste	long term, predictable, reversible	Waste Management Plan Minimise litter and waste, where possible	Water quality (8) Medium Sediment quality (8) Medium Saltmarsh and Mangroves (3) Low Seagrass and macroalgae (3) Low Coral and rocky communities (3) Low Soft sediment communities (3) Low Mobile biota (8) Medium Listed species (8) Medium	Water quality (3) Low Sediment quality (3) Low Saltmarsh and Mangroves (3) Low Seagrass and macroalgae (3) Low Coral and rocky communities (3) Low Soft sediment communities (3) Low Mobile biota (3) Low Listed species (3) Low
●		●	Improve water quality in and adjacent to Fison Channel	long-term, predicable	Design channel to minimise turbid plumes	Not applicable – beneficial potential impact	Not applicable – beneficial potential impact

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Appendix A Survey and Laboratory Methods

A1 Survey of Habitat

Surveys of habitat and associated flora and fauna were conducted from 5 to 6 November 2014. Habitats were assessed visually and differences in habitats were marked using a handheld GPS. The GPS waypoints were also compared to recent aerial imagery and then mapped. The entire PDA, including a small areas outside of the PDA boundary, were surveyed.

A2 Description of Marine Plant Communities

Marine plant communities were classified according to the dominant species present and the relevant understorey or sub-dominant species present.

A3 Condition of Marine Plant Communities

The marine plant communities were also qualitatively assessed for their relative value to aquatic ecology and fisheries. The abundance of crabs or crab burrows was used as an indicator of the ability of the site to support marine fauna. The availability of physical habitat for fauna, the amount of human or cattle disturbance, the ponding of water, and the relative proximity of each point to permanent water at low tide (to assess the likely frequency of tidal inundation) were also assessed. Categories used to describe the habitat value of marine plants to aquatic ecology and fisheries are described in Table A1 and Table A2.

Table A1 Categories used to qualitatively assess the value of marine plants excluding seagrass and macroalgae to aquatic ecology and fisheries.

Value	Criteria
Excellent	High abundance of fauna / crab burrows present, very complex structural habitat for fauna, likely to be regularly inundated
Very Good	High abundance of fauna / crab burrows present, complex structural habitat for fauna, likely to be regularly inundated, but some disturbance
Good	Some fauna / crab burrows present, periodical tidal inundation, some structural habitat for fauna provided, little anthropogenic disturbance
Fair	Low abundance of fauna / crab burrows, habitat is disturbed, little structural habitat provided to fauna, infrequent tidal inundation
Poor	Little to no fauna present, poorly flushed, little / no structural habitat provided to fauna, habitat is heavily disturbed, infrequent or no tidal inundation, only opportunistic species present

Table A2 Categories used to qualitatively assess the value of seagrass and macroalgae to aquatic ecology and fisheries.

Value	Criteria
Very good	High percent cover and biomass of seagrass, offering complex structural habitat for fauna, proximal to mangroves, high densities of fauna / crab burrows and no damage such as burning or discolouration
Good	Moderate percent cover and biomass of seagrass, offering good structural habitat, proximal to mangroves, moderate densities of fauna / crab burrows and little damage evident
Fair	Moderate percent cover and biomass of seagrass, offering some structural habitat, proximal to limited mangroves, some fauna / crab burrows and some damage evident
Poor	Low percent cover and biomass of seagrass, offering little structural habitat, distal to mangroves, few fauna / crab burrows and damage evident
Very poor	Very low percent cover and biomass of seagrass, offering very little structural habitat, distal to mangroves or mangroves absent, very few fauna / crab burrows with only opportunistic species present and extensive damage evident

1.1.1 Structural Elements

Structural elements, such as trees, seedlings, aerial roots and pneumatophores, provide habitat for marine organisms. Leaf litter on the forest floor, such as fallen mangrove leaves, and large debris (including dead tree trunks), also provide structural habitat in mangrove forests. However, very high cover of litter (> 50%) suggests that an area has a low frequency of tidal inundation and is poorly flushed, which reduces the fisheries value of the habitat.

Smaller structures, such as pneumatophores, seedlings and small aerial roots, provide habitat for certain species, while larger structures, such as tree trunks and large aerial roots, provide habitat for other species. The presence of structural elements with a range of different sizes provides heterogeneity of habitat, thereby offering a greater range of habitats to a larger number of different species of fish and crustaceans. That is, each structural element provides a degree of structural habitat, yet the presence of multiple structural elements provides structural heterogeneity and generally supports a more diverse community of marine organisms.

1.1.2 Abundance of Infauna

The abundance of infauna, such as crabs and molluscs, is a direct indicator of habitat use and food availability. Relative densities of crab burrows also provide an indication of use; however, the number of burrows does not necessarily equate to the number of individual crabs using the habitat, as some species create more than one burrow while others share burrows. Crabs and molluscs also provide food for fishes and large crustaceans.

Benthic Epi- and Infauna

Epifauna was visually observed at low tide in each habitat, except for the channel. Additionally, pitfall traps were set in mangrove habitats at low tide and remained in the sediment for one tidal cycle. After 24 hours (+/- 2 hrs) the pitfall traps were retrieved and fauna was identified and counted; and all fauna was returned to the environment.

Benthic infauna was assessed by taking three invertebrate cores at two sites from each habitat, except mangrove habitat (Map 2). Cores were collected using an Eyer's corer with a diameter of 10.5 cm to a depth of 30 cm. Samples were sieved in the field through a 500 µm sieve and preserved using ethanol solution. The samples were transported to the laboratory where they were stained with Rose Bengal and macroinvertebrates were picked, sorted and identified to the lowest taxonomic level, in most instances to family.

1.1.3 Data Analysis

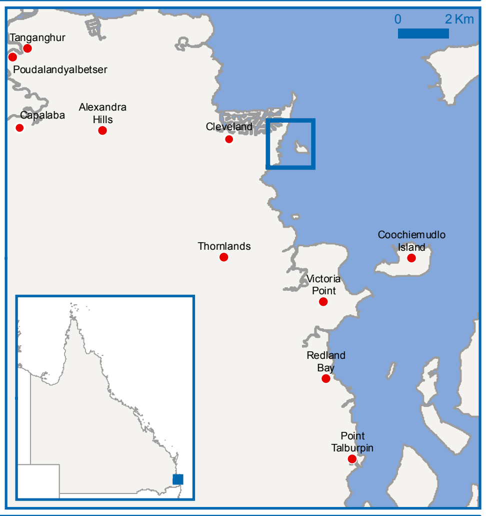
Means of abundance (total number of individuals) and taxonomic richness (family richness) were determined for each site.

Toondah Harbour Marine Ecology
EPBC Referral

Map A1:
Macroinvertebrate sites surveyed

LEGEND

- Macroinvertebrate Sampling Site
- Toondah Harbour PDA



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Appendix B EPBC Protected Matter Search Results

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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Coordinates

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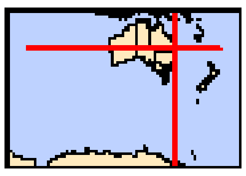

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	68
Listed Migratory Species:	72

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	111
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	42
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Moreton bay	Within Ramsar site

Listed Threatened Ecological Communities		[Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community may occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Anthochaera phrygia		
Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Roosting known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Cyclopsitta diophthalma coxeni		
Coxen's Fig-Parrot [59714]	Endangered	Species or species habitat may occur within area
Dasyornis brachypterus		
Eastern Bristlebird [533]	Endangered	Species or species habitat may occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat may occur within area
Insects		
Phyllodes imperialis smithersi Pink Underwing Moth [86084]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [331]	Endangered	Species or species habitat may occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Arthraxon hispidus Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Baloghia marmorata Marbled Balogia, Jointed Baloghia [8463]	Vulnerable	Species or species habitat may occur within area
Bosistoa transversa Three-leaved Bosistoa, Yellow Satinheart [16091]	Vulnerable	Species or species habitat likely to occur within area
Corchorus cunninghamii Native Jute [14659]	Endangered	Species or species habitat likely to occur within area
Cryptocarya foetida Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Macadamia integrifolia Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat likely to occur within area
Macadamia tetraphylla Rough-shelled Bush Nut, Macadamia Nut, Rough-shelled Macadamia, Rough-leaved Queensland Nut [6581]	Vulnerable	Species or species habitat likely to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat likely to occur within area
Phaius bernaysii Yellow Swamp-orchid [4918]	Endangered	Species or species habitat may occur within area
Samadera bidwillii Quassia [29708]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Name	Status	Type of Presence
Saiphos reticulatus Three-toed Snake-tooth Skink [88328]	Vulnerable	Species or species habitat may occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Migratory Marine Species		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Roosting known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba		
Sanderling [875]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Roosting known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Roosting known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus		
Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur

Name	Threatened	Type of Presence
		within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Roosting known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Roosting known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Roosting known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Himantopus himantopus Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area

Name	Threatened	Type of Presence
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Hippocampus kelloggi Kellogg's Seahorse, Great Seahorse [66723]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus andersonii Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Microphis manadensis Manado Pipefish, Manado River Pipefish [66258]		Species or species habitat may occur within area
Solegnathus dunckeri Duncker's Pipehorse [66271]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area

Name	Status	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Bird Island	QLD
Dawson Road	QLD
Goat Island	QLD
Teerk Roo Ra	QLD
Teerk Roo Ra	QLD

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Rattus rattus		
Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides		
Alligator Weed [11620]		Species or species habitat likely to occur within area
Annona glabra		
Pond Apple, Pond-apple Tree, Alligator Apple, Bullock's Heart, Cherimoya, Monkey Apple, Bobwood, Corkwood [6311]		Species or species habitat may occur within area
Anredera cordifolia		
Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus		
Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. rotundata		
Bitou Bush [16332]		Species or species habitat likely to occur within area
Cryptostegia grandiflora		
Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana		
Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis		
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Parthenium hysterophorus		
Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp.		
Mesquite, Algaroba [68407]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Protasparagus densiflorus Asparagus Fern, Plume Asparagus [5015]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Moreton Bay	QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-27.525453 153.279669,-27.513806 153.305075,-27.513502 153.332455,-27.52355 153.344042,-27.533597 153.351166,-27.544784 153.351338,-27.553688 153.33606,-27.553764 153.29778,-27.544936 153.284133,-27.537554 153.278468,-27.525833 153.279326,-27.525453 153.279669

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix C Maps

Toondah Harbour Marine Ecology EPBC Referral

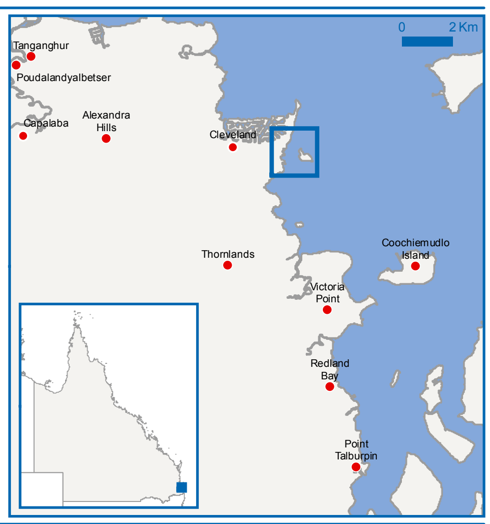
Map 1:
Marine habitats of Toondah Harbour and the PDA

LEGEND

Toondah Harbour PDA

Dominant Marine Habitats

- *Avicennia marina*
- *Rhizophora stylosa*
- *Aegiceras corniculatum*
- *Ceriops tagal var. australis*
- Saltpan / Saltmarsh
- *Juncus kraussii*
- Seagrass
- Rubble
- Sand / Mud



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DATE	DRAWN BY	VERSION	PROJECTION
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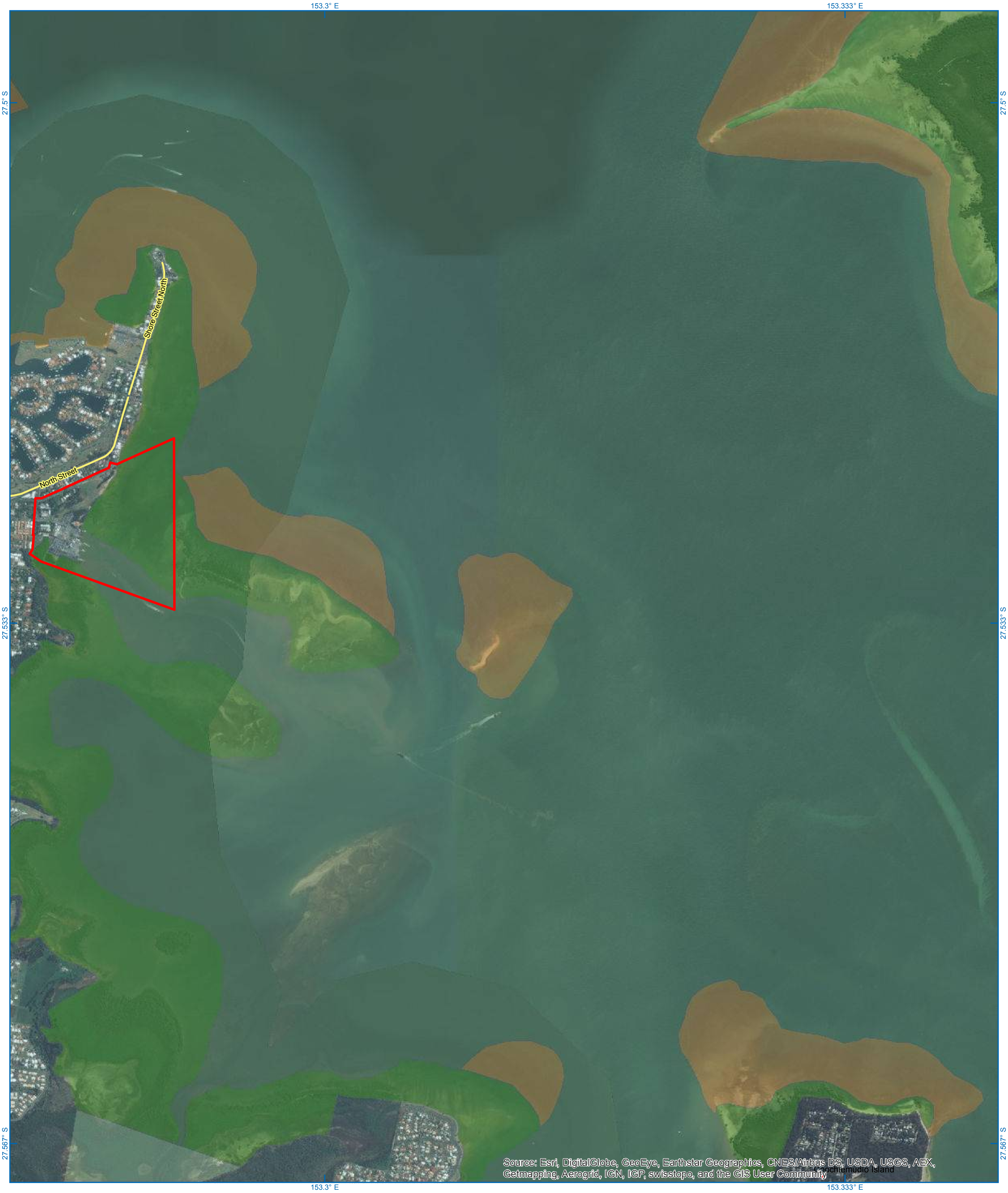


Toondah Harbour Marine Ecology EPBC Referral

Map 2:
Marine habitats in the vicinity of the PDA

LEGEND

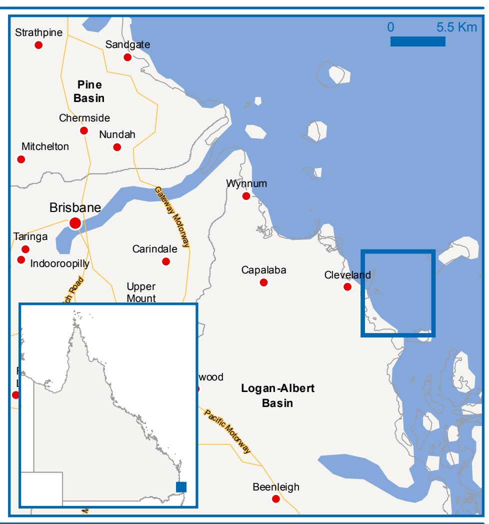
Toondah Harbour PDA

Habitat Type

- Inshore, algae/sponge habitat
- Inshore reef
- Mangrove/intertidal habitat
- Riverine/estuarine

Road Network

Main Road



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Metres

Scale: 1:25,000 @ A3

Toondah Harbour Marine Ecology EPBC Referral

Map 3:
Mangrove and saltmarsh habitat
in the vicinity of the PDA

LEGEND

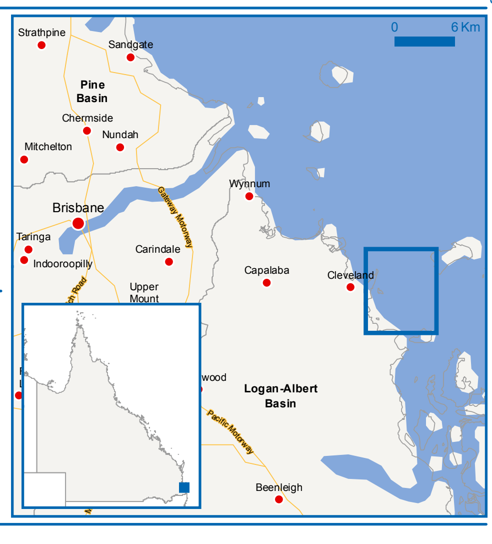
- Toondah Harbour PDA

Species and Habitats

- *Aegiceras corniculatum* closed-scrub, open-scrub, low closed-scrub, low open-scrub
- *Avicennia marina* subsp. australasica closed-forest, open-forest, woodland, low closed-forest, low open-forest, low woodland, low open-woodland
- *Avicennia marina* subsp. australasica closed-scrub, open-scrub
- *Avicennia marina* subsp. australasica low open-scrub, low shrubland, low open-shrubland
- *Avicennia marina* subsp. australasica tall shrubland, tall open-shrubland
- *Ceriops australis* low open-scrub, low shrubland, low open-shrubland
- *Rhizophora stylosa* closed-scrub, open-scrub, tall shrubland, tall open-shrubland
- *Sporobolus virginicus* closed grassland, grassland
- Claypan

Road Network

- Main Road



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Metres

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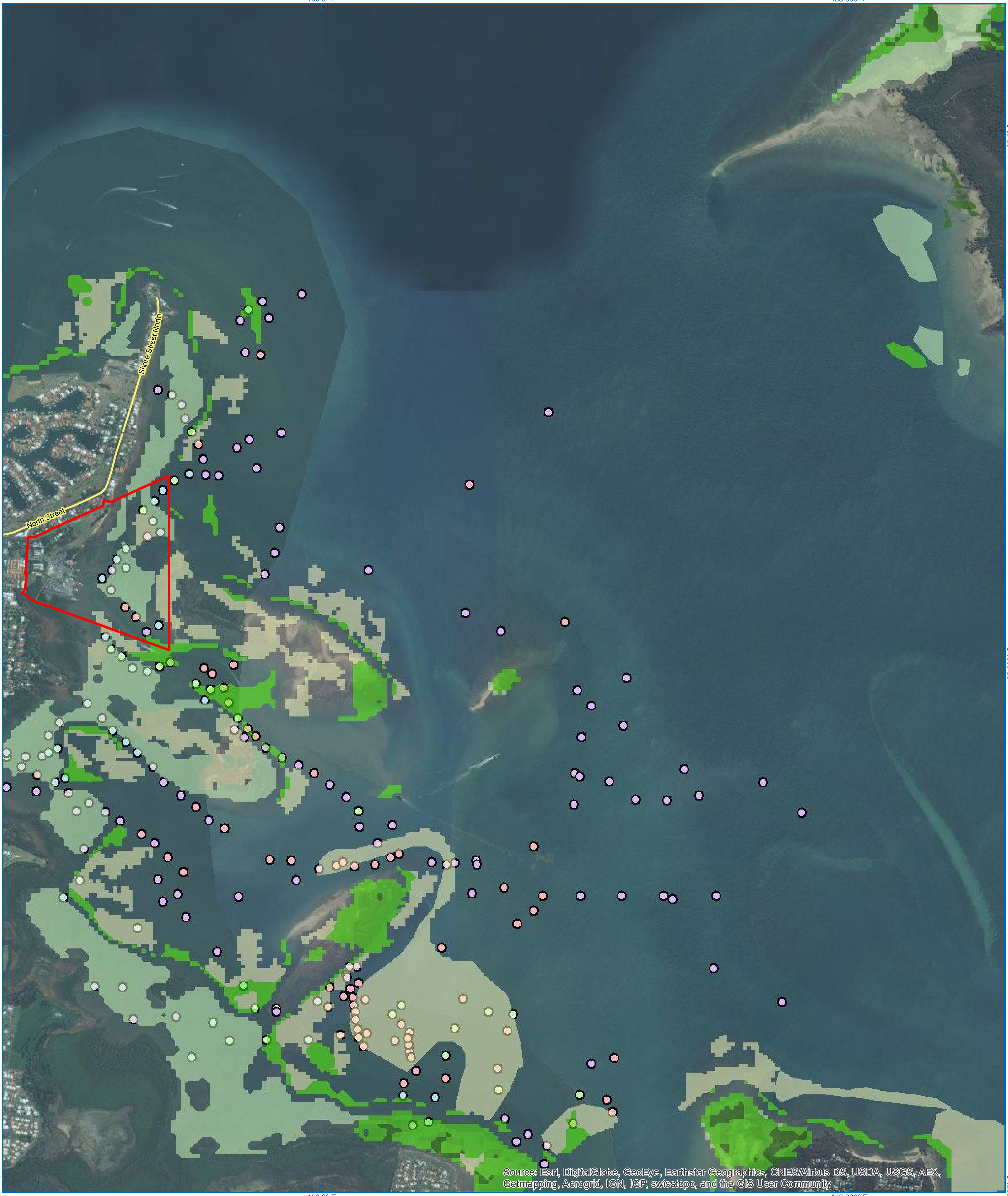


Toondah Harbour Marine Ecology EPBC Referral

Map 4: Seagrass habitat in the vicinity of the PDA

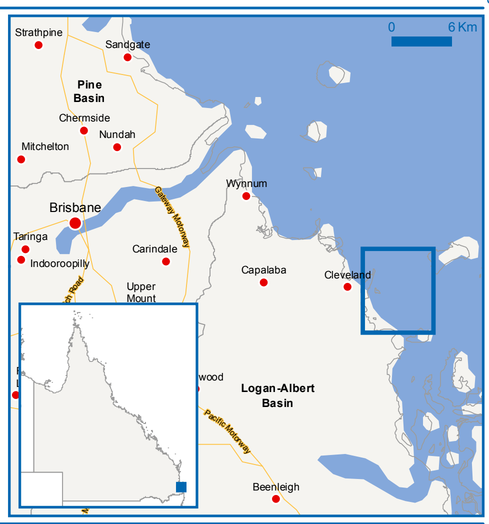
LEGEND

Toondah Harbour PDA

Seagrass Cover Moreton Bay (2011)
- 1-25%
- 25-50%
- 50-75%
- 75-100%
- Sand

Dominant species 2015-16
- *Halophila ovalis*
- *Halophila spinulosa*
- *Zostera muelleri*
- No Seagrass Recorded

Road Network
- Main Road



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Metres

Scale: 1:25,000 @ A3

Toondah Harbour Marine Ecology EPBC Referral

Map 5:
Coral and algal habitat in the vicinity of the PDA

LEGEND

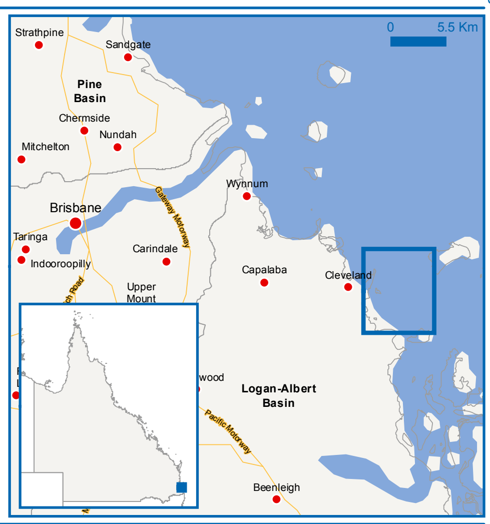
Toondah Harbour PDA

Coral Cover
- Medium
- Sparse
- Sparse - Med-Dense
- Sparse - Medium

Substrate type (Healthy Waterways (2015))
- Coral
- Coral Rubble

Algae
- Algae
- *Caulerpa taxifolia*
- Macro

Road Network
- Main Road



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SCALE
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Metres
Scale: 1:25,000 @ A3

Toondah Harbour Marine Ecology EPBC Referral

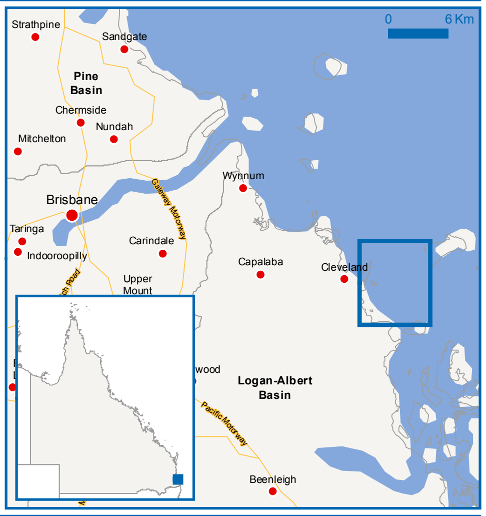
Map 6: Ramsar wetlands in the vicinity of the PDA

LEGEND

- Toondah Harbour PDA
- Ramsar Wetlands

Road Network

- Main Road



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Metres

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