13 Intertidal and terrestrial fauna

13.1 Background

As the WB and WBE reclamation areas are situated directly adjacent to the coastline within the Port of Gladstone, the potential direct and indirect impact areas encompass a variety of fauna habitats, including both the terrestrial environment and the intertidal zone (transitional habitat between the marine and terrestrial environments). Furthermore, due to the unique and complex geological and geomorphological processes that have shaped the coastline within the Port (refer Section 6.1.2), there is a diverse range of intertidal and terrestrial habitats along the coast within the Port Curtis region.

The variation and complexity within the intertidal and terrestrial environments provides a range of different habitats for fauna species. These habitats are also typically dynamic due to ongoing coastal processes, seasonal variations and current developments. For example, seasonal variations result in changes to plant growth, which in turn provides foraging resources and breeding habitat for a range of fauna species, particularly in terrestrial woodlands during flowering periods of *Eucalyptus* or *Melaleuca* species. Some fauna migrations are specifically timed to coincide with flowering and seeding times, where species will migrate between habitats based on the availability of food resources (e.g. flying-foxes, birds).

The intertidal habitat and areas which are tidally influenced provide distinctly different habitats, in comparison to freshwater areas, and are host to a range of species that specialise in utilising resources within the intertidal zone (e.g. shorebirds and migratory birds). As the intertidal zone is a transitional ecosystem between marine and terrestrial habitats, it also provides habitat for species common to both marine and terrestrial habitats. The intertidal environments within the Project impact areas are comprised of a diverse range of vegetation communities, including mangroves, mudflats and saltmarshes, as described in Section 4 of this report.

Terrestrial habitats are situated in the Project potential indirect impact areas and comprise *Eucalyptus* woodlands on alluvial plains with *Melaleuca* species in the understorey. These areas are discussed in detail in Section 3 of this report.

Areas of remnant vegetation within the Project impact areas were observed to contain a high diversity of fauna species, including both foraging and breeding habitats for some species. Areas that were cleared or disturbed, were typically observed to contain a lower diversity of fauna species and generally contained less diversity and abundance of microhabitat features (e.g. leaf litter, rocky outcrops, hollow-bearing trees, dense ground cover, bed and banks of waterways and drainage lines). These areas, however, retain important foraging habitat values for raptors, small ground mammals, macropods, some reptiles (e.g. snakes), and other bird species.

13.2 Methodology

13.2.1 General

The purpose of this intertidal and terrestrial fauna section is to describe and document the existing local fauna assemblages and key habitat values within the Project direct and potential indirect impact areas (Project impact areas). The assessment was informed by Government database resources, review of existing literature and Project EIS ecological surveys.

For the purposes of the database reviews, the search area was defined on a regional basis to ensure that transient species and key fauna habitat areas within the region were captured (refer Figure 13.1).

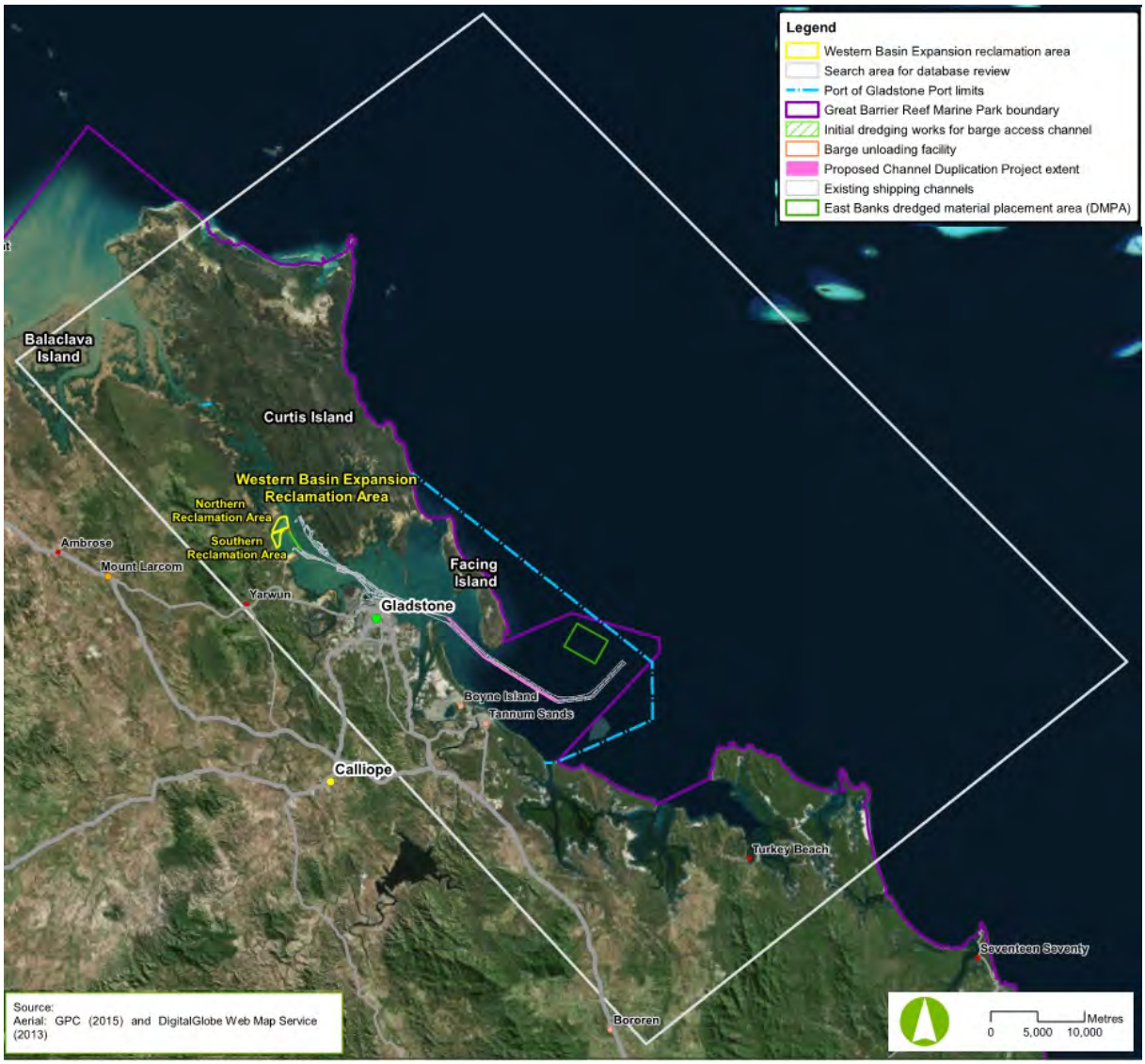


Figure 13.1 Search area for database review

The information sources that were used as part of the assessment are summarised in Table 13.1.

Table 13.1 Resources used for the assessment of intertidal and terrestrial fauna species and habitat values

Title	Reference
Reports	
Migratory Shorebird Monitoring - Understanding Ecological Impact Report	Choi et al. (2015, 2016 and 2017)
Databases	
ALA (incorporates Queensland Museum Wildnet data and Queensland Herbarium HERBRECS data)	ALA (2019)
Biodiversity Assessment and Mapping Methodology	EHP (2014b)
EPBC Act PMST (refer Figure 13.1 for search area)	DoEE (2019)
Regulated vegetation and Essential Habitat mapping	DNRME (2018a)
Wildnet database (refer Figure 13.1 for search area)	DES (2019)
Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity	DERM (2010)

To supplement the existing information, an ecological field assessment was conducted within the Project impact areas by two suitably qualified and experienced Aurecon ecologists between 10 and 12 February 2015. The ecological field assessment was conducted to identify the likely occurrence of any conservation significant fauna species present within the Project impact areas, provide a description of the key habitat values of the areas, and to provide a list of incidental fauna observations which would provide an indication of the key local fauna assemblages in the areas.

The field assessment traversed intertidal and terrestrial habitats present within the Project impact areas. The location of the survey sites is shown in Figure 13.2.

The field assessment methodology was informed by relevant survey methods detailed in the *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland* (Eyre et al. 2014). The guidelines (Eyre et al. 2014) were not relevant for the Project direct impact areas, due to their marine and intertidal nature. However, survey methods detailed by Eyre et al. (2014) regarding habitat and condition assessments, incidental records, active diurnal searches, survey design and animal handling were considered for assessments of the Project potential indirect impact areas which correlated with terrestrial environments.

The field assessment included a preliminary Water mouse (*Xeromys myoides*) survey within areas of potentially suitable habitat (i.e. mangrove and saltmarsh communities) within the Project potential indirect impact areas. The preliminary Water mouse survey assisted in providing baseline information to determine the likelihood of the species occurrence within the areas, and included a habitat suitability assessment to identify any notable habitat features (e.g. vegetation types and flora species, presence of prey species, presence of hollow trunks, presence of suitable foraging and nesting habitats) and targeted searches were conducted for evidence of Water mouse activity (i.e. nest mounds, distinctive mud 'ramps' at the base of hollow trees, and feeding middens). The survey methods used were in accordance with the Survey guidelines for Australia's threatened mammals (Commonwealth of Australia 2011).

During the field assessment an incidental fauna list was collected, which captured bird, reptile, mammal and amphibian species encountered during the field assessment. Native and exotic pest species were also recorded (refer Appendix C).

At each site, a systematic search targeting herpetofauna (amphibians and reptiles) and larger mammalian species was conducted using transects. A plot size of 0.5ha (i.e. 100m x 50m) was actively searched for a minimum of one person hour. At each site, a search was conducted in the earlier hours of the day, late afternoon as well as midday in order to capture as many species as possible. Systematic searches involved intensive searches within appropriate habitat (e.g. reedbeds, water soaks, ground litter along creek beds), searching for basking or sheltering fauna. Any appropriate cover (e.g. ground boulders, logs, tufts of vegetation and bark on trees) were searched for fauna. Other information was collected and/or examined to assist in identifying the resident and transient biodiversity values of the area, including scats, tracks, bones and hair samples.

Scientific and common names used in this report to describe fauna species were obtained from:

- Amphibian Research Centre (2013) and Cogger (2014) for amphibians
- Cogger (2014), and Wilson and Swan (2010) for reptiles
- Menkhorst and Knight (2011), and Triggs (2004) for mammals
- Morcombe (2003) for birds.

Vegetation communities within the Project potential indirect impact areas were traversed to collect information pertaining to the habitat value of the areas. Fauna habitat features recorded included:

- Presence and relative density of hollow bearing trees
- Presence of canopy, sub-canopy and shrubs suitable for perching, shelter and foraging
- Presence of coarse fallen woody material
- Presence of boulders and other rocky material that would provide fauna habitat

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

The Narrows
Graham's Creek
Curtis Island
North Entrance
Facing Island
Clinton Ash Ponds
Gladstone
Calliope River
Gatcombe Channel
South Trees Island
Golding Cutting Channel
Marine Park Line
East Banks DMPA
Boyne Island
Tannum Sands
Boyne River
Wild Cattle Island
Colosseum Inlet
Hummock Hill Island
Rodds Peninsula
Rodds Bay

Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area

WB1
WB2
WB3
WB4
WB5
WB6
WB7
WB8
WB9
WB10
WB11
WB12
WB13
WB14
PC6
PC7
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Construction compound
- Field survey sites (intertidal and terrestrial fauna)
- Field survey sites (migratory shorebird species)

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_103.mxd 18/01/2019 11:58

0 1,900 3,800 Metres

Date: 18/01/2019 Version: 6 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 13.2: Location of intertidal and terrestrial fauna field survey sites

- Presence of features such as watercourses and formed banks that may provide shelter and nesting opportunities
- Availability/proximity to water
- Level of weed cover
- Level of vegetation in the ground stratum and its potential to provide fauna habitat
- Presence of feeding resources (i.e. fruiting/flowering trees).

13.2.2 Potential habitat mapping

Potential habitat models were developed for intertidal and terrestrial fauna species identified as having Essential Habitat within the Project impact areas. This habitat modelling was developed for intertidal and terrestrial fauna species that are not addressed in other sections of this report (e.g. habitat for shorebirds is provided in Section 12 and therefore not reproduced for this section). The habitat mapping was developed using the known species ecological requirements (as obtained by reliable data sources and publications) and available GIS layers relating to these habitat requirements, including the Vegetation Management Supporting Map (including Essential Habitat), version 8.0 (DNRME 2018a).

13.3 Intertidal and terrestrial fauna values

The WBE reclamation area is situated within the intertidal zone and is defined by exposed mudflats, saltmarsh and mangrove communities. The area to be dredged is located offshore and will not result in the direct disturbance of intertidal or terrestrial areas.

The barge access channel is located offshore within or in close proximity to the existing channels within the Port. The dredging activities will not result in the direct disturbance of intertidal or terrestrial areas (refer Figure 13.2).

This section provides a general overview of the intertidal and terrestrial environments, and their habitat value for conservation significant fauna species, within the direct and potential indirect impact areas.

13.3.1 Threatened species

A total of 30 threatened intertidal and terrestrial fauna species (excluding migratory shorebirds, refer Section 12) protected under the provisions of the EPBC Act and/or the NC Act were identified from database searches as potentially occurring within the search area (as defined in Figure 13.1) (refer Appendix A). Fauna species included on the Fitzroy NRM BoT species prioritisation framework are listed in Appendix K (Table 2).

Of the threatened species that have been identified as potentially occurring within the search area, an assessment of their likelihood of occurrence within the Project impact areas was undertaken. This assessment of occurrence was based on species' habitat associations and existing information and is detailed in Appendix B of this report.

The results of the likelihood of occurrence assessment (refer Appendix B) identified that:

- One species was confirmed to occur within the Project impact areas (i.e. Beach stone-curlew (*Esacus magnirostris*))
- Water mouse was considered to have a high likelihood of occurrence within the Project impact area
- Four species were considered to have a moderate likelihood of occurrence within the Project indirect impact areas (refer Appendix B, Powerful owl (*Ninox strenua*); Common death adder (*Acanthophis antarticus*); Coastal sheathtail bat (Taphozous australis); and Saltwater crocodile (*Crocodylus porosus*))

- Twenty-four species were considered to have a low likelihood of occurrence within the Project areas (refer Appendix B)

13.3.2 Essential Habitat

There are no areas of mapped Essential Habitat for conservation significant fauna species within the Project direct impact areas. Essential Habitat for the Coastal sheath-tail bat, Koala and the Water mouse has been mapped in potential indirect impact areas, associated with the WB and WBE reclamation areas (DNRME 2018a) (refer Figure 4.5 and Table 13.2). There are no areas of mapped Essential Habitat for conservation significant fauna species within the barge access channel or the BUF (refer Figure 4.5).

Table 13.2 Essential Habitat mapped for conservation significant fauna species within, or in close proximity to, the Western Basin and Western Basin Expansion reclamation areas

Project area	Scientific name	Common name	NC Act status	EPBC Act status	Area in hectares
WB and WBE reclamation areas direct impact area	There are no conservation significant fauna species within the direct impact area		-	-	0ha
WB and WBE reclamation areas potential indirect impact area (within 500m of direct impact area)	*Taphozous australis*	Coastal sheath-tail bat	NT	-	15.10ha
	Phascolarctos cinereus	Koala	V	V	14.81ha
	Xeromys myoides	Water mouse	V	V	5.17ha

Table notes:
V Vulnerable listed species
NT Near threatened
- Not listed

13.3.3 Potential habitat for threatened species

Based on the results of database searches and Project EIS field surveys, one intertidal fauna species (excluding migratory shorebirds, refer Section 12) was identified as having a 'high' likelihood of occurring within the Project impact areas, namely Water mouse (*Xeromys myoides*).

Potential habitat modelling has been mapped for Water mouse, in addition to two species (Koala [*Phascolarctos cinereus*] and Coastal sheath-tail bat [*Taphozous australis*]) for which Essential Habitat has been mapped in potential indirect impact areas, associated with the WB and WBE reclamation areas (DNRME 2018a) (refer Section 13.3.2). The potential habitat maps for these three species are shown in Figure 13.3 to Figure 13.5.

One additional intertidal bird species (non-migratory) has been confirmed within the Project impact areas, namely the Beach stone-curlew (refer Appendix B for likelihood of occurrence assessment, and the species list in Appendix C). The Beach stone-curlew is a non-migratory, resident shorebird listed as vulnerable under the provisions of the NC Act. As such, this species is not listed within the migratory bird species list in Section 12. However this species is likely to utilise the same habitat as migratory shorebirds, as mapped in Figures 12.3a to 12.3c in Section 12. The mapping for this species is therefore not reproduced in this section.

The results of the potential habitat mapping are indicative only, as they are based on regional GIS datasets. It is expected that some habitats will not be mapped accurately to a 'property-level' scale. As such, the objective of these potential habitat maps is to provide a general overview of the areas that may contain suitable habitat for these species. These maps are considered to be a suitable tool for the purposes of the impact assessment for this Project as they provide a regional context to potentially suitable habitat and will be utilised in conjunction with the results of EIS field investigations.

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

Cawarral
Emu Park
Mount Chalmers
Keppel Sands
Broadmount
Bajool
Marmor
Raglan
Curtis Island
Western Basin Expansion Reclamation Area
Ambrose
Mount Larcom
Yarwun
Facing Island
Gladstone
Boyne Island
Tannum Sands
Calliope
Turkey Beach
Seventeen Seventy
Bororen

Northern Reclamation Area
Southern Reclamation Area

Legend

- Western Basin Expansion reclamation area
- Search area for database review
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks dredged material placement area (DMPA)
- Construction compound

Potential habitat mapping

- Potential habitat

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: NKM/RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_121.mxd 13/02/2019 15:28

Metres
0 5,000 10,000

Date: 13/02/2019 Version: 8 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 13.3: Potential habitat mapping for Coastal sheath-tailed bat

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

Cawarral
Emu Park
Mount Chalmers
Keppel Sands
Broadmount
Bajool
Marmor
Raglan
Curtis Island
Western Basin Expansion Reclamation Area
Ambrose
Mount Larcom
Yarwun
Gladstone
Facing Island
Boyne Island
Tannum Sands
Calliope
Turkey Beach
Seventeen Seventy
Bororen

Northern Reclamation Area
Southern Reclamation Area

Legend

- Western Basin Expansion reclamation area
- Search area for database review
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks dredged material placement area (DMPA)
- Construction compound

Potential habitat mapping

- Potential habitat

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: NKM/RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_091.mxd 13/02/2019 15:29

0 5,000 10,000 Metres

Date: 13/02/2019 Version: 9 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 13.4: Potential habitat mapping for Koala

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

Cawarral
Emu Park
Mount Chalmers
Keppel Sands
Broadmount
Bajool
Marmor
Raglan
Curtis Island
Western Basin Expansion Reclamation Area
Ambrose
Mount Larcom
Yarwun
Gladstone
Facing Island
Boyne Island
Tannum Sands
Calliope
Turkey Beach
Seventeen Seventy
Bororen

Northern Reclamation Area
Southern Reclamation Area

Legend

- Western Basin Expansion reclamation area
- Search area for database review
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks dredged material placement area (DMPA)
- Construction compound

Potential habitat mapping

- Potential habitat

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: NKM/RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_093.mxd 13/02/2019 15:30

0 5,000 10,000 Metres

Date: 13/02/2019 Version: 10 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 13.5: Potential habitat mapping for Water mouse

13.3.3.1 Areas to be dredged and navigational aid changes

As the areas to be dredged and the navigational aid changes are located within the marine environment, the habitat value of these areas is discussed in Sections 8 to 16 of this report.

13.3.3.2 Western Basin and Western Basin Expansion reclamation areas

The fauna habitat values of the WB and WBE reclamation areas impact areas are provided in Sections 8 to 16 of this report.

The intertidal and terrestrial areas adjacent to the WB and WBE reclamation areas are defined by mangrove and saltmarsh communities, mudflats and foreshore vegetation. Field investigations conducted by Aurecon in February 2015 assessed the key habitat values of the WB and WBE reclamation areas indirect impact areas. The following habitat resources were identified within the potential indirect impact areas:

- Intertidal habitats used for foraging by shorebirds and potential foraging habitat for the threatened Water mouse
- Mangrove ecosystems providing fishery nursery habitat and foraging and nesting habitat for some bird species
- Saltmarsh communities providing important foraging and roosting habitat for a range of bird species, including shorebirds (migratory and non-migratory) and waterbirds
- Areas of adjoining mangrove and saltmarsh vegetation which may provide potential foraging and shelter habitat for the Water mouse
- Large remnant areas containing Eucalyptus woodlands on alluvial plains providing important habitat values to the local fauna assemblages and providing connective habitat enabling, wildlife movement into other areas of suitable habitat
- Canopy cover suitable for shelter, foraging and perching of bird species, including raptors
- Fissured tree bark providing suitable habitat for small reptiles
- Isolated patches of dense shrub stratum vegetation, providing suitable shelter resources for ground dwelling mammal species and bird species
- Woody debris (i.e. felled timber, limited quantity of hollow-bearing logs present in groundcover)
- Hollow bearing trees, including stags, suitable for nesting of arboreal mammals and some bird species.

As outlined in Section 13.3.2, there are large areas of Essential Habitat mapped in the WB and WBE reclamation areas potential indirect impact areas. These areas are situated onshore and are approximately 200m to 250m from the WB and WBE reclamation areas and are predominantly associated with the Koala.

13.3.4 Fauna corridors

Terrestrial biodiversity values in a region, or bioregion, are mapped across Queensland using the BAMM to develop a spatial GIS dataset showing local, regional and state-wide biodiversity values, known as the BPA mapping (EHP 2014b). Biodiversity values mapped in the BPA mapping include, but are not limited to:

- Habitat for threatened species
- Large tracts of intact vegetation, or vegetation considered to provide important ecosystem functions
- Biodiversity values as assessed by an expert panel (e.g. habitat for priority taxa, fauna corridors, special biodiversity values).

As part of the BAMM, an expert panel reviews the BPA mapping and determines the importance of fauna corridors (e.g. local, regional or state importance) (EHP 2014b). These corridors include areas of contiguous vegetation, as well as areas that could function as fauna corridors in the future (e.g. if revegetated).

The biodiversity values and presence of fauna corridors within and adjacent to the WB and WBE reclamation areas are shown in Figure 3.4.

The biodiversity values mapped within the potential indirect impact areas for the WB and WBE reclamation areas are predominantly associated with significant wetland habitats and habitat for threatened species.

Fauna corridors of state importance are mapped within the potential indirect impact area associated with the WB and WBE reclamation areas, and are largely associated with remnant vegetation on the Many Peaks Range, which traverses north to south on land to the west of Gladstone (refer Figure 3.4).

Fauna movement outside of the mapped fauna corridors in areas surrounding the WB and WBE reclamation areas is constrained by surrounding residential and industrial development.

The areas to be dredged are located offshore within the marine environment, as a result there are no terrestrial biodiversity values mapped and no direct or potential indirect impacts are expected to occur on biodiversity values as mapped by the BPA mapping.

13.3.5 Landscape Fragmentation and Connectivity Tool

The EHP Landscape Fragmentation and Connectivity Tool has been developed to identify and quantify potential impacts on the connectivity value of regulated vegetation for an ‘impact site’.

The Landscape Fragmentation and Connectivity Tool uses GIS to measure the extent and arrangement of the regulated vegetation present ‘pre impact’, and compares it to the extent that would remain ‘post impact’ if the proposed impact was to occur at that impact site (EHP 2014a).

The Landscape Fragmentation and Connectivity Tool considers the significance of the potential impact on connectivity values at both the local and regional landscape scale. The local landscape scale is defined by a 5km buffer of the Project direct impact area and the regional landscape scale is defined by a 20km buffer of the Project direct impact area.

The Landscape Fragmentation and Connectivity Tool identifies an impact on connectivity areas as significant if either of the following occur:

- The change in the core remnant ecosystem extent at the local scale (‘post impact’) is greater than a threshold determined by the level of fragmentation at the regional scale; or
- Any core area that is greater than, or equal to, 1ha is lost or reduced to patch fragments ‘post impact’ (i.e. core area to non-core area).

The Landscape Fragmentation and Connectivity Tool analysis was undertaken for the WBE reclamation area and associated construction compound. The analysis was not conducted for the areas to be dredged as there are no areas of remnant vegetation mapped within the area due to its offshore location within the marine environment.

The Landscape Fragmentation and Connectivity Tool analysis identified no core remnant areas identified within the WBE reclamation area and associated areas ‘pre impact’ (refer Figure 13.6).

The results of the analysis of the WBE reclamation area and associated construction compound were that works would not impact on core remnant areas, with 0.00% change of core remnant areas ‘post impact’ (refer Figure 13.7). The Landscape Fragmentation and Connectivity Tool analysis concluded that the Project would not have a significant impact on connectivity areas based on the establishment of the WBE reclamation area and the associated construction compound.

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

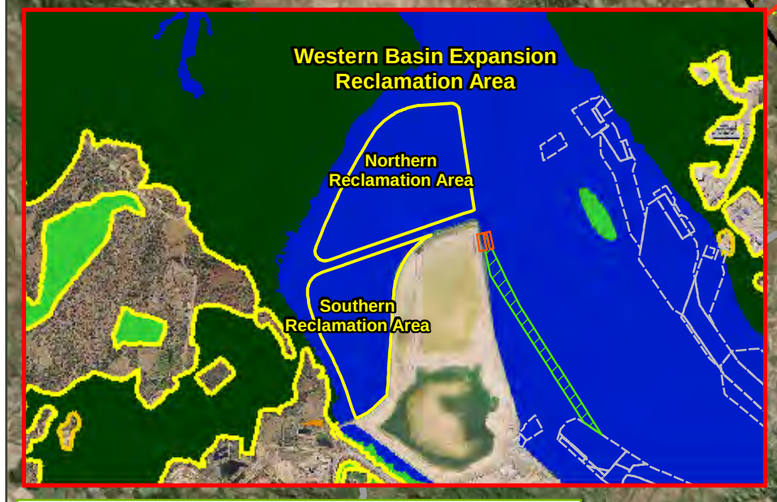
Cawarral
Emu Park
Mount Chalmers
Keppel Sands
Rockhampton
Broadmount
Bouldercombe
Port Alma
Balaclava Island
Bajool
Marmor
Raglan
Curtis Island
Ambrose
Mount Larcom
Facing Island
Gladstone
Boyne Island
Tannum Sands
Calliope
Turkey Beach
Seventeen Seventy
Bororen

Legend

- Western Basin Expansion reclamation area
- Search area for database review
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks DMPA
- Impact site local buffer
- Impact site regional buffer

Regional fragmentation pre impact

- patch
- edge
- perforated
- core (< 100 hectares)
- core (100-500 hectares)
- core (> 500 hectares)
- other



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Environmental offset landscape connectivity assessment tool: Department of Environment and Heritage Protection (2016b)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_125.mxd 15/02/2019 10:16

Metres
0 5,000 10,000

Date: 15/02/2019 Version: 7 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 13.6: Landscape fragmentation and connectivity (pre impact)

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

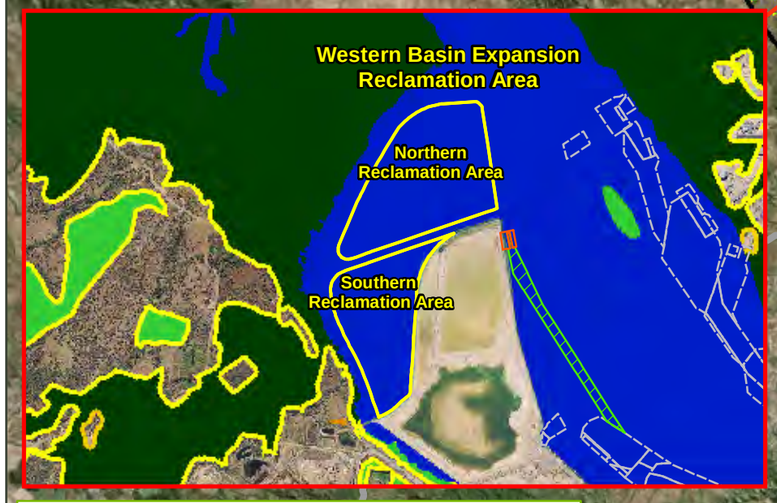
Cawarral
Emu Park
Mount Chalmers
Keppel Sands
Rockhampton
Broadmount
Bouldercombe
Port Alma
Balaclava Island
Bajool
Marmor
Raglan
Curtis Island
Ambrose
Mount Larcom
Facing Island
Gladstone
Boyne Island
Tannum Sands
Calliope
Turkey Beach
Seventeen Seventy
Bororen

Legend

- Western Basin Expansion reclamation area
- Search area for database review
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks dredged material placement area (DMPA)
- Impact site local buffer
- Impact site regional buffer

Regional fragmentation post impact

- patch
- edge
- perforated
- core (< 100 hectares)
- core (100-500 hectares)
- core (> 500 hectares)
- other



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Environmental offset landscape connectivity assessment tool: Department of Environment and Heritage Protection (2016b)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_119.mxd 15/02/2019 10:21

0 5,000 10,000 Metres

Date: 15/02/2019 Version: 6 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 13.7: Landscape Fragmentation and Connectivity (Post impact)

13.3.6 Special least concern animals

Section 34, Part 3 of the *Nature Conservation (Wildlife) Regulation 2006* provides for the classification of 'special least concern animals'. Special least concern animals as defined in the Regulation include:

(a) Echidna (*Tachyglossus aculeatus*)

(b) Platypus (*Ornithorhynchus anatinus*)

(c) A least concern bird to which any of the following apply:

(i) The agreement called 'Agreement Between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment' and signed at Tokyo on 6 February 1974 (i.e. JAMBA)

(ii) The agreement called 'Agreement Between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment' and signed at Canberra on 20 October 1986 (i.e. CAMBA)

(iii) The convention called 'Convention on the Conservation of Migratory Species of Wild Animals' and signed at Bonn on 23 June 1979 (i.e. Bonn Convention).

Special least concern animals present within the Project impact areas are listed in Table 13.3.

Table 13.3 Special least concern animals present within the Project impact areas

Scientific name	Common name	Conservation status		Western Basin Expansion reclamation area
		EPBC Act	NC Act	
Calidris acuminata	Sharp-tailed sandpiper	Migratory, Marine	Special Least Concern	✓
Gallinago hardwickii	Latham's snipe	Migratory, Marine	Special Least Concern	✓
Numenius madagascariensis	Eastern curlew	Critically Endangered, Migratory, Marine	Endangered	✓
Numenius minutus	Little curlew	Migratory, Marine	Special Least Concern	✓
Numenius phaeopus	Whimbrel	Migratory, Marine	Special Least Concern	✓
Hydroprogne caspia	Caspian tern	Migratory, Marine	Special Least Concern	✓

The special least concern animal species recorded within the WB and WBE reclamation areas during field surveys were all migratory bird species. The habitat values for migratory bird species within the Project impact areas are discussed in Section 12.

The Echidna was not identified within the Project impact areas during field investigations. The Echidna is known to inhabit a wide range of terrestrial habitats wherever there are suitable food sources (i.e. ants or termites). Areas considered to provide habitat include desert, rainforest, open forest, bushland, farmland and suburban backyards (WPSQ 2016).

Terrestrial environments within the Project impact areas provide potential habitat value for the Echidna as suitable food sources are present (i.e. ants or termites).

The Project impact areas are not considered to provide suitable habitat values for the Platypus. The Platypus is associated with freshwater creeks, slow-moving rivers, lakes joined by rivers and built water storages such as farm dams (EHP 2016a).

13.3.7 Introduced fauna species

13.3.7.1 Restricted matter pest species

Three invasive animal species listed under the provisions of the Biosecurity Act as a restricted matter were recorded within the Project impact areas during EIS field investigations conducted by Aurecon in February 2015. These species and their restricted matter status are detailed in Table 13.4.

Table 13.4 Restricted matter (pest species) identified within the Project impact areas

Scientific name	Common name	Biosecurity Act restricted matter category number	Recording type	Location and abundance
Oryctolagus cuniculus	European rabbit	Category 3* Category 4^ Category 5% Category 6#	Scat identification	WB and WBE reclamation areas potential indirect impact area Low density with respect to the nature of available habitat, no burrows identified and quantity of scats recorded
Canis familiaris	Feral dog	Category 3* Category 4^ Category 6#	Direct observation, scat and track identification	WB and WBE reclamation areas potential indirect impact area High density likely with respect to urban nature of sites, quantity of tracks and scats recorded
Vulpes vulpes	European fox	Category 3* Category 4^ Category 5% Category 6#	Scat identification	WB and WBE reclamation areas potential indirect impact area Low density with respect to the nature of available habitat, no burrows identified and quantity of scats recorded

Table notes:

* Category 3 restricted matter = A category 3 restricted matter must not be distributed or disposed of. That is, the matter must not be given as a gift, sold, traded or released into the environment unless the distribution or disposal is authorised in a regulation or under a permit. Deliberate human distribution or disposal contrary to the legislation is a key source of spread into other areas of the State

^ Category 4 restricted matter = A category 4 restricted matter must not be moved to ensure that is does not spread into other areas of the State

% Category 5 restricted matter = A category 5 restricted matter must not be possessed or kept under a person's control. Category 5 pests have a high risk of negatively impacting on the environment. A Category 5 pest may only be kept under a permit of the Biosecurity Act or another Act

Category 6 restricted matter = A category 6 restricted matter must not be fed by a person. Feeding Category 6 restricted pests may cause their numbers to increase and negatively impact the economy or the environment. Feeding for the purpose of preparing for or undertaking a control program is exempted (DAF 2017).

13.3.7.2 Notifiable pest species

The Red imported fire ant (*Solenopsis invicta*) is a notifiable pest species under the provisions of the Biosecurity Act and a Category 1 restricted matter under the provisions of the Biosecurity Act. Consequently landholders must report suspected sightings of Red imported fire ants to Biosecurity Queensland within 24 hours of the sighting.

The fire ant restriction areas within Yarwun, Callemondah, Targinnie and Curtis Island in Gladstone have been removed, and restriction of the movement of potential fire ant carrying material has been lifted (DAF 2016a). There are no fire ant biosecurity zones within the Project impact areas.

13.3.7.3 Exotic pest species

The Cane toad (*Rhinella marinus*) was identified via direct observations within the WB and WBE reclamation areas potential indirect impact area during EIS field investigations conducted by Aurecon in February 2015. The Cane toad is classified as an 'invasive biosecurity matter' under the Biosecurity Act. The '*Biological effects, including lethal toxic ingestion, caused by Cane toads*' is listed as a key threatening process under the provisions of the EPBC Act. The Threatened Species Scientific Committee identified the Cane toad as a threatening process for most native fauna species, and that is therefore eligible for the listing criteria; '*could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent'* (DoEE 2015b).

14 Marine turtles

14.1 Background

Marine turtles are an integral part of oceanic ecosystems throughout the world. They are also an important part of the traditional culture of many coastal Indigenous people throughout the world.

There are seven extant species of marine turtle worldwide and Australia has resident or migratory populations of six of these species, all of which occur within the GBRWHA (GBRMPA 2018). These species include the Green turtle (*Chelonia mydas*), Loggerhead turtle (*Caretta caretta*), Hawksbill turtle (*Eretmochelys imbricata*), Flatback turtle (*Natator depressus*), Leatherback turtle (*Dermochelys coriacea*), and Olive ridley turtle (*Lepidochelys olivacea*) (GBRMPA 2018). Turtles in Queensland have been studied for over the past 50 years (EHP 2017), with a significant amount of research undertaken by the Queensland Turtle Conservation Project (undertaken by the former EHP, now DES). It is commonly known that the Port Curtis region supports populations of Green, Loggerhead, and Flatback turtles, while other species such as the Hawksbill, Olive ridley, Leatherback turtles are known to occur in the GBRWHA but are recorded within Port Curtis either occasionally or rarely (as is the case for Leatherback turtles) (GBRMPA 2018; Limpus et al. 2013).

Marine turtles undertake extensive migrations of up to 3,000km between nesting beaches and feeding areas, but repeatedly return to the same nesting and feeding areas throughout their lives. In Queensland, marine turtles breed at a limited number of nesting sites with varying density. Individual females return at intervals to nest at beaches in the same area in which they were born (Limpus and Chatto 2004).

The complex ecology of marine turtles provides challenges for their effective management in response to human-related threats and the size and status of populations are often difficult to quantify (DoEE 2017b).

14.2 Methodology

The purpose of the baseline marine turtle information is to understand the existing marine turtle species and populations that utilise Port Curtis to allow the assessment of direct impacts and potential indirect impacts associated with the Project. The assessment was informed by Government database resources and a review of existing literature and ecological surveys which document the marine ecological and MNES values of the Port Curtis region. This includes information from studies undertaken for the Queensland Turtle Conservation Project and the ERMP.

For the purposes of the database review, the search area was defined on a regional basis and included Port Curtis and adjoining marine areas to ensure that transient species are captured in the assessment (refer Figure 14.1).

For the purposes of the StrandNet database review (EHP 2016b), which identifies stranding occurrences of marine megafauna, the review area was modified to span the coastline between Yeppoon down south to Eurimbula. Due to the nature of marine animal strandings (i.e. long distance carcass movement/displacement), it should be noted that historical StrandNet data has been cautiously reviewed in this assessment, and this data is not considered a reliable indicator of species presence and/or abundance.

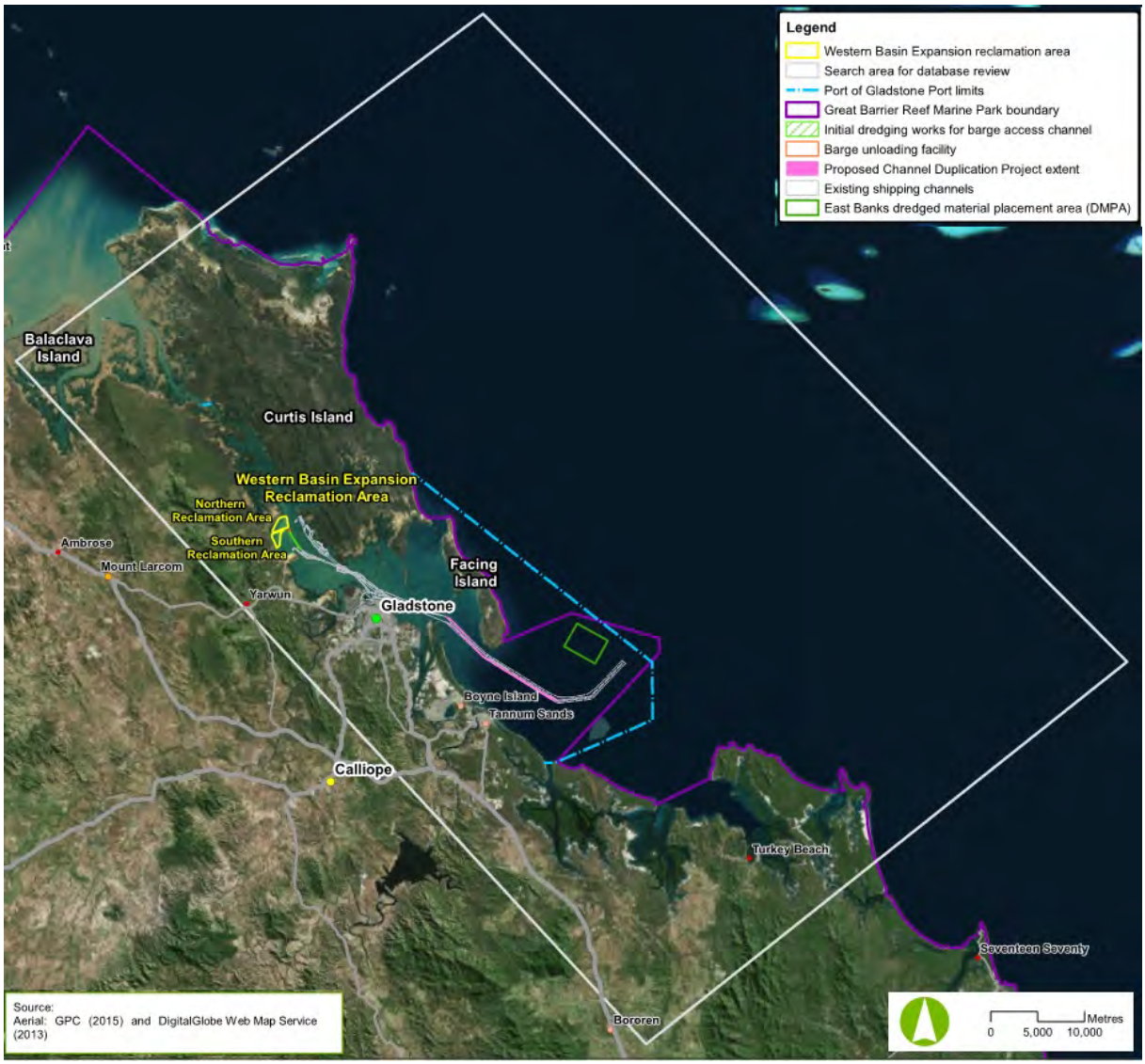


Figure 14.1 Search area for database review

The information sources which were consulted as part of the desktop assessment are summarised in Table 14.1.

Table 14.1 Resources used for the assessment of marine turtle values

Title	Reference
Reports (tracking)	
Curtis Island Marine Turtle Monitoring 2011-2012 breeding season	Limpus et al. (2012a)
Monitoring of Coastal Sea Turtles: Gap Analysis (Parts 1 to 6)	Limpus et al. (2013)
EHP Threatened Species Unit Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtles, 2013-2014 breeding season	Limpus et al. (2014)
EHP Threatened Species Unit Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtles, 2014-2015 breeding season	Limpus et al. (2015)
Annual report on Green turtle tracking and habitat use in Port Curtis	Hamann et al. (2015a)
Interim report on green turtle tracking and habitat use in Port Curtis – Report on field trip 10-17 July 2015	Hamann and Limpus (2015)
Flatback Turtle, Natator depressus, 2017-2018 Breeding Season, at Curtis, Peak and Avoid Islands	Limpus et. al. (2018)

Title	Reference
Reports (nesting)	
Queensland Turtle Conservation Project: Facing Island Turtle Nesting Survey 1999-2000	Clifton and Bell (2000)
Queensland Turtle Conservation Project: Facing Island Marine Turtle Nesting Study 2002-2003	Clifton and Bell (2003)
Gladstone Region Marine Turtle Hatchling Orientation Monitoring Program 2014	Pendoley and Bell (2014)
Marine Turtle Nesting Populations: Avoid Island Flatback Turtles, 2013-2014 breeding season	Fitzsimmons and Limpus (2014)
Marine Turtle Nesting Population: Peak Island Flatback Turtles, 2013-2014 breeding season	Twaddle et al. (2014)
Marine Turtle Nesting Population: Peak Island Flatback Turtles, 2014-2015 breeding season	Twaddle et al. (2015)
Marine Turtle Nesting Populations: Avoid Island Flatback Turtles, 2014-2015 breeding season	Fitzsimmons and Limpus (2015)
Annual report on the internesting habitat use by Flatback turtles off the Curtis Island coast – 2013-2014 nesting season	Hamann et al. (2015b)
Marine Turtle Nesting Population: Avoid Island Flatback Turtles, 2015-2016 breeding season	Fitzsimmons and Limpus (2016)
Marine Turtle Nesting Population: Curtis Island and Woongarra Coast Flatback Turtles, 2015-2016 breeding season	Limpus et al. (2016a)
Marine Turtle Nesting Populations: Peak Island Flatback Turtles, 2015-2016 breeding seasons	Pople et al. (2016)
Marine Turtle Nesting Populations: Flatback Turtle, Natator depressus, 2016-2017 Breeding Season at Curtis, Peak and Avoid Islands	Limpus et al. (2017b)
Reports (health)	
Health Surveillance of Stranded Green Turtles in Southern Queensland, Australia (2006-2009): An Epidemiological Analysis of Causes of Disease and Mortality	Flint et al. (2010)
Status of Turtles In Queensland After 2010 Flood Events: A Review	Mustoe (2011)
Investigation of contaminant levels in green turtles from Gladstone	Gaus et al. (2012)
Health assessment of Green turtles in South and Central Queensland following extreme weather impacts on coastal habitat during 2011	Limpus et al. (2012b)
Green Turtle Disease Investigation at Port Curtis, Gladstone South Central Queensland, Final Report	Flint (2015)
Reports (others)	
Long-term Turtle Management Plan (LTTMP), LNG Facilities – Curtis Island	SKM (2014)
Fitzroy Basin Association Marine Turtle Summary Report	Ecosure (2015)
Increase the understanding of the Green Turtle population in Port Curtis – Year 1 (2016) Final Report	Limpus et al. (2016b)
Increase the Understanding of the Green Turtle Population in Port Curtis: Annual Report for 2017	Limpus et. al. (2017a)
Final report on inter-nesting habitat use by flatback turtles from the Curtis Island rookery, 2013 to 2015	Hamann et al. (2017)
Databases	
EPBC Act protected matters search tool (refer Figure 14.1 for search area)	DoEE (2019)

Title	Reference
Marine Turtles. Queensland marine wildlife stranding and mortality database annual report, 2004	Greenland and Limpus (2008)
Marine Turtle. Marine wildlife stranding and mortality database annual report, 2011	Meager and Limpus (2012)
Wildnet database (refer Figure 14.1 for search area)	DES (2019)

14.3 Marine turtle research and monitoring summaries

14.3.1 Overview

There have be a range of research projects and monitoring programs established to examine the potential impacts on coastal development and capital dredging works within the Port Curtis region. These projects supplement the information collected through the various marine turtle nesting surveys as outlined in Table 14.1. Many of these studies have coincided with the Project EIS baseline data collection period and provide up to date information on aspects of marine turtle species in Port Curtis.

14.3.2 Gap analysis

The tier one ERMP project: *Monitoring of Coastal Sea Turtles: Gap Analysis* (Limpus et al. 2013) summarised available scientific literature and data on marine turtles in Central Queensland, particularly the Port Curtis region, which includes Port Alma. For some species this gap analysis also included an assessment of:

- Baseline data of suitable turtle habitat in and around the ERMP survey area
- Quality and robustness of historical survey data
- Historical trends in marine turtle numbers
- Migratory links between resident foraging turtles and their nesting areas.

The datasets used in this review included the Queensland Turtle Conservation database and the Queensland Government StrandNet database.

14.3.3 Marine turtle hatchling orientation monitoring program

This study was conducted in February 2014 (Pendoley and Bell 2014) to gain an understanding of the spectral properties of the light horizons and associated horizon topography measured at the significant turtle nesting beaches, including Peak Island, South End Curtis Island and Facing Island, along the Port Curtis-Yeppoon coast. The 2014 study also analysed the temporal and spatial distribution of disruption of ocean finding behaviour of nesting adult and hatchling marine turtles to inform the ongoing assessment and management of the impacts on these species in the Port Curtis and Port Alma regions.

These works have involved monitoring hatchling sea-finding ability on Flatback turtle nesting beaches potentially exposed to the influencing variable of artificial light at Curtis and Peak Islands resulting from the construction and operation of LNG plants on Curtis Island.

14.3.4 Marine turtle nesting populations: Avoid Island, Peak Island and Curtis Island Flatback turtles

Studies have been conducted on Avoid, Peak and Curtis Islands to monitor the Eastern Australian Flatback turtle nesting population at a reference index beach towards the northern extent of the population nesting range during the 2013-2014, 2014-2015, 2015-2016, 2016-2017 and 2017-2018 breeding seasons (Fitzsimmons and Limpus 2014; Twaddle et al. 2014; Fitzsimmons and Limpus 2016; Pople et al. 2016; Limpus et al. 2016a; 2018). Census of the Peak Island Flatback turtle nesting population commenced in the 1980-1981 breeding season (Pople et al. 2016); in 2007 (using the standardised methodology) for Avoid Island (Fitzsimmons and Limpus 2016); and since 1969 on Curtis Island (Limpus et al. 2016a).

Standard EHP Threatened Species Unit Turtle Conservation Project methodologies (Limpus et al. 1983; Limpus 1985) were adopted for the project to monitor nesting females and their clutches. This included tagging of untagged nesting females (titanium tags and/or Passive Integrated Transponders), recording animal measurements (e.g. recording tag identification number, carapace length, visible damage), photographs, recording the location of nests with clutches, counting and weighing of egg clutches, numbering and recording GPS location of nest beaches, assessment of potential disorientation of hatchling turtles to altered light, and an assessment of clutch incubation success.

14.3.5 Internesting habitat use by Flatback turtles off the Curtis Island coast

This project aimed to assess the behaviour and habitat usage of the ERMP region by Flatback turtles. Thirty three post nesting Flatback turtles between 2013 and 2015 were fitted with satellite tags configured to measure location and depth during their internesting habitat use. Tracking data was downloaded from the ARGOS website and GPS data calculated using the Wildlife Computers software (Hamann et al. 2015b; 2017).

14.3.6 Satellite tagging of Green turtles

In May 2014, 11 Green turtles (consisting of adults and sub-adults) were fitted with satellite tags configured to measure location and depths to gain an understanding of the habitat utilisation by the marine turtles within the ERMP region. The Green turtles were tagged at Pelican Banks and Wiggins Islands.

In July 2015, an additional 11 Green turtles were captured from intertidal flats and or adjacent sub-tidal waters of Pelican Banks and fitted with satellite tags before being released back into Port Curtis, near Auckland Creek (Hamman and Limpus 2015). Of the 11 turtles fitted with satellite tags, 4 were immature turtles and 7 were adult turtles (3 female, 4 male) (Hamman and Limpus 2015; Hamann et al. 2015).

Between May and October 2016, 11 Green turtles were captured from intertidal flats and/or adjacent sub-tidal waters of Pelican Banks and fitted with satellite tags before being released back into Port Curtis, including 10 adults and 1 sub-adult (Hamann et al. 2017a). Sex determination resulted in 5 males and 6 females.

In May 2017, 2 sub-adult Green turtles were captured and tagged, including one female and one male (Hamann et al. 2017a).

A total of 35 Green turtles were captured and tagged during the 2014-2017 period (Hamann et al. 2017a).

14.3.7 Increase the understanding of Green turtle population in Port Curtis

A four year ERMP study was commenced in 2016 to conduct integrated research and monitoring of foraging Green turtles in Port Curtis (Limpus et al. 2016b). The research is being undertaken in intertidal and subtidal waters at multiple sites within the Port, including Pelican Banks off the southeast corner of Curtis Island; waters surrounding Wiggins Island; Quoin Island and the eastern tidal areas of Facing Island; South Trees Inlet; and water off the Boyne Estuary and Boyne River.

All captured turtles were tagged on their flippers (titanium tags), measured and assessed for external evidence of injury or disease. Capture information recorded included the date captured, GPS location and the method of capture. All of the data collected from captured turtles has been added to the DES (previously known as EHP) maintained database for foraging turtles in Port Curtis (Limpus et al. 2016b). Standardised DES methods for turtle identification, tagging, measurements, health assessment and other examinations were undertaken as described by Limpus et al. (1994; 2005).

The first year annual report was finalised in 2017 (Limpus et al. 2016b), reporting on the results and discussion of the four field trips undertaken in 2016 as part of the study. An annual report was also finalised in 2018 (Limpus et al. 2018) discussing the results of the 2017 field work.

14.3.8 Analysis of Green turtle samples

Several studies of Green turtle health have been undertaken by the University of Queensland (Gaus et al. 2012), Limpus et al. (2012b), and Flint (2015). These studies were undertaken to assess potential changes in the health of the Port Curtis Green turtle population.

In 2011, report concluded that a combination of environmental and anthropogenic factors contributed to the elevated mortality rates in Green turtles (Limpus et al. 2012b).

The study by Limpus et al. (2012b) found high levels of heavy metals, and underlying disease processes consistent with potential toxin exposure and chronic environmental stressors in Green turtles sampled in the Boyne River estuary.

In May 2014, the health status of Port Curtis Green turtles were assessed and compared to baseline blood reference ranges established during a previous study in 2010 (Flint 2015) and 2011 (Gaus et al. 2012). The aims of this study were to determine the health status of the Green turtles within Port Curtis in 2014, and to compare with previous results for Port Curtis (2011), and Queensland (2007 to 2009) (Flint 2015).

Blood biochemistry was performed on 99 captured Green turtles, and haematology was performed on 94 Green turtles (Flint 2015). The findings from the current study suggest that the Green turtle population of Port Curtis has made a significant, but not a complete recovery since the 2011 and subsequent environmental and anthropogenic stressors that resulted in elevated stranding and disease prevalence (Flint 2015).

14.4 Database searches

Appendix B provides the likelihood of occurrence assessments for all of the migratory species identified by the database searches, as well as identifying areas of known and potential habitat for these species within the Project impact areas. The database search results are provided in Appendix A and the conservation status of each species is summarised in Table 14.2. All of the Australian resident turtle species are listed as vulnerable or endangered in Australian waters under the EPBC Act and in Queensland under the NC Act. Marine turtles included on the Fitzroy NRM BoT species prioritisation framework are listed in Appendix K (Table 2).

Table 14.2 Conservation status of marine turtles found in Australia and likelihood of occurring in Port Curtis

Family	Species	Conservation status		Back on Track status	Preferred habitat	Likelihood of occurring in Port Curtis
		NC Act	EPBC Act			
Cheloniidae	Flatback turtle (*Natator depressus*)	Vulnerable	Vulnerable Migratory Marine	Critical priority	Nests on open sandy beaches without reef front, shallow inshore waters	Confirmed (breed in the region)
Cheloniidae	Green turtle (*Chelonia mydas*)	Vulnerable	Vulnerable Migratory Marine	Critical priority	Open, sandy beaches, rocky reef, inshore seagrass beds or algae mats	Confirmed (Feed in the region. Occasionally breed in the region)
Cheloniidae	Loggerhead turtle (*Caretta caretta*)	Endangered	Endangered Migratory Marine	Critical priority	Open, sandy beaches, tidal and sub-tidal habitat	Moderate (occasionally breed in the region)
Cheloniidae	Hawksbill turtle (*Eretmochelys imbricata*)	Endangered	Vulnerable Migratory Marine	Critical priority	Open sandy beaches, coral and rocky reefs, and seagrass	Moderate (may occasionally migrate through the region)
Cheloniidae	Olive ridley turtle (*Lepidochelys olivacea*)	Endangered	Endangered Migratory Marine	-	Open, sandy beaches, open marine waters	Low (may migrate occasionally through the region)
Dermochelidae	Leatherback turtle (*Dermochelys coriacea*)	Endangered	Endangered Migratory Marine	Critical priority	Open, sandy beaches, open marine waters	Low (oceanic species, may occasionally migrate through the region)

Table notes:

Further details on the Back on Track status are provided in Appendix K.
Further details on likelihood definitions are provided in Section 2.2.

Source: DoEE (2019); DES (2019); SKM (2014); BMT WBM (2014a)

14.5 Overview of marine turtle ecology

14.5.1 General

This section provides an overview of the ecology, health and habitats of the four turtle species found most commonly within the Port Curtis region (i.e. Green, Flatback, Hawksbill and Loggerhead turtles). The Port Curtis region provides a range of niche habitats for these four species of turtles, including nesting and foraging areas (refer Figure 14.2), making it an important location for the conservation of marine turtles in Australia. While habitat for the Olive ridley turtle occurs within Port Curtis, the species has been rarely recorded throughout the Port or broader area and there has been no recorded breeding by Olive ridley turtles in eastern Australia or in fact around the rim of the Coral Sea (Limpus et al. 2013). For Leatherback turtles, no large rookeries have been recorded in Australia however scattered nesting is known to occur from Bundaberg to Round Hill Head, approximately 75km southeast of Gladstone. Only one Leatherback turtle has been recorded nesting within or near the Port Curtis region (Limpus et al. 2013).

Long term baseline data has been collected for a number of important nesting beaches in the Port Curtis region over the years by EHP/DES and JCU. Long term monitoring of nesting sites at Curtis Island by EHP/DES has occurred since 1969 (and annually since 1994). More recently, monitoring of turtle nesting behaviour has been undertaken by Clifton and Bell (2003); Limpus et al. (2012a); Hamann et al. (2015a; 2015b); Limpus et al. (2015); Fitzsimmons and Limpus (2016); Limpus et al. (2016a; 2016b); and Pople et al. (2016).

Marine turtles have a similar life cycle, and share common lifecycle traits involving the development from egg to juvenile to adult and they grow slowly, and have been known to take 30 to 50 years to reach sexual maturity (DoEE 2017b).

In Queensland, marine turtles breed at a limited number of nesting sites with varying density. In a breeding year, individual females migrate over long distances between feeding and nesting grounds, and return to nest at beaches in the same area in which they were born (Limpus and Chotto 2004). Both male and female turtles mate with a number of partners and females store sperm in their bodies to fertilise the three to seven clutches of eggs laid during the season. The nesting females of most species will nest multiple times during a nesting season, at intervals of two to four years over the course of their lifetime (DoEE 2017b).

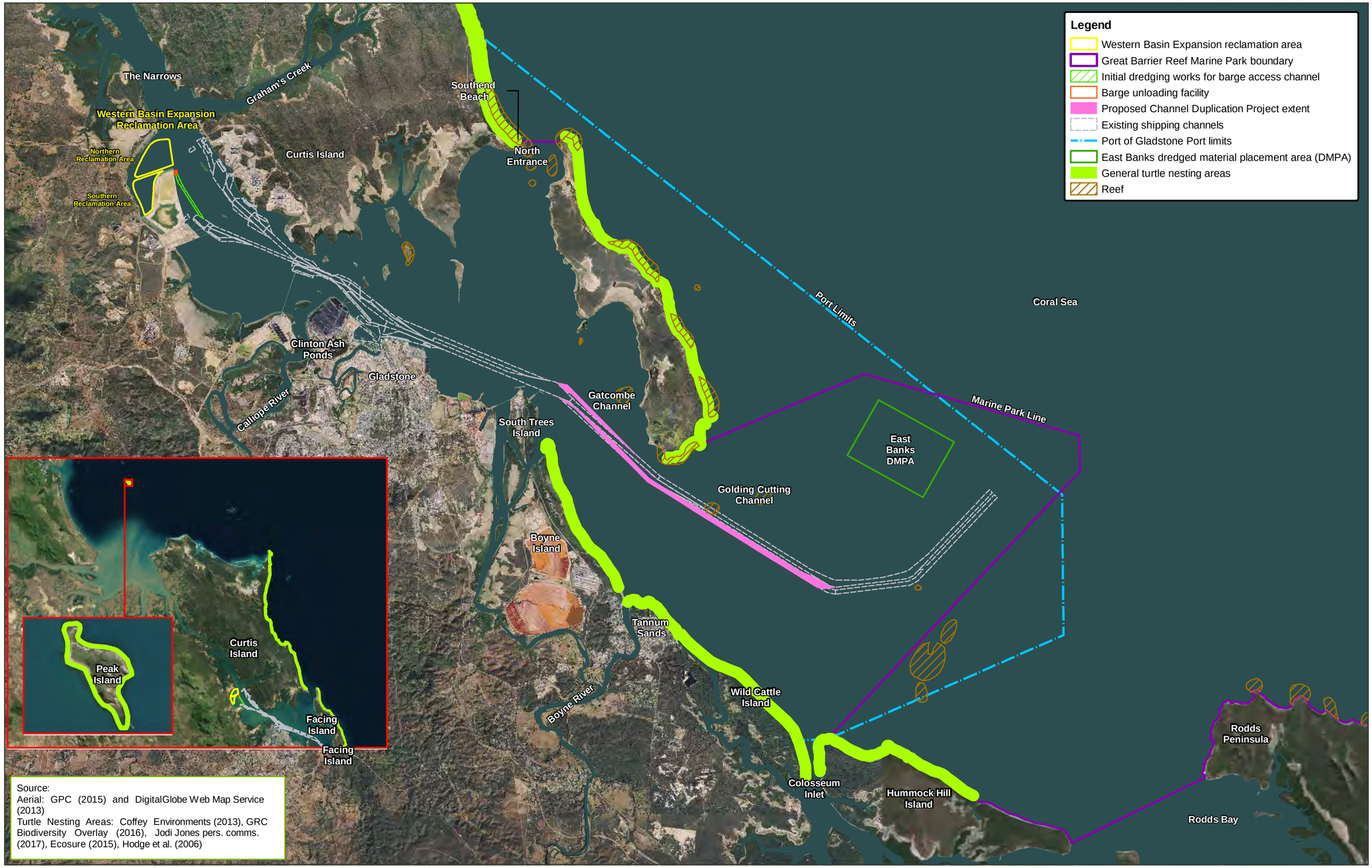
The incubation period of the eggs varies from six weeks to two months, during which time the eggs in each nest hatch synchronously. Emergence from the nesting chamber occurs synchronously during the night and hatchlings instinctively head towards the lit horizon (i.e. moonlight on the sea) which indicates the location of the sea. In general, mature marine turtles have extremely small home ranges and single turtles will generally forage over little more than a few kilometres (Mustoe 2011; Hamann et al. 2015b).

14.5.2 Green turtle

Green turtles are the most common species of turtle found in Port Curtis utilising the area for feeding on a diet of seagrass (including *Halophila, Halodule and Zostera* species), algae and mangrove fruits (Limpus 2008a; Limpus et al. 2013). Aerial and boat-based surveys for marine turtles undertaken in Port Curtis in 2008/2009 and 2011 to assess habitat utilisation, recorded a total of 522 turtles with the most commonly observed species being Green turtles (GHD 2009c). These surveys recorded a large number of juvenile and sub-adult Green turtles, although overall the densities of these local cohorts are not well documented. Immature turtles are regularly encountered in the shallow water habitats, while larger turtles are found in the deeper sub-tidal water (Limpus et al. 2013).

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Turtle Nesting Areas: Coffey Environments (2013), GRC Biodiversity Overlay (2016), Jodi Jones pers. comms. (2017), Ecosure (2015), Hodge et al. (2006)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_012.mxd 13/02/2019 13:05

0 1,875 3,750 Metres

Date: 13/02/2019 Version: 12 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 14.2: General location of marine turtle nesting areas in Port Curtis and Peak Island

Within the southern Great Barrier Reef population, dietary studies on Green turtles have indicated that macroalgae such as *Gracilaria* sp. are also consumed (Brand-Gardner et al. 1999; Chaloupka et al. 2004) and algae is the major food source for many Green turtles (Limpus et al. 2013). With a rich diversity of seagrasses, reef algae and mangroves, Port Curtis provides an important resource to foraging Green turtles. Within Port Curtis during a 2016 study, Green turtles were recorded foraging on seagrass (*Zostera muelleri subsp. capricorni* and *Halophila ovalis*), mangrove (*Avicennia marina* propagules; *Rhizophora stylosa* propagules and apical shoots) and a range of algal species (Chlorophyte: *Ulva polyclada*, Rhodophyte: *Catenella nipae*, *Hynea sp.* and *Gracillaria sp*.) (Limpus et al. 2016b). This study observed Green turtles foraging within Port Curtis displaying very diverse vegetarian diets across a range of sampling sites throughout the Port, with diet also varying seasonally between sampling locations within the Port (Limpus et al. 2016b, Limpus et al. 2017a).

The region also provides internesting habitat for southern Great Barrier Reef populations of females breeding around the Capricorn Bunker Group of islands (including Heron Island, Tryon Island and North West Island) (Limpus et al. 2013).

While Green turtles have been recorded nesting within the Port Curtis region on the beaches of Curtis Island and Facing Island, they prefer the offshore islands of the Great Barrier Reef (Limpus et al. 2000; Limpus et al. 2006; Limpus 2008a). Green turtle nesting for the southern Great Barrier Reef management unit (population) commences in mid to late October, peaking in late December to early January, and ends in late March to early April (Limpus et al. 2013).

Limpus et al. (2016b) collected data on Green turtles within Port Curtis to determine if the area is an important aggregation area for the species. Observations were made during October 2016 (during their breeding season) of their behaviour (i.e. courtship behaviour) and the breeding condition of captured individuals (Limpus et al. 2016b). The results from the first year (of the four year study) identified that none of the 264 observations of Green turtles in Port Curtis were of turtles engaged in courtship or mating behaviour. Furthermore, none of the 25 Green turtles that were captured, were in breeding condition for the 2016-2017 breeding season (Limpus et al. 2016b). The same data was collected in 2017 for the second year of study (Limpus et al. 2017a). Only one of the 256 observations of Green turtles involved turtles engaged in courtship/mating behaviour with an additional two Green turtle courting pairs reported by the public. It was also reported that five of the 23 Green turtles that were captured were in breeding condition for the 2017-2018 breeding season (Limpus et al. 2017a).

These results are consistent with non-breeding Green turtle adults that had remained within their home foraging area in Port Curtis, and that the adult Green turtles preparing to breed in the 2016-2017 and 2017-2018 breeding seasons, having already migrated to breeding locations outside of Port Curtis (Limpus et al. 2016b, Limpus et al. 2017a). This data indicates that Port Curtis is not a significant area for aggregation of breeding Green turtles for courtship and mating.

Satellite tagging studies undertaken as part of the ERMP by Hamann et al. (2015a) have indicated that Green turtles have very distinct home ranges and strong site fidelity within Port Curtis. Of the turtles tracked using satellite transmitters, it was noted that the home ranges of all turtles was small but within expectations, ranging from 3km^2 to 81km^2 (Hamann et al. 2015). They used a range of habitat types including estuarine areas, mangroves deeper waters, intertidal and shallow water habitats and areas of Port Curtis that coincide with high levels of human use (e.g. vessel activity, fishing) (refer Figure 14.3 and Figure 14.4).

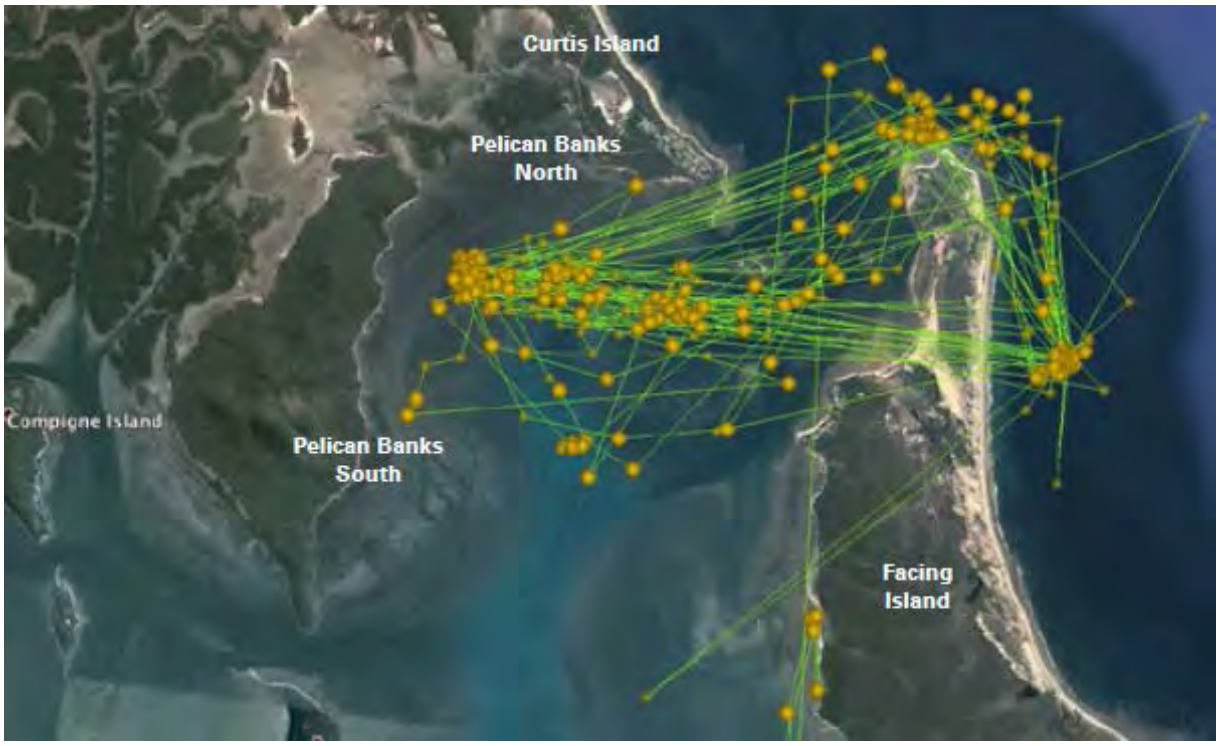


Figure 14.3 Tracking data of a Green turtle tagged in Port Curtis

Source: GPC (2015c) via JCU

Initial results of this tracking study indicated that once released, three of the 10 tracked turtles remained within Port Curtis. Six turtles spent some time outside of Port Curtis, comprising four that moved in and out of the North Entrance through the North Channel, between Curtis Island and Facing Island, and one turtle that spent the entire tracking period outside of Port Curtis. Nine turtles were released at sites removed from their capture site. Eight of the displaced turtles went back to the vicinity of their capture location indicating that capture location is a strong predictor of habitat use (Hamann et al. 2015a). Not unexpectedly, a large number of turtles were observed to have converged at Pelican Banks seagrass meadows. Diving data revealed that the turtles spent most of their time at water depths less than 4m and had regular dive patterns (Hamann et al. 2015a).

The final report, examining tracking data from the 2014-2017 period (34 turtles) similarly found a high degree of site fidelity to foraging habitat (Hamann et al. 2017a). Diving data from the final report also demonstrated that Green turtles in the Port of Gladstone region spend most of their time at water depths of less than 10m.

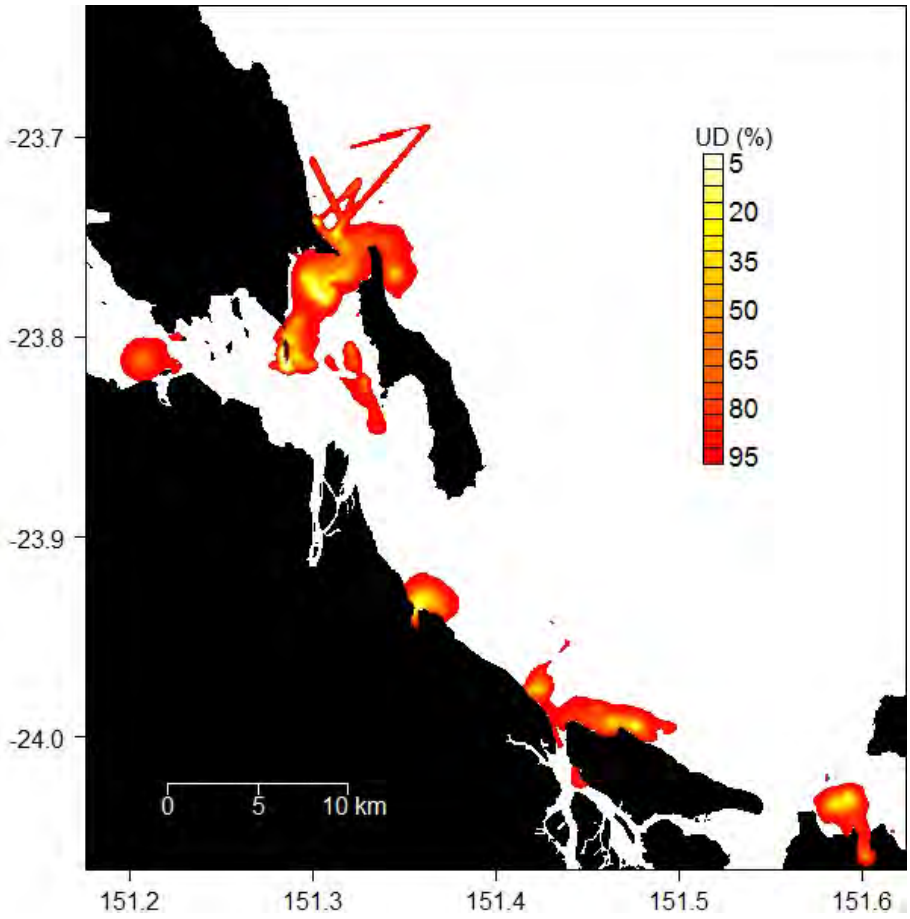


Figure 14.4 Home ranges of Green turtles tracked via satellite within Port Curtis

Figure note:
UD (%) = refers to the percentage of time each 100m grid is used by the turtle during foraging

Source: Hamann et al. (2015a)

Limpus et al. (2016b; 2017a) further assessed foraging behaviour of Green turtles within Port Curtis in the first and second year of a four year study. During the 2016 study, a total of 328 individual Green turtles were captured (Limpus et al. 2016b). The 2017 study resulted in 367 individual turtles being captured (Limpus et al. 2017a). Captured Green turtles were recorded predominantly at Pelican Banks in both years (refer Figure 14.5 and Figure 14.6). Observed Green turtles were also mostly seen in the Pelican Banks area (refer Figure 14.7 and Figure 14.8). The data collected for 2016 and 2017 indicated that adult Green turtles were most abundant at Pelican Banks and Wiggins Island, with small, juvenile turtles dominating the captures in proximity to shallow intertidal areas around mangrove habitats or rocky reefs (Limpus et al. 2016b; 2017a).

Figure 14.5 Locations where Green turtles were captured in Port Curtis 2016

Source: Limpus et al. (2016b)

Figure 14.6 Locations where Green turtles were captured in Port Curtis 2017

Source: Limpus et al. (2017a)

Figure 14.7 Locations where Green turtles were observed but not captured in Port Curtis 2016

Source: Limpus et al. (2016b)

Figure 14.8 Locations where Green turtles were observed but not captured in Port Curtis 2017

Source: Limpus et al. (2017)

Previous studies by Limpus and Nicholls (2000) have established that there is a significant correlation between Green turtle annual reproductive rate in eastern Australia and the climate variable, El Nino Southern Oscillation Index, more than a year before a particular breeding season. Increased rainfall and increased cyclone activity in La Nina years is associated with flood runoff and damage to Green turtle coastal food sources such as seagrass and algal pasture. Two summers after a large La Nina event, the proportion of adult female Green turtles that come into breeding condition for that year will have significantly reduced (Limpus et al. 2012b).

In response to the increasing incidence of strandings of sick, injured and dead Green turtles by mid-2011, especially small immature turtles, studies were undertaken by the former DERM to assess the health of resident Green turtle populations in Queensland. A more in depth veterinary assessment associated with this study was also conducted in July 2011 by Eden et al. (2011).

Eden et al. (2011) examined Green turtles in poor health in the Boyne River estuary within the Port of Gladstone and identified that chronic malnutrition was the most likely cause of poor health, following the loss of pasture from this area in early 2011. Cachexia (wasting of the body) was diagnosed as the primary illness in nine out of the ten turtles that underwent necropsy examinations. Spirorchiid fluke infection was identified in all ten turtles and was considered to have contributed to poor health in one of these turtles (Eden et al. 2011). In Port Curtis, Green turtles were captured and assessed in 2011 from Pelican Banks and the Boyne River estuary, which was severely impacted by turbid flood plumes during early 2011.

Gaus et al. (2012) conducted a study of contaminants within the blood and tissue of Green turtles captured from the Boyne River estuary in 2011. This study identified a range of contaminant groups present on the blood samples taken from the population; from relatively low levels of organic compounds unlikely to present a substantial hazard to the population, to elevated levels of dioxins and other metal contaminants (e.g. silver, copper, chromium, lead) where exposure presented a potential concern to the health of the population (Gaus et al. 2012). Clearly elevated levels of metals and metalloids (e.g. arsenic, cadmium, cobalt, mercury, nickel) were recorded at or above concentrations where acute adverse health effects have been recorded in other fauna species (Gaus et al. 2012). In the absence of sensitivity information relating to these contaminants in turtles, levels observed were considered to be a risk to the health of the Green turtle population (Gaus et al. 2012).

The majority of turtles from the Boyne River (55%) captured live were in ‘poor’ to ‘very poor’ (19%) body condition (Limpus et al. 2012b). The body condition of the Green turtles foraging in the Boyne River estuary were found to be in considerably poorer condition that those foraging in Moreton Banks in Moreton Bay and Western Shoalwater Bay. Small immature Green turtles captured foraging at Pelican Banks were in ‘intermediate’ in body condition compared to the ‘very poor’ condition turtles foraging in the Boyne River estuary. As previously mentioned in Section 14.3.8, high levels of heavy metals, and underlying disease processes consistent with potential toxin exposure and chronic environmental stressors were found in Green turtles sampled in the Boyne River estuary (Limpus et al. 2012b). Recent studies to assess the health of current Green turtle populations in Port Curtis are ongoing at the time of reporting.

In May 2014, Green turtles were sampled again from the same area sampled in the 2011 study (Flint 2015). This study served as a reassessment of the health of turtles for comparison with the 2011 study undertaken at the Boyne River Estuary and Boyne Island. The purpose of this study was to assess the state of health of Green turtles and to utilise turtle health as an indicator of environmental recovery and/or stressor persistence (Flint 2015). This study captured and conducted health assessments on 99 Green turtles from the intertidal and subtidal waters of Port Curtis. A range of assessments were conducted, including assessment of gender, maturity, breeding status, external health assessments and clinical assessments (condition assessment, assessment of lesions and other abnormalities, and blood samples taken for blood biochemistry and haematology analyses) (Flint 2015).The overall clinical health assessment of the Green turtles within Port Curtis of this survey was that the population had recovered significantly from the 2011 and 2013 population health assessments in Port Curtis (Flint 2015). The population age class structure reflected the expected number of juvenile, sub-adult and adult turtles for a coastal foraging population, with observed poor body conditions consistent with the expected functional wild population morbidity rates (i.e. 3%) (Flint 2015). Turtles presented an outward appearance of being healthy and had consistently good body condition scores; their growth rates however, were notably lower than that of the Green turtles of the same size class in the southern Great Barrier Reef population (Flint 2015).

The results of blood analyses indicated that there were potentially chronic disease processes in the population that are currently below clinical significance (e.g. due to early disease stage or mild disease) (Flint 2015). These blood anomalies were observed in more than 60% of the turtles examined, indicating regional level factors (of natural or anthropogenic origin) affecting all age classes of the population (Flint 2015). Flint (2015) identified that this is likely as a result of the ingestion of toxins present in either water or seagrass, though based on the current data, it is not able to be determined if this is an acute or chronic impact.

14.5.3 Flatback turtle

The Flatback turtle is of great significance to Australian marine conservation as it is a species of turtle found only in Australian waters (Limpus 2007). Flatback turtles have a high degree of site fidelity and significant stable nesting occurs along the coastal islands of Queensland, several of which are within the southern Great Barrier Reef region (Limpus et al. 2002). Low-density nesting occurs along the entire mainland coastline and on adjacent islands from Port Douglas to Bundaberg.

A carnivorous species with a diet that includes soft corals, jellyfish, cuttlefish, sea-pens and sea-cucumbers, Flatback turtles utilise the abundant invertebrate resources of the Great Barrier Reef and its coastal areas, including Port Curtis (Chatto 1998; Limpus 2007). Flatback turtles are the dominant nesting marine turtle species in the Port Curtis region and around 20% of Queensland's Flatback turtle population nests on inshore islands of the region (EPA 2003).

Primary rookeries (turtle breeding colonies) of as many as 500 females nest annually on the beaches of Wild Duck and Avoid Island (off the coast of Rockhampton), and Peak Island (Limpus et al. 2002), which are outside of the Project study area (though it is noted that Peak Island is in the waters surrounding the Port Curtis region). The species is also known to nest at other beaches in the region, including Facing Island, Hummock Hill Island and Tannum Sands (refer Figure 14.2). South End Beach on the southern tip of Curtis Island is approximately 5km in length and is one of 30 rookeries reporting 10 to 100 females present at the nesting beach annually, and there are at least 50 additional, smaller rookeries reporting between 1 and 10 females present at the nesting habitat in each reproductive season (Limpus et al. 2013). In some years, there is occasional nesting by Green turtles and/or Loggerhead turtles. While the rookery has been monitored intermittently since 1969 (Limpus et al. 2014; 2016a), it has been monitored annually since 1994 (Limpus et al. 2014; 2016a).

The peak period of nesting activity is mid-November to mid-December, with the peak period of hatching during February. Nesting numbers vary between seasons, with 38 nesting females recorded on Curtis Island during the 2 week nesting census in late November to early December 2012, and 70 nesting Flatback turtle females and 1 Green turtle recorded during 3 weeks of peak nesting in late November and early December of 2013/2014 (Limpus et al. 2014).

During the 2014-2015 breeding season a moderately sized population with 40 nesting females was recorded on Curtis Island during peak nesting in late November to early December 2014 (Limpus et al. 2015). The 2015-2016 breeding season again recorded a moderately sized population of nesting Flatback turtles, with 44 nesting females recorded at South End Beach on Curtis Island (Limpus et al. 2016b). The stability of the previous two years of census data indicates that the eastern Australian Flatback turtle stock breeding at Curtis Island has had a stable breeding population over recent decades (or a single generation for this species) (Limpus et al. 2015; 2016b). In the 2017-2018 breeding period Limpus et al. (2018) monitored Flatback turtle breeding populations on the Curtis, Peak and Avoid Islands. During the two-week census period, a total of 28 nesting individuals were recorded at Curtis Island, while Peak Island and Avoid Island experienced nesting populations of 158 and 69, respectively during the same period. While there was demonstrated stability over previous years the 2018 report showed that the number of nesting individuals on Curtis Island during the two-week census period has almost halved during the past decade even though the recruitment of new adults into the nesting population has been increasing (Limpus et al. 2017a; 2017b; 2018). The nesting population on Peak Island appears to be stable or decreasing at a slow rate (Limpus et.al. 2017a; 2017b; 2018).

Flatback turtles have been known to enter Port Curtis during part of their internesting period (Hamann et al. 2017b; Limpus et al. 2013). The behaviour between nesting events within the same season and physiology of the Flatback turtle has been reported in Sperling et al. (2010) and more recently by Hamann et al. (2015b).

Sperling et al. (2010) recorded horizontal and vertical movements of Flatback turtles obtained through satellite telemetry and with Time-Depth-Recorders, respectively. Two genetically and geographically distinct populations were studied; Curtis Island, Queensland and Bare Sand Island, Northern Territory. While the Flatback turtles at Bare Sand Island appeared to spread randomly out from the island, the Flatback turtles at Curtis Island made use of the protected waters of the Port. The Flatback turtle's vertical movements were compared to that of Loggerhead turtles nesting at Mon Repos Conservation Park, Queensland. Both species spent < 10% of their time at or near the surface and displayed dive types that could be referenced to terminology developed for sea turtle species. Most prevalent were dive types 1, 3 and 4, where the first is thought to represent dives during which turtles are inactive on the seabed. In the latter, two turtles are thought to slowly ascend in mid-water, as a result of a slow increase in buoyancy, while swimming some distance horizontally. Dive type 1 was by far the most common dive type in the Flatback turtle, while dive type 3 was equally as important as type 1 in the Loggerhead. Dive type 1 was in both species more common in the middle third of the period, when eggs are maturing. There was some evidence of a diel pattern, with dive type 1 more common during the day in Flatback turtles and during the night in Loggerheads (Sperling et al. 2010).

Recent studies by Hamann et al. (2015b) undertaken as part of the ERMP, used GPS satellite tags to examine the movement patterns of female Flatback turtles nesting at Curtis Island to understand whether the turtles used the Port Curtis region during their internesting period. Data was collected from November 2013 to March 2014. In November 2013, eleven Flatback turtles were caught on the southern beach of Curtis Island after they completed a nesting cycle (Hamann et al. 2015b). Each turtle was fitted with a satellite tag configured to transmit GPS location and depth. Eight of the turtles were found to have remained within the Curtis Island region to lay a second or third clutch of eggs, thus providing data on habitat use during the internesting period (Hamann et al. 2015b). The other three turtles did not lay another clutch and instead began a migration back to their foraging areas.

To examine habitat use, the distribution and density of GPS locations was examined for each tagged turtle to determine key use areas (refer Figure 14.9) (Hamann et al. 2015b). The 50% or 90% key use areas explain where an individual turtle spends 50% or 90% of its time. For the eight turtles that provided data during their internesting period, the size of their key habitat ranged from 7km^2 to 165km^2 (50%) and 21km^2 to 558km^2 (90%) (Hamann et al. 2015b). The overall combined mean key use area was 51km^2 (50%) and 292km^2 (90%). Seven of the eight turtles spent time within the waters of the Port. Three had 50% core use areas in the Mid Harbour zone of the Port, around the existing Gatcombe and Auckland Channels, and another four turtles used habitat within the limits of the Port, but outside of the Mid Harbour zone. Overall, approximately 20% of all habitat used by the seven turtles was located within the Port limits (Hamann et al. 2015b). A final report, summarising data from 2013 to 2015 found similar results (Hamann et al. 2017b). The overall combined mean area used by the turtles did not differ greatly between years and the size of the core habitat used by the tagged turtles during the internesting period ranged from 6 to 458km^2 (50%) and 51 to 1,501km^2 (95%). It was thus concluded that waters around Curtis and Facing Islands and the waters between Facing Island and the mainland is important habitat for internesting Flatback turtles (Hamann et al. 2017b).

The turtles spent 91% of their time in water depths less than 25m, 41% of time in water depths between 15m and 20m and 11% of their time in water < 2m deep. This was also supported by Hamann et al. (2017) which found that the turtles spent 10% of their time in depths less than 2m. A comparison of home range area and bathymetry indicates that the turtles spent most of their time at the seabed (Hamann et al. 2015b).

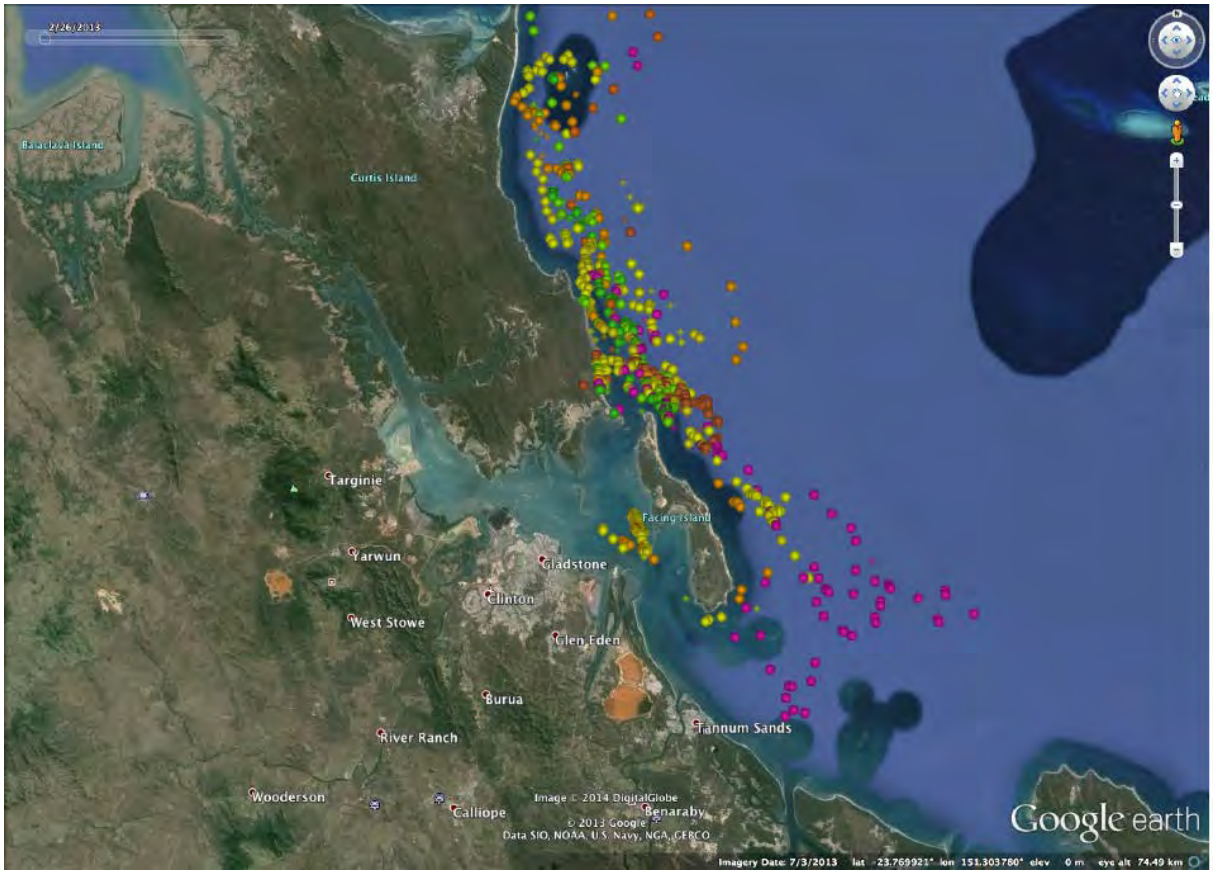


Figure 14.9 **GPS points for eight Flatback turtles tracked during their internesting period (November to December 2013)**

Figure note:

Different coloured points represent individually tagged turtles

Source: Hamann et al. (2015b)

It is noted that management actions for the Flatback turtle in the Port Curtis region should be focussed on the preservation of deep water foraging grounds and maintenance of the index beach on Curtis Island. Given the individuals are not believed to leave the continental shelf, Australia has a distinct east coast genetic stock of Flatback turtles and preservation of all breeding sites within the Great Barrier Reef is important for conservation of the species (Limpus et al. 2013).

14.5.4 Loggerhead turtle

The Port Curtis region and southern Great Barrier Reef provide a potential foraging resource for breeding Loggerhead turtles, with turtles known to nest occasionally on the beaches of Curtis and Facing Islands, but not on an annual basis (Limpus et al. 2013). Apart from a small but unquantified nesting population in Vanuatu, eastern Australia and New Caledonia account for almost the entire Loggerhead turtle nesting population in the South Pacific Ocean (Limpus and Limpus 2003). Loggerhead turtles have been recorded within the Port limits, although to date no known studies of the Loggerhead turtle within Port Curtis have been conducted (Limpus et al. 2013).

The peak period of nesting is during December, with hatching occurring in the following months up until the end of April (DoEE 2017b). In addition to the Woongarra coast (including Mon Repos beach), other nesting rookeries for Loggerhead turtles include Wreck Rock beaches (to the south of Port Curtis), Wreck Island, Heron Island, and North West Island (to the northwest of Port Curtis) (Limpus et al. 2013). These nesting habitats collectively form the major rookery of the Capricornia Cays National Park (Limpus 2008b) with breeding Loggerhead turtles supported by the foraging resources of the Port Curtis region.

Loggerhead turtles recruit to coastal benthic zones from the open ocean at approximately 13 years of age having reached sub-adulthood. Here they continue their carnivorous diet, feeding on over a 100 recorded taxa, predominantly invertebrates such as gastropods and bivalve molluscs, and to a lesser extent on soft invertebrates and fish (Limpus 2008b). The Port Curtis region offers a diverse perennial resource for feeding grounds of internesting females and resident Loggerhead turtles. The invertebrate biomass is supported by the rich diversity of seagrasses, algal turfs, and sand and mud flats, the latter of which are utilised by Loggerhead turtles during high tides (SKM 2014).

Fisheries and shipping activities can significantly impact on Loggerhead turtle survivorship (Greenland and Limpus 2008), with disease also playing a major role in the causes of mortality (Flint et al. 2010). According to the Marine wildlife stranding and mortality database annual report 2011, one out of the 39 deceased Loggerhead turtles examined in Queensland in 2011 was determined to have died from disease/ill health; with 15 out of 39 examinations resulting in undetermined causes of mortality (Meager and Limpus 2012). The most common mortalities from anthropogenic sources are boat strike, entanglement in crab pot float lines, entrapment associated with the Queensland Shark Control Program, and fishing line/rope entanglement (Limpus et al. 2013). From a management perspective, the preservation of resident foraging grounds and surrounding reefs for sub-adult and adult age classes is important. Minimising anthropogenic impacts is a key management objective, given the conservation significance of the species (SKM 2014).

14.5.5 Hawksbill turtle

There are no known Hawksbill turtle nesting beaches in Queensland outside of the northern Great Barrier Reef and Torres Strait. However, small populations of predominantly sub-adult and juvenile turtles are found in resident populations in the southern parts of Queensland. This is in contrast with the northern parts of Queensland, where the largest remaining populations in the world are found (Limpus et al. 2013). Nesting for Hawksbill turtles occurs commonly on the islands along the inner shelf of the Great Barrier Reef north of Princess Charlotte Bay, central and western Torres Strait, and the mainland beaches of north western Cape York Peninsula. Based on a decline in the number of turtles at index nesting beaches of northern Queensland, there is a predicted localised loss of > 90% of the Queensland population within one generation, by 2020 (Limpus 2009).

Although there is a significant Hawksbill turtle population in the coral reefs offshore from Port Curtis, and Hawksbill turtles may forage in Port Curtis, it has not been demonstrated that there is a significant feeding population within Port Curtis. However, the broader Port Curtis region (including areas of the Great Barrier Reef east of Port Curtis) includes areas of soft coral, algae and seagrass, which form part of their dietary requirements (Limpus 2009), making the Port Curtis region a potential resident feeding ground and resource for the species. In this context, it is important for the conservation of the species that resident foraging grounds and surrounding reefs for juvenile and sub-adult age classes are preserved (SKM 2014).

Migration data has indicated that Hawksbill turtles foraging within a 500km radius of Port Alma and Port Curtis are most likely to originate from the nesting populations in eastern Papua New Guinea, Solomon Islands or Vanuatu (Limpus et al. 2013).

Similar to the Green turtle, disease is a significant cause of mortality in Hawksbill turtles and may be utilised as an indicator of environmental health. According to the Marine wildlife stranding and mortality database annual report 2011, 19 out of the 107 deceased Hawksbill turtles examined in Queensland in 2011 were determined to have died from disease/ill health; with 61 out of 107 examinations resulting in undetermined causes of mortality (Meager and Limpus 2012). Fishing activities and other anthropogenic activities are also known threats to this species (Limpus 2009).

15 Marine megafauna

15.1 Background

Within Australian waters, 46 species of marine mammals (herein referred to as marine megafauna) are known to occur (DoEE 2018d). In summary, eight conservation significant marine megafauna species (listed under the provisions of the EPBC Act or the NC Act) are known to occur within Australian waters, and are presented in Table 15.1.

Table 15.1 Conservation significant marine megafauna species known from Australian waters

Family	Scientific name	Common name	EPBC Act Status	NC Act Status
Balaenidae	*Eubalaena australis*	Southern right whale	E, Mi	LC
Balaenopteridae	*Balaenoptera musculus*	Blue whale	E, Mi	LC
Balaenopteridae	*Balaenoptera borealis*	Sei whale	V, Mi	LC
Balaenopteridae	*Megaptera novaeangliae*	Humpback whale	V, Mi	V
Balaenopteridae	*Balaenoptera physalus*	Fin whale	V, Mi	LC
Delphinidae	*Sousa sahulensis,* formerly *S. chinensis**	Australian humpback dolphin	-	V
Delphinidae	*Orcaella heinsohni*, formerly *O. brevirostris*	Australian snubfin dolphin	-	V
Dugongidae	*Dugong dugon*	Dugong	-	V

Table notes:

E: Endangered, V: Vulnerable, LC: Least Concern, M: Migratory -: not listed

*: Previously included with *Sousa chinensis*, *Sousa sahulensis* was elevated to a species in 2014 (Jefferson and Rosenbaum 2014). *Sousa chinensis* is now used for humpack dolphins in the eastern Indian and western Pacific Oceans and *S. sahulensis* is used for humpack dolphins in the waters of the Sahul Shelf from northern Australia to southern New Guinea (Jefferson and Rosenbaum 2014).

In addition to the conservation significant marine megafauna species listed in Table 15.1, marine megafauna species known to occur within Australian waters include 14 species which are listed as migratory (Bonn Convention) under the EPBC Act

All cetaceans within Australia are protected within the Australian Whale Sanctuary under the provisions of the EPBC Act. The Australian Whale Sanctuary includes all Commonwealth waters from the 3 nautical mile (nm) state waters limit, extending out to the boundary of the Exclusive Economic Zone (i.e. 200nm offshore and further in some places).

Port Curtis and adjoining waterways support a range of marine megafauna species, including whales, dolphins and dugongs. Marine megafauna species form an important component of the marine biodiversity values of the GBRMPA due to their ability to regulate and maintain balance in the food chain. They do this by managing the abundance of prey species that have the ability to reduce the populations of species at the bottom of the food chain to unsustainable levels. In addition, whales, dolphins and dugongs are iconic species that hold a special significance for many users of the Great Barrier Reef.

15.2 Methodology

The purpose of the baseline marine megafauna information is to understand the existing marine megafauna species and populations that utilise the Port Curtis region to allow the assessment of direct impacts and potential indirect impacts associated with the Project. The assessment was informed by Government database resources and a review of existing literature and ecological surveys which document the marine ecology and MNES values of the Port Curtis region.

For the purposes of the database review, the Project EIS search area (as defined in Section 2.1.1 of this report) was assessed. However, to ensure that transient marine megafauna species were captured in this assessment, a broader search area, including offshore islands and coral cays, was also applied as a secondary dataset. This broader search area is herein referred to as the regional search area (refer Figure 15.1).

The StrandNet database identifies stranding occurrences of marine megafauna. For the purposes of the StrandNet database review (EHP 2016b), the review area was modified to span the coastline between Yeppoon in the north and Eurimbula in the south. Due to the nature of marine megafauna strandings (i.e. long distance movement or displacement of carcasses), it should be noted that historical StrandNet data has been cautiously reviewed in this assessment and this data is not considered to be a reliable indicator of species presence and/or abundance.

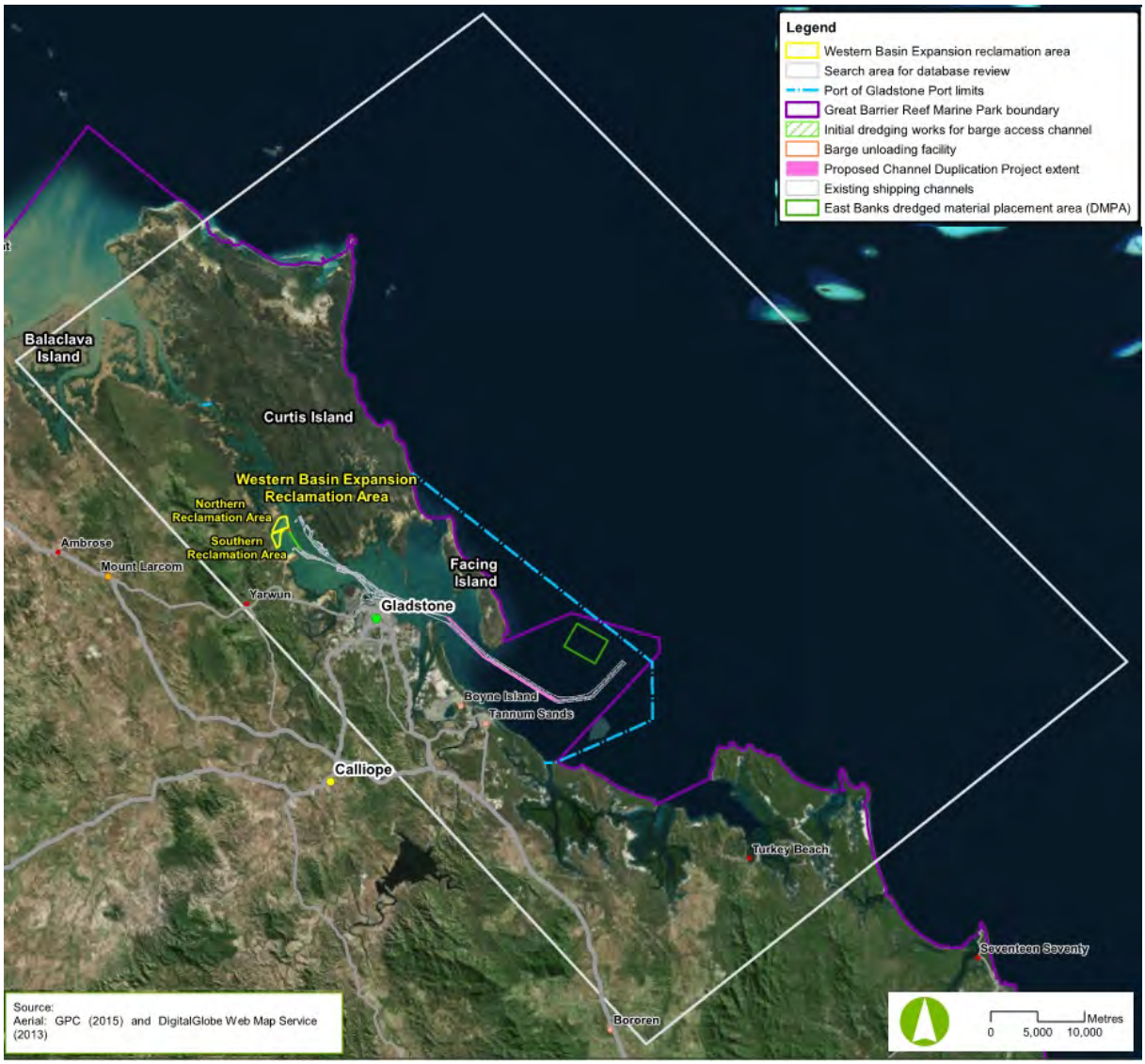


Figure 15.1 Search area for database review (Regional search area)

The information sources which were reviewed as part of the desktop assessment are summarised in Table 15.2.

Table 15.2 Resources used for the assessment of marine megafauna values

Title	Reference
Reports	
General megafauna studies	
Report for Western Basin Dredging and Disposal Project – Marine Megafauna Baseline and Impact Assessment	GHD (2009d)
Report for Marine Megafauna and Acoustic Survey: Autumn Survey	GHD (2011a)
Report for Marine Megafauna and Acoustic Survey: Summer Survey	GHD (2011b)
Curtis Coast Coastal and Marine Resource Inventory Report	GPC (2012)
Monitoring Aquatic Ambient Noise and the Associated Pressure Impacts in Port Curtis and Port Alma	Blue Planet Marine (2013)
Great Barrier Reef Outlook Report 2014	GBRMPA (2014)
Dugong studies	
Dugong distribution and abundance in the Southern Great Barrier Reef Marine Park and Hervey Bay: Results of an aerial survey in October-December 1999	Marsh and Lawler (2001)
Dugong status report and action plans for countries and territories	Marsh et al. (2002)
Project 2: Dugong distribution and abundance on the urban coast of Queensland: a basis for management	Marsh and Lawler (2007)
The ecology and conservation of sirenia; Dugongs and manatees	Marsh et al. (2011)
Marine wildlife stranding and mortality database annual report 2012. I. Dugong	Flint and Limpus (2013)
Status of the Dugong population in the Gladstone area	Sobtzick et al. (2013)
Annual report on Dugong tracking and habitat use in Gladstone 2014	Cleguer et al. (2015a)
Annual report on Dugong tracking and habitat use in Gladstone in 2015	Cleguer et al. (2015b)
Marine wildlife stranding and mortality database annual report 2013-2015, Dugong	Meager (2016a)
Distribution and abundance of dugong and large marine turtles in Moreton Bay, Hervey Bay and the southern Great Barrier Reef	Sobtzick et al. (2017)
Dugong feeding ecology and habitat use on intertidal banks of Port Curtis and Rodds Bay – Final Report	Rasheed et al. (2017)
Dolphin studies	
Marine wildlife stranding and mortality database annual report 2008-2010. II. Cetaceans and Pinnipeds	Meager et al. (2012)
Review of coastal dolphins in central Queensland particularly Port Curtis and Port Alma regions	Cagnazzi (2013)
First Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma	Cagnazzi (2015a)
Second Project Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma	Cagnazzi (2015b)
Third Project Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma	Cagnazzi (2015c)
Fourth Project Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma	Cagnazzi (2016)
Marine wildlife stranding and mortality database annual report 2013-2015, Cetacean and Pinniped	Meager (2016b)
Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma Final Project Report	Cagnazzi (2017)

Title	Reference
Databases	
EHP StrandNet data 2004 to 2014: Corio Bay to Eurimbula	EHP (2016b)
Atlas of Living Australia (incorporates Queensland Museum Wildnet data and Queensland Herbarium HERBRECS data)	ALA (2019)
EPBC Act PMST (refer Figure 15.1 for search area)	DoEE (2019)
Wildnet database (refer Figure 15.1 for search area)	DES (2019)

Review and analysis of existing literature and publicly available databases for the Port Curtis region have indicated that a significant amount of research on marine megafauna (i.e. dugong and dolphins) has been undertaken within the Gladstone region in recent years. Sections 15.2.2 and 15.2.3 provide summaries of the methodology used in recent dugong and dolphin surveys conducted within the Port Curtis region.

15.3 Marine megafauna research and monitoring summaries

15.3.1 Dugong surveys

Aerial surveys for dugong and other marine megafauna (e.g. dolphins, whales) along the urban coast of Queensland have been conducted by Professor Helene Marsh and others from JCU TropWATER since 1986. The surveys were developed for regional scales (i.e. tens of thousands of square km) and an overview of survey dates and references for the Moreton Bay, Hervey Bay, Southern and Central section, and Cairns section of the GBRMP are provided in Appendix P (Sobtzick et al. 2013). As part of the EIS for the WBDDP a series of three aerial surveys were conducted in the Curtis Island-Rodds Bay area over a nine month period in 2008/2009, using methodology modified from that developed by JCU. Although the JCU TropWATER methodology was developed for regional scales, the WBDDP EIS surveys were applied at a local scale (i.e. hundreds of square km). Potential limitations and consequences of this approach are discussed in Appendix P. In summary, a strip transect aerial survey methodology was adopted by JCU TropWATER and GHD, and is detailed in Marsh and Sinclair (1989a) and summarised in Appendix P.

The *Ecosystem Research and Monitoring Program Project CA14000187, Dugong Feeding Ecology and Habitat Use on Intertidal Banks of Port Curtis and Rodds Bay* (ERMP), was initiated for GPC. This program involved the identification of key seagrass areas within Port Curtis and Rodds Bay which were surveyed quarterly to assess temporal and spatial feeding activity by dugongs between May 2015 to November 2016 (Rasheed et al. 2017).

The ERMP successfully developed a new methodology to quantify dugong feeding trails using low-level aerial photography and next generation photogrammetry techniques and software, suitable for identifying dugong feeding scars or trails. This methodology allowed, for the first time, effective examination of dugong feeding over large scales, and was used as an effective tool to address knowledge gaps associated with the temporal and spatial use of intertidal seagrass habitat and its relationship to changes in season, weather, and seagrasses (Rasheed et al. 2017).

In 2014 and 2015, dugong satellite-tracking surveys were conducted which involved deploying satellite tags on dugongs, and examining the movement, behaviour, and habitat use of the species as opportunity permitted to increase understanding of habitat use by dugongs within Port Curtis (Cleguer et al. 2015a; Cleguer et al. 2015b). One adult female, and one sub-adult male were tracked for 76 days and 32 days (respectively) during the 2014 survey period (Cleguer et al. 2015a), whilst one 2.32m sub-adult male was tracked for 90 days during the 2015 survey (Cleguer et al. 2015b).

Aerial surveys of dugong within the southern Great Barrier Reef region were also undertaken during 1999 (Marsh and Lawler 2001) and 2016 (Sobtzick et al. 2017).

In addition to the aforementioned dugong surveys, Southern Cross University conducted dolphin surveys of the Port Alma and Port Curtis area annually from 2014 to 2016, in which one to five dugongs (including at least one calf) were incidentally observed in each annual sampling period (Cagnazzi 2015a; 2015b; 2016). Furthermore, incidental observations of Dugongs were recorded as part of marine turtle research in Point Curtis (Limpus et al. 2017a).

15.3.2 Australian humpback dolphin and Australian snubfin dolphin surveys

In order to increase the understanding of the status of the Australian humpback dolphin and the Australian snubfin dolphin in the Port Curtis and Port Alma regions, dolphin mark-recapture (photo-identification) surveys were conducted over the period of 2014 to 2016, extending on previous baseline programs (Cagnazzi 2015b).

The dolphin mark-recapture surveys were conducted within an area encompassing approximately 1,147km^2 of open water, shallow inshore waters and intricate estuarine systems between Peak Island to the north and Turkey Beach to the south (refer Figure 15.2). The survey area was divided into five strata with varying physical characteristics, including Outer Fitzroy River, Inner Fitzroy River, Eastern Curtis Island, Port Curtis and Rodds Bay (Cagnazzi 2015b).

Dolphin mark-recapture surveys were boat-based, and were conducted at an average speed ranging between 10km/hr and 12km/hr (approximately 6kts). Photographic imagery of dorsal fins were recorded in order to record permanent marks which enabled individuals to be identified.

Biopsy samples were also collected during these surveys from Australian humpback dolphins and Australian snubfin dolphins for genetic, toxicological, and heavy metal analysis (Cagnazzi 2015a).

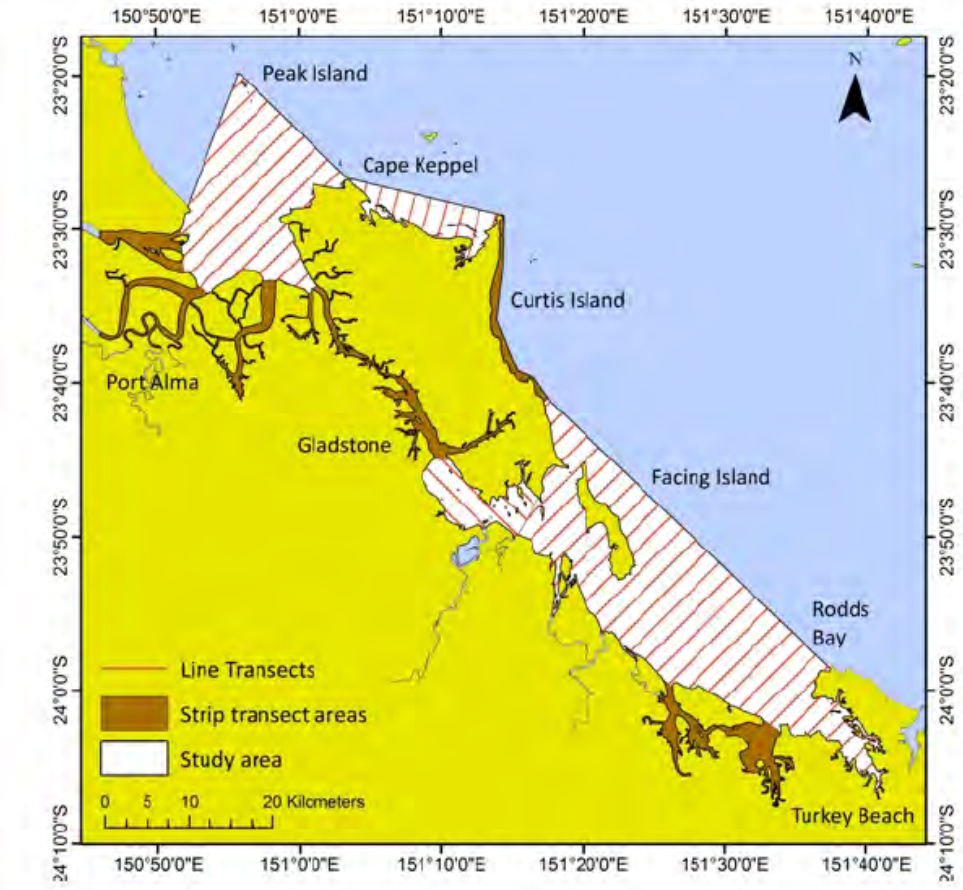


Figure 15.2 **Mark-recapture survey area and transect patterns**

Source: Cagnazzi (2016)

15.4 Database searches

Appendix B provides the likelihood of occurrence assessments for all of the conservation significant marine megafauna species identified by the database searches, as well as identifying areas of known and potential habitat for these species within the Project impact areas.

The database search results are provided in Appendix A.

Species included on the Fitzroy NRM BoT species prioritisation framework are listed in Appendix K (Table 2).

15.4.1 Whales

Table 15.4 summaries the whale species of conservation significance that have been identified by database searches as potentially occurring within the regional search area, and assesses the likelihood of each species occurring within Port Curtis, based on habitat assessments, and actual sightings.

Table 15.3 Conservation status of whales and likelihood of occurring in Port Curtis

Family	Scientific name	Common name	Conservation status		Back on Track status	Preferred habitat	Likelihood of occurring in Port Curtis
			EPBC Act	NC Act			
Balaenopteridae	*Balaenoptera edeni*	Bryde's whale	Mig	LC	-	Limited to the 200m depth isobar. No specific feeding or breeding grounds are known in Australia	Low (unlikely to occur within Port Curtis due to absence of preferred habitat, and rarity of Australian sightings)
Balaenopteridae	*Balaenoptera musculus*	Blue whale	E, Mig	LC	-	Prefers higher latitudes and migrate to lower latitudes for feeding, breeding and calving during the Australian summer, whilst some remain within the Antarctic waters year-round	Low (unlikely to occur within Port Curtis due to absence of preferred habitat)

Family	Scientific name	Common name	Conservation status		Back on Track status	Preferred habitat	Likelihood of occurring in Port Curtis
			EPBC Act	NC Act			
Balaenidae	*Eubalaena australis*	Southern right whale	E, Mig	LC	-	Preferred breeding habitat characterised by near-shore, shallow water depths. This species is restricted in their ability to colonise unused areas of potentially suitable habitat, due to a high degree of site fidelity (individuals returning to the same breeding site each year). Preferred habitat for feeding very poorly known.	Low (unlikely to occur within Port Curtis due to absence of preferred habitat)
Balaenopteridae	*Megaptera novaeangliae*	Humpback whale	V, Mig	V	-	Prefers near coastal migration routes to and from their winter breeding areas. The southern end of the Great Barrier Reef is a suspected calving area – preliminary research identifies key habitat parameters as a water depth of 30-50m and sea surface temperatures of 21-23 °C	Confirmed (this species is known to utilise the coastal waters east of Curtis Island for migration, and is occasionally observed within Port Curtis. No calving areas are known within Port Curtis)

Family	Scientific name	Common name	Conservation status		Back on Track status	Preferred habitat	Likelihood of occurring in Port Curtis
			EPBC Act	NC Act			
Physeteridae	*Physeter macrocephalus*	Sperm whale	Mig (Bonn)	LC	-	Sperm whales tend to inhabit offshore areas with a water depth of 600 m or more, and are uncommon in waters less than 300 m deep (DoEE 2018b) Sperm whales are most common in submarine canyons at the edges of the continental shelf, but they also occur in mid-ocean (DoEE 2018b).	Low (preferred habitat not present within Port Curtis)

Table notes:
E Endangered V Vulnerable LC Least Concern Mig Migratory
- Not listed
Further details on the Back on Track status are provided in Appendix K.
Further details on likelihood definitions are provided in Section 2.2.

Source: DoEE (2019); DES (2019); ALA (2019); IUCN (2018)

15.4.2 Dolphins

Table 15.4 summaries the conservation status of dolphin species that have been identified by database searches as potentially occurring within the regional search area, and assesses the likelihood of each species occurring within Port Curtis, based on habitat assessments.

The database search results are provided in Appendix A.

Species included on the Fitzroy NRM BoT species prioritisation framework are listed in Appendix K (Table 2).

Table 15.4 Conservation status of dolphins and likelihood of occurring in Port Curtis

Family	Scientific name	Common name	Conservation status		Back on Track status	Preferred habitat	Likelihood of occurring in Port Curtis
			EPBC Act	NC Act			
Delphinidae	*Orcaella heinsohni*+	Australian snubfin dolphin	Migratory	Vulnerable	Critical priority	Australian Snubfin Dolphins have been recorded almost exclusively in coastal and estuarine waters	Low (typically encountered in the Port Alma region, to the north of Curtis Island)

Family	Scientific name	Common name	Conservation status		Back on Track status	Preferred habitat	Likelihood of occurring in Port Curtis
			EPBC Act	NC Act			
Delphinidae	*Orcinus orca*	Killer whale	Migratory	Not listed	-	Preferred habitat includes oceanic, pelagic and neritic regions, in both warm and cold waters.	Low (preferred habitat not present within Port Curtis)
Delphinidae	*Sousa sahulensis**	Australian humpback dolphin	Migratory	Vulnerable	Critical priority	Prefers relatively shallow and protected coastal habitats such as inlets, estuaries, major tidal rivers, shallow bays, inshore reefs and coastal archipelagos	Confirmed (frequently recorded within Port Curtis, including The Narrows)

Table notes:
[+] formerly known as Irrawaddy dolphin (*Orcaella brevirostris*)
* formerly known as Indo-Pacific humpback dolphin (*Sousa chinensis*)
Further details on the Back on Track status are provided in Appendix K.
Further details on likelihood definitions are provided in Section 2.2.

Source: DoEE (2019); DES (2019); ALA (2019); Cagnazzi (2014; 2015a; 2015b; 2016; 2017)

15.5 Overview of marine megafauna ecology

15.5.1 Whales

Analysis of environmental databases indicates that several whale species are known, or are predicted to occur within the regional search area (i.e. oceanic waters offshore from Port Curtis, as defined in Section 15.2.1) (refer Table 15.5).

ALA records exist for five species of whale within the regional search area, since 1980 (refer Table 15.2). Within the Project EIS search area records for only two species of whale (i.e. Humpback whale and Sperm whale) exist (ALA 2019; DES 2019).

The Humpback whale is considered to be seasonally present within offshore waters in the vicinity of Port Curtis (GHD 2011a; GHD 2011b). Five sightings of Humpback whales have been recorded within the Project EIS search area, between 1985 and 2012, all within the months of June and September (ALA 2019; DES 2019). The Humpback whale's distribution within Australian waters is shown in Figure 15.3.

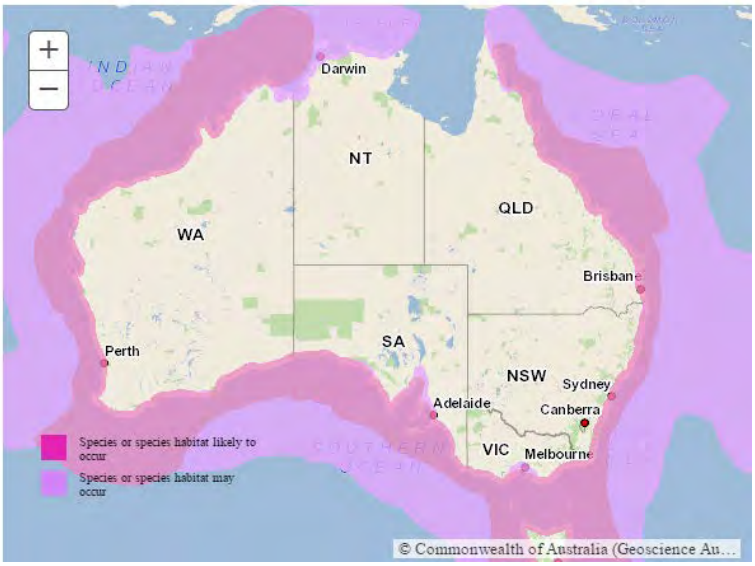


Figure 15.3 Humpback whale distribution in Australian waters

Source: DoEE (2018a)

One historical (1983) Sperm whale record (preserved specimen) has been captured by the ALA (2018) database at Cape Capricorn, within the Project EIS search area. One additional Sperm whale was recorded within the regional search area, on Joskeleigh Beach, approximately 30km northwest of Curtis Island in 1995. The Sperm whale's distribution within Australian waters is shown in Figure 15.4.

Figure 15.4 Sperm whale distribution in Australian waters

Source: DoEE (2018b)

Table 15.5 Whale species known or predicted to occur within the Project EIS search area and regional search area

Scientific name	Common name	EPBC Act	NC Act	Data source			
				EPBC Act protected matters search tool*	Wildnet data*	Atlas of Living Australia – Project EIS search area*	Atlas of Living Australia – Regional search area+
Balaenoptera acutorostrata	Minke whale	-	LC	✓	-	-	-
Balaenoptera acutorostrata unknown *subsp.*	Dwarf minke whale	-	-	-	-	-	✓
Balaenoptera borealis	Sei whale	V, Mig	LC	-	-	-	✓
Balaenoptera edeni	Bryde's whale	Mig	LC	✓	-	-	-
Balaenoptera musculus	Blue whale	E, Mig	LC	✓	-	-	✓
Eubalaena australis	Southern right whale	E, Mig	LC	✓	-	-	-
Megaptera novaeangliae	Humpback whale	V, Mig	V	✓	✓	✓	✓
Physeter macrocephalus	Sperm whale	Mig	LC	-	-	✓	✓

Table notes:
E Endangered V Vulnerable LC Least Concern Mig Migratory
- Not listed
Excludes data recorded prior to 1980:
* Project EIS search area applied for this database search, includes species listed as conservation significant, migratory, and/or cetacean
+ Regional search area applied for this database search (refer to Figure 15.1)
- Species not identified in database search results

Source: DoEE (2019); DES (2019) and ALA (2019)

Bryde's whale (*Balaenoptera edeni*) and Southern right whale (*Eubalaena australis*) are considered likely to occur off the Curtis Coast (GPC 2012; DoEE 2018c; 2018d), though no records of these species have been captured by Wildnet (DES 2019) or ALA (2019) within the Project EIS search area, or regional search area. The Bryde's whale and Southern right whale species distribution is shown in Figure 15.5 and Figure 15.6, respectively.

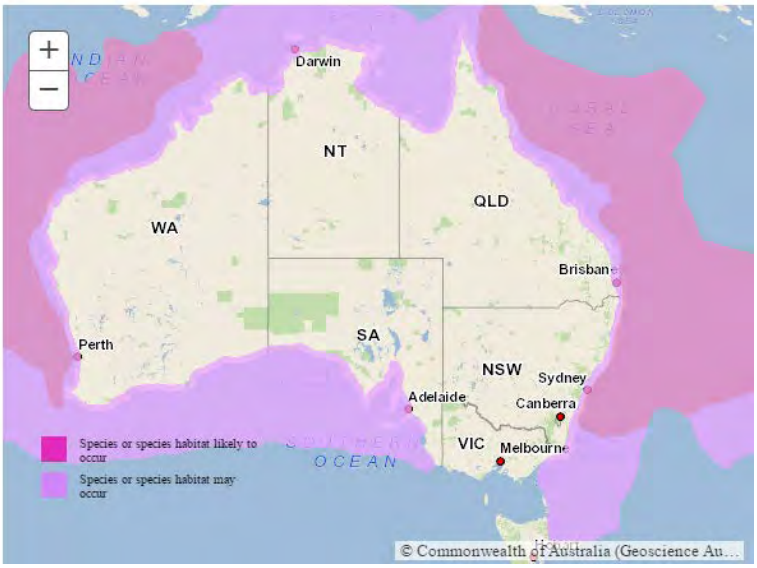


Figure 15.5 Bryde's Whale distribution in Australian waters

Source: DoEE (2018c)

Figure 15.6 Southern right whale distribution in Australian waters

Source: DoEE (2018d)

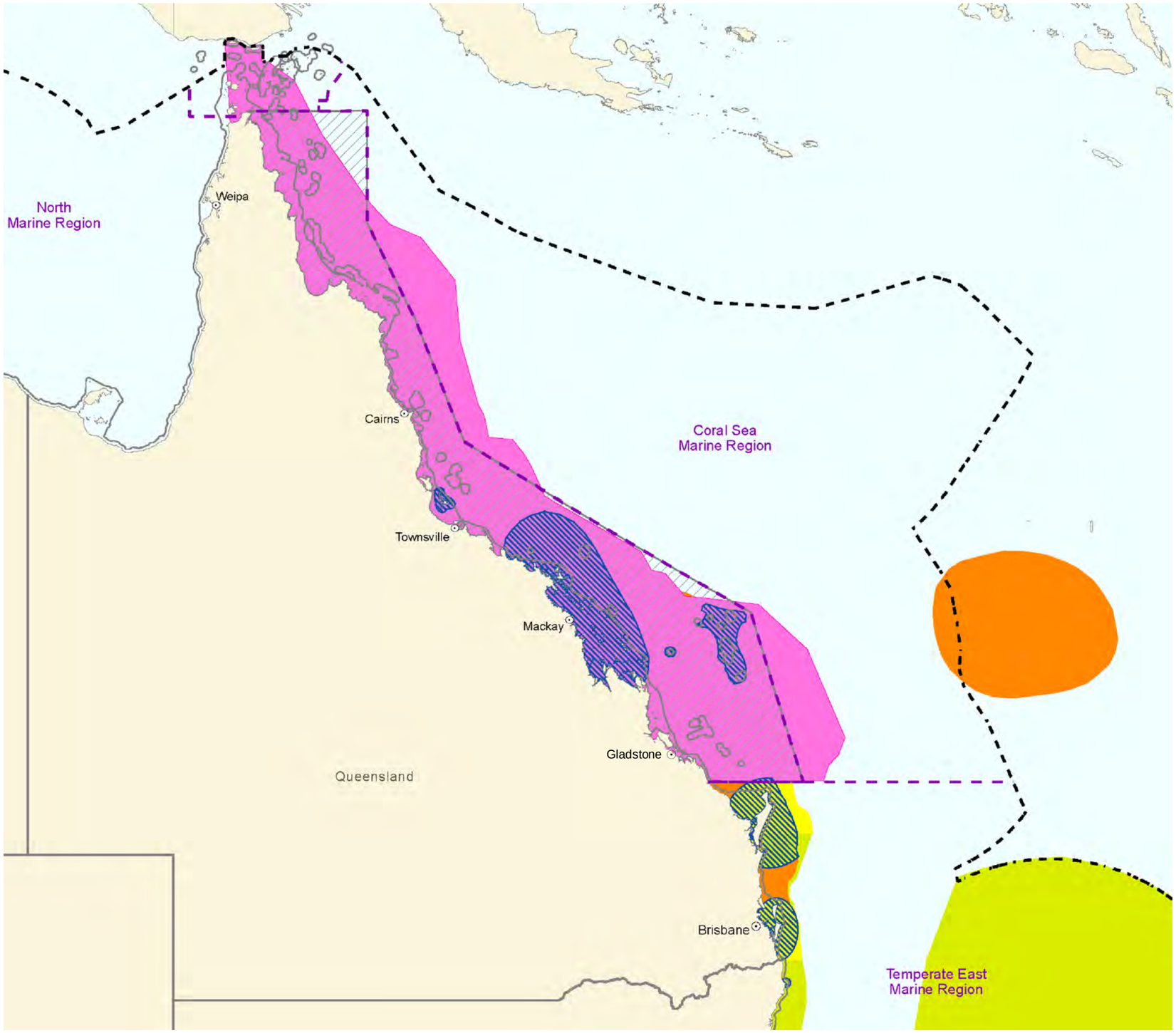
Waters off Port Curtis are known to support calving activities for the Humpback whale (refer Figure 15.7) and correspond with the migration routes of this species.

Shows the location of confirmed whale recordings within the regional search area (ALA 2019). Data has been sourced from the ALA which compiles species records collected from academic, scientific and environmental organisations. The data presented Figure 15.8 excludes records collected prior to 1980 and has been sourced from the National Marine Mammal Database, National Whale and Dolphin Sightings and Strandings Database, Ocean Biogeographic Information System, Queensland Wildlife Data (DES) and the Queensland Museum. The most recent whale recordings within the regional search area identified in the ALA (2019), were collected in 2012.

Table 15.6 provides a summary of whale recordings which have been identified within the regional search area between 1980 and 2012 (ALA 2019).

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Legend

Behaviour

- Calving known to occur
- Breeding known to occur
- Foraging known to occur
- Resting known to occur
- Migration known to occur
- Species known core range
- Other known aggregation area

Maritime boundaries

- Limit of coastal waters
- Marine region boundaries
- Limit of Australian exclusive economic zone
- Great Barrier Reef Marine Park

Source:
Department of the Environment (2015b)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_087.mxd 20/02/2018 22:27

0 120 240 Metres

Date: 20/02/2018 Version: 1 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.7: Important areas for the Humpback whale

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

Yeppoon
Rossiyn
Emu Park
Keppel Sands
Broadmount
Port Alma
Balaclava Island
Curtis Island
Marmor
Raglan
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Ambrose
Mount Larcom
Yarwun
Gladstone
Facing Island
Boyne Island
Tannum Sands
Calliope
Turkey Beach

Legend

- Western Basin Expansion reclamation area
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks dredged material placement area (DMPA)

Whale observations (2015)

- Dwarf Minke whale *(Balaenoptera acutorostrata)*
- Humpback whale *(Megaptera novaeangliae)*
- Sperm whale *(Physeter macrocephalus)*

Whale observations (2018)

- Dwarf minke whale *(Balaenoptera acutorostrata)*
- Humpback Whale *(Megaptera novaeangliae)*
- Sperm Whale *(Physeter macrocephalus)*

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Whale observations: National Research Infrastructure for Australia (NCRIS) (2015 and 2018) Atlas of Living Australia Database Search Tool viewed 11 February 2016

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_128.mxd 13/02/2019 19:43

0 5,500 11,000 Metres

Date: 13/02/2019 Version: 8 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.8: Whale observations within the regional search area

Table 15.6 Summary of whale recordings within the regional search area (1980 to 2012)

Scientific name	Common name	EPBC Act Status	NC Act Status	Count	Species dominance (% of occurrence)
Balaenoptera acutorostrata unknown subsp.	Dwarf minke whale	-	-	4	4.12
Balaenoptera borealis	Sei whale	V, M	LC	2	2.06
Balaenoptera musculus	Blue whale	E, M	LC	2	2.06
Megaptera novaeangliae	Humpback whale	V, M	V	87	89.7
Physeter macrocephalus	Sperm whale	M	LC	2	2.06
Totals				97	100

Table notes:
E Endangered V Vulnerable LC Least Concern Mig Migratory
- Not listed

Source: ALA 2019

Minke whale, Sei whale and Blue whale species distribution within Australian waters are shown in Figure 15.9, Figure 15.10 and Figure 15.11, respectively. There was no species distribution map within Australian waters for the Dwarf minke whale.

Figure 15.9 Minke whale distribution in Australian waters

Source: DoEE (2018e)

Figure 15.10 Sei whale distribution in Australian waters

Source: DoEE (2018f)

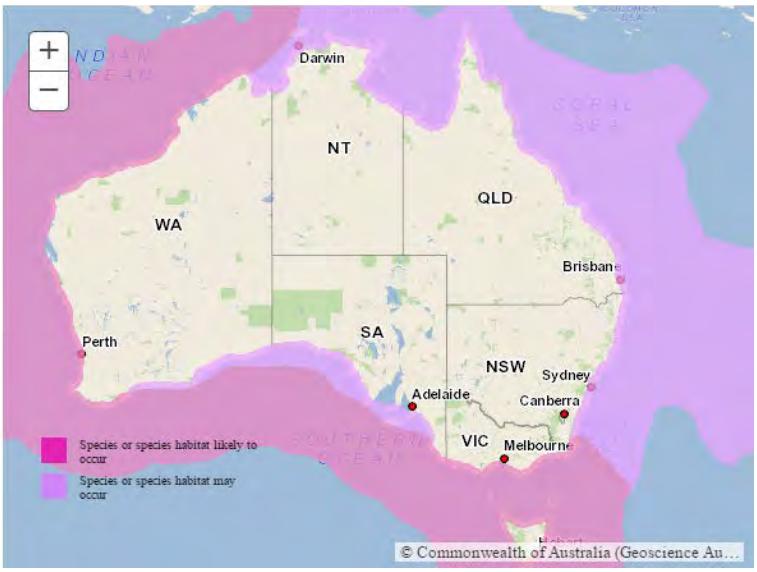


Figure 15.11 Blue whale distribution in Australian waters

Source: DoEE (2018g)

15.5.2 Whale strandings

Records of whale strandings in the Port Curtis and wider region are available from DES for the period 2004 to 2014 (refer Table 15.7) (Meager et al. 2012; EHP 2016b). As discussed in Section 15.2.1, for the purposes of the StrandNet database review, the search area spanned the coastline between Yeppoon in the north and Eurimbula in the south.

As discussed in Section 15.2, due to the nature of marine megafauna strandings (i.e. long distance movement or displacement of carcasses), it should be noted that historical StrandNet data has been cautiously reviewed in this assessment, and this data is not considered a reliable indicator of species presence and/or abundance.

No more than three individual whales were recorded as stranded within the search area in one year. Of the species that could be identified, four whale species (i.e. Sperm whale, Humpback whale, Pygmy sperm whale (*Kogia breviceps*) and Strap-toothed whale (*Mesoplodon layardii*)) were recorded stranded within search area between 2004 to 2014 (DEHP 2016b).

Table 15.7 Whale stranding records for Port Curtis and wider region (2004 to 2014)

Year	Found in the Port Curtis region: Port Curtis, Curtis Island, Facing Island or Rodds Bay	Found in the wider area StrandNet search area: Port Alma to Yeppoon, Rodds Bay to Eurimbula	Total
2004	1 x Sperm whale	1 x Humpback whale 1 x Strap-toothed whale	**3**
2005	0	0	**0**
2007	0	0	**0**
2008	1 x Unidentified	0	**1**
2009	0	0	**0**
2010	1 x Humpback whale	0	**1**
2011	1 x Humpback whale	1 x Humpback whale	**2**
2012	0	1 x Humpback whale	**1**
2013	1 x Sperm whale	1 x Pygmy sperm whale	**2**
2014	0	0	**0**
Total	**5 individuals**	**5 individuals**	**10 individuals**

Source: StrandNet data (EHP 2016b)

15.6 Dolphins

Analysis of environmental databases indicates that 10 dolphin species are known, or are predicted to occur within Project EIS search area (defined in Section 15.2.1) (refer Table 15.8). The likelihood of occurrence of dolphin species included on the Fitzroy NRM BoT species prioritisation framework within the Project EIS search area are listed in Appendix K (Table 2).

Table 15.8 Dolphin species known or predicted to occur within the Project EIS search area

Scientific name	Common name	EPBC Act	NC Act	Data source			
				EPBC Act PMST	Wildnet data	Atlas of Living Australia^	Cagnazzi 2015a; 2015b; 2016; 2017
Delphinus delphis	Common dolphin	-	LC	✓	-	-	✓
Grampus griseus	Risso's dolphin	-	LC	✓	-	✓	-
Orcinus orca	Killer whale	M	LC	✓	-	-	-
Pseudorca crassidens	False killer whale	-	LC	-	-	✓	-
*Sousa sahulensis**	Australian humpback dolphin	M	V	✓	✓	✓	✓
Stenella attenuata	Pantropical spotted dolphin	-	LC	✓	-	-	-
Stenella longirostris	Spinner dolphin	-	LC	-	-	-	✓
Tursiops aduncus	Indian Ocean bottlenose dolphin	-	LC	✓	✓	✓	✓
Tursiops truncatus s. str.	Coastal bottlenose dolphin	-	LC	✓	-	✓	✓

Table notes:

E Endangered V Vulnerable LC Least Concern Mig Migratory
- Not listed
[+] formerly known as Irrawaddy dolphin (*Orcaella brevirostris*)
* formerly known as Indo-Pacific humpback dolphin (*Sousa chinensis*)
^ Regional search area applied
PMST Protected Matters Search Tool

Source: DoEE (2019); DES (2019); ALA (2019); Cagnazzi (2015a; 2015b; 2016)

Although 10 species of dolphin are predicted to potentially occur within the Project EIS search area (i.e. those species listed in Table 15.8), only three species of coastal dolphin (i.e. Australian humpback dolphin, Coastal bottlenose dolphin and the Indian Ocean bottlenose dolphin) are frequently encountered within the vicinity of Port Curtis (GPC 2012; GHD 2009d; GHD 2011a; GHD 2011b; Blue Planet Marine 2013; Cagnazzi 2013; 2015a; 2015b; 2016). Further information on the dolphin species frequently encountered within Port Curtis is provided below.

15.6.1 Australian humpback dolphin (*Sousa sahulensis*)

The Australian humpback dolphin (refer Photograph 15.1) is characterised by a robust and medium sized body with a short, slightly recurved and triangular-shaped dorsal fin. Colouration is uniformly grey, with flanks shading to off-white. Age related changes include a loss of grey colour (shading to white or pinkish) and increased ventral spotting in older animals (Ross 2002). In Australian waters, male Australian humpback dolphins are recorded to attain lengths of 2.62m, while females have measured up to 2.6m (Ross 2002).

Photograph 15.1Australian humpback dolphin (*Sousa sahulensis*)

Source: EHP (2015)

Adult Australian humpback dolphins may be found singly or in pairs, while immature individuals tend to associate with groups containing more than one adult. Group size is generally four to seven individuals, but may be as large as 25 (Ross 2002). Larger Australian humpback dolphin groups are comprised of all age classes, with adults representing between one half and two thirds of the group (Jefferson and Karczmarski 2001).

Australian humpback dolphins inhabit shallow coastal, estuarine, and occasionally riverine habitats, in tropical and subtropical regions. The species usually occurs close to the coast, generally in depths of less than 20m, but they have been seen 55km offshore in shallow water (Corkeron et al. 1997; Jefferson 2000). The species distribution within Australian waters is shown in Figure 15.12.

Figure 15.12 Australian humpback dolphin distribution in Australian waters

Source: DoEE (2018h)

Dolphin surveys conducted within the Port Curtis and Port Alma regions recorded the Australian humpback dolphin as the most frequently encountered dolphin species throughout the survey area (refer Section 15.2.3) (Cagnazzi 2017). During these surveys, a large number of sightings of Australian humpback dolphins were observed throughout The Narrows, however, it was noted that the extent to which this species uses The Narrows is not yet fully understood (Cagnazzi 2017).

Female Australian humpback dolphins mature at about 10 years of age, and males at about 13 years (Jefferson and Karczmarski 2001; Ross 2002). Individuals may live to more than 40 years old (Bannister et al. 1996; Ross et al. 1994).

Calves may be born throughout the year, but spring and summer peaks are reported for many parts of their range (Jefferson and Karczmarski 2001). Gestation lasts between 10 and 12 months (Cockcroft 1989) and calving interval has been estimated as three years in South Africa (Kaczmarksi 1996; 1999). Reproductive data derived from Australian and South African dolphins indicate that the length and weight at birth range between 0.97 to 1.08m and around 14 kilograms (kg), respectively. Australian humpback dolphins are thought to be opportunist-generalist feeders, eating a wide variety of coastal and estuarine-associated fishes, although reef, littoral and demersal fish species are also taken. Bony fish, some cephalopods and crustaceans have also been recorded as prey. Australian humpback dolphins are recorded feeding in association with prawn trawlers in Moreton Bay and presumably elsewhere throughout the species' range in Australia (Bannister et al. 1996; Ross et al. 1994). Feeding may occur in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and/or coral reefs. Feeding primarily occurs in shallow waters (< 20m depth) and may incorporate beaching behaviour on sandbanks.

15.6.2 Coastal bottlenose dolphin (*Tursiops truncatus* s. str.)

The Coastal bottlenose dolphin (refer Photograph 15.2) has a medium-sized, robust body with a short rostrum and well marked melon. They have a moderately tall and falcate (sickle-shaped) dorsal fin. The coloration is generally dark grey in the dorsal cape with a paler grey dorsal overlay extending onto the flanks, and an off-white ventral area. In eastern Australia, a blaze in the dorsal cape has been recorded. The blaze is indented at the level of the dorsal fin by a posterior pointed blaze which extends from the light grey lateral side (Hale et al. 2000).

Photograph 15.2Coastal bottlenose dolphin (*Tursiops truncatus* s. str.)

Source: ALA (2014)

Coastal bottlenose dolphins live in fission-fusion societies, where groups fuse into larger units and split into smaller ones, with stable, long term associations between same-sex individuals (Connor et al. 2000). The size of Coastal bottlenose dolphin groups is highly variable. Mean group sizes range from about five individuals (Irvine et al. 1981) up to about 140 animals (Saayman and Tayler 1973). In offshore waters of the eastern Pacific Ocean, aggregations estimated to contain as many as 10,000 individual dolphins have also been observed (Scott and Chivers 1990). Very little information is available on the social structure of offshore Coastal bottlenose dolphins.

Coastal bottlenose dolphins inhabit inshore areas such as bays, lagoons, fjords and estuaries, and nearshore (open coast) and offshore environments, including the coast of oceanic islands (Reynolds et al. 2000). They are associated with many types of substrate and habitats, including mud, sand, seagrasses, mangroves and reefs (Barros and Wells 1998). The species distribution of the Coastal bottlenose dolphin within Australian waters is shown in Figure 15.13.

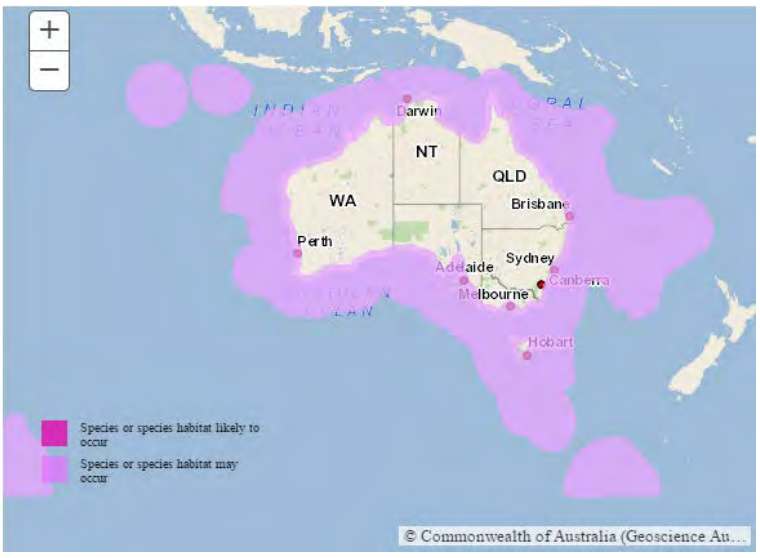


Figure 15.13 Coastal bottlenose dolphin distribution in Australian waters

Source: DoEE (2018j)

Female Coastal bottlenose dolphins become sexually mature at five to 13 years of age and males at eight to 12 years of age (Wells and Scott 2002). Females appear to live longer than males, reaching more than 50 years of age compared to 45 years for males (Wells and Scott 1999). There is high calf mortality and an exponentially increasing risk of senescent mortality (Stolen and Barlow 2003). In several non-Australian populations, calving is known to peak in spring and summer or spring and autumn (Wells and Scott 2002). Gestation is about 12 months. The mating system is believed to be promiscuous (Wells et al. 1987). After becoming sexually mature, females may give birth to calves every three to six years (Wells and Scott 1999; 2002).

Coastal bottlenose dolphins feed mainly on a variety of fish and invertebrates from both the littoral and sub-littoral zones, while offshore animals feed primarily on mesopelagic fish and oceanic squids (Reyes 1991). They usually feed individually, but cooperative feeding is also observed.

15.6.3 Indian Ocean bottlenose dolphin (*Tursiops aduncus*)

The Indian Ocean bottlenose dolphin (refer Photograph 15.3) closely resembles the Coastal bottlenose dolphin in appearance. The Indian Ocean bottlenose dolphin can be distinguished from the Coastal bottlenose dolphin by the absence of a blaze on the dorsal cape (Hale et al. 2000).

Photograph 15.3Indian Ocean bottlenose dolphin (*Tursiops aduncus*)

Source: ALA (2010)

The Indian Ocean bottlenose dolphin lives in fission-fusion societies, with mean group sizes ranging between 5 and 16 individuals (DoEE 2018k). The species demonstrates long term associations between same-sex individuals (Connor et al. 2000). The Indian Ocean bottlenose dolphin has been observed in mixed groups with the Australian humpback dolphin and is known to associate with whale species, including the Humpback whale (DoEE 2018k).

In Australia, the Indian Ocean bottlenose dolphin is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters, including coastal areas around oceanic islands (Hale et al. 2000). The species distribution within Australian waters is shown in Figure 15.14.

Figure 15.14 Indian Ocean bottlenose dolphin distribution in Australian waters

Source: DoEE (2018k)

15.6.4 Surveys during Western Basin Dredging and Disposal Project

Within the Gladstone region, aerial and boat-based surveys conducted by GHD (2011a; 2011b) (refer Figure 15.15) resulted in the recording of 81 dolphins (including the Australian humpback, Australian snubfin and inshore Bottlenose dolphins). The survey area covered by GHD (2011a; 2011b) extended from the Fitzroy River entrance (Port Alma) to the southern region of Rodds Bay, encompassing eastern Curtis and Facing Island. For the purposes of the study the survey area was divided into five zones including; Port Alma, The Narrows, Port Curtis, Rodds Bay and Eastern Curtis, and Facing Island.

GHD reported that dolphins were observed to occur in association with recreational vessel traffic, which was widespread throughout much of the survey area, particularly in The Narrows and Port Curtis. Dolphins were observed to be present in association with anthropogenic activities such as commercial fishing, slow shipping movements, ferries used for transporting construction crews and adjacent (west) to the Curtis Island LNG development site.

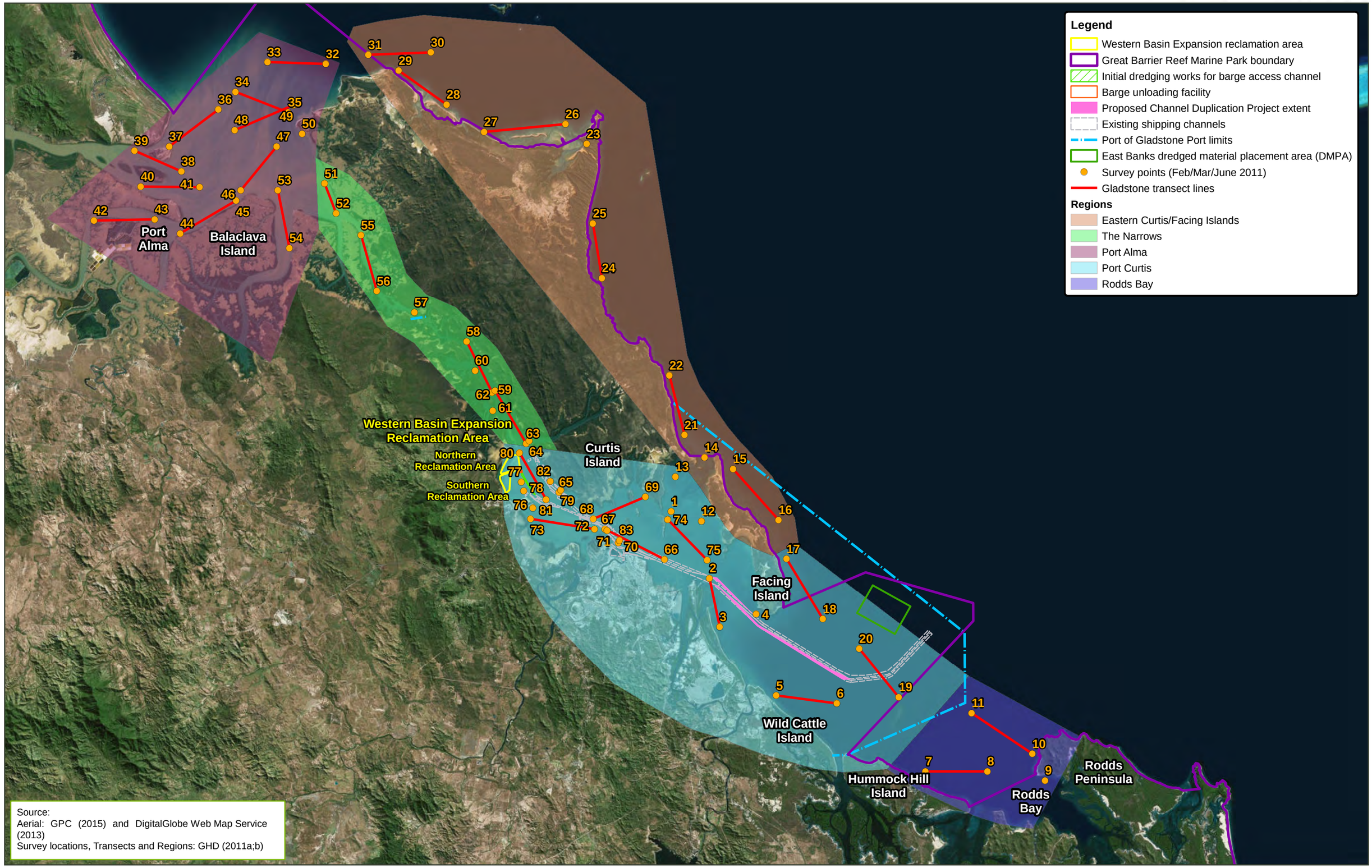
During these surveys, dolphins were not recorded in the presence of pile driving or rock dumping activity. The average group size of Australian humpback dolphins observed on boat-based surveys was 3.5 individuals, with the majority of groups sighted in Port Curtis. During the WBDDP, Australian humpback dolphins were sighted in all survey regions. Australian humpback dolphins were the most frequently observed species on boat-based surveys with 25 groups comprising 85 sightings. A total of 34 Australia snubfin dolphins were observed during the boat-based surveys with all Australian snubfin dolphin groups (n=8) being sighted in Port Alma and to the north of Curtis Island (adjacent to Port Alma). Two inshore Coastal bottlenose dolphins were observed north of Curtis Island (GHD 2011b).

Some density change in species was detected between aerial surveys with an increase in sightings of Australian humpback dolphins and Australian snubfin dolphins. Changes were most notable in the southern region of the survey area in Rodds Bay and Port Curtis (GHD 2011b).

Marine megafauna were not observed to occur within the immediate coastal construction sites adjacent to Curtis Island, however they were observed to be present (in low numbers) near the recently developed reclamation bund wall and barge landing facility in Graham's Creek, which was consistent with historic records. The area north east of the Calliope River and south of Graham's Creek has undergone substantial changes over recent years due to infrastructure development. This area was observed to have reduced presence of dolphins compared to historic surveys (GHD 2011b) suggesting an indirect impact of habitat displacement has likely occurred.

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Survey locations, Transects and Regions: GHD (2011a;b)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_078.mxd 13/02/2019 15:35

Metres
0 3,850 7,700

Date: 13/02/2019 Version: 11 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.15: Location of boat-based marine megafauna transects indicating the five regions

15.6.5 Australian snubfin and Australian humpback dolphin surveys in Port Curtis and Port Alma (2014 to 2016)

As described in Section 15.2.3, in order to increase the understanding of the status of the Australian humpback dolphin and the Australian snubfin dolphin in the Port Curtis and Port Alma regions, dolphin mark-recapture (photo-identification) surveys were conducted over the period of 2014 to 2016, extending on previous baseline programs (Cagnazzi 2015b).

In total, five species of dolphin (i.e. Australian humpback dolphin, Australian snubfin dolphin, Coastal bottlenose dolphin, Common dolphin (*Delphinus delphis*) and Spinner dolphin (*Stenella longirostris*)) were identified during surveys conducted between 2014 and 2016 (Cagnazzi 2016).

Dolphin surveys conducted within the Port Curtis and Port Alma regions recorded the Australian humpback dolphin as the most frequently encountered dolphin species throughout the survey area (refer Section 15.3.2) (Cagnazzi 2017). During these surveys, a large number of sightings of Australian humpback dolphins were observed throughout The Narrows (refer Figure 15.16). Australian snubfin dolphins were recorded only in the northern section of The Narrows (Cagnazzi 2017) (refer Figure 15.17). It was noted that the extent to which both of these species use The Narrows is not yet fully understood (Cagnazzi 2017).

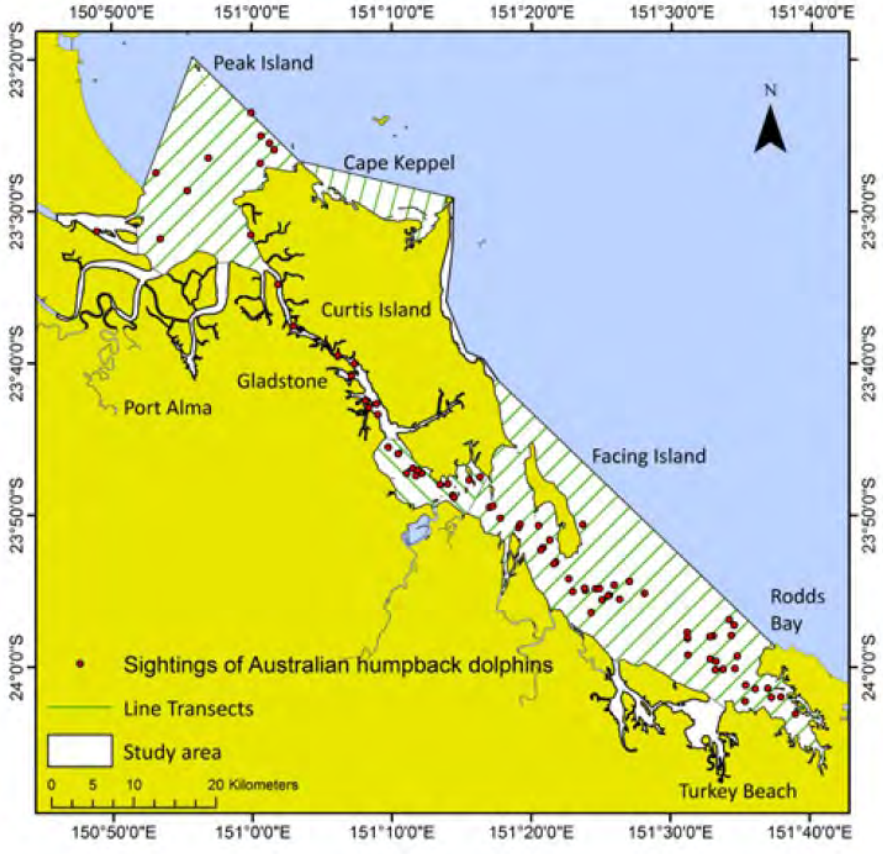


Figure 15.16 **Distribution of groups of Australian humpback dolphins sighted in the Ecosystem Research Monitoring Program survey area during boat-based surveys using line transects in 2016**

Source: Cagnazzi (2016)

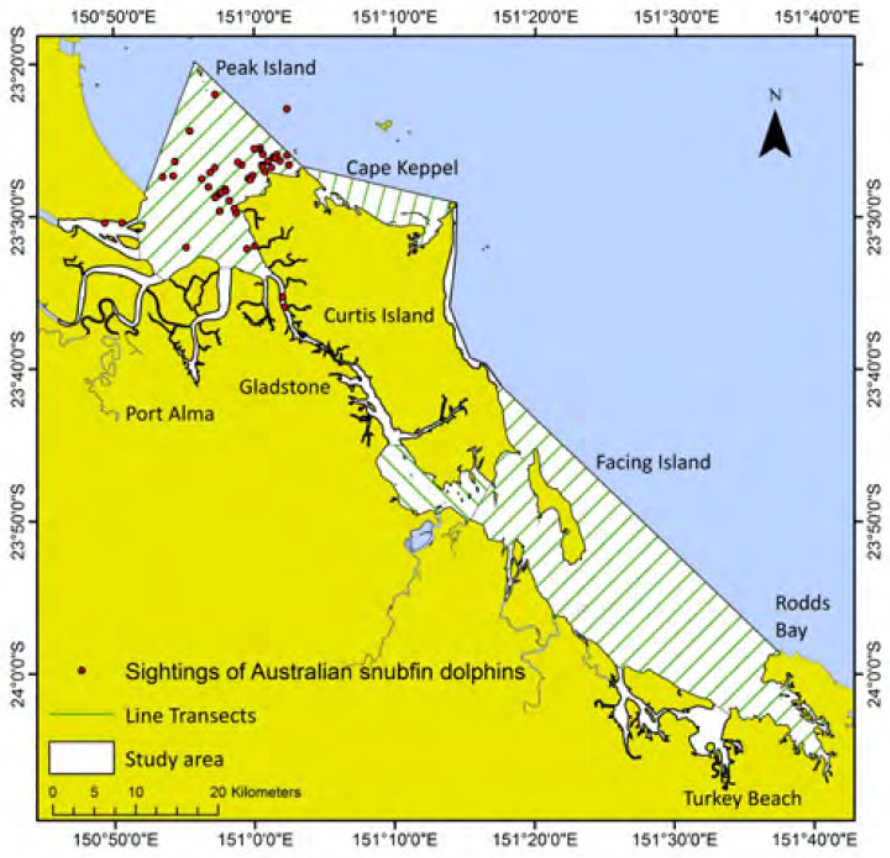


Figure 15.17 **Distribution of groups of Australian snubfin dolphins sighted in the ERMP survey area during boat-based surveys using line transects in 2016**

Source: Cagnazzi (2016)

Review of data collected in the 2015 survey suggests that Australian humpback dolphins and Australian snubfin dolphins do not frequently use the waters along the east of Curtis island. All groups of Coastal bottlenose, Spinner and Common dolphins were recorded off Curtis Island and Facing Island (Cagnazzi 2015b).

Relatively few Coastal bottlenose dolphins, Spinner dolphins and Common dolphins were observed within the survey area, hence the 2014-2016 mark-recapture surveys focussed on Australian snubfin and Australian humpback dolphins (Cagnazzi 2015a; 2015b; 2016).

Both the Australian snubfin dolphin and the Australian humpback dolphin were most commonly observed in groups of less than six individuals, although some larger groups were also observed (Cagnazzi 2015a). During the three year study period (2014-2016), a total of 181 and 122 individual Australian humpback dolphins and Australian snubfin dolphins were identified respectively (Cagnazzi 2017). Population estimates were derived from this data, and indicate that approximately 140 to 162 adult Australian humpback dolphins, and 100 to 163 adult Australian snubfin dolphins used the survey area between May and September each year (Cagnazzi 2017).

Biopsy samples were also collected during these surveys from Australian humpback dolphins and Australian snubfin dolphins for genetic, toxicological, and heavy metal analysis (Cagnazzi 2015a).

Further there were a small number of dugongs that were incidentally observed during the 2014 to 2016 mark recapture dolphin surveys of the Port Alma and Port Curtis area (Cagnazzi 2015a; Cagnazzi 2015b) (refer Section 15.3.1).

15.6.6 Dolphin strandings

Records of dolphin strandings in the Port Curtis and wider region are available from the former DEHP StrandNet database for the period 2004 to 2014 (refer Table 15.9). As discussed in Section 15.2.1, for the purposes of the StrandNet database review, the search area spanned the coastline between Yeppoon in the north, to Eurimbula in the south.

As discussed in Section 15.2.1, due to the nature of marine megafauna strandings (i.e. long distance movement or displacement of carcasses), it should be noted that historical StrandNet data has been cautiously reviewed in this assessment, and this data is not considered a reliable indicator of species presence and/or abundance.

For the period 2004 to 2014, Meager et al. (2012) and the former EHP (2016b) indicated that within the region between Yeppoon and Eurimbula, dolphin strandings were greatest in 2011, representing 12.1% of the total State wide strandings for that year (Meager et al. 2012). Of these strandings, four were recorded as being within either Port Curtis, Curtis Island, Facing Island or Rodds Bay.

No dolphin strandings were identified in 2014, however stranding rates are variable between years. Of the species that could be identified, five different dolphin species (i.e. Australian humpback dolphin, Australian snubfin dolphin, Indo-Pacific bottlenose dolphin, Pantropical spotted dolphin (*Stenella attenuate*), and False killer whale (*Pseudorca crassidens*)) have been recorded as stranded within the search area.

Table 15.9 Dolphin stranding records for the Port Curtis and wider region (2004 to 2014)

Year	Found in the Port Curtis region: Port Curtis, Curtis Island, Facing Island or Rodds Bay	Found in the wider area: Port Alma to Yeppoon, Rodds Bay to Eurimbula	Total
2004	2 x Australian humpback dolphin 1 x Unidentified bottlenose dolphin species	0	**3**
2005	3 x Australian humpback dolphin	1 x Australian snubfin dolphin 1 x Indo-Pacific bottlenose dolphin	**5**
2006	2 x False killer whale	0	**2**
2007	1 x Australian snubfin dolphin 2 x Indo-Pacific bottlenose dolphin	1 x Australian humpback dolphin	**4**
2008	1 x Australian humpback dolphin	1 x Australian humpback dolphin	**2**
2009	0	1 x Unidentified species	**1**
2010	1 x Unidentified dolphin	1 x Australian snubfin dolphin	**2**
2011	4 x Australian humpback dolphin	1 x Australian humpback dolphin 1 x Australian snubfin dolphin 1 x Pantropical spotted dolphin	**7**
2012	1 x Australian humpback dolphin	2 x Australian humpback dolphin 1 x Indo-Pacific bottlenose dolphin	**4**
2013	1 x Australian humpback dolphin	1 x Indo-Pacific bottlenose dolphin 1 x Australian snubfin dolphin	**3**
2014	0	0	**0**
Total	**19 individuals**	**14 individuals**	**33 individuals**

Source: StrandNet data (EHP 2016b)

15.7 Dugong

In Australia, Dugongs (*Dugong dugon*) are protected as a migratory species under the EPBC Act and are considered a MNES. The dugong is also listed as a vulnerable species under the NC Act and as a critical priority under the Queensland Government's BoT species prioritisation framework (refer Appendix K). The international significance of Australia's dugong populations was made explicit in 1981 when the Great Barrier Reef was declared a WHA, by recognising that one of the World Heritage values of the Great Barrier Reef is that it provides major feeding grounds for large populations of the threatened dugong species (Anon 1981).

The information in this section has been largely sourced from the key review report of the status of dugongs within the Gladstone area undertaken by Sobtzick et al. (2013), as well as more recent studies on dugong habitat and usage conducted by Rasheed et al. 2017. The following section summarises and analyses the findings from:

- Dedicated dugong aerial surveys
- Spatially-explicit population models of relative dugong density
- Dugong satellite tracking surveys
- Incidental dugong sightings
- Evidence of dugong feeding trails recorded during seagrass monitoring
- Historical anecdotal evidence.

15.7.1 Dugong biology

The dugong is predominantly herbivorous and is strictly a marine mammal. It is the only extant species in the family Dugongidae (WoRMS 2018). Together with three species of manatee (Trichechidae), dugongs form the order Sirena (commonly referred to as sea cows) (Illiger 1811).

Dugongs are long-lived animals with late maturity, low fecundity, and a low potential rate of population increase even under ideal conditions. Adult survivorship needs to be very high (> 95% per annum) for dugong numbers to be maintained (Marsh et al. 2011).

Dugongs spend most of their time beneath the surface of the water and generally surface cryptically and only for one to two seconds (Chilvers et al. 2004).

Seagrasses are undoubtedly the most important component of dugongs' diet, however, this can be supplemented with algae and invertebrate animals such as shellfish, sea squirts, and polychaete worms. Most, if not all, seagrass species that occur in their range are consumed by dugongs, including species from the following genera *Halodule, Halophila, Zostera, Thalassia, Thalassodendron* and *Enhalus*.

The seagrass communities of Port Curtis and Rodds Bay are of regional significance, functioning as important habitat for the dugong (Lanyon 1991; Preen 1995). The area of Port Curtis from Rodds Bay to The Narrows was declared a DPA in 1997 to recognise the importance of this seagrass habitat to dugong populations.

Five seagrass species known to be consumed by the dugong were identified during the 2014 seagrass surveys conducted within Port Curtis and the Rodds Bay DPA as part of the Project EIS baseline surveys. These species included *H. decipiens, H. ovalis, H. spinulosa, H. uninervis, and Z. mulleri* subsp. *capricorni* (Carter et al. 2015).

Two different dugong feeding modes have been described:

- Excavating, where the animal consumes the entire plant, including rhizomes
- Cropping, where only the above ground parts of the plant are consumed (Marsh et al. 2011)

Dugongs mostly use excavating when feeding on seagrasses with accessible rhizomes, but may use cropping when rhizomes are difficult to excavate (e.g. depending on the seagrass morphology or the nature of the sediment) (Marsh et al. 2011).

Dugongs occur in the waters of many countries, including tropical and subtropical coastal and inland waters from east Africa to Vanuatu. Throughout much of its range, the Dugong is represented by relict populations separated by large areas where its numbers have been greatly reduced, or the species is already extirpated. A significant proportion of the world's dugongs are found in northern Australian waters from Moreton Bay in the east to Shark Bay in the west. In the area which extends from Cooktown in the north to the Queensland/New South Wales border in the south (also referred to as 'urban' coastal waters of Queensland), dugongs are sparsely dispersed compared with populations in the northern Great Barrier Reef and the Torres Strait. This is not surprising considering the small known area of shallow seagrass (< 15m) south of Cooktown (< 2,000km^2), compared to the northern regions with approximately 15,000km^2 of known seagrass area (McKenzie et al. 2010).

15.7.2 Dugong conservation status

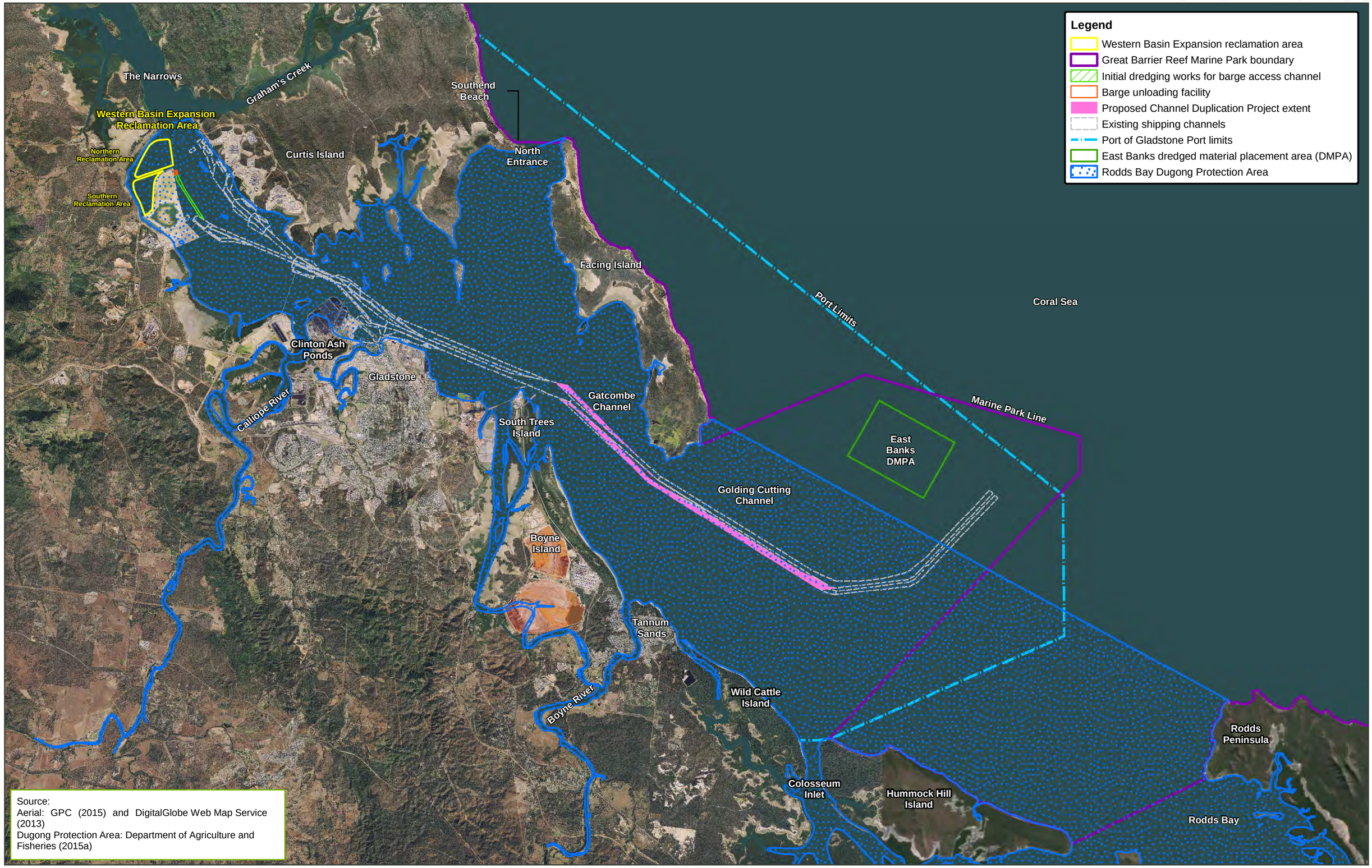
All extant members of the order Sirenia, including the Dugong, are listed as vulnerable to extinction at a global scale by the International Union for Conservation of Nature (IUCN) (2018). As charismatic megafauna, the dugong is also an 'umbrella species', which relates to species 'with large area requirements which, when given sufficient protected area, will bring many other species under protection' (Jones and Kaly 1995) for the conservation of tropical coastal environments throughout much of the Indo-West Pacific.

In Australia, dugongs are protected as a migratory species and a MNES under the EPBC Act, which provides the legal framework to protect and manage MNES and provides a streamlined national assessment and approval process for activities that are likely to significantly impact on MNES. Further protection in Queensland includes listing dugongs as a vulnerable species in the *Nature Conservation (Wildlife) Regulation 2006* (Qld) under the NC Act. The international significance of Australia's dugong populations was made explicit in 1981 when the Great Barrier Reef was declared a World Heritage Area, by recognising that one of the World Heritage values of the Great Barrier Reef is that it 'provides major feeding grounds for large populations of the threatened species *Dugong dugon*' (Anon 1981). Nonetheless, a recent international assessment of the dugong's status by Marsh et al. (2011) concluded that the dugong population on the urban coast of Queensland met the IUCN criteria for critically endangered.

In August 1997, the Great Barrier Reef Ministerial Council recognised the importance of several areas along the Queensland coast to support significant dugong populations by announcing a chain of DPAs in the southern Great Barrier Reef. Seven DPAs A and eight DPAs B (which differ in restrictions referring to fishing practices) cover a total of 4,650km^2 along the southern Great Barrier Reef coastline. One of them, Rodds Bay, is a DPA B located within Port Curtis, from The Narrows to Rodds Bay (refer Figure 15.18). The benefits of DPAs were significantly enhanced under the *Great Barrier Reef Marine Park Zoning Plan 2003*, which increased the proportion of strictly protected zones in the GBRMP from less than 5% to over 33% (GBRMPA 2014).

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Dugong Protection Area: Department of Agriculture and Fisheries (2015a)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_110.mxd 13/02/2019 15:37

0 1,900 3,800 Metres

Date: 13/02/2019 Version: 8 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.18: Rodds Bay Dugong Protection Area

15.7.3 Summary of available datasets

15.7.3.1 Results of aerial surveys in Port Curtis region

There have been numerous dedicated dugong aerial surveys conducted within the Port Curtis region since 1986. Six of these surveys have been conducted by JCU TropWATER within the Port Curtis region, including surveys conducted in 1986, 1992, 1994, 1999, 2005 and 2011. Aerial surveys in the Port Curtis region were also undertaken as part of the WBDDP EIS and consisted of a series of three surveys completed by GHD over a period of nine months from 2008 to 2009 (GHD 2009d).

Figure 15.19a and Figure 15.19b illustrate the transects flown across the Gladstone region, during aerial surveys conducted by JCU TropWATER (1986-2011) and GHD (2009d).

These aerial surveys were designed to investigate the spatial patterns of abundance and temporal trends in dugong populations (Sobtzick et al. 2013). Due to the large-scale movements of dugong and their response to changes in habitat availability and quality, aerial surveys are not designed to investigate relative abundance at local spatial scales (e.g. Port Curtis and Rodds Bay) and tend towards underestimating actual population size, providing standardised minimum estimates only (Marsh and Sinclair 1989a, 1989b; Marsh et al. 2002; 2011; Sobtzick et al. 2013).

The sighting distribution of dugong varied between surveys, with the highest number of dugong in Port Curtis and Rodds Bay recorded by GHD in 2009 with 19 sightings, and abnormally low numbers of dugong sighted in the same area during 2011 (JCU TropWATER), likely as a result of extreme weather events restricting visibility (Sobtzick et al. 2013). The results of the JCU TropWATER and GHD surveys are shown in Figure 15.20 and Figure 15.21, respectively.

15.7.3.2 Population estimates

The JCU TropWATER dugong survey data (1986 to 2011) was utilised to estimate population size for the urban coastal waters of Queensland. Results for blocks S2 and S3 (refer Figure 15.19a) are summarised in Table 15.10. However, as aerial surveys are confounded by movements of animals, such surveys are not suited for analyses at local spatial scales, such as individual blocks, and the results presented must be understood in a wider context. Numbers of dugong sightings per survey were low in individual surveys, resulting in population estimates with wide standard errors (i.e. high uncertainty) (Sobtzick et al. 2013).

Dugong population size estimates from aerial surveys showed large standard errors and variations between surveys. At local spatial scales (e.g. individual bays or ports), dugong population sizes fluctuate due to animal movements (Marsh and Lawler 2007). Variations in relative distribution between dedicated aerial surveys may at least be partially attributed to such movements either within a survey region or between regions, driven either by changes in sea surface temperature (seasonal differences) or changes in seagrass distribution (inter-annual differences) (Sobtzick et al. 2013).

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

Cawarral
Emu Park
Mount Chalmers
Keppel Sands
Broadmount
Bajool
Marmor
Raglan
Curtis Island
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Ambrose
Mount Larcom
Yarwun
Gladstone
Facing Island
Boyne Island
Tannum Sands
Calliope
Turkey Beach
Seventeen Seventy
Bororen

Legend

- Western Basin Expansion reclamation area
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks dredged material placement area (DMPA)

Transects

- JCU only
- JCU and GHD

Survey sections

- S2
- S2A
- S3

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Dugong survey sections layer: Sobtzich et al. (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_084A.mxd 13/02/2019 15:39

0 5,000 10,000 Metres

Date: 13/02/2019 Version: 14 Job No: 237374

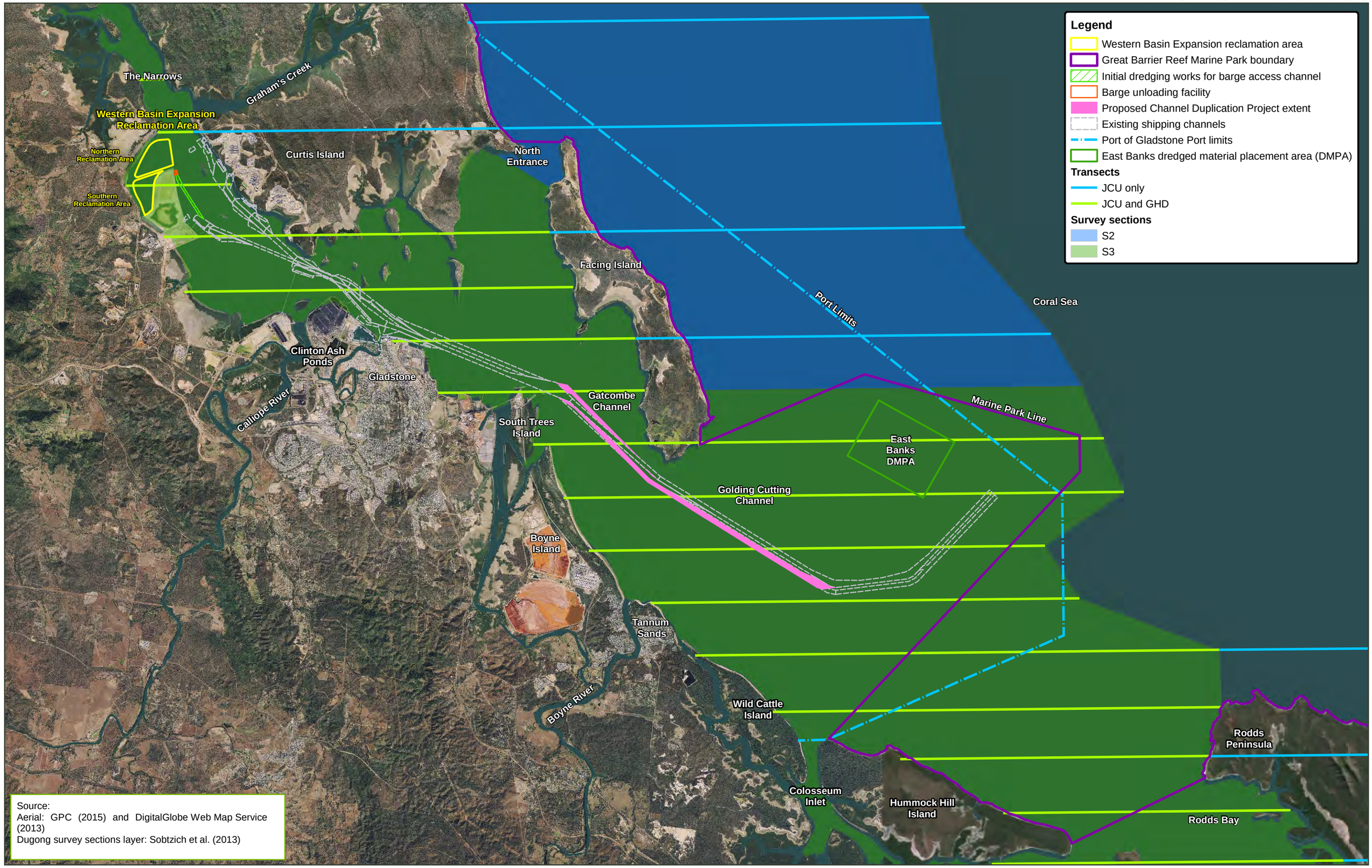
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.19a: Transects flown during aerial surveys conducted by JCU TropWATER (1986 to 2011) and GHD (2009) (Overview)

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Dugong survey sections layer: Sobtzich et al. (2013)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_0848.mxd 13/02/2019 15:42

0 1,900 3,800 Metres

Date: 13/02/2019 Version: 12 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.19b: Transects flown during aerial surveys within the Gladstone region conducted by JCU TropWATER (1986 to 2011) and GHD (2009)

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

The Narrows
Graham's Creek
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Curtis Island
North Entrance
Facing Island
Port Limits
Coral S
Clinton Ash Ponds
Gladstone
Calliope River
Gatcombe Channel
South Trees Island
Marine Park Line
East Banks DMPA
Golding Cutting Channel
Boyne Island
Tannum Sands
Boyne River
Wild Cattle Island
Rodds Peninsula
Colosseum Inlet
Hummock Hill Island
Rodds Bay

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)

Dugong sightings

November 1986
- 1

November/December 1992
- 1
- 2 - 4

November 1984
- 1
- 2

October/December 1999
- 1
- 2

November 2005
- 1
- 2
- 3

November 2011
- 1

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Dugong sightings layer: Sobtzich et al. (2013)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_085.mxd 13/02/2019 15:43

0 1,900 3,800 Metres

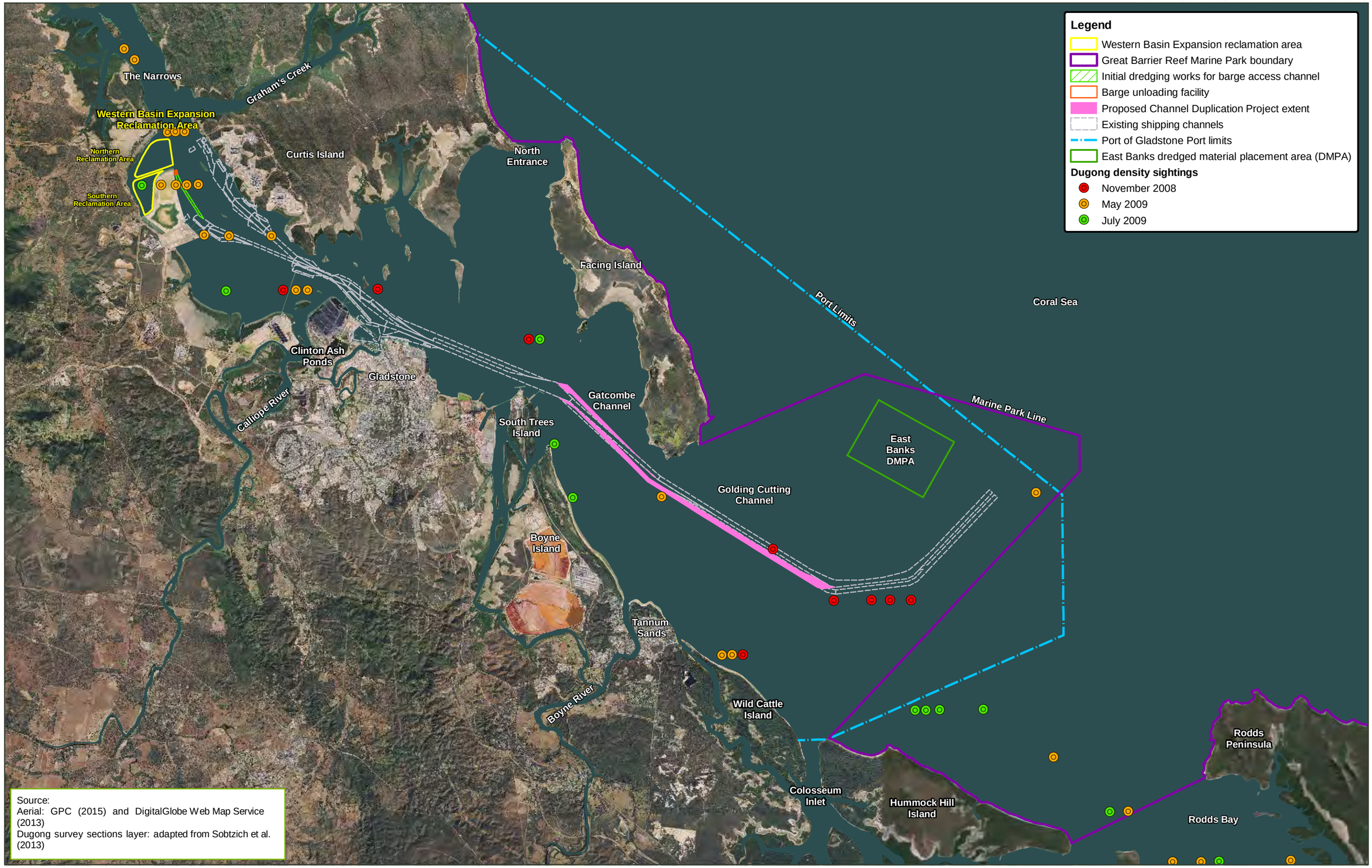
Date: 13/02/2019 Version: 12 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.20: Dugong sightings and group sizes during JCU TropWATER aerial Dugong and megafauna surveys (1986 to 2011)

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Dugong survey sections layer: adapted from Sobtzich et al. (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_111.mxd 13/02/2019 15:46

0 1,900 3,800 Metres

Date: 13/02/2019 Version: 9 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.21: Dugong density sightings during aerial surveys conducted by GHD

Table 15.10 Summary of dugong population size estimations from aerial surveys conducted by James Cook University between 1987 and 2011

Block (area)	Marsh and Sinclair (1989)						Pollock et al. (2006)		Hagihara method		
	1987	1992	1994	1999	2005	2011	2005	2011	2005	2011	2016
S2 (836km^2)	0	94 (± 50)	0	0	tfs	0	tfs	0	tfs	0	tfs
S3 (1,021km^2)	301 (± 95)	91 (± 60)	104 (± 56)	55 (± 37)	183 (± 66)	tfs	116 (± 64)	tfs	134 (± 82)	tfs	tfs

Table notes:
Historical data from Marsh and Saalfeld (1990a, b); Marsh et al. (1996; 2004); Marsh and Lawler (2001; 2007).
Hagihara method data from Sobtzick et al. (2015) and Sobtzick et al. 2017)
tfs = too few sightings

Source: Sobtzick et al. (2013; 2015)

On the basis that aerial surveys generally underestimate dugong population size, Sobtzick et al. (2013) suggest that the Port Curtis and Rodds Bay supports a dugong population in the low hundreds of individuals at the most.

Sobtzick et al. (2015) has undertaken a study and report titled *Improving the time series of estimates of Dugong abundance and distribution by incorporating revised availability bias corrections*. The report improves the usefulness and validity of archival dugong aerial survey data for management by:

- Developing and using revised Availability Correction Factors that incorporate variations in dugong dive behaviour with bathymetry (referred to as the Hagihara method), to reanalyse archival aerial survey data for dugong abundance and distribution, and
- Using improved statistical and spatial modelling techniques (Sobtzick et al. 2015).

Archival data collected since 2002 from five regions in Australia were re-analysed for Moreton Bay, Hervey Bay, the southern Great Barrier Reef region, the northern Great Barrier Reef region and the Gulf of Carpentaria. The Project is located in the southern Great Barrier Reef region.

Dugong population size estimations using the previous standard, the Pollock et al. (2006) method, were compared with the population estimates using the Hagihara method (Sobtzick et al. 2015). The comparison between the two methods is shown in Table 15.10.

Dugong population estimates prior to aerial survey data were largely based on anecdotal evidence and inferenced data (Sobtzick et al. 2013). Though there are no historical records on the population size of dugong population along the Queensland coast, anecdotal evidence suggest that historical population sizes exceeded estimations from recent years. From 1847 to 1969 dugong populations were of a sufficient size to support European commercial fisheries in the Moreton Bay area, and for shorter periods in other locations along the Queensland coast (Daley et al. 2008).

Other historical data shows large variations in population size estimates, some of which are partially attributable to spatial and temporal changes in habitat availability and large-scale movements of individuals (Sobtzick et al. 2013). Overall, however, the available information suggests a long term decline in the abundance of dugong at a regional scale along the Queensland coast.

Appendix P provides further detail on the information sources utilised to estimate dugong population size and the inherent limitations of the data sources.

15.7.3.3 Habitat availability and utilisation

The Gladstone region supports extensive areas of seagrass (refer Section 7.3, Figure 7.10). As these meadows are the only known major areas of seagrass between Hervey Bay and Shoalwater Bay, the meadows are likely to provide important connecting habitat for dugong populations in southern Queensland (Blair 2012; Sheppard et al. 2006; Sobtzick et al. 2013).

To identify important areas of habitat and to quantify habitat utilisation in the urban coastal waters of Queensland, Grech et al. (2011) incorporated the JCU TropWATER aerial survey data (1986 to 2011) to develop a spatial model of relative dugong density (refer Figure 15.22). The spatial model classified dugong sighting numbers into categories or units per square kilometre of survey area. Categories included:

- Low density: 0 dugongs per square kilometre
- Medium density: 0.0015 to 0.25 dugongs per square kilometre
- High density: 0.25 to 0.5 dugongs per square kilometre
- Very high density: > 0.5 dugongs per square kilometre.

Within Port Curtis and Rodds Bay, the relative density of dugong shown in the model outputs ranged between low, medium and high density (refer Figure 15.22). The model outputs, and the data collated from the JCU TropWATER and GHD aerial surveys indicate that the Gladstone region is an important habitat for a relatively small population of dugong (Sobtzick et al. 2013). Furthermore, dugongs are frequently sighted in varying locations throughout Port Curtis and Rodds Bay, suggesting wide use of the area by that population.

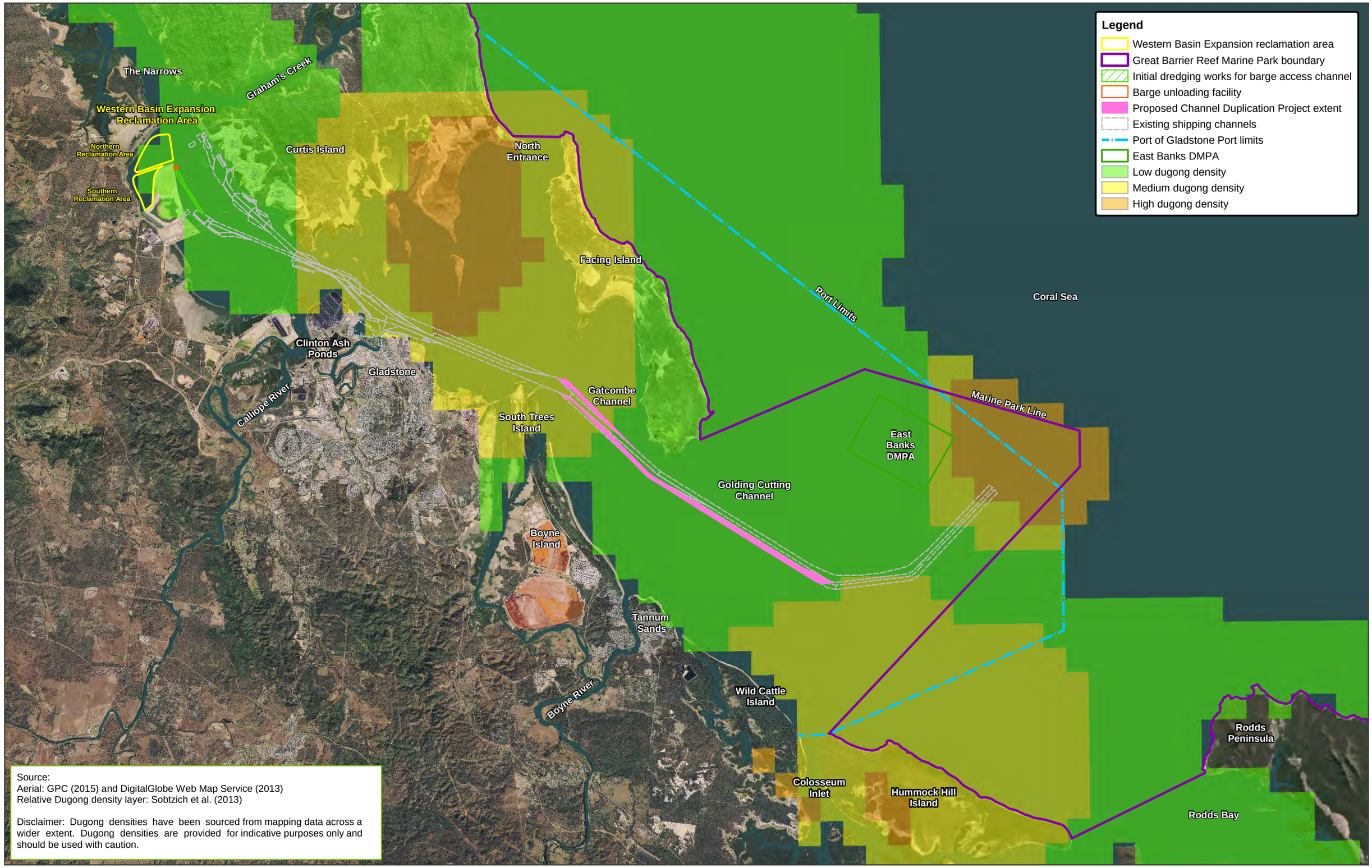
Rasheed et al. (2017a) conducted a series of ERMP Seagrass Surveys which identified key seagrass areas within Port Curtis and Rodds Bay. The ERMP surveys involved quarterly assessments within established dugong feeding trail monitoring areas, to assess temporal and spatial feeding activity by dugongs between May 2015 to November 2016 (Rasheed et al. 2017a). Three dugong feeding trail monitoring areas occur within the Project impact area (i.e. Pelican Banks, South Trees Island, and Wiggins Island), as depicted in Figure 15.23.

Figure 15.23 Dugong feeding trail monitoring areas (2013)

Source: Rasheed et al. (2017a)

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Relative Dugong density layer: Sobtzich et al. (2013)

Disclaimer: Dugong densities have been sourced from mapping data across a wider extent. Dugong densities are provided for indicative purposes only and should be used with caution.

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_086.mxd 13/02/2019 15:49

0 1,900 3,800 Metres

Date: 13/02/2019 Version: 11 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 15.22: Relative Dugong density in Port Curtis based on aerial surveys conducted by JCU TropWATER from 1986 to 2005

As discussed in Section 15.3.1, the ERMP successfully developed a new methodology which allowed, for the first time, effective examination of dugong feeding over large scales. The methodology was used as an effective tool to address knowledge gaps associated with the temporal and spatial use of intertidal seagrass habitat, and its relationship to changes in season, weather, and seagrasses (Rasheed et al. 2017a).

Results presented by Rasheed et al. (2017a) highlight the importance of intertidal seagrass meadows as foraging habitat for the dugong population of Port Curtis and Rodds Bay throughout the region. The report also indicated that dugong feeding activity occurred within the sampling meadows throughout the year, with no consistent temporal patterns among sites (Rasheed et al. 2017a). It was also noted that sites closest to the Port (i.e. Wiggins Island, South Trees and Pelican Banks) exhibited higher levels of feeding than the Rodds Bay meadows (Rasheed et al. 2017a).

Rasheed et al. (2017a) concluded that, in general, dugong feeding trails were positively correlated with increased seagrass presence and aboveground biomass. It was noted that seagrass abundance was typically linked to the amount of rainfall (and linked river flow), received in the previous months.

The results of the ERMP seagrass surveys provide a baseline and method for effective quantitative comparisons of intertidal dugong feeding to assess potential impacts of future activities (Rasheed et al. 2017a).

Additional dugong surveys have been conducted, which involved satellite-tracking individual dugongs in order to examine the heterogeneity in movements and habitat use of dugongs in the Gladstone region (Cleguer et al. 2015a; Cleguer et al. 2015b). The data collected during the 2014 survey indicated that the areas frequented by the tracked dugongs were close to the shore, and included areas close to the main Port (Cleguer et al. 2015a). The 2015 survey data collected demonstrated connectivity between dugongs in the Gladstone region and Shoalwater Bay (Cleguer et al. 2015b).

The associated reports concluded that, if combined with studies of the distribution of seagrass and dugong feeding trails, quantifying the areas used by satellite-tracked dugongs can inform the design of strategies to mitigate the impacts of human activities on this species and their habitats within the Gladstone region (Cleguer et al. 2015a; Cleguer et al. 2015b).

15.7.4 Dugong strandings

Records of dugong strandings in the Port Curtis and wider area are available for the period 2004 to 2014 (refer Table 15.11) (EHP 2016b). As discussed in Section 15.2, for the purposes of the StrandNet database review, the search area spanned the coastline between Yeppoon in the north and Eurimbula in the south.

As discussed in Section 15.2, due to the nature of marine mammal strandings (i.e. long distance movement or displacement of carcasses), it should be noted that historical StrandNet data has been cautiously reviewed in this assessment, and this data is not considered a reliable indicator of species presence and/or abundance.

Dugongs undergo large-scale movements (Holley et al. 2006; Sheppard et al. 2006; Whiting 2008) and are typically difficult to detect in surveys, leading to large variability in population estimates. Management actions have therefore often depended on detecting anthropogenic mortalities rather than population declines (Lanyon 2003; Marsh et al. 2004).

Data indicated that dugong strandings have varied between 2004 and 2014 with the highest number of strandings in the Port Curtis area recorded in 2005, 2011 and 2012. State wide records (with data available up to 2012) report that dugong strandings over the whole of Queensland were highest in 2011 (249 in total), following the extreme weather events of late 2010 and early 2011, before falling in 2012 (52). In 2011, 57 dugong strandings were attributed to Indigenous hunting and 30 strandings were caused by disease and ill health. The causes of 142 dugong strandings were undetermined (Flint and Limpus 2013). StrandNet records for Port Curtis indicate that in 2011 the cause of death was 'unknown or uncertain' or not indicated, with the exception of two records which recorded 'boat strike' and 'pneumonia'. StrandNet records for Port Curtis indicate that in 2012 the cause of death was 'unknown or uncertain' or not indicated for most strandings with the exception of one which was reported to have drowned in a net.

Table 15.11 Dugong stranding records for the Port Curtis and wider region (2004 to 2014)

Year	Found in the Port Curtis region: Port Curtis, Curtis Island, Facing Island or Rodds Bay	Found in the wider area: Port Alma to Yeppoon, Rodds Bay to Eurimbula	Total
2004	2	2	**4**
2005	9	2	**11**
2006	3	1	**4**
2007	1	1	**2**
2008	5	0	**5**
2009	1	1	**2**
2010	3	0	**3**
2011	11	1	**12**
2012	9	1	**10**
2013	2	0	**2**
2014	1	1	**2**
Total	**47 individuals**	**10 individuals**	**57 individuals**

Source: StrandNet data (EHP 2016b)

16 Marine pests

16.1 Background

Marine pests are generally considered to be taxa that are non-native and have been introduced to an area, and that have the potential to pose a threat to the environment, economy or society of the area into which they have been introduced (DAF 2016). Marine pests may be either animal, plant or algae, and once taken from their natural/native environment have the potential to become invasive and displace native species and/or alter the environment. Marine pest species have the potential to prey upon and/or displace native species, reduce biodiversity, alter ecosystem processes and pollute waterways (DAWR 2015; EPA 2003).

A formal marine pest survey was undertaken in the Port of Gladstone in 2000 (Lewis et al. 2001), and though no introduced marine pest species were recorded at the time of the survey, eight of the species identified have since been included on the National Introduced Marine Pest Information System (NIMPIS) (NIMPIS 2014). The NIMPIS is an initiative of the Australian Government which aims to prevent the introduction of new marine pests, to guide the response to management of new pest species, and to minimise the spread and impact of pest species that are already established in Australia (Department of Agriculture 2013).

In the Port of Gladstone in 2006, investigation of a suspected marine pest incursion positively identified the presence of the pest bivalve species the Asian green mussel (*Perna viridis*) (Anderson et al. 2006; Vision Environment 2015d). Due to the potential for this species to cause extensive ecological, economic and human health impacts, measures were undertaken to eradicate the species and prevent the spread of the species (Anderson et al. 2006; Vision Environment 2015d).

An additional marine pest survey was undertaken in 2015, which included the survey of 18 locations within the Port of Gladstone, including wharves, anchorages, marina berths, slipways and other potential vector nodes for the introduction and/or spread of marine pest species (Vision Environment 2015d). This survey identified four introduced marine pest species within the Port, however the Asian green mussel was not recorded during the surveys (Vision Environment 2015d). The four introduced species identified in this survey are no new incursions to Australia, however two of the species had not been previously reported in the Port of Gladstone (Vision Environment 2015b).

16.2 Methodology

The purpose of the baseline marine pest information is to understand the existing state of the environment in relation to non-native marine species and to assess the risk of accidental introduction of marine species into the Port Curtis region. An assessment of the pest and non-native marine species known to occur within the Port Curtis region will facilitate the assessment of potential impacts associated with the Project activities and the potential risks associated with the introduction and colonisation of non-native marine species.

This assessment was informed by Government database resources and a review of existing literature and surveys undertaken for non-native marine species within the Port Curtis region (refer Table 16.1).

Table 16.1 Information used for the assessment of marine pests

Title	Reference
Reports	
An investigation to prevent marine pest incursion in Port Curtis. Centre for Environmental Management, Central Queensland University, Gladstone	Andersen et al. (2006)
Port survey for introduced marine species - Port Curtis, Central Queensland University, Gladstone Qld	Lewis et al. (2001)
Port of Gladstone Biosecurity Monitoring Program 2015, Prepared for Gladstone Ports Corporation, July 2015	Vision Environment (2015d)
Report for Western Basin Dredging and Disposal Project Marine Ecology Assessment. Prepared for Gladstone Ports Corporation as part of the WBDPP EIS, November 2009	GHD (2009c)
Australian marine pest monitoring guidelines	DAFF (2010)
Databases	
National Introduced Marine Pest Information System – declared pests (Queensland)	Department of Agriculture (2013)
Atlas of Living Australia (incorporates Queensland Museum Wildnet data and Queensland Herbarium HERBRECS data)	ALA (2019)
Wildnet	DES (2019)

16.2.1 Port survey for introduced marine species Port Curtis (Lewis et al. 2001)

The GPA funded a port survey for introduced marine species in Port Curtis in March 2000. The aim of the survey was to establish a baseline list of native and introduced species in the port and provide recommendations for ongoing monitoring for introduced species (Lewis et al. 2001).

There were 22 sites selected in Port Curtis, representing habitats likely to be colonised by introduced species and are likely to be influenced by ballast water discharges (Lewis et al. 2001). All six major wharf centres and tug berths were sampled.

Quantitative and semi-quantitative sampling occurred which included: core samples, net samples, traps, visual searches, and sediment samples (Lewis et al. 2001). All specimens collected as part of the survey were formally taxonomically identified at museums.

16.2.2 Port of Gladstone Biosecurity Monitoring Program 2015 (Vision Environment 2015d)

The marine pest monitoring methodology was guided by the Australian Marine Pests Monitoring Guidelines and utilised some of the methods outlined in the Australian Marine Pest Monitoring Manual (Vision Environment 2015d).

There were 18 locations chosen to survey which included nine previous areas from the Lewis et al. (2000) study.

Survey methods included pylon scraping (45 samples total), plankton tows (15 samples total) and benthic grabs (12 samples total) (Vision Environment 2015d). This methodology implemented for each site was based on identifying the most likely introduced marine pest vector nodes and habitat type at each location (Vision Environment 2015d).

For pylon scrap and benthic grab samples, samples were removed from the collection bags and washed in a 0.25mm sieve and were placed in vial with ethanol for identification. For net trawls samples were initially viewed using dissecting microscope and then sorted into taxonomic groups (Vision Environment 2015d).

16.3 Marine pest risks and management

Marine pest species have the potential to be introduced into marine waters via a range of different mechanisms (or vectors), including:

- The aquarium trade: Exotic marine pests may be liberated into new location by aquarium owners (*Caulerpa taxifolia* (Green macroalga, Aquarium caulerpa) is a typical example of this mechanism of dispersal)
- Shipping: Shipping and trade are major vectors for marine pest spread. Commercial and recreational vessels in Queensland have the potential to translocate marine pests via the following methods:
  - Marine pests can be introduced to new sites in Queensland by organisms that attach to vessel hulls or other niche areas, such as anchor wells or intake pipes. This process is known as biofouling, and was the means of introduction of *P. viridis* at Cairns in 2007 (Wilson et al. 2015).
  - Ballast water is taken on by ships to provide stability when they are unladen. A single ship may carry 70,000 tonnes of ballast water and release it at a foreign port when cargo is loaded. Ballast may contain planktonic species, the larvae of bottom-dwelling invertebrates, fish and pathogens (Low 2003).

Concern about the potentially devastating impacts of introduced marine pests, led the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Ministerial Council on Forestry, Fisheries and Aquaculture to agree to establish the National Taskforce on the Prevention and Management of Marine Pest Incursions in 1999 (Commonwealth of Australia 1999). The taskforce was instructed to report to the Ministerial Councils in 1999, through their respective standing committees, with recommendations for interim improvements and for longer term reforms to the national arrangements for the prevention and management of introduced marine pests.

The taskforce report identified that prevention of pest species is best achieved via vector control (Commonwealth of Australia 1999). Prevention management minimises the risk of a species establishing by targeting responses to the early parts of the invasion process which is consistent with international policy of the management of non-indigenous species (Bax et al. 2001).

As part of the National system for the prevention and management of marine pest incursions, the former Commonwealth Department of Agriculture, Fisheries and Forestry (DAFF) has prepared the *Australian marine pest monitoring guidelines* (DAFF 2010). These guidelines present monitoring strategies and protocols to undertake a consistent approach in the identification of marine pests. Within these guidelines, 55 species have been identified by the National Introduced Marine Pest Coordination Group as they have a high invasion potential within Australian waters. These species are presented in Table 16.2.

NIMPIS is a web-based database providing information on approximately 110 marine pest species known to have been introduced into Australia (DAWR 2015). NIMPIS provides biological, ecological and distribution information on marine pests, and contains a database search function to identify marine pest species in a particular location (DAWR 2015). Table 16.3 outlines 26 declared marine pest species recorded on the NIMPIS as occurring within Queensland, of these species, two are also identified as target species in Table 16.2: *C. taxifolia* and *P. viridis*.

Table 16.2 Target species for monitoring identified in the Australian marine pest monitoring guidelines

Number	Scientific name	Common name
1	*Acartia tonsa*	Calanoid copepod
2	*Alexandrium catenella**	Toxic dinoflagellate
3	*Alexandrium minutum**	Toxic dinoflagellate
4	*Alexandrium monilatum*	Toxic dinoflagellate
5	*Alexandrium tamarense*	Toxic dinoflagellate
6	*Asterias amurensis**	Northern Pacific seastar
7	*Balanus eburneus*	Ivory barnacle
8	*Balanus improvisus*	Bay barnacle (marine/estuarine incursions only)
9	*Beroe ovata*	Comb jelly
10	*Blackfordia virginica*	Black Sea jelly
11	*Bonnemaisonia hamifera*	Red macroalga
12	*Callinectes sapidus*	Blue crab
13	*Carcinus maenas**	European shore crab
14	*Caulerpa racemosa*	Green macroalga (Australian native question)
15	*Caulerpa taxifolia*	Green macroalga (exotic strains only)
16	*Chaetoceros concavicornis*	Centric diatom
17	*Chaetoceros convolutus*	Centric diatom
18	*Charybdis japonica**	Asian paddle/lady crab
19	*Codium fragile* spp. *fragile* [1]	Green macroalga
20	*Corbula (Potamocorbula) amurensis*	Brackish-water/Asian clam
21	*Crassostrea gigas**	Pacific oyster
22	*Crepidula fornicata*	American slipper limpet
23	*Didemnum* spp.	Tunicate – sea squirt (exotic invasive species only)
24	*Dinophysis norvegica*	Toxic dinoflagellate
25	*Ensis directus*	Jack-knife clam
26	*Eriocheir* spp.	Mitten crabs
27	*Grateloupia turuturu*	Red macroalga
28	*Gymnodinium catenatum**	Toxic dinoflagellate
29	*Hemigrapsus sanguineus*	Japanese shore crab
30	*Hemigrapsus takanoi/penicillatus*	Pacific crab
31	*Hydroides dianthus*	Tube worm
32	*Limnoperna fortunei*	Golden mussel
33	*Marenzelleria* spp.	Red-gilled mud worm (invasive species and marine/estuarine incursions only)
34	*Mnemiopsis leidyi*	Comb jelly
35	*Musculista senhousia**	Asian bag/date mussel
36	*Mya arenaria*	Soft shell clam
37	*Mytilopsis sallei*	Black-striped mussel
38	*Neogobius melanostomus*	Round goby (marine/estuarine incursions only)
39	*Perna perna*	South African brown mussel

Number	Scientific name	Common name
40	*Perna viridis**	Asian green mussel
41	*Pfiesteria piscicida**	Dinoflagellate
42	*Pseudodiaptomus marinus*	Asian copepod
43	*Pseudo-nitzschia seriata*	Pennate diatom
44	*Rapana venosa*	Asian/veined rapa whelk
45	*Rhithropanopeus harrisii*	Harris mud crab
46	*Sabella spallanzanii**	European/Mediterranean fan worm
47	*Sargasso muticum*	Asian seaweed
48	*Siganus luridus*	Dusky spinefoot
49	*Siganus rivulatus*	Marbled spine foot/rabbit fish
50	*Tortanus dextrilobatus*	Asian copepod
51	*Tridentiger bifasciatus*	Shimofuri goby
52	*Tridentiger barbatus*	Shokohazi goby
53	*Undaria pinnatifida**	Japanese seaweed
54	*Varicorbula (Corbula) gibba**	European clam
55	*Womersleyella setacea*	Red seaweed

Table notes:

1 *Codium fragile* spp. fragile is on the Interim Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) Trigger List. Noting that the CCIMPE criteria for removal requires that data indicates that impacts overseas/in Australia are likely to be less than previously thought or it becomes widely distributed in Australia, it does not seem likely at this time that justification could be provided to remove this species from the CCIMPE Trigger List.

* Species with a genetic/molecular probe or barcoded

Source: DAFF (2010)

Table 16.3 Declared marine pests in Queensland as listed on the National Introduced Marine Pest Information System

Number	Scientific name	Common name
1	*Amathia distans*	Bryozoan
2	*Anteaeolidiella indica*	Japanese aeolid
3	*Antennella secundaria*	Knotted thread hydroid
4	*Botrylloides leachi*	Colonial ascidian
5	*Botryllus schlosseri*	Star ascidian
6	*Bugula flabellata*	Bryozoan
7	*Bugula neritina*	Bryozoan
8	*Caulerpa taxifolia*	Aquarium caulerpa
9	*Ciona intestinalis*	Solitary ascidian
10	*Cordylophora caspia*	Hydroid
11	*Cryptosula pallasiana*	Bryozoan
12	*Halecium delicatulum*	Hydroid
13	*Hopkinsia plana*	Sea slug
14	*Hydroides elegans*	Fouling serpulid
15	*Hydroides sanctaecrucis*	Caribbean serpulid tubeworm
16	*Megabalanus tintinnabulum*	Acorn barnacle
17	*Obelia dichotoma*	Hydroid

Number	Scientific name	Common name
18	*Paracerceis sculpta*	Sponge isopod
19	*Paradella dianae*	Sphaeromatid isopod
20	*Perna viridis*	Asian green mussel
21	*Plumularia setacea*	Hydroid
22	*Schizoporella unicornis*	Lace coral
23	*Sphaeroma walkeri*	Marine pill bug
24	*Teredo navalis*	Naval shipworm
25	*Ulva fasciata*	Sea lettuce
26	*Watersipora arcuata*	Lace coral

Source: Department of Agriculture (2013)

16.4 Port Curtis marine pest surveys

16.4.1 Port survey in 2000 for introduced marine species

In 2000, a survey of Port Curtis was undertaken to establish a baseline list of native and introduced species (Lewis et al. 2001). The survey was conducted by Central Queensland University, in collaboration with Commonwealth Scientific and Industrial Research Organisation's (CSIRO's) Centre for Research on Introduced Marine Pests. All specimens collected as part of the survey were formally taxonomically identified at museums. In total, 22 introduced species sites were surveyed and monitored within the greater Port Curtis area (refer Figure 16.1).

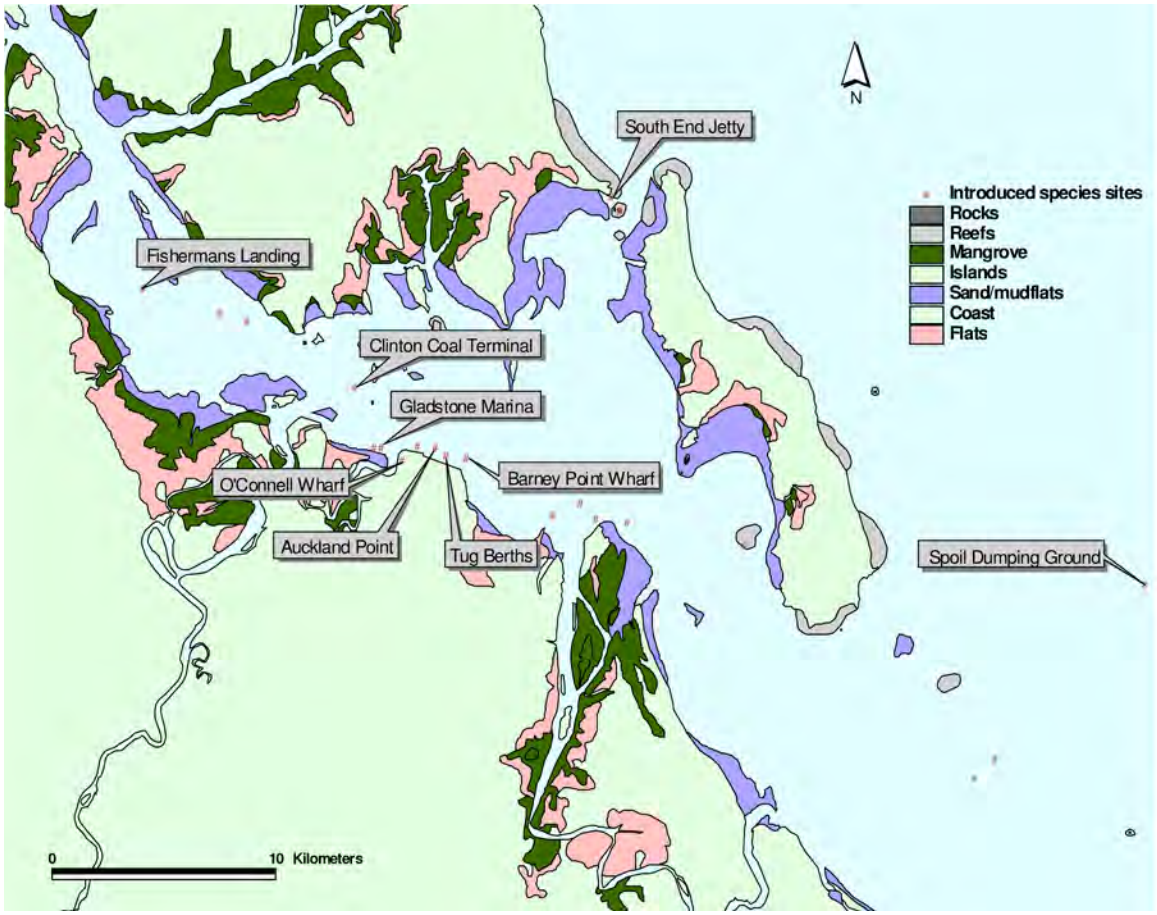


Figure 16.1 Marine pest survey locations undertaken in 2000

Source: Lewis et al. (2001)

Lewis et al. (2001) observed no marine pest species, during their investigations. However, 10 introduced species were identified. These species consisted of the following:

- Two ascidians:
  - *Styela plicata*
  - *Botrylloides leachi*
- Five bryozoans:
  - *Amathia distans*
  - *Bugula neritina*
  - *Cryptosula pallasiana*
  - *Watersipora subtorquata*
  - *Zoobotryon verticillatum*
- A hydrozoan: *Obelia dichotoma*
- An isopod: *Paracerceis sculpta*
- A dinoflagellate: *Alexandrium* sp.

The species identified by Lewis et al. (2001) were noted as being widespread in ports across Australia and across the world, and were not thought to represent a threat to native species in Port Curtis, other than through direct competition for habitat between some bryozoans (Lewis et al. 2001).

Eight of the species that were observed during the investigations have since been listed on the NIMPIS Queensland target pest species list (DAFF 2009).

16.4.2 An investigation in 2006 to prevent a marine pest incursion in Port Curtis

In 2006, GPC and Queensland Parks and Wildlife Service investigated a suspected marine pest incursion in Port Curtis (Andersen et al. 2006; Vision Environment 2015d). A positive identification was made of a pest bivalve species (*P. viridis*), which is considered a marine pest emergency (DAFF 2005) due to its potential to cause extensive ecological, economic and human impacts. Measures were undertaken at the time to eradicate the species and to prevent spreading (Andersen et al. 2006).

16.4.3 Port of Gladstone Biosecurity Monitoring Program 2015

In 2015, a survey of Port Curtis was undertaken to determine the presence/absence of introduced species and marine pest species within key areas frequented by vessels, and subject to shipping and dredging activities (Vision Environment 2015d). In total, 18 locations were surveyed to align with potential vector nodes, as identified by the Australian Marine Pest Monitoring Guidelines (DAFF 2010) (refer Figure 16.2).

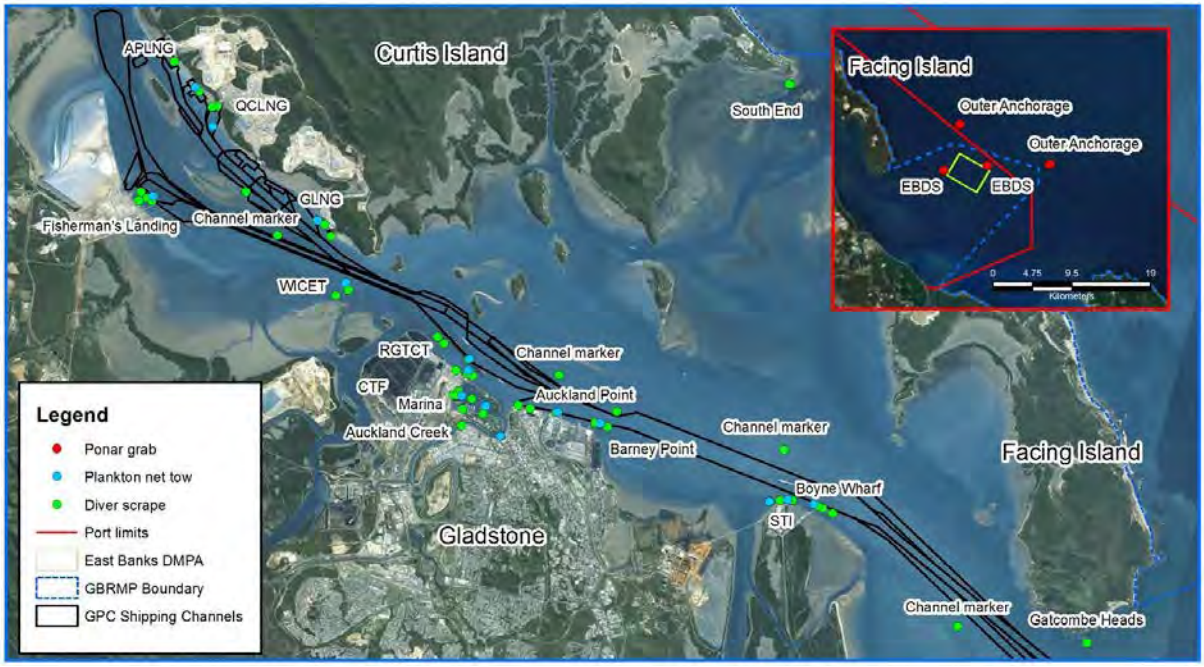


Figure 16.2 Biosecurity survey locations undertaken in 2015

Source: Vision Environment (2015d)

Four introduced species from the NIMPIS Queensland target pest species list (DAFF 2009) were identified, including:

- *Hydroides sanctaecrucis* (Caribbean tubeworm)
- *Ulva fasciata* (Sea lettuce)
- *Paracerceis sculpta* (Sponge isopod)
- *Cryptosula pallasiana* (Encrusting bryozoan) (Vision Environment 2015d).

The above pest species have been previously recognised as having been translocated to Australia, potentially as biofouling on ships' hulls and through ballast water discharge (Vision Environment 2015d). Two of the species, the Caribbean tubeworm and Sponge isopod, were also previously recorded by Lewis et al. (2001) in Port Curtis.

None of the species recorded as part of the 2015 Biosecurity Survey are listed as high risk species in either the Introduced Marine Pest, or Declared Pest lists on NIMPIS (DAFF 2009), although the *H. sanctaecrucis* is listed as a potential medium impact on the domestic list (Vision Environment 2015d). Similarly, these species do not appear on the Australian Emergency Marine Pest Plan (EMP Plan) Trigger List, nor do they satisfy the criteria to be included on this list (DAFF 2005), indicating that their identification does not warrant a marine pest emergency response. Actions to eradicate, or limit the distribution of these species were not recommended, as these species are ubiquitous nature in other Australian ports and that they are likely already well established in Port Curtis (Vision Environment 2015d).

16.4.4 Other marine baseline assessments within the Port Curtis region

The marine baseline assessment for the WBDDP EIS did not detect any introduced marine pest taxa within Port Curtis (GHD 2009c).

More recently, surveys conducted by Rasheed et al. (2003) (refer Appendix M), McKenna et al. (2013) (refer Appendix D), Davies et al. (2015c) (refer Appendix O), Vision Environment (2015b) (refer Appendix N) to assess microbenthic communities (i.e. macroinvertebrates and algae) did not identify the presence of any listed marine pest species within Port Curtis.

17 Matters of National and State Environmental Significance

17.1 Background

The EPBC Act requires that any action (i.e. a project, development, undertaking, activity or series or activities) that has, will have or is likely to have a significant impact on a MNES, or other matters protected under the Act such as the environment of Commonwealth land, requires approval from the Commonwealth Environment Minister.

The EPBC Act, which is administered by the DoEE, identifies the following MNES as triggers for potential Commonwealth assessment and approval:

- World Heritage properties
- National Heritage properties
- Wetlands of international importance (listed under the Ramsar Convention)
- Nationally threatened species and ecological communities
- Migratory species (protected under international agreements)
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines)
- A water resource, in relation to coal seam gas development and large coal mining development
- The environment, where actions proposed are on, or will affect Commonwealth land and the environment
- The environment, where Commonwealth agencies are proposing to take an action.

On 23 October 2012, the Project was declared to be a 'controlled action' for which an EIS is required under the EPBC Act. The controlling provisions for the Project are:

- World Heritage properties (Sections 12 and15A)
- National Heritage places (Sections 15B and 15C)
- Listed threatened species and communities (Sections 18 and 18A)
- Listed migratory species (Sections 20 and 20A
- Commonwealth marine areas (Sections 23 and 24A)
- Great Barrier Reef Marine Park (Sections 24B and 24C).

Approval is required from the Commonwealth Environment Minister prior to any action in relation to the Project being undertaken. Assessment of the Project under the provisions of the EPBC Act is being undertaken at the same time as the Queensland Government EIS assessment under the SDPWO Act, with one EIS covering the requirements of both assessments.

Environmental matters of State level significance are protected under the Queensland legislative framework and are defined as MSES. MSES are identified in Schedule 2 of the Offsets Regulation and include the following themes:

- Regulated vegetation
- Connectivity areas
- Wetlands and watercourses
- Designated precinct in a strategic environmental area
- Protected wildlife habitat
- Protected areas
- Highly protected zones of State marine parks
- Fish habitat areas
- Waterway providing for fish passage
- Marine plants
- Legally secured offset areas.

This section collates all of the MNES and MSES relevant to the Project which have been identified throughout this technical report into summary sections.

17.2 Methodology

The purpose of this MNES and MSES assessment was to determine the relevant matters protected under the provisions of the EPBC Act and Queensland legislation that are either confirmed or highly likely to occur within the Project EIS database search area (refer Figure 17.1), including the Project impact areas. This section collates all of the MNES and MSES identified throughout this technical report into summary sections, which specifically references the relevant elements of the EPBC Act and Queensland legislation.

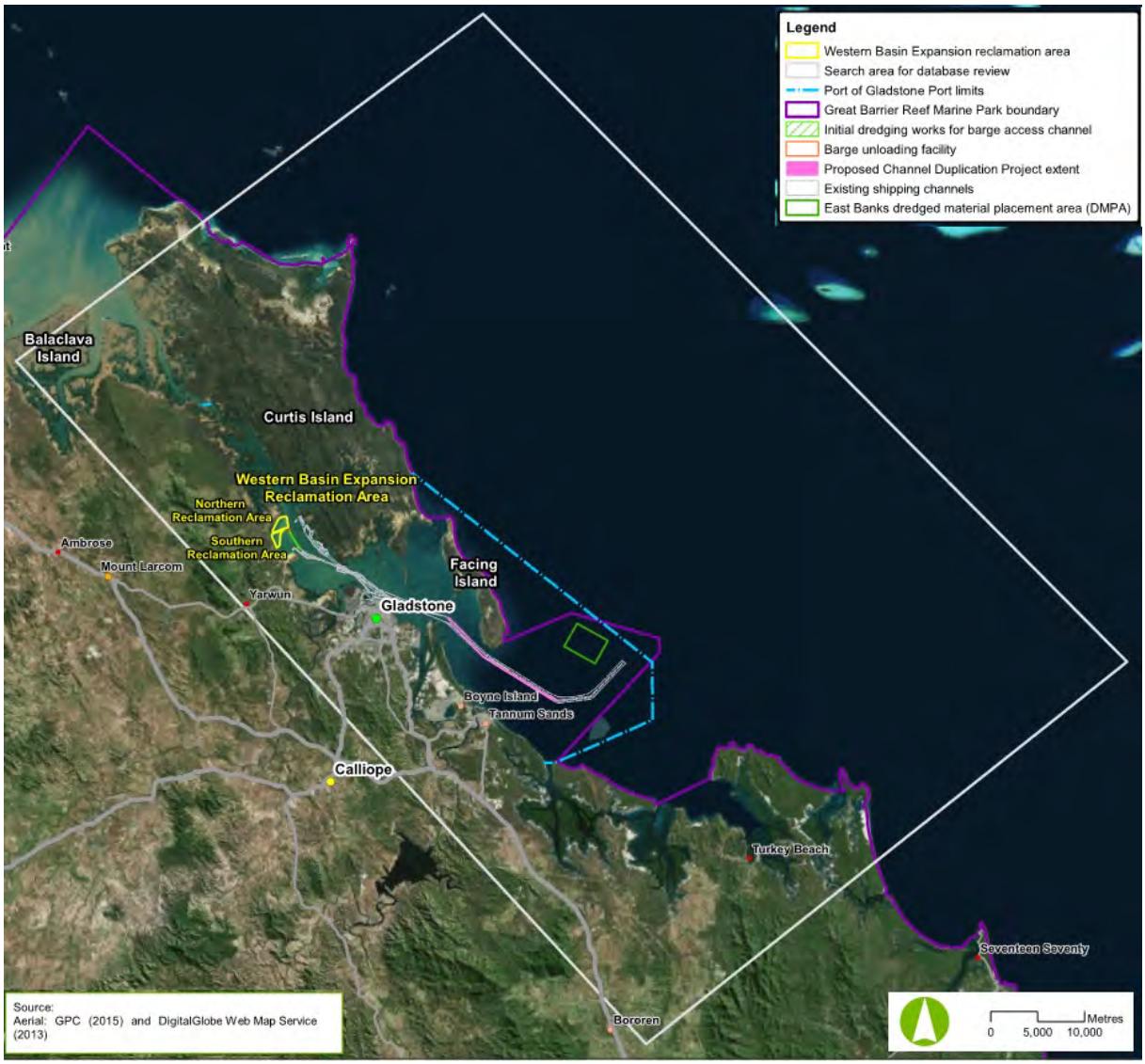


Figure 17.1 **Project EIS database search area for review of Matters of National Environmental Significance**

17.3 Matters of national environmental significance

The MNES assessed in this section (and the applicable sections of the EPBC Act) include:

- World heritage properties (Sections 12 and 15A)
- National heritage places (Sections 15B and 15C)
- Wetlands of international importance (Ramsar wetlands) (Sections 16 and 17B)
- Nationally threatened species and ecological communities (Sections 18 and 18A)
- Migratory species (Sections 20 and 20A)
- Commonwealth marine areas (Sections 23 and 24A)
- Great Barrier Reef Marine Park (Sections 24B and 24C).

A summary of the MNES located in the Project impact areas is provided in Table 17.1, including the relevant sections of the EPBC Act. The table outlines where controlling provisions under the EPBC Act are not relevant to the Project activities (e.g. nuclear actions).

The section references provided in Table 17.1 refer to sections within this technical report where the MNES is discussed in detail, including existing values and associated mapping (where relevant).

The location of the GBRWHA, Commonwealth marine areas and the extent of the GBRMP are shown in Figure 17.2. Other MNES are shown in figures within the relevant sections of this technical report as referenced in Table 17.1.

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

Cawarral
Emu Park
Mount Chalmers
Keppel Sands
Broadmount
Bajool
Marmor
Raglan
Ambrose
Mount Larcom
Yarwun
Gladstone
Curtis Island
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Facing Island
Boyne Island
Tannum Sands
Calliope
Turkey Beach
Seventeen Seventy
Bororen

Legend

- Proposed additional navigational aids
- Proposed removal of navigational aids
- Reposition of existing navigational aids
- Initial dredging works for barge access channel
- Barge unloading facility
- Western Basin Expansion reclamation area
- Search area for database review
- Port of Gladstone Port limits
- Great Barrier Reef Marine Park boundary
- Proposed Channel Duplication Project extent
- Existing shipping channels
- East Banks dredged material placement area (DMPA)
- Great Barrier Reef World Heritage Area
- Commonwealth marine area

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Great Barrier Reef World Heritage Area: Department of the Environment (2015a)
Australian maritime boundaries: Geoscience Australia (2006)

P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_104.mxd 13/02/2019 14:30
Map by: RB

0 5,000 10,000 Metres

Date: 13/02/2019 Version: 8 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 17.2: Great Barrier Reef World Heritage Area, Commonwealth marine areas and the Great Barrier Reef Marine Park

Table 17.1 Matters of national environmental significance and their relevance to the Project

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section(s) within this technical report
World Heritage properties (Sections 12 and 15A) and National Heritage places (Sections 15B and 15C)		
The areas to be dredged (including the channel duplication and barge access channel), location of new navigational aids, BUF and the WB and WBE reclamation areas are situated within the boundaries of the GBRWHA which is both a World Heritage property and a National Heritage place (i.e. Project activities below the LAT within the Port are located within the GBRWHA)	The 2012 *Statement of Outstanding Universal Value for the Great Barrier Reef World Heritage Area* establishes that the GBRWHA meets all four natural heritage criteria of the current Operational Guidelines, all of which are considered to be present within the Port of Gladstone. These are:	Section 6 provides a summary
	■ Criterion vii – contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance	
	■ Criterion viii – be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features	
	■ Criterion ix – be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals	
	■ Criterion x – contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of OUV from the point of view of science or conservation	
Wetlands of international importance (Ramsar wetlands) (Sections 16 and 17B)		
No Ramsar wetlands are located within close proximity to the Project impact areas. Shoalwater and Corio Bay Ramsar wetlands are located approximately 98km to the north of the WB and WBE reclamation areas	■ These wetlands are located outside of the Project impact areas and will not be impacted by the Project	Section 5.3
Nationally threatened species and ecological communities (Sections 18 and 18A)		
Subtropical and Temperate Coastal Saltmarsh Threatened Ecological Community	■ There will be no direct loss of this TEC as a result of the Project activities, however this TEC is located within the Project indirect impact areas as it is situated approximately 200m to 300m west of the WB and WBE reclamation areas	Sections 3.3.2 and 4.4.3
Suitable habitat for threatened flora species occurs in Project indirect impact areas	■ No threatened flora species were identified during Project EIS field investigations and no species are known to occur within the direct impact areas as identified during previous and Project EIS studies ■ Potentially suitable habitat identified within Project potential indirect impact areas, approximately 200m west of the WB and WBE reclamation areas	Sections 3.3.6

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section(s) within this technical report
Marine turtle species are known to forage and nest within Port Curtis, and foraging habitat is present within the Project impact areas (direct and potential indirect impact areas)	■ Flatback turtle known to nest regularly in Port Curtis ■ Green turtle known to occur in Port Curtis on a regular basis (only occasionally for nesting) ■ Loggerhead turtle occasionally nests in Port Curtis ■ Hawksbill turtle occasionally migrates through Port Curtis	Section 14.4
Marine mammal species are known to occur within Port Curtis	■ Humpback whale known to occur in Port Curtis ■ Other marine mammals occur within Port Curtis, however are not listed as threatened species under the EPBC Act (refer to assessments for migratory species below)	Sections 15.3 to 15.5
Threatened migratory shorebirds are known from Port Curtis, and foraging and roosting habitat is located within Project impact areas	The Project impact areas include known foraging and roosting habitat for threatened migratory shorebirds, including: ■ Common sandpiper ■ Ruddy turnstone ■ Sanderling ■ Sharp-tailed sandpiper ■ Pectoral sandpiper ■ Red-necked stint ■ Double-banded plover ■ Broad-billed sandpiper ■ Bar-tailed godwit ■ Black-tailed godwit ■ Little curlew ■ Whimbrel ■ Pacific golden plover ■ Grey-tailed tattler ■ Wandering tattler ■ Common greenshank	Section 12.3.5

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section(s) within this technical report
	■ Marsh sandpiper ■ Terek sandpiper ■ Western Alaskan bar-tailed godwit ■ Curlew sandpiper ■ Eastern curlew ■ Great knot ■ Northern Siberian bar-tailed godwit ■ Red knot ■ Greater sand plover ■ Lesser sand plover	
Threatened migratory seabirds have a moderate potential to occur within the Project impact areas	The Project impact areas include potential habitat for threatened migratory seabirds, including: ■ Black-browed albatross ■ Campbell albatross ■ Chatham albatross ■ Fairy prion (southern) ■ Kermadec petrel (western) ■ Salvin's albatross ■ Shy albatross ■ Southern giant-petrel ■ White bellied storm petrel	Section 12.3.5
Potentially suitable habitat for two threatened fauna species occurs within terrestrial and intertidal Project impact areas	Potential habitat for the following threatened species occurs in the Project indirect impact areas: ■ Koala ■ Water mouse	Section 13.3.3

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section(s) within this technical report
Migratory species (Sections 20 and 20A)		
Migratory marine fish species are confirmed or have a moderate likelihood of occurring in the Project impact areas	The Project impact areas provide suitable habitat for: ■ Five shark species ■ Two manta ray species	Section 9.3.1
Migratory reptiles are known to occur or have a moderate likelihood of occurring within the Project impact areas	■ Four marine turtles (refer assessment for marine turtles above)	Section 14.4
	■ Saltwater crocodile (*Crocodylus porosus*)	Section 10.3
Migratory megafauna species are confirmed or have a moderate likelihood of occurring in the Project impact areas	■ Humpback whale known to occur in Port Curtis ■ Australian humpback dolphin known to occur in Port Curtis, and has been recorded in the Project impact areas ■ Dugong known to occur in Port Curtis and foraging habitat is present within Project impact areas	Sections 15.3, 15.4 and 15.5
Migratory bird species are confirmed or have a moderate likelihood of occurring in the Project impact areas	■ Sixty migratory bird species are confirmed or have a moderate likelihood of occurrence within the Project impact areas, this includes migratory shorebirds and migratory seabirds ■ Including populations which have exceeded approximately 0.1% of the flyway population on at least one occasion for the following species: – Eastern curlew – Wedge-tailed shearwater – Red knot – Curlew sandpiper – Great knot – Grey-tailed tattler – Terek sandpiper – Lesser sand plover – Greater sand plover – Western Alaskan bar-tailed godwit – Northern Siberian bar-tailed godwit	Section 12.3.5

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section(s) within this technical report
	– Southern giant-petrel – Sooty albatross – Ruddy turnstone – Shy albatross – White-capped albatross – Chatham albatross – Campbell albatross – Black-browed albatross – Salvin's albatross – White-throated needletail – Oriental cuckoo – Black-faced monarch – Satin flycatcher – Rufous fantail – Common noddy – Flesh-footed shearwater – Sooty shearwater – Short-tailed shearwater – White-winged black tern – Lesser frigatebird – Great frigatebird – Gull-billed tern – Caspian tern – Wilson's storm petrel – Bridled tern – Red-tailed tropicbird	

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section(s) within this technical report
	– Light-mantled sooty albatross – Brown booby – South polar skua – Little tern – Roseate tern – Common tern – Black-napped tern – Crested tern Common sandpiper – Sanderling – Sharp-tailed shearwater – Pectoral sandpiper – Red-necked stint – Double-banded plover – Latham's snipe – Broad-billed sandpiper – Bar-tailed godwit – Black-tailed godwit – Little curlew – Whimbrel – Osprey – Grey plover – Wandering tattler – Common greenshank – Marsh sandpiper – Terek sandpiper	

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section(s) within this technical report
Commonwealth marine areas (Sections 23 and 24A)		
Commonwealth marine areas include any part of the sea, including the waters, seabed and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia. Commonwealth marine areas stretch from 3 to 200 nautical miles from the coast The Project impact areas are not located within Commonwealth marine areas, with the nearest Commonwealth marine areas situated more than 9km from the area to be dredged and the new navigational aids	Not applicable to the Project	N/A
Great Barrier Reef Marine Park (Sections 24B and 24C)		
The GBRMP boundary is situated on the open coastal waters side of Curtis and Facing Islands, with the closest Project impact area located more than 2km southwest of the boundary (i.e. the areas to be dredged, near the southern end of Facing Island)	■ The GBRMP is located outside of the Project direct impact areas (i.e. nearest direct impact area is approximately 2km from the GBRMP boundary) ■ Indirect impacts associated with dredging are likely to result in short term declines in water quality within the GBRMP boundary	Sections 8, 9, 10, 14 and 15
Nuclear actions (including uranium mining) (Sections 21 and 22A)		
Not relevant to the Project	Not applicable to the Project	N/A
A water resource, in relation to coal seam gas development and large coal mining development (Sections 24D and 24E)		
Not relevant to the Project	Not applicable to the Project	N/A

17.4 Matters of State Environmental Significance

The purpose of the MSES assessment is to identify MSES listed in Schedule 2 of the Offset Regulation which are either confirmed or highly likely to occur within the Project EIS database search area (refer Figure 17.1), including the Project impact areas.

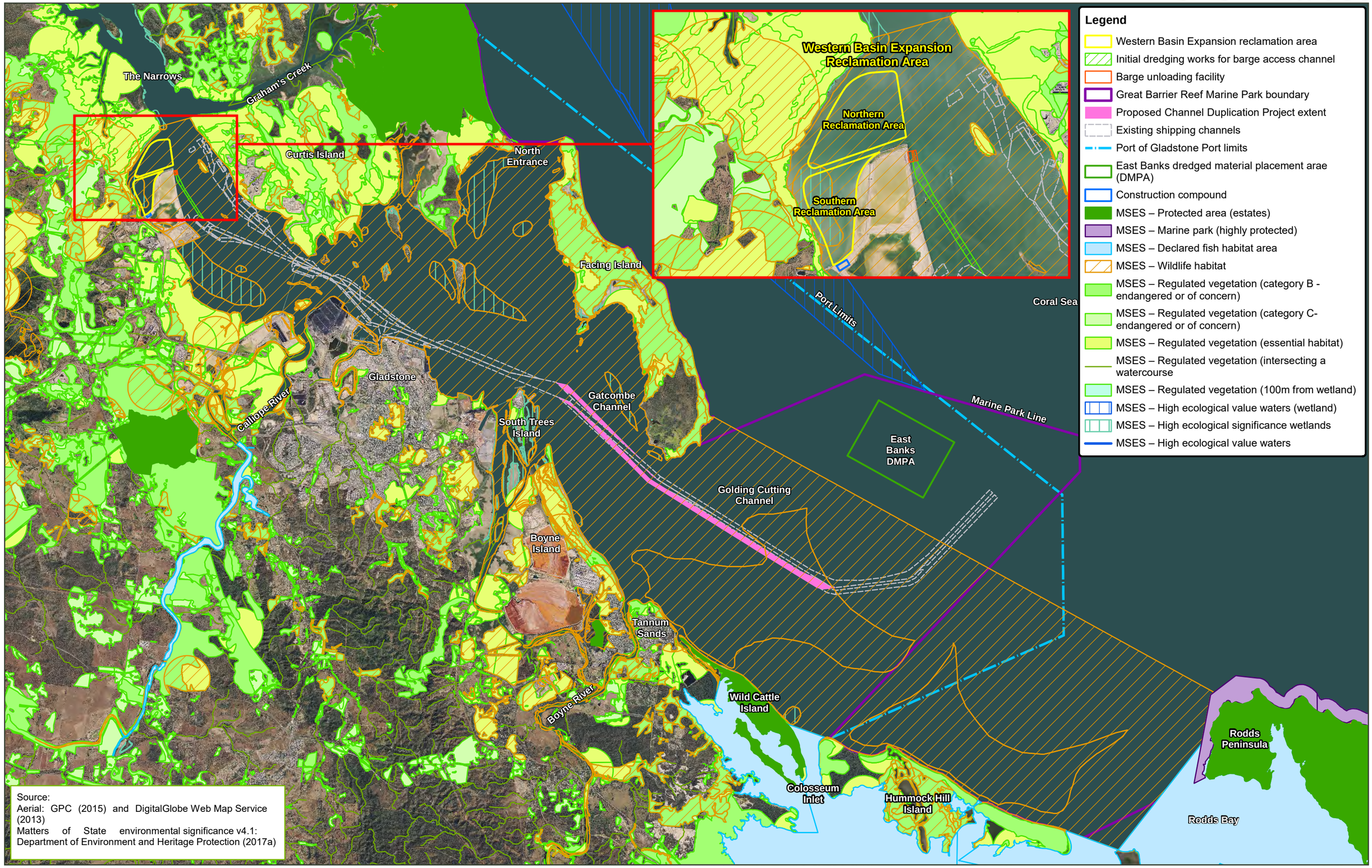
This section collates all of the MSES identified throughout this technical report into a single summary section.

A summary of the MSES located in the Project impact areas is provided in Table 17.2. Figure 17.3 identifies MSES within the Project impact areas.

The section references provided in Table 17.2 refer to sections within this technical report where the MSES is discussed in detail, including existing values and associated mapping (where relevant).

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Legend

- Western Basin Expansion reclamation area
- Initial dredging works for barge access channel
- Barge unloading facility
- Great Barrier Reef Marine Park boundary
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement arae (DMPA)
- Construction compound
- MSES – Protected area (estates)
- MSES – Marine park (highly protected)
- MSES – Declared fish habitat area
- MSES – Wildlife habitat
- MSES – Regulated vegetation (category B - endangered or of concern)
- MSES – Regulated vegetation (category C- endangered or of concern)
- MSES – Regulated vegetation (essential habitat)
- MSES – Regulated vegetation (intersecting a watercourse
- MSES – Regulated vegetation (100m from wetland)
- MSES – High ecological value waters (wetland)
- MSES – High ecological significance wetlands
- MSES – High ecological value waters

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Matters of State environmental significance v4.1: Department of Environment and Heritage Protection (2017a)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_120.mxd 30/01/2019 12:07

0 1,900 3,800 Metres

Date: 30/01/2019 Version: 8 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 17.3: Matters of State Environmental Significance

Table 17.2 Matters of state environmental significance and their relevance to the Project

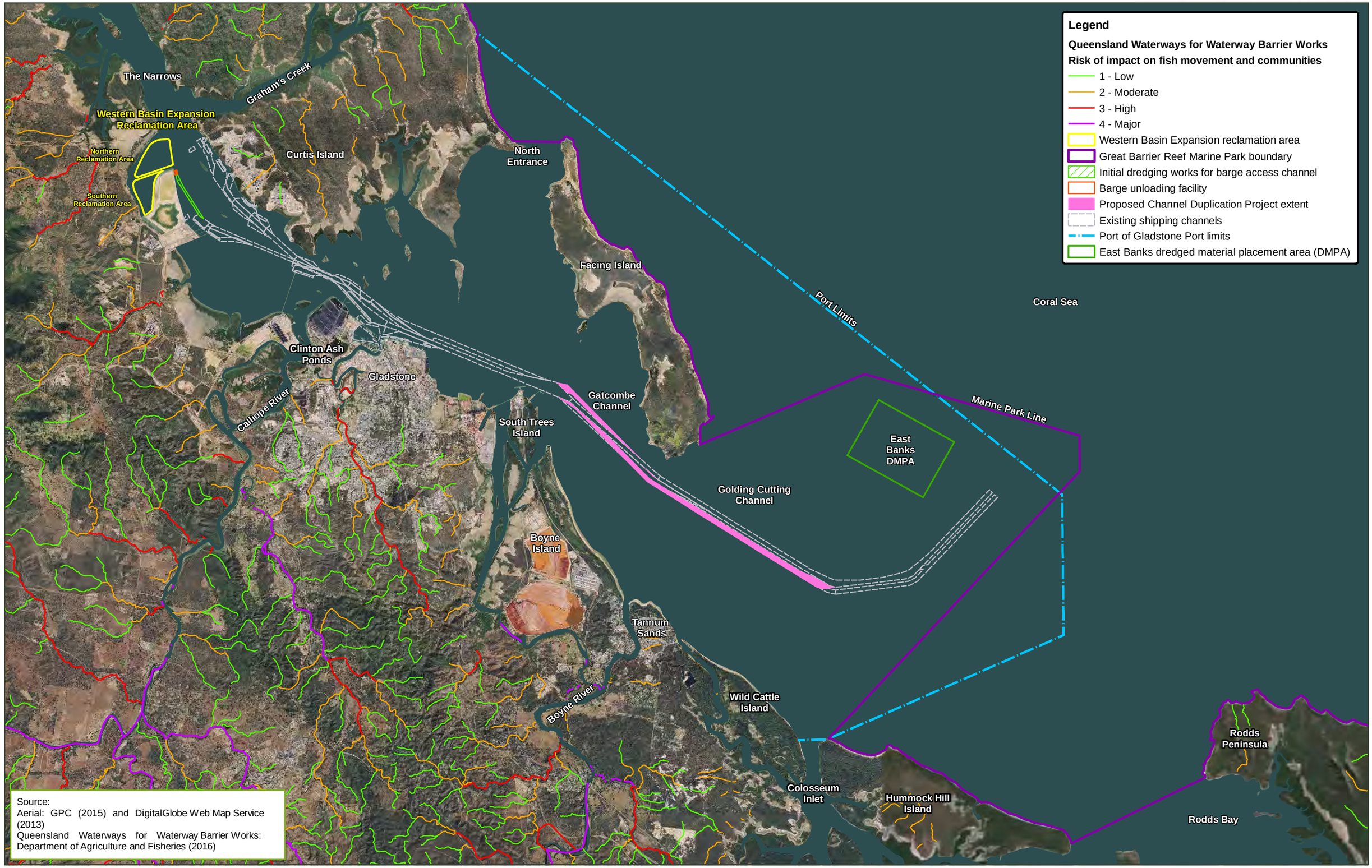
MSES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section and/or figures within this technical report
Regulated vegetation		
Regulated vegetation mapped within the WB and WBE reclamation areas, barge access channel and BUF potential indirect impact area	■ 111.67ha of remnant vegetation is located within the Project indirect impact area (i.e. none located within the direct impact area) ■ 0ha of RE mapped within 500m of the barge access channel potential indirect impact area ■ 0ha of RE mapped within 500m of the BUF potential indirect impact area	Figures 4.3 and 17.3 Section 3.3
Connectivity areas		
Connectivity value of regulated vegetation	■ The DEHP Landscape Fragmentation and Connectivity Tool analysis determined that any Project impact on connectivity areas is not significant. The analysis is specific to the terrestrial connectivity values of regulated vegetation ■ There are no core remnant areas occurring within the WB or WBE reclamation areas reclamation area. The percent change of core remnant areas at a local scale following Project impact is 0%	Figures 13.6 and 13.7 Section 13.3.5
Wetlands and watercourses		
MSES HES Wetlands mapped within the Project potential direct and indirect impact areas	■ 48.62ha mapped within the WBE reclamation area ■ 60.86ha mapped within the WBE reclamation area potential indirect impact area ■ 0ha mapped within the barge access channel potential impact area ■ 0ha mapped within the BUF potential impact area	Figures 5.2 and 17.3 Section 5
Designated precinct in a strategic environment area		
The Project impact areas are not situated within a strategic environmental area	N/A	N/A
Protected wildlife habitat		
Protected Dugong habitat mapped within the Project impact areas	■ The areas to be dredged, the barge access channel, the BUF and the WB and WBE reclamation areas are located within the Rodds Bay DPA Zone B ■ The area which extends from Friend Point, at the base of The Narrows, to the bottom of Rodds Bay was declared the 'Rodds Bay DPA Zone B' to recognise the importance of the seagrass communities present as important habitat for the Dugong ■ DPA were established to reduce the mortality of Dugongs due to commercial fishing practices	Figure 15.19 Section 15.7

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section and/or figures within this technical report
Protected wildlife habitat mapped within the WB and WBE reclamation areas potential indirect impact area	■ 258.34ha of Essential Habitat for the Coastal sheath-tail bat (*Taphozous australis*) is mapped within the WB and WBE reclamation areas potential indirect impact area ■ 14.81ha of Essential Habitat for the Koala (*Phascolarctos cinereus*) mapped within the WB and WBE reclamation areas potential indirect impact area ■ 5.17ha of Essential Habitat for the Water mouse (*Xeromys myoides*) mapped within the WB and WBE reclamation areas potential indirect impact area	Figures 13.3 to 13.5 Section 13.3.3
Protected areas		
There are no Protected areas, under the provisions of the NC Act, present within the Project impact areas	N/A	Figure 17.3
Highly protected zones of State marine parks		
There are no highly protected areas of a Queensland marine park present within the Project impact areas	N/A	Figure 17.3
The GBRMP boundary is situated on the open coastal waters side of Curtis and Facing Islands, with the closest Project impact area located more than 2km southwest of the boundary (i.e. the areas to be dredged, near the southern end of Facing Island)	■ Highly protected areas of a Queensland marine park present within the Project region include areas of the Great Barrier Reef Marine Park zoned as: – Conservation Park – Marine National Park – Preservation	Figure 1.4 Section 1.4.1.2
Fish habitat areas		
There are no declared FHA present within the Project direct impact areas	■ Declared FHA 'Colosseum Inlet', 'Rodds Harbour' and 'Calliope River' are located outside of the Project impact areas	Figures 9.18 and 17.3 Section 9.4
Waterway providing for fish passage		
No DAF waterways classified as suitable for fish movement are mapped within the Project direct impact areas	The nearest DAF waterway mapped within proximity to the Project impact areas is a 'medium' watercourse, approximately 150m to the southwest of the WBE reclamation area	Figure 17.4
Marine plants		
Marine plant species are present within the Project impact areas	■ Seagrass communities are present within the Project impact areas ■ Marine plant communities are also present within the Project impact areas	Section 4.3 Section 7

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Relevant section and/or figures within this technical report
Legally secured offset areas		
There are no legally secured offset areas situated within the Project impact areas	N/A	Section 3.3.4 Figure 3.2

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Queensland Waterways for Waterway Barrier Works: Department of Agriculture and Fisheries (2016)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_116.mxd 18/01/2019 14:15

0 1,900 3,800 Metres

Date: 18/01/2019 Version: 8 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 17.4: Waterways providing for fish passage

18 References

A

Adaptive Strategies, GHD and RMC 2017, *Method for identifying the presence of Outstanding Universal Value within the Great Barrier Reef World Heritage Area*, Prepared for Queensland Department of State Development, Adaptive Strategies, Brisbane.

Alquezar, R & Boyd, W 2007, 'Development of rapid, cost effective coral survey techniques: tools for management and conservation planning', *Journal of Coastal Conservation*, vol. 11, pp. 105-119.

Alquezar, R & Scannell, J 2010, 'Fish habitat assessment of the Narrows pipeline crossing', Centre for Environmental Management, Central Queensland University, Gladstone.

Alquezar, R 2008, 'Macroinvertebrate and sediment assessment for the Curtis Island gas pipeline EIS', Centre for Environmental Management, Central Queensland University, Gladstone.

Alquezar, R 2010, *Shell Australia LNG Project: Estuarine and Marine Field Investigations*, Centre for Environmental Management, Central Queensland University, Gladstone.

Alquezar, R 2011, *Arrow Energy LNG Plant: Estuarine and Marine Ecology Field Investigations (Phase I & II)*, Prepared for Coffey Environments, Centre for Environmental Management, Central Queensland University, Gladstone.

Alquezar, R, Boyd, W & Bunce, A 2007, *Coral community extent and mapping of Burnett Mary's coastal fringing reefs: field validation techniques*, Prepared for the Burnett Mary Regional Group, Centre for Environmental Management, Central Queensland University, Gladstone.

Alquezar, R, Scannell, J & Boyd, W 2011, *Coastal fringing reefs of the Burnett Mary Region*, Prepared for the Burnett Mary Regional Group, Centre for Environmental Management, Central Queensland University, Gladstone.

Alquezar, R, Small, K & Stratford, P 2006, *Port Curtis Macrobenthic Monitoring Programme: Queensland Energy Resources Limited surveys: November 1995-November 2005*, Centre for Environmental Management, Central Queensland University, Gladstone.

Amphibian Research Centre (2013)

Anderson, E 2003, *Plants of central Queensland: Their identification and uses,* Department of Primary Industries, Brisbane.

Anderson, LE, Melville, F & Alquezar, R 2006, *An Investigation to prevent a marine pest incursion in Port Curtis*, Centre for Environmental Management, Central Queensland University, Gladstone.

Angonesi, LG, Bemvenuti, CE & Gandra, MS 2006, 'Effects of dredged sediment disposal on the coastal marine macrobenthic assemblage in southern Brazil', *Brazilian Journal of Biology*, vol. 66, pp. 413-420.

Anon 1981, Nomination of the Great Barrier Reef by the Commonwealth of Australia for inclusion in the World Heritage List, Great Barrier Reef Marine Park Authority Report to the World Heritage Committee, UNESCO.

APHA 2005, *Standard Methods for the Examination of Water and Wastewater*, 21st edition, Port City Press, Baltimore, United States of America.

Arnold, P & Heinsohn, G 1996, 'Phylogenetic status of the Irrawaddy dolphin Orcaella brevirostris (Owen in Gray): a cladistic analysis', *Memoirs of the Queensland Museum*, vol. 39, pp. 141-204.

Atlas of Living Australia (ALA) 2019, *The Atlas of Living Australia Spatial Portal*, viewed 30 January 2019, <www.ala.org.au>.

Atlas of Living Australia 2010, *Tursiops aduncus, Indian Ocean Bottlenose Dolphin*, photograph, viewed 24 January 2018, <https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:aab6d06c-0f49-4567-913b-c29ac529bd3f#gallery>.

Atlas of Living Australia 2014, *Tursiops truncates, Bottlenose Dolphin*, photograph, viewed 24 January 2018, <https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:f2c8b22b-f0b1-45ea-8853-891c4a527293.

Aurecon 2017, *Addendum to evidence base – Priority Port of Gladstone*, Prepared for the Queensland Department of State Development, Aurecon, Brisbane.

Aurecon 2019, *Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project – Environmental Impact Statement Water Quality Technical Report.*

Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

Australian Institute of Marine Science (AIMS) 2016, *Declining coral growth on the Great Barrier Reef*, viewed 6 February 2018 <http://www.aims.gov.au/docs/research/climate-change/declining-coral-growth.html>.

Ayling, AM, Ayling, AL & Ceccarelli, D 2012, *The Impact of Dredge Spoil Dumping on Fringing Coral Reefs Around Facing Island*, Prepared for Gladstone Ports Corporation, Sea Research, Gladstone.

Ayling, AM, Ayling, AL & Ceccarelli, D 2013, *Changes in Benthic Communities on Fringing Coral Reefs around Facing Island: August 2013*, Prepared for Gladstone Ports Corporation, Sea Research, Gladstone.

B

Baird, A & Marshall, P 2002, 'Mortality, growth and reproduction in Scleractinian corals following bleaching on the Great Barrier Reef', Marine Ecology Progress Series, vol. 237, pp. 133-141.

Baker, AC, Glynn, PW & Reigl, B 2008, 'Climate change and coral reef bleaching: An ecological assessment of long-term impacts, recovery trends and future outlook', Estuarine, Coastal and Shelf Science, vol. 80, pp. 435-471.

Baker, N 2014, Site Inspection Report, Port of Gladstone – Field Trip, 23-24 September 2013, Great Barrier Reef Marine Park Authority, Townsville.

Bannister, JL, Kemper, CM & Warneke, RM 1996, The Action Plan for Australian Cetaceans, Australian Nature Conservation Agency, Canberra.

Barros, NB & Wells, RS 1998, 'Prey and feeding patterns of resident bottlenose dolphins (Tursiops truncatus) in Sarasota Bay, Florida', Journal of Mammalogy, vol. 79, pp. 1045-1059.

Bates, D, Maechler, M, Bolker, B & Walker, S 2013, Ime4: Linear mixed-effects models using Eigen and S4.R package version 1.0-4.

Battersby, E 2014, 'Top beach fishing spots near Gladstone', The Observer, 17 April 2014, viewed 23 May 2018, <http://www.gladstoneobserver.com.au/news/top-beach-fishing-spots-near-gladstone/2230839/>.

Bax, N, Carlton, J, Matthews-Amos, A, Haedrich, R, Howarth, F, Purcell, J, Rieser, A & Gray, A 2001, 'The control of biological invasions in the world's oceans', Conservation Biology, vol. 15, pp. 1234-1246.

Beasley, I, Robertson, KM & Arnold, P 2005, 'Description of a new dolphin: The Australian snubfin dolphin Orcaella heinsohni sp.n. (Cetacea, Delphinidae)', *Marine Mammal Science*, vol. 21, no. 3, pp. 365-400.

Berkelmans, R & Oliver, JK 1999, 'Large-scale bleaching of corals on the Great Barrier Reef', *Coral Reefs*, vol. 18, pp. 55-60.

Berkelmans, R, De'ath, G, Kininmonth, S & Skirving, WJ 2004, 'A comparison of the 1998 and 2002 coral bleaching events on the Great Barrier Reef: Spatial correlation, patterns, and predictions', *Coral Reefs*, vol. 23, pp. 74-83.

Berkelmans, R, Jones, AM & Schaffelke, B 2012, 'Salinity thresholds of Acropora spp on the Great Barrier Reef', *Coral Reefs*, vol. 31, pp. 1103-1110.

Bjork, M, Uku, J, Weil, A & Beer, S 1999, 'Photosynthetic tolerances to desiccation of tropical intertidal seagrasses', *Marine Ecology Progress Series*, vol. 191, pp. 121-126.

Blair, D 2012, Genetic evidence for distinctiveness and connectivity among Australian Dugongs, Prepared for the Australian Marine Mammal Centre, James Cook University, Cairns.

Blue Planet Marine 2013, Final report: July 2013 Survey – Monitoring Aquatic Ambient Noise and the Associated Pressure Impacts in Port Curtis and Port Alma, Prepared for Gladstone Ports Corporation, Kingscliff.

BMT WBM 2006, Benthic Macroinvertebrate Monitoring – Port of Gladstone Dredged Material Ocean Disposal Site, Prepared for Central Queensland Ports Authority, Brisbane.

BMT WBM 2009, Port Curtis Reef Assessment – Final Report, Prepared for Queensland Gas Company, Brisbane.

BMT WBM 2012, Port of Gladstone Offshore Disposal Monitoring Program, Prepared for Gladstone Ports Corporation, Brisbane.

BMT WBM 2013, Central Queensland Corals and Associated Benthos: Monitoring Review and Gap Analysis, Prepared for Gladstone Ports Corporation, Brisbane.

BMT WBM 2014a, Identification of Coral Reef Sites for Restoration and Enhancement in Port Curtis – Phase 1, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Biodiversity Offset Strategy.

BMT WBM 2014b, Maintenance Dredging of the Western Basin Dredging and Disposal Footprint - Sediment Quality Report, Prepared for Gladstone Ports Corporation, Brisbane.

BMT WBM 2014c, Draft Numerical Modelling of Rehandling of Dredged Material and Reclamation Options in Port Curtis, Prepared for Aurecon, Brisbane.

BMT WBM 2015, Prioritisation of reef restoration and enhancement sites – Phase 2 and 3 report, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Biodiversity Offset Strategy.

BMT WBM 2018, Facing Island Reef Surveys, Prepared for Gladstone Ports Corporation, Brisbane.

BMT WBM 2019, Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS – Coastal Processes and Hydrodynamics Technical Report.

Brand-Gardner, SJ, Lanyon, JM & Limpus, CJ 1999, 'Diet selection by immature green turtles, Chelonia mydas, in sub-tropical Moreton Bay, south-east Queensland', Australian Journal of Zoology, vol. 47, pp. 181-191.

Bryant, CV & Rasheed, MA 2013, Gladstone Permanent Transect Seagrass Monitoring – December 2013 Updated Report, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Bryant, CV, Carter, AB, Jarvis, JC, Reason, CL & Rasheed, MA 2016a, *Port Curtis Seagrass Seed Bank Density and Viability Studies - Year 2*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 16/46, James Cook University, Cairns.

Bryant, CV, Davies, JD, Jarvis, JC, Tol, S & Rasheed, MA 2014, *Seagrasses in Port Curtis and Rodds Bay 2013: Annual Long Term Monitoring*, Biannual Western Basin Surveys & Updated Baseline Survey, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 14/23, James Cook University, Cairns, 71 pp.

Bryant, CV, Davies, JN, Sankey, T & Rasheed, MA 2016b, *Long-Term Seagrass Monitoring in Port Curtis: Quarterly Permanent Transect Monitoring Progress Report 2009 to 2015*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 16/34, James Cook University, Cairns.

Bucher, D, M. Baronio M, and Stokes, D 2013, *Monitoring mangrove condition: Gladstone Harbour, Fisherman's Landing* - March 2013. Southern Cross University, New South Wales, Australia.

Bureau of Meteorology (BoM) 2013, Climate Data Online, viewed 24 January 2018, <http://www.bom.gov.au/climate/data/>

Bureau of Meteorology (BoM) 2018, Weather Observations, GLADSTONE RADAR weather station ID 039123, viewed 22 January 2018, <http://www.bom.gov.au/products/IDQ60801/IDQ60801.94380.shtml>.

Burkholder, JM, Tomasko, DA & Touchette, BW 2007, 'Seagrasses and eutrophication', Journal of Experimental Marine Biology and Ecology, vol. 350, pp. 46-72.

C

Cagnazzi, D 2013, *Review of Coastal Dolphins in central Queensland, particularly Port Curtis and Port Alma regions*, report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program, 53pp.

Cagnazzi, D 2015a, *First Project Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Cagnazzi, D 2015b, *Second Project Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Cagnazzi, D 2015c, *Third Project Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Cagnazzi, D 2016, *Fourth Project Report: Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Cagnazzi, D 2017, *Increase understanding of the status of the Australian snubfin and Australian humpback dolphins within Port Curtis and Port Alma Final Project Report*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Campbell, S & McKenzie, L 2004, 'Flood related loss and recovery of intertidal seagrass meadows in southern Queensland, Australia', *Estuarine, Coastal and Shelf Science*, vol. 60, pp. 477-490.

Carter, A, Davies, J, Bryant, C, Jarvis, J, McKenna, S & Rasheed, M 2015, *Seagrass in Port Curtis and Rodds Bay 2014: Annual long-term monitoring, biannual Western Basin, and updated baseline survey*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Carter, A, Taylor, H, McKenna, S & Rasheed, M 2014, *Long-term Seagrass Monitoring in the Port of Thursday Island: March 2014*, Prepared for Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Chaloupka, M, Limpus, CJ & Miller, J 2004, 'Green turtle somatic growth dynamics in a spatially disjunct Great Barrier Reef metapopulation', *Coral Reefs*, vol. 23, pp. 325-335.

Chartrand, KM, Bryant, CV, Carter, AB, Ralph, PJ & Rasheed, MA 2016, 'Light Thresholds to Prevent Dredging Impacts on the Great Barrier Reef Seagrass, *Zostera muelleri* spp. *capricorni*', *Frontiers in Marine Science*, vol. 3, pp. 1-17.

Chartrand, KM, McCormack, CV & Rasheed, MA 2011, *Port Curtis and Rodds Bay seagrass monitoring program*, Department of Employment, Economic Development and Innovation, Cairns.

Chartrand, KM, Ralph, PJ, Petrou, K & Rasheed, MA 2012, 'Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program', Department of Agriculture, Fisheries and Forestry (DAFF Publication), Fisheries Queensland, Cairns 126 pp.

Chartrand, KM, Rasheed, MA, & Carter, AB 2018, *Seagrasses in Port Curtis and Rodds Bay 2017 Annual long-term monitoring*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Chatto, R 1998, 'A preliminary overview of the locations of marine turtle nesting in the Northern Territory', in *Marine Turtle Conservation and Management in Northern Australia*, eds R Kennett, A Webb, G Duff, M Guinea & G Hill, Centre for Indigenous Natural and Cultural Resource Management Centre for Tropical Wetlands Management, Northern Territory University, Darwin, pp. 33-40.

Chen, CA, Wang, JT, Fang, LS & Yang, YW 2005, 'Fluctuating algal symbiont communities in *Acropora palifera* (Scleractinia: Acroporidae) from Taiwan', *Marine Ecology Progress Series*, vol. 295, pp. 113-121.

Chen, JQ, Franklin, JF & Spies, TA 1995, 'Growing-season microclimatic gradients from clearcut edges into old-growth Douglas-fir forests', *Ecology Applied*, vol. 5, no. 1, pp. 74-86.

Chilvers, BL, Delean, S, Gales, NJ, Holly, DK, Lawler, IR, Marsh, H & Preen, AR 2004, 'Diving behaviour of dugongs', *Journal of Experimental Marine Biology and Ecology*, vol. 304, pp. 203-224.

Chin, A 2003, 'Inter-reefal and lagoonal benthos', in Chin, A (ed) *State of the Great Barrier Reef On-line,* Great Barrier Reef Marine Park Authority, Townsville, viewed 28 May 2018, <https://www.researchgate.net/publication/268688260_Inter-reefal_and_lagoonal_benthos>

Choi, CY, Coleman, J, Klaassen, M, Moffitt, DJ, Rogers, D, Skilleter, G & Fuller, RA 2017, *Annual Report: Migratory Shorebird Monitoring – Understanding Ecological Impact (CA12000284)*, Report produced for Ecosystem Research and Monitoring Program Advisory Panel as part of GPCs Ecosystem Research and Monitoring Program.

Choi, CY, Moffitt, DJ, Fuller, RA, Skilleter, G, Rogers, D, Coleman, J & Klaassen, M 2015, *Annual Report: Migratory Shorebird Monitoring – Understanding Ecological Impact (CA12000284)*, Report produced for Ecosystem Research and Monitoring Program Advisory Panel as part of GPCs Ecosystem Research and Monitoring Program.

Choi, CY, Moffitt, DJ, Fuller, RA, Skilleter, G, Rogers, D, Coleman, J & Klaassen, M 2016, *Annual Report: Migratory Shorebird Monitoring – Understanding Ecological Impact (CA130019)*, Report produced for Ecosystem Research and Monitoring Program Advisory Panel as part of GPCs Ecosystem Research and Monitoring Program.

Christidis, L & Boles, W 2008, *Systematics and Taxonomy of Australian Birds*, CSIRO Publishing, Collingwood.

Cleguer C, Limpus CG, Hamann M, & Marsh, H 2015b, *Annual report on dugong tracking and habitat use in Gladstone in 2015*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Cleguer, C, Limpus, CG, Gredzens, C, Hamann, M & Marsh, H 2015a, *Annual report on dugong tracking and habitat use in Gladstone in 2014*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Clifton, D & Bell, I 2000*, Queensland Turtle Conservation Project – Facing Island Turtle Nesting Survey 1999-2000*, Prepared for Gladstone Port Authority and Queensland Parks and Wildlife Service.

Clifton, D & Bell, I 2003, *Queensland Turtle Conservation Project – Facing Island Marine Turtle Nesting Study 2002-2003*, Prepared for the Gladstone Port Authority and Queensland Parks and Wildlife Service.

Cockcroft, VG 1989, 'Biology of Indopacific humpback dolphin (*Sousa plumbea*) off Natal, South Africa', *Abstracts of the Biennial Conference on the Biology of Marine Mammals*, vol. 8, p. 13.

Cogger, H. 2014, *Reptiles and Amphibians*, 7th edition, CSIRO publishing, Collingwood.

Coles, R.G., Rasheed, M.A., McKenzie, L.J., Grech, A., York, P.H., Sheaves, M., McKenna, S. and Bryant, C., 2015. The Great Barrier Reef World Heritage Area seagrasses: managing this iconic Australian ecosystem resource for the future. *Estuarine, Coastal and Shelf Science*, *153*, pp. A1-A12.

Coles, RG, Lee Long, WJ, Helmke, SA, Bennett, R.E, Miller, KJ & Derbyshire, KJ 1992, *Seagrass Beds and Juvenile Prawn and Fish Nursery Grounds: Cairns to Bowen*, Queensland Department of Primary Industries, Brisbane.

Collier, C, Uthicke, S & Waycott, M 2011, 'Thermal tolerance of two seagrass species at contrasting light levels: Implications for future distribution in the Great Barrier Reef', *Limnology and Oceanography*, vol. 56, pp. 2200-2210.

Collier, CJ, Lavery, PS, Ralph, PJ & Masini, RJ 2009, 'Shade-induced response and recovery of the seagrass Posidonia sinuosa', *Journal of Experimental Marine Biology and Ecology*, vol. 370, pp. 89-103.

Collier, CJ, Waycott, M & Ospina, AG 2012, 'Responses of four Indo-West Pacific seagrass species to shading', *Marine Pollution Bulletin*, vol. 65, pp. 342-354.

Coman, FE, Connolly, RM & Preston, NP 2003, 'Zooplankton and epibenthic fauna in shrimp ponds: factors influencing assemblage dynamics', *Aquaculture Research*, vol. 34, pp. 359-371.

Commonwealth of Australia 1999, Joint SCC/SCFA National Taskforce on the Prevention and Management of Marine Pest Incursions, Report of the Taskforce.

Commonwealth of Australia 2009, *National Assessment Guidelines for Dredging* (NAGD), Commonwealth of Australia, Canberra, 2009.

Commonwealth of Australia 2011, *Survey guidelines for Australia's threatened mammals, p*repared for the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Commonwealth of Australia 2013, *Independent Review of the Port of Gladstone – Report on Findings – July 2013*, Prepared for the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Commonwealth of Australia 2015, *Reef 2050 Long-Term Sustainability Plan*, Department of the Environment & the Queensland Government, Canberra.

Commonwealth of Australia 2018, *Australian Wetlands Database Ramsar Wetlands*, viewed 9 March 2018, <http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl>.

Connolly RM, Bunn S, Campbell M, Escher B, Hunter J, Maxwell P, Page T, Richmond S, Rissik D, Roiko A, Smart J, Teasdale P (2013). Review of the use of report cards for monitoring ecosystem and waterway health. Report to: Gladstone Healthy Harbour Partnership. November 2013. Queensland, Australia.

Connolly, RM 2009, 'Seagrass', in *A Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, eds ES Poloczanska, AJ Hobday & AJ Richardson, National Climate Change Adaptation Research Facility, Gold Coast.

Connolly, RM, Currie, DR, Danaher, KF, Dunning, M, Melzer, A, Platten, JR, Shearer, D, Stratford, PJ, Teasdale, PR & Vandergragt, M 2006, *Intertidal wetlands of Port Curtis: ecological patterns and processes, and their implications*, Technical Report No. 43, CRC for Coastal Zone, Estuary and Waterway Management, Brisbane.

Connor, RC, Wells, RS, Mann, J & Read AJ 2000, 'The bottlenose dolphin: social relationships in a fission-fusion society', in *Cetacean societies: field studies of dolphins and whales*, eds J Mann, RC Connor, PL Tyack & H Whitehead, The University of Chicago Press, Chicago.

Corkeron, PJ, Morissette, NM, Porter, l & Marsh, H 1997, 'Distribution and status of Humpback Dolphins, *Sousa chinensis*, in Australian waters', *Asian Marine Biology*, vol. 14, pp. 49-59.

Costanza, R, De Groot, R, Sutton, P, Van De Ploeg, S, Anderson, SJ, Kubiszewski, I, Farber, S & Turner, RK 2014, 'Changes in global value of ecosystem services', *Global Environmental Change*, vol. 26, pp. 152-158.

Costanzo, S, Donohue, M & Dennison, W 2003, 'Assessing the seasonal influence of sewage and agricultural nutrient inputs in a subtropical river estuary', *Estuaries and Coasts*, vol. 26, pp. 857-865.

Costanzo, SD, O'Donohue, MJ & Dennison, WC 2004, 'Assessing the influence and distribution of shrimp pond effluent in a tidal mangrove creek in north-east Australia', *Marine Pollution Bulletin*, vol. 48, pp. 514-525.

Crawley, A, Kline, DI, Dunn, S, Anthony, K & Dove, S 2010, 'The effect of ocean acidification on symbiont photorespiration and productivity in *Acropora formosa*', *Global Change Biology*, vol. 16, pp. 851-863.

CRC Reef Research Centre 2002, Research centre, viewed 1 March 2018, <http://rrrc.org.au/crc-reef-publications/>

Cribb, AB 1996, 'Seaweeds of Queensland – A Naturalists Guide', *The Queensland Naturalists Club*, vol. 2, p. 33.

Cruz-Motta, JJ & Collins, J 2004, 'Impacts of dredged material disposal on a tropical soft-bottom benthic assemblage', *Marine pollution bulletin*, vol. 48, pp. 270-280.

Currie, DR & Connolly, RM 2004, *Distribution and assemblage composition of demersal fish in shallow, nearshore waters of Port Curtis*, CRC for Coastal Zone Estuary & Waterway Management, Brisbane.

Currie, DR & Small, KJ 2005, 'Macrobenthic community responses to long-term environmental change in an east Australian sub-tropical estuary', *Estuarine, Coastal and Shelf Science*, vol. 63, pp. 315-331.

Currie, DR & Small, KJ 2006, 'The influence of dry-season conditions on bottom dwelling fauna of an east Australian sub-tropical estuary', *Hydrobiologia*, vol. 560, pp. 345-361.

D

Daley, B, Griggs, P & Marsh, H 2008, 'Exploiting marine wildlife in Queensland: the commercial dugong and marine turtle fisheries, 1847-1969', *Australian Economic History Review*, vol. 48, no. 3, pp. 227-265.

Dambacher, J.M., Hodge, K.B., Babcock, R.C., Fulton, E.A., Apte, S.C., Plagányi, É.E., Warne, M. & Marshall, N.A. (2013). Models and indicators of key ecological assets in Gladstone Harbour. A report prepared for the Gladstone Healthy Harbour Partnership. CSIRO Wealth from Oceans Flagship, Hobart.

Danaher, KF, Rasheed, MA & Thomas, R 2005, *The intertidal wetlands of Port Curtis*, Information Series Q105031, Department of Primary Industries and Fisheries, Queensland.

Davies JD, Bryant CV, Carter AB and Rasheed MA 2016, *Seagrasses in Port Curtis and Rodds Bay 2015: Annual long-term monitoring*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 16/02, James Cook University, Cairns.

Davies, J, McKenna, S & Rasheed M 2015a, *Port Curtis, Rodds Bay and Channel Duplication Seagrass and Light Monitoring: January 2013 to May 2015*, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Davies, J, McKenna, S, Jarvis, J, Carter, A & Rasheed, M 2014, *Port of Townsville Annual Monitoring and Baseline Survey: October 2013*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Davies, J, Sankey, T, Jarvis, J, Bryant, C & Rasheed, M 2015b, *Long Term Seagrass Monitoring in Port Curtis: Quarterly Seagrass Assessments & Permanent Transect Monitoring Progress Report, 2009-2014*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Davies, JD, McCormack, CV & Rasheed, MA 2013, *Port Curtis and Rodds Bay seagrass monitoring program, Biannual Western Basin & Annual Long Term Monitoring November 2012*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Davies, JN, Scott, EL, Bryant, CV & Rasheed, MA 2015d, *Gladstone Western Basin and Channel Duplication BPAR Monitoring: May – August 2015*, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Davies, JN, Sozou, AM, Sankey, TL & Rasheed, MA 2015c, *Assessment of macro-benthic communities and sediment particle size analysis from Port Curtis samples - February 2015*, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) 15/21, James Cook University, Cairns, pp. 17.

De'ath, G, Fabricius, KE, Sweatman, H & Puotinen, M 2012, 'The 27-year decline of coral cover on the Great Barrier Reef and its causes', *PNAS,* vol. 109, no. 44, pp. 17,734-17,735.

Dennison, W., Orth, R., Moore, K., Stevenson, J., Carter, V., Kollar, S., Bergstrom, P. and Batiuk, R. 1993. Assessing water quality with submersed aquatic vegetation: Habitat requirements as barometers of Chesapeake Bay health. BioScience, 43: 86-94

Department of Agriculture 2013, *About the National System for the Prevention and Management of Marine Pest Incursions,* viewed 20 March 2018, <http://www.marinepests.gov.au/national-system/Pages/default.aspx>

Department of Agriculture and Fisheries (DAF) 2013, *Commercial trawling in Queensland*, viewed 28 May 2018, <https://www.daf.qld.gov.au/fisheries/commercial-fisheries/queenslands-commercial-fisheries/trawl-fishery>

Department of Agriculture and Fisheries (DAF) 2016, *Maps of fire ant biosecurity zones*, viewed 25 January 2018, <https://www.daf.qld.gov.au/plants/weeds-pest-animals-ants/invasive-ants/fire-ants/restricted-areas/restricted-area-maps>.

Department of Agriculture and Fisheries (DAF) 2017, *Restricted matter*, viewed 25 January 2018, <https://www.daf.qld.gov.au/biosecurity/about-biosecurity/biosecurity-act-2014/biosecurity-matter/restricted-matter>

Department of Agriculture and Fisheries (DAF) 2018, *QFish dataset for the S30 Commercial Fishing Logbooks between the years 2008/2009-2017/2018*, viewed 17 and 29January 2019

Department of Agriculture and Water Resources (DAWR) 2015, *Review of national marine pest biosecurity,* Department of Agriculture and Water Resources, Canberra.

Department of Agriculture, Fisheries and Forestry (DAFF) 2005*, Australian Emergency Marine Pest Plan (EMP Plan)*, viewed 23 May 2018, <http://www.agriculture.gov.au/pests-diseases-weeds/marine-pests/empplan>.

Department of Agriculture, Fisheries and Forestry (DAFF) 2010*, Australian marine pest monitoring guidelines Version 2.0: Keeping marine pests out of Australian Waters*, Prepared for Commonwealth of Australia, Canberra.

Department of Agriculture, Fisheries and Forestry 2009*, National System for the Prevention and Management of Marine Pests Incursions (NIMPIS),* Department of Agriculture, Fisheries and Forestry, Canberra.

Department of Environment and Heritage Protection (EHP) 2013, *Analysis of Water Quality in Relation to Fish Health in Gladstone Harbour and Waterways September 2011 – September 2012*, Department of Environment and Heritage Protection, Queensland Government, Brisbane.

Department of Environment and Heritage Protection (EHP) 2014a, *Queensland Environmental Offsets Policy*, Version 1.1, viewed 12 January 2018, **http://www.ehp.qld.gov.au/assets/documents/pollution/management/offsets/offsets-policyv1-1.pdf**

Department of Environment and Heritage Protection (EHP) 2014b, *Biodiversity Assessment and Mapping Methodology*, Version 2.2, Prepared for Department of Environment and Heritage Protection, Brisbane.

Department of Environment and Heritage Protection (EHP) 2014c, *Queensland Map of Referable Wetlands,* Version 1.1, viewed 28 May 2018, **https://www.ehp.qld.gov.au/ecosystems/wetlands/referable-wetlands-maps.html**

Department of Environment and Heritage Protection (EHP) 2015, *Australian Humpback Dolphin*, viewed 24 January 2018, **https://www.ehp.qld.gov.au/wildlife/animals-az/indopacific_humpback_dolphin.html**

Department of Environment and Heritage Protection (EHP) 2016a, *Species Profile: Platypus*, viewed 28 May 2018, **https://www.ehp.qld.gov.au/wildlife/animals-az/platypus.html**

Department of Environment and Heritage Protection (EHP) 2016b, *StrandNet Database*, version 1.2, Queensland Government, viewed February 2018, **https://www.derm.qld.gov.au/strandnet/application/public/security/logon.xhtml**

Department of Environment and Heritage Protection (EHP) 2016c, *A Biodiversity Planning Assessment Southeast Queensland Bioregion Landscape Expert Panel Report*, version 4.1, Department of Environment and Heritage Protection, Queensland Government, viewed 28 May 2018, **https://www.ehp.qld.gov.au/assets/documents/plants-animals/biodiversity/bpa-seq-landscape.pdf**

Department of Environment and Heritage Protection (EHP) 2016d, *A Biodiversity Planning Assessment Southeast Queensland Bioregion* version 4.1. Flora Expert Panel Report: Department of Environment and Heritage Protection, Queensland Government.

Department of Environment and Heritage Protection (EHP) 2017, Queensland scientist honoured at VIP event celebrating 50 years of turtle research, 2 May 2018, <https://www.ehp.qld.gov.au/mediareleases/2017-11-13-queensland-scientist-honoured-vip-event.html>

Department of Environment and Resource Management (DERM) 2010a, *Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity*, Department of Environment and Resource Management, Brisbane.

Department of Environment and Resource Management (DERM) 2010b, *Monitoring and Sampling Manual, Version 2 September 2010*, Department of Environment and Resource Management, Brisbane.

Department of Environment and Science (DES) 2017, *Wetland Management Series,* Available; <https://data.qld.gov.au/dataset/wetland-management-series> 24 May 2018.

Department of Environment and Science (DES) 2019, *WildNet Records*, Queensland Government, viewed 30 January 2019, <https://environment.ehp.qld.gov.au/report-request/species-list/>.

Department of Environment, Water, Heritage and the Arts (DEWHA) 2010, *Wetlands Australia*, National Wetlands Update, Issue no. 18.

Department of National Parks, Recreation, Sport and Racing (DNPRSR) 2012, *Declared Fish Habitat Area summary – Colosseum Inlet*, viewed 23 January 2018, <https://www.npsr.qld.gov.au/managing/area-summaries/colosseum.html>

Department of National Parks, Recreation, Sport and Racing (DNPRSR) 2014a, *Fisheries Resources of Calliope River, Gladstone: Central Queensland 2014,* Department of National Parks, Recreation, Sport and Racing, Brisbane.

Department of National Parks, Recreation, Sport and Racing (DNPRSR) 2014b, *Guidelines for conducting an inventory of instream structures in coastal Queensland*, viewed 29 March 2018, <https://www.npsr.qld.gov.au/managing/pdf/fish-habitat-guideline.pdf>

Department of National Parks, Sport and Racing (DNPRSR) 2016, *Declared fish habitat areas*, viewed 28 May 2018, <http://www.nprsr.qld.gov.au/managing/habitat-areas/index.html>.

Department of Natural Resources, Mines and Energy (DNRME) 2017, *Map of referable wetlands*

Department of Natural Resources, Mines and Energy (DNRME) 2018a, *Regulated vegetation management map*, Version 8.0, viewed 12 January 2018, <https://www.dnrm.qld.gov.au/forms/land-property/vegetation-map-request>.

Department of Natural Resources, Mines and Energy n.d, *Water monitoring information panel*, viewed 24 January 2018, <https://water-monitoring.information.qld.gov.au>

Department of Nature Resources, Mines and Energy (DNRME) 2018b, Vegetation management Essential Habitat, version 7.19, viewed 31 January 2019, <http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={4D8FA588-7363-4054-9885-C0009689BE5D}>

Department of Primary Industries, Parks, Water and Environment 2006, *Cheilanthes distans (Bristly rockfern)*, viewed 24 May 2018, <https://www.naturalvaluesatlas.tas.gov.au/downloadattachment?id=13834>.

Department of State Development (DSD) 2016, Master planning for the priority Port of Gladstone master planned area – capacity for growth scenarios, State of Queensland, Department of State Development, Brisbane.

Department of the Environment (DoE) 2012, *Statement of Outstanding Universal Value*, viewed 23 May 2018, <https://www.environment.gov.au/heritage/places/world/gbr/values>.

Department of the Environment 2015a, Australia World Heritage Areas, viewed 24 May 2018, <http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B6C54FE6C-2773-47C6-8CBC-4722F29081EF%7D>.

Department of the Environment and Energy (DoEE) 2015b, *The biological effects, including lethal toxic ingestion, caused by Cane Toads (Bufo marinus)*, viewed 5 April 2018, <http://www.environment.gov.au/biodiversity/threatened/key-threatening-processes/biological-effects-cane-toads>

Department of the Environment and Energy (DoEE) 2017a, *EPBC Act Policy Statement 3.21 – Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) 2017b, *Recovery Plan for Marine Turtles in Australia*, viewed 29 January 2018, <http://www.environment.gov.au/system/files/resources/46eedcfc-204b-43de-99c5-4d6f6e72704f/files/recovery-plan-marine-turtles-2017.pdf>

Department of the Environment and Energy (DoEE) 2018a, *Megaptera novaeangliae* in Species Profile and Threats Database, Department of the Environment, Canberra. viewed 27 May 2018 <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2018b, *Physeter macrocephalus* in Species Profile and Threats Database, Department of the Environment, viewed 27 May 2018 Canberra. <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2018c, *Balaenoptera edeni* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed 27 May 2018 <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2018d. *Eubalaena australis* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed 27 May 2018 <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2018e, *Balaenoptera acutorostrata* in Species Profile and Threats Database, Department of the Environment, Canberra. viewed 27 May 2018 <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2018f, *Balaenoptera borealis* in Species Profile and Threats Database, Department of the Environment, Canberra. viewed 27 May 2018 <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2018g, *Balaenoptera musculus* in Species Profile and Threats Database, Department of the Environment, Canberra. viewed 27 May 2018 <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2018h, *Sousa sahulensis* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed 6 February 2018, <http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=50>

Department of the Environment and Energy (DoEE) 2018i, *Oracaella heinsohni* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed 6 February 2018, <http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=45>

Department of the Environment and Energy (DoEE) 2018j, *Tursiops truncatus* s. str. in Species Profile and Threats Database, Department of the Environment, Canberra.

Department of the Environment and Energy (DoEE) 2018k. *Tursiops aduncus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>

Department of the Environment and Energy (DoEE) 2019, *EPBC Act Protected Matters Report*, Commonwealth of Australia, viewed 24 January 2019, <https://www.environment.gov.au/epbc/protected-matters-search-tool>

Department of the Environment and Resource Management 2010, *National recovery plan for the water mouse (false water rat)* Xeromys myoides, report to Department of Sustainability, Environment, Water, Population and Communities, Canberra, Department of the Environment and Resource Management, Brisbane.

DeVantier, LM, De'ath, G, Tural, E, Done, TJ & Fabricius, KE 2006, 'Species richness and community structure of reef building corals on the near shore reefs of the Great Barrier Reef', *Coral Reefs,* vol. 25, no. 3, pp. 329-340.

DHI Water and Environment 2013, *Gladstone Coral Desktop Study – Desktop Study of the distribution and Ecological Value of Corals and Coral Reef in the Gladstone Region and Wider Bioregion*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Biodiversity Offset Strategy.

Diaz-Pulido, G & McCook, LJ 2008, *State of the Reef Report, Environmental Status of the Great Barrier Reef: Macroalgae (Seaweeds)*, Prepared for the Great Barrier Reef Marine Park Authority, Townsville.

Diaz-Pulido, G, McCook, LJ, Larkum, AWD, Lotze, HK, Raven, JA, Schaffelke, B, Smith, J & Steneck, RS 2007, 'Vulnerability of macroalgae of the Great Barrier Reef to climate change', in *Climate Change and the Great Barrier Reef: A Vulnerability Assessment*, eds JE Johnson & PA Marshall, Great Barrier Reef Marine Park Authority and The Australian Greenhouse Office, Townsville, pp. 151-192.

Dignan, P & Bren, L 2003, 'Modelling light penetration edge effects for stream buffer design in mountain ash forest in southeastern Australia', *Forest Ecology and Management*, vol. 179, pp. 95-106.

Driscoll, P 1997, 'The distribution of shorebirds along the Queensland coastline' in *Shorebird conservation in the Asia-Pacific region*, ed P Straw, Australasian Wader Studies Group, pp. 80-123.

Duarte, C 2002, 'The future of seagrass meadows', *Environmental Conservation,* vol. 29, pp. 2-206.

Duarte, CM & Sand-Jensen, K 1990, 'Seagrass colonization: Biomass development and shoot demography in *Cymodocea nodosa* patches', *Marine Ecology Progress Series*, vol. 67, pp. 97-103.

Duarte, CM, Terrados, J, Agawin, NSR, Fortes, MD, Bach, S & Kenworthy, WJ 1997, 'Response of a mixed Philippine seagrass meadow to experimental burial', *Marine Ecology Progress Series*, vol. 147, pp. 285-294.

Duke, N 2006, *Australia's Mangroves: The authoritative guide to Australia's mangrove plants*, University of Queensland, Brisbane.

Duke, NC & Mackenzie, J 2015, *Port Curtis and Port Alma Coastal Habitat Archive and Monitoring Program 2015 Annual Report CA14000114: Monitoring the survival and recovery of shorelines, specifically Tidal Wetlands (Mangroves/Saltmarsh/Saltpans),* Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Duke, NC, Mackenzie, J, Kovacs, J, Hill, D, Carder, D, Eilert, F, Atkinson, I & van der Valk, S 2017, *Port Curtis and Port Alma Coastal Habitat Archive and Monitoring Program 2016-2017 Annual Report CA14000114: Monitoring the survival and recovery of shorelines, specifically Tidal Wetlands (Mangroves/Saltmarsh/Saltpans),* Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Duke, NC, Mackenzie, J, Kovacs, J, Hill, D, Eilert, F, Atkinson, I & van der Valk, S 2016, *Port Curtis and Port Alma Coastal Habitat Archive and Monitoring Program 2015-2016 Annual Report CA14000114: Monitoring the survival and recovery of shorelines, specifically Tidal Wetlands (Mangroves/Saltmarsh/Saltpans),* Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Durako, M, Kunzelman, J, Kenworthy, W & Hammerstrom, K 2003, 'Depth-related variability in the photobiology of two populations of *Halophila johnsonii* and *Halophila decipiens', Marine Biology*, vol. 142, pp. 1219-1228.

E

Ecosure 2013, Arrow LNG Plant Supplementary Report to the EIS Addendum - Final Shorebird Technical Study, viewed 29 May 2018, <https://www.arrowenergy.com.au/__data/assets/pdf_file/0012/6420/GE241-RE.Final_Shorebird-report_Arrow_LNG_Plant.pdf>.

Ecosure 2015, Marine Turtle Summary Report June 2015, Report prepared on behalf of the Fitzroy Basin Association.

Ecosure 2017, Environmental Survey of Facing Island Final report, Prepared for Gladstone Ports Corporation, Brisbane.

Eden, P, Flint, M, Mills, PC & Owen, H. 2011, Health assessment of green sea turtles from Gladstone Harbour: July to October 2011, University of Queensland School of Veterinary Science, Gatton.

Environmental Protection Agency 2003, State of the Environment Queensland 2003, Queensland Government, Brisbane.

Erftemeijer, PA & Lewis, RR 2006, 'Environmental impacts of dredging on seagrasses: a review', Marine Pollution Bulletin, vol. 52, pp. 1553-1572.

Ewers, RM & Didham, RK 2006, 'Continuous response functions for quantifying the strength of edge effects', Journal of Applied Ecology, vol. 43, pp. 527-536.

Eyre, TJ, Ferguson, DJ, Hourigan, CL, Smith, GC, Mathieson, MT, Kelly, AL, Venz, MF, Hogan, LD & Rowland, J 2014, Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland, Department of Science, Information Technology, Innovation and the Arts, Brisbane.

F

Fabricius, K, De Ath, G, McCook, L, Turak, E & Williams, DM 2005, 'Changes in algal, coral and fish assemblages along water quality gradients on the inshore Great Barrier Reef', *Marine Pollution Bulletin*, vol. 51, pp. 384-398.

Fabricius, KE 2006, 'Effects of irradiance, flow, and colony pigmentation on the temperature microenvironment around corals: Implications for coral bleaching?' *Limnology and Oceanography*, vol. 51, pp. 30-37.

Faunce, CH & Serafy, JE 2006, 'Mangroves as fish habitat: 50 years of field studies', *Marine Ecology Progress Series*, vol. 318, pp. 1-18.

Fitzsimmons, NN & Limpus, CJ 2014, *Marine Turtle Nesting Populations: Avoid Island Flatback Turtles, 2013-2014 breeding season*, Department of Environment and Heritage Protection, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Fitzsimmons, NN & Limpus, CJ 2015, *Marine Turtle Nesting Populations: Avoid Island Flatback Turtles, 2014-2015 breeding season*, Department of Environment and Heritage Protection, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Fitzsimmons, NN & Limpus, CJ 2016, *Marine Turtle Nesting Populations: Avoid Island Flatback Turtles, 2015-2016 breeding season*, Department of Environment and Heritage Protection, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Flint, J & Limpus CJ 2013, 'Marine wildlife stranding and mortality database annual report 2012. I. Dugong', in *Conservation Technical and Data Report 2012(1)*, Department of Environment and Heritage Protection, Brisbane.

Flint, M 2015, *Green turtle disease investigation at Port Curtis, Gladstone South Central Queensland-Final Report*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Flint, M, Patterson-Kane, JC, Limpus, CJ & Mills, PC 2010, 'Health Surveillance of Stranded Green Turtles in Southern Queensland, Australia (2006–2009): An Epidemiological Analysis of Causes of Disease and Mortality', *Ecohealth*, vol. 7, pp. 135-145.

G

Garnett, ST, Szabo, JK & Dutson, G 2011, *The Action Plan for Australia Birds 2010,* Birds Australia and CSIRO Publishing, Melbourne.

Gaus, C, Grant, S, Jin, NL, Goot, K, Chen, L & Villa, CA, 2012, *Investigation of contaminant levels in green turtles from Gladstone,* National Research Centre for Environmental Toxicology (Entox), Brisbane.

Geoscience Australia 2013, *Gazetteer of Australia 2012 Release*, viewed 28 May 2018, <http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_76695>.

GHD 2009a, *Western Basin Dredging and Disposal Project Environmental Impact Statement*, Prepared for Gladstone Ports Corporation, Brisbane.

GHD 2009b, *Report for Western Basin Dredging and Disposal Project: Terrestrial Ecology Report,* Prepared for Gladstone Ports Corporation, Brisbane.

GHD 2009c, *Report for Western Basin Dredging and Disposal Project: Marine Ecology Assessment*, Prepared for Gladstone Ports Corporation, Brisbane.

GHD 2009d, *Report for Western Basin Dredging and Disposal Project: Marine Megafauna Baseline and Impact Assessment*, Prepared for Gladstone Ports Corporation, Brisbane.

GHD 2011a, *Report for Marine Megafauna and Acoustic Survey, Autumn Survey*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

GHD 2011b, *Report for Marine Megafauna and Acoustic Monitoring, Summery Survey,* Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Gladstone Fish Health Scientific Advisory Panel 2012, *Final Report*, viewed 27 May 2015, <http://images.brisbanetimes.com.au/file/2012/01/06/2876982/gladstone-sap-report.pdf>.

Gladstone Healthy Harbour Partnership (GHHP) 2014a, *Gladstone Harbour Pilot Report Card 2014*, GHHP, Gladstone.

Gladstone Healthy Harbour Partnership (GHHP) 2014b, *Technical report for the Gladstone Harbour 2014 pilot report card: 1 Methodology and Results*, *Technical Report No.1*, GHHP, Rockhampton.

Gladstone Healthy Harbour Partnership (GHHP) 2015a, *Technical Report, Gladstone Harbour Report Card 2015*, *GHHP Technical Report No. 2*, Gladstone Healthy Harbour Partnership, Gladstone.

Gladstone Healthy Harbour Partnership (GHHP) 2015b, *Gladstone Harbour Report Card 2015*, GHHP, Gladstone.

Gladstone Healthy Harbour Partnership (GHHP) 2016a, *Gladstone Harbour Report Card 2016*, GHHP, Gladstone.

Gladstone Healthy Harbour Partnership (GHHP) 2016b, *Technical Report, Gladstone Harbour Report Card 2016*, *GHHP Technical Report No. 3,* Gladstone Healthy Harbour Partnership, Gladstone.

Gladstone Healthy Harbour Partnership (GHHP) 2017a, *Gladstone Harbour Report Card 2017*, GHHP, Gladstone.

Gladstone Healthy Harbour Partnership (GHHP) 2017b, *Technical Report, Gladstone Harbour Report Card 2017*, *GHHP Technical Report No. 4*, GHHP, Gladstone.

Gladstone Ports Corporation (GPC) 2011a, *Report for Migratory Shorebird Monitoring Port Curtis to Port Alma, Survey One – January*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Gladstone Ports Corporation (GPC) 2011b, *Report for Migratory Shorebird Monitoring Port Curtis to Port Alma Survey 3*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Gladstone Ports Corporation (GPC) 2012, Curtis Coast Coastal and Marine Resource Inventory Report, viewed 1 February 2018, **http://gpcl.com.au/EnvironmentDocuments/GPCCurtisCoastCoastalandMarineResourceInventoryReport-January2012.pdf**

Gladstone Ports Corporation (GPC) 2014, *Western Basin Dredging and Disposal Project (EPBC 2009/4904) Annual Environmental Performance Report,* December 2014, viewed 12 January 2018, **http://gpcl.com.au/EnvironmentDocuments/GPCAnnualEnvironmentalPerformanceReport-December2014.pdf**

Gladstone Ports Corporation (GPC) 2015a, *Gladstone's Big 6 – Mudflats Fact Sheet*, viewed 29 March 2018, **http://www.gpcl.com.au/big6/Documents/Fact%20Sheet_Mudflats.pdf**

Gladstone Ports Corporation (GPC) 2015b, *Gladstone's Big 6 – Prawns Fact Sheet*, viewed 29 March 2018, **http://www.gpcl.com.au/big6/Documents/Fact%20Sheet_Prawns.pdf**

Gladstone Ports Corporation (GPC) 2015c, *Green turtle Fact Sheet: Meet the Green turtles of the Gladstone region*, viewed 27 May 2018, **http://www.gpcl.com.au/big6/Documents/Fact%20Sheet_Green%20Turtles.pdf**

Gladstone Ports Corporation (GPC) 2016, *Port Curtis and Port Alma Ecosystem Research and Monitoring Program (ERMP)*, viewed 11 October 2016, **http://www.gpcl.com.au/SiteAssets/Environment/GPC_Ecosystem_Research_and_Monitoring_Program_Approved_by_DoE_January_2016.pdf**

Gladstone Region 2018, *Fishing Hot Spots – Gladstone*, viewed 11 May 2018, available at: **https://www.gladstoneregion.info/things-to-do/fishing/fishing-hot-spots**

Gladstone Regional Council (GRC) 2016, Biosecurity Plan 2016 – 2019, viewed 1 May 2018, <http://www.gladstone.qld.gov.au/documents/1570002/10512454/Biosecurity%20Plan%202016-2019>

Glynn, PW 1993, 'Coral reef bleaching: ecological perspectives', *Coral Reefs*, vol. 12, pp. 1-17.

Goudkamp, K and Chin, A 2006, 'Mangroves and Saltmarshes', Prepared for The Great Barrier Reef Marine Park Authority, Townsville.

Graham, N, Ferro, RST, Karp, WA & MacMullen, P 2007, 'Fishing practice, gear design, and the ecosystem approach - Three case studies demonstrating the effect of management strategy on gear selectivity and discards', *ICES Journal of Marine Science*, vol. 64, pp. 744-750.

Great Barrier Reef Marine Park Authority (GBRMPA) & Queensland Government 2015a, *Reef 2050 Integrated Monitoring and Reporting Program Strategy*, Great Barrier Reef Marine Park Authority, Townsville.

Great Barrier Reef Marine Park Authority (GBRMPA) 2006, *Overview: The current status of the Great Barrier Reef: Feb 2006*, viewed 27 May 2018, <http://www.gbrmpa.gov.au/__data/assets/pdf_file/0005/3974/SORR_Overview.pdf>.

Great Barrier Reef Marine Park Authority (GBRMPA) 2007, *Biophysical assessment of the reefs of Keppel Bay: a baseline study*, April 2007, Climate Change Group, Great Barrier Reef Marine Park Authority, Townsville.

Great Barrier Reef Marine Park Authority (GBRMPA) 2012, *Animals*, viewed 22 January 2018 http://www.gbrmpa.gov.au/the-reef/animals

Great Barrier Reef Marine Park Authority (GBRMPA) 2014, *Great Barrier Reef Outlook Report 2014,* GBRMPA, Townsville.

Great Barrier Reef Marine Park Authority (GBRMPA) 2015b, *Differences between the Marine Park and the World Heritage Area*, viewed 23 May 2018, <http://www.gbrmpa.gov.au/about-the-reef/heritage/great-barrier-reef-world-heritage-area/differences-between-the-marine-park-and-the-world-heritage-area2>.

Great Barrier Reef Marine Park Authority (GBRMPA) 2016, Great Barrier Reef Marine Parks Zoning Map 17 – Capricorn, GBRMPA and Queensland Government, viewed 19 January 2018, <http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/609/4/Map17-EditionV-Capricorn.pdf>

Great Barrier Reef Marine Park Authority (GBRMPA) 2018, *Marine turtles*, viewed 22 January 2018 <http://www.gbrmpa.gov.au/about-the-reef/animals/marine-turtles>.

Grech, A, Sheppard, J & Marsh, H 2011, 'Informing species conservation at multiple scales using data collected for marine mammal stock assessments', *PLoS ONE*, vol. 6, no. 3, pp. 1-8.

Greenland, JA & Limpus, CJ 2008, *Marine Turtles. Queensland marine wildlife stranding and mortality database annual report, 2004*, Queensland Environmental Protection Agency, Brisbane.

H

Hale, P, Long, S, & Tapsall, A 1998, Distribution and conservation of delphinids in Moreton Bay. In I. R. Tibbetts, N. J. Hall, & W. D. Dennison (Eds.), Moreton Bay and catchment (pp. 477-486). Brisbane: School of Bay and catchment (pp. 477-486). Brisbane: School of Bay and catchment Marine Science, University of Queensland

Hale, PT, Barreto, AS & Ross, GJB 2000, 'Comparative Morphology and Distribution of the aduncus and truncatus forms of Bottlenose Dolphin Tursiops in the Indian and Western Pacific Oceans', *Aquatic Mammals*, vol. 26, no. 2, pp. 101-110.

Hamann M., Limpus C.J., Shimada T., and Preston S. (2017a) Final report on green turtle habitat use in Port Curtis 2014 to 2017. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program. 25pp.

Hamann, M, Limpus, CJ, Shimada, T & Preston, S 2015a, *Annual report on green turtle tracking and habitat use in Port Curtis*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Hamann, M, Shimada, T & Limpus, CJ 2015b, *Annual report on the internesting habitat use by flatback turtles off the Curtis Island coast – 2013-2014 nesting season*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Hamann, M, Wildermann, N, Williams, G, Daff, K, & Limpus, CJ 2017b, *Final report on inter-nesting habitat use by flatback turtles off the Curtis Island coast - 2013 to 2015*, Produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Hamman, M & Limpus, CJ 2015, *Interim report on green turtle tracking and habitat use in Port Curtis – Report on field trip 10-17 July 2015*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Hammerstrom, K, Kenworthy, W, Fonseca, M & Whitfield, P 2006, 'Seed bank, biomass, and productivity of *Halophila decipiens,* a deep water seagrass on the west Florida continental shelf', *Aquatic Botany*, vol. 84, pp. 110-120.

Harriott, VJ 1998, 'Growth of the staghorn coral *Acropora formosa* at Houtman Abrolhos, Western Australia', *Marine Biology*, vol. 132, pp. 319-325.

Hay, ME 1984, 'Patterns of fish and urchin grazing on Caribbean coral reefs: are previous results typical?' *Ecology*, vol. 65, pp. 446-454.

Heinsohn, GE 1979, B*iology of small cetaceans in north Queensland waters*, Prepared for Great Barrier Reef Marine Park Authority, Townsville.

Hemminga, MA & Duarte, CM 2000, *Seagrass Ecology*, Cambridge University Press, Cambridge.

Hoegh-Guldberg, O, Anthony, K, Berkelmans, R, Dove, S, Fabricus, K, Lough, J, Marshall, P, van Oppen, MJH, Negri, A & Willis, B 2007, 'Chapter 10 Vulnerability of reef-building corals on the Great Barrier Reef to climate change', in *Climate Change and the Great Barrier Reef*, ed. Johnson, JE & Marshall, P, Great Barrier Reef Marine Park Authority and Australian Greenhouse Office, Australia.

Holley, DK, Lawler, IR & Gales, NJ 2006, Summer survey of dugong distribution and abundance in Shark Bay reveals additional key habitat area, *Wildlife Research* 33: 243-250.

Hopley, D, Smithers, SG & Parnell, KE 2007, *The Geomorphology of the Great Barrier Reef; Development, diversity and change*, Cambridge University Press, Cambridge.

Hothorn, T, Bretz, F & Westfall, P 2008, 'Simultaneous Inference in General Parametric Models', *Biometrical Journal*, vol. 50, pp. 346-363.

Hughes, TP 1994, 'Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef', *Science*, vol. 265, pp. 1547-1551.

Hutchinson, J, Spalding, M and zu Ermgassen, P 2014, 'The Role of Mangroves in Fisheries Enhancement', *The Nature Conservancy and Wetlands International*, pp. 16-24.

I

Illiger, JKW 1811, *Prodromus systematis mammalium et avium*, sumptibus C. Salfeld, The University of Michigan.

IMEMS Pty Ltd 2013, *Migratory Shorebird Monitoring Review: Consultancy Agreement CA120022*, Prepared for Gladstone Ports Corporation, Palmwoods.

Infofish Australia 2018, Commercial and recreational fish catch data (2014-2018), December 2018.

International Union for Conservation of Nature 2018, *The IUCN Red List of Threatened Species*, International Union for Conservation of Nature.

Irvine, AB, Scott, MD, Wells, RS & Kaufmann, JH 1981, 'Movements and activities of the Atlantic bottlenose dolphin, *Tursiops truncatus*, near Sarasota, Florida', *Fishery Bulletin*, vol. 79, pp. 671-678.

J

Jarvis, J, Rasheed, M, McKenna, S & Sankey, T 2014, *Seagrass habitat of Cairns Harbour and Trinity Inlet: Annual and Quarterly Monitoring Report 2013*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Jarvis, J, Scott, E, Bryant, C & Rasheed, M 2015, *Port Curtis Seagrass Seed Bank Density and Viability Studies – Year 1 Report*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Jarvis, JC & Moore, KA 2010, 'The role of seedlings and seed bank viability in the recovery of Chesapeake Bay Zostera marina populations following a large scale decline', *Hydrobiologia*, vol. 649, pp. 55-68.

Jefferson, T.A., & H.C. Rosenbaum (2014). Taxonomic revision of the humpback dolphins (Sousa spp.), and description of a new species from Australia. *Marine Mammal Science*. 30(4):1494-1541

Jefferson, TA & Karczmarski, L 2001, 'Sousa chinesis', *Mammalian Species*, vol. 655, pp. 1-9.

Jefferson, TA 2000, 'Population biology of the Indo-Pacific hump-backed dolphin in Hong Kong waters', *Wildlife Monographs*, vol. 144, p. 65.

Johansen, JL & Jones, GP 2013, 'Sediment-induced turbidity impairs foraging performance and prey choice of planktivorous coral reef fishes, *Ecological Applications*, vol. 23, pp.1504-1517.

Johns, L 2014, *Field guide to common saltmarsh plants of Queensland*, 2nd Edition, Queensland Government, Brisbane.

Johnson, R, Shearer, D, Melzer, A, Wild, D & Houston, W 1999, *Port Curtis Mangrove Monitoring Program*, Prepared for Gladstone Ports Corporation, Central Queensland University, Gladstone.

Jones, GP & Kaly, UL 1995, 'Conservation of rare, threatened and endemic marine species in Australia', in *State of the Marine Environment Report for Australia Technical Annex 1, The Marine Environment*, eds LP Zann & P Kailola, Great Barrier Reef Marine Park Authority, Townsville.

Jones, MV & West, RJ 2005, 'Spatial and temporal variability of seagrass fishes in intermittently closed and open coastal lakes in southeastern Australia', *Estuarine, Coastal and Shelf Science*, vol. 64, pp. 277-288.

K

Kavanagh, KD 2000, 'Larval brooding in the marine damselfish *Acanthochromis polyacanthus* (Pomacentridae) is correlated with highly divergent morphology, ontogeny and life-history traits', *Bulletin of Marine Science*, vol. 66, pp. 321-337.

Kenworthy, W, Currin, C, Fonseca, M & Smith, G 1989, 'Production, decomposition and heterotrophic utilization of the seagrass *Halophila decipiens* in a submarine canyon', *Marine Ecology Progress series*, vol. 51, pp. 277-290.

King, RJ 1981, *Marine Botany: an Australian Perspective*, 1st Edition, Longman Cheshire, Melbourne.

Kirkman, H 1978, 'Growing *Zostera caprcorni* Aschers. in tanks', *Aquatic Botany*, vol. 4, pp. 367-372.

Klinka, K, Chen, HYH, Wang, QL & Demontigny, L 1996, 'Forest canopies and their influence on understorey vegetation in early-seral stands on West Vancouver island', *Northwest Science*, vol. 70, no. 3, pp. 193-200.

Koop, K, Booth, D, Broadbent, A, Brodie, J, Capone, D, Coll, J, Dennison, W, Erdmann, M, Harrison, P, Hoegh-Guldberg, O, Hutchings, P, Jones, G, Larkum, A, O'Neil, J, Steven, A, Tentori, E, Ward, S, Williamson, J & Yellowlees, D 2001, 'ENCORE: The effect of nutrient enrichment on coral reefs. Synthesis of results and conclusions', *Marine Pollution Bulletin*, vol. 42, pp. 91-120.

Kuo, J & McComb, AJ 1989, 'Seagrass taxomony, structure and development', in *Biology of seagrasses: a treatise on the biology of seagrasses with special reference to the Australia region*, eds AWD Larkum, AJ.McComb & SA Shepherd, Elsevier Science Limited, pp. 6-73.

L

Lanyon, J 1991, *The Nutritional Ecology of the* Dugong *Dugong dugon in Tropical North Queensland*, PhD thesis, Monash University, Melbourne.

Lanyon, JM 2003, Distribution and abundance of dugongs in Moreton Bay, Queensland, Australia, *Wildlife Research*, 30: 397-409.

Lapointe, BE, Barile, PJ, Littler, MM & Littler, DS 2005, 'Macroalgal blooms on southeast Florida coral reefs', *Harmful Algae*, vol. 4, pp. 1106-1122.

Lapointe, BE, Langton, R, Bedford, BJ, Potts, AC, Day, O & Hu, C 2010, 'Land-based nutrient enrichment of the Buccoo Reef Complex and fringing coral reefs of Tobago, West Indies', *Marine Pollution Bulletin*, vol. 60, pp. 334-343.

Lee Long, WJ, Cole, RG, Miller, KJ, Vidler, KP & Derbyshire, KJ 1992, *Seagrass Beds and Juvenile Prawn and Fish Nursery Ground, Water Park Point to Hervey Bay*, Queensland Department of Primary Industries, Brisbane.

Lee, KS, Park, SR & Kim, YK 2007, 'Effects of irradiance, temperature, and nutrients on growth dynamics of seagrasses: A review', *Journal of Experimental Marine Biology and Ecology*, vol. 350, pp. 144-175.

Letourneur, Y, Galzin, R & Harmelin-Vivien, M 1998, 'Temporal variations in the diet of the damselfish Stegastes nigricans (Lacepede) on a Reunion fringing reef', *Oceanographic Literature Review*, vol. 45, pp. 318-318.

Lewis, S, Hewitt, C & Melzer, A 2001, *Port survey for introduced marine species - Port Curtis*, Central Queensland University, Gladstone.

Limpus C, Parmenter, J & Chaloupha, M 2013, *Monitoring of Coastal Turtles in the Port Curtis and Port Alma Region: Gap Analysis Parts 1 to 6*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus, C & Chatto, R 2004, 'Marine Turtles', in *Description of Key Species groups in the Northern Planning Area*, National Oceans Office, Hobart.

Limpus, CJ & Limpus, DJ 2003, 'The biology of the loggerhead turtle, Caretta caretta, in southwest Pacific Ocean foraging areas', in *Biology and Conservation of Loggerhead Turtles*, eds AB Bolten & BE Witherington, Smithsonian Institution Press, Washington DC, pp. 93-113.

Limpus, CJ 1985, *A study of the loggerhead turtle Caretta caretta in eastern Australia*, PhD thesis, Zoology Department, University of Queensland, Brisbane.

Limpus, CJ 2007, *A biological review of Australian marine turtle species. 5. Flatback turtle*, *Natator depressus (Garman)*, Environmental Protection Agency, Brisbane.

Limpus, CJ 2008a, *A biological review of Australian marine turtles. 2. Green turtle*, *Chelonia mydas (Linnaeus)*, Environmental Protection Agency, Brisbane.

Limpus, CJ 2008b, *A biological review of Australian marine turtles. 1. Loggerhead turtle*, *Caretta caretta* (Linnaeus), Environmental Protection Agency, Brisbane.

Limpus, CJ 2009, *A biological review of Australian marine turtle species. 3. Hawksbill turtle, Eretmochelys imbricata (Linnaeus)*, Environmental Protection Agency.

Limpus, CJ, Couper, PJ & Read, MA 1994, 'The green turtle, Chelonia mydas, in Queensland: population structure in a warm temperate feeding area', *Memoirs of the Queensland Museum,* vol. 35, pp. 139-154.

Limpus, CJ, Fitzsimmons, N, Bell, I, Chaousis, Coffee, I, Finlayson, K, Flint, M, Megaer, J, Reinhold, L & Shimada, T 2016b, *Increase the Understanding of the Green Turtle Population in Port Curtis – year 1 final report*, Department of Environment and Heritage Protection, Queensland Government, Brisbane, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of the Gladstone Port Corporation's Ecosystem Research and Monitoring Program.

Limpus, CJ, FitzSimmons, N, Finlayson, Harmonn, C, McKinnon, A, Sergeev, JM & Shimada, T 2017a, *Increase the Understanding of the Green Turtle Population in Port Curtis: Annual Report for 2017,* Department of Environment and Science, Queensland Government, Brisbane, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus, CJ, Fitzsimmons, N, Hoffmann, F, Hoffmann, E, Laws, J, Limpus, DJ, McLaren, M, Sergeev, JM, Shapland, F & Turner, T 2018, *Flatback Turtle,* Natator depressus*, 2017-2018 Breeding Season, at Curtis, Peak and Avoid Islands*, Brisbane: Department of Environment and Science, Queensland Government, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.Lin, DT & Fong, P 2008, '*Macroalgal bioindicators* (growth, tissue N, Î´15N) detect nutrient enrichment from shrimp farm effluent entering Opunohu Bay, Moorea, French Polynesia', *Marine Pollution Bulletin*, vol. 56, pp. 245-249.

Limpus, CJ, FitzSimmons, N,. Sergeev, JM, Ferguson, J, Hoffmann, F, Phillot, A, Pople, L, Ross, A, Tompkins, B, Turner, T & Wenk, L 2017b, *Marine turtle nesting populations: flatback turtle,* Natator depressus*, 2016-2017 breeding season at Curtis Peak and Avoid Islands*, Brisbane: Department of Environment and Heritage Protection, Queensland Government, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus, CJ, Gatley, C, McLaren, M, McLaren, G & Pearson, R 2014, *EHP Threatened Species Unit Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtles, 2013-2014 breeding season*, Department of Environment and Heritage Protection, Brisbane.

Limpus, CJ, Gilmore, K & Barrett, P 2000, *Queensland Turtle Conservation Project - Curtis Island Marine Turtle Nesting Study 1999-2000*, Prepared for Gladstone Port Authority and Queensland Park and Wildlife Service, Gladstone.

Limpus, CJ, Limpus, DJ, Arthur, KE & Parmenter, CJ 2005, 'Monitoring green turtle population dynamics in Shoalwater Bay: 2000-2004', *GBRMPA Research Publication*, vol. 83, pp. 1-51.

Limpus, CJ, Limpus, DJ, Savige, M & Shearer, D 2012b, 'Health assessment of green turtles in South and Central Queensland following extreme weather impacts on coastal habitat during 2011', *Conservation Technical and Data Report 2011*, vol. 4, pp. 1-13.

Limpus, CJ, McLaren, M & McLaren, G 2012a, *Curtis Island Marine Turtle Monitoring 2011-2012 breeding season*, Queensland Turtle Conservation Project, Department of Environment and Heritage Protection, Brisbane.

Limpus, CJ, McLaren, M, McLaren, G & Knuckey, B 2006, *Queensland Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtle Studies 2005 – 2006*, Environment Protection Agency, Brisbane.

Limpus, CJ, McLaren, M, McLaren, G, Gatley, C & Twaddle, H 2015, *EHP Threatened Species Unit Turtle Conservation Project: Curtis Island and Woongarra Coast Flatback Turtles, 2014-2015 breeding season*, Department of Environment and Heritage Protection, Brisbane.

Limpus, CJ, McLaren, M, McLaren, Gatley, C, Limpus D, O'Leary, K, & Turner, T & Knuckey, B 2016a, *Marine Turtle Nesting Populations: Curtis Island and Woongarra Coast Flatback Turtles, 2015-2016 breeding season,* Department of Environment and Heritage Protection, Queensland Government, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of the Gladstone Port Corporation's Ecosystem Research and Monitoring Program.

Limpus, CJ, Parmenter, CJ & Limpus, DJ 2002, 'The status of flatback turtle in Eastern Australia', *Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation*, National Oceanic and Atmospheric Administration, pp. 140-142.

Limpus, CJ, Parmenter, CJ, Baker, V & Fleay, A 1983, 'The Crab Island sea turtle rookery in north eastern Gulf of Carpentaria', *Australian Wildlife Research*, vol. 10, pp. 173-84.

Lin, D.T & Fong, P 2008, *Macroalgal bioindicators (growth, tissue N, Î´15N) detect nutrient enrichment from shrimp farm effluent entering Opunohu Bay, Moorea, French Polynesia*. Marine Pollution Bulletin, 56, 245-249.

Llewellyn, L, Wakeford, M & McIntosh, E 2013, *Mapping and synthesis of data and monitoring in Gladstone Harbour*, Prepared for the Independent Science Panel of the Gladstone Healthy Harbour Partnership, Townsville.

Long, P & McKinnon, S 2002, *Habitats and Fisheries Resources of the Fitzroy River Estuary (Central Queensland),* Department of Primary Industries and Fisheries, Brisbane.

Low, T 2003*, Ballast Invaders: the Problem and Response*, Invasive Species Council Australia.

Lucas, PHC, Webb, T, Valentine, PS & Marsh H 1997, *The Outstanding Universal Value of the Great Barrier Reef World Heritage Area*, Great Barrier Reef Marine Park Authority, Townsville.

M

Macreadie, PI, Baird, ME, Trevathan-Tackett, SM, Larkum, AWD, Ralph, PJ, 2014, Quantifying and modelling the carbon sequestration capacity of seagrass meadows. A critical assessment. Mar. Pollut. Bull. 83, 430–439.

Marsh, H & Lawler, I 2007, *Project 2: Dugong distribution and abundance on the urban coast of Queensland: a basis for management*, Marine and Tropical Science Research Facility, Cairns.

Marsh, H & Lawler, IR 2001, *Dugong distribution and abundance in the Southern Great Barrier Reef Marine Park and Hervey Bay: Results of an aerial survey in October-December 1999*, Great Barrier Reef Marine Park Authority, Townsville.

Marsh, H & Saalfeld, WK 1990a, 'The distribution and abundance of dugongs in the Great Barrier Reef Marine Park, south of Cape Bedford', *Australian Wildlife Research*, vol. 17, pp. 511-524.

Marsh, H & Saalfeld, WK 1990b, *The distribution & abundance of dugongs in southern Queensland*, Fisheries Management Branch, Department of Primary Industries.

Marsh, H & Sinclair, DF 1989a, 'Correcting for visibility bias in strip transect aerial surveys of aquatic fauna', *Journal of Wildlife Management*, vol. 53, no. 4, pp. 1017-1024.

Marsh, H & Sinclair, DF 1989b, 'An experimental evaluation of dugong and sea turtle aerial survey techniques', *Australian Wildlife Research*, vol. 16, pp. 639–650.

Marsh, H, Corkeron, P, Lawler, IR, Lanyon, JM & Preen, AR 1996, *The status of the dugong in the Southern Great Barrier Reef Marine Park*, Great Barrier Reef Marine Park Authority, Townsville.

Marsh, H, Dennis, A, Hines, H, Kutt, A, McDonald, K, Weber, E, Williams, S & Winter, J 2007, 'Optimizing allocation of management resources for wildlife', *Conservation Biology*, vol. 21, pp. 387-399.

Marsh, H, Eros, C, Penrose, H & Hughes, J 2002, *Dugong status report and action plans for countries and territories*, United Nations Environment Programme (UNEP) Early Warning and Assessment Report Series 1, Cambridge.

Marsh, H, Lawler, I, Kwan, D, Delean, S, Pollock, K & Alldredge, M 2004, 'Aerial surveys and the potential biological removal technique indicate that the Torres Strait dugong fishery is unsustainable', *Animal Conservation*, vol. 7, pp. 1-9.

Marsh, H, O'Shea, TJ & Reynolds, JR 2011, *The ecology and conservation of sirenia; dugongs and manatees*, Cambridge University Press, Cambridge, 521pp.

Matlack, GR 1993, 'Microenvironment variation within and among forest edge sites in the eastern United States', *Biological Conservation*, vol. 66, no. 3, pp. 185-194.

McCormack, C, Rasheed, M, Davis, J, Carter, A, Sankey, T & Tol, S 2013, *Long term seagrass monitoring in the Port Curtis Western Basin: Quarterly seagrass assessments and permanent transect monitoring progress report November 2009 – November 2012*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

McKenna, S & Rasheed, M 2014, *Port of Abbot Point Long-Term Seagrass Monitoring: Annual Report 2012-2013*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

McKenna, S, Jarvis, J, Sankey, T, Reason, C, Coles, R & Rasheed, M 2015, 'Declines of seagrasses in tropical harbour, North Queensland, Australia, are not the result of a single event', *Journal of Biosciences*, vol. 40, no. 2, pp. 389-398.

McKenna, SA, Bryant, CV, Tol, SJ & Rasheed, MA 2014, 'Baseline assessment of benthic communities (algae and macro-invertebrates) in the Port Curtis Region November 2013', Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns, 27pp.

McKenna, SA, Rasheed MA, Lewis, SE, Tol, SJ & Sankey, T 2013a, *Abbot Point Proposed Dredge Disposal Areas: Benthic Habitat Survey - 2013,* Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

McKenna, SA, Rasheed, MA, Sankey, T & Tol, SJ 2013b, *Benthic macro-invertebrates of Cairns Harbour and Trinity Inlet: baseline survey – 2012/13*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

McKenzie LJ, Mellors, J & Waycott, M 2008, *Marine Monitoring Program Intertidal Seagrass for the sampling period 1st September 2007 – 31st May 2008*, Marine and Tropical Sciences Research Facility James Cook University, Cairns.

McKenzie, LJ 1994, 'Seasonal changes in biomass and shoot characteristics of a Zostera capricorni Aschers. dominant meadow in Cairns Harbour, northern Queensland', *Australian Journal of Marine and Freshwater Research*, vol. 45, pp. 1337-1352.

McKenzie, LJ, Campbell, SJ, Vidler, KE & Mellors, JE 2007, *Seagrass-Watch: Manual for Mapping and Monitoring Seagrass Resources*, Seagrass-Watch HQ, Cairns.

McKenzie, LJ, Lee Long, WJ, Coles, RG & Roder, CA 2000, 'Seagrass-Watch: Community Based Monitoring Of Seagrass Resources', *Biologia marina mediterranea*, vol. 7, pp. 393-396.

Meager, JJ & Limpus, CJ 2012, 'Marine wildlife stranding and mortality database annual report 2011. III. Marine Turtle', *Conservation Technical and Data Report 2012*, vol. 3, pp. 1-46.

Meager, JJ 2016a, 'Marine wildlife stranding and mortality database annual report 2013-2015 Dugong', *Conservation Technical and Data Report*, vol. 2, pp. 1-22.

Meager, JJ 2016b, 'Marine wildlife stranding and mortality database annual report 2013-2015 Cetacean and Pinniped, *Conservation Technical and Data Report*, vol. 1, pp. 1-33.

Meager, JJ, Winter, KM, Biddle, TM & Limpus, CJ 2012, 'Marine wildlife stranding and mortality database annual report 2008-2010. II. Cetacean and Pinniped', *Conservation Technical and Data Report 2012*, vol. 2, pp. 1-76.

Mellors, J, Marsh, H & Coles, R 1993, 'Intra-annual changes in seagrass standing crop, Green Island, Northern Queensland', *Marine and Freshwater Research*, vol. 44, pp. 33-41.

Mellors, JE 1991, 'An evaluation of rapid visual technique for estimating seagrass biomass', *Aquatic Botany,* vol. 42, pp. 67-73.

Melville, F & Andersen, L 2008, *PCIMP Intertidal Monitoring 2007, North Harbour Zones,* Port Curtis Integrated Monitoring Program, Centre for Environmental Management, Central Queensland University, Gladstone.

Melzer, R & Plumb, J 2007, *Plants of Capricornia*, Capricorn Conservation Council, Rockhampton.

Menkhorst, P & Knight, F 2011*, A field guide to the mammals of Australia*, 3rd Edition, Oxford University Press, South Melbourne.

Meynecke, JO 2009, 'Coastal habitat connectivity - Implications for declared fish habitat networks in Queensland, Australia', *Pacific Conservation Biology*, vol. 15, pp. 96-101.

Meynecke, JO, Lee, SY & Duke, NC 2008a, 'Linking spatial metrics and fish catch reveals the importance of coastal wetland connectivity to inshore fisheries in Queensland', Australia, *Biological Conservation*, vol. 141, pp. 981-996.

Meynecke, JO, Poole, GC, Werry, J & Lee, SY 2008b, 'Use of PIT tag and underwater video recording in assessing estuarine fish movement in a high intertidal mangrove and salt marsh creek', *Estuarine, Coastal and Shelf Science*, vol. 79, pp. 168-178.

Miller, SJ, Skilleter, GA & Quinn, RJ 2003, 'Assessment of habitat function - A case study in estuarine fish habitat creation', in *Aquatic Protected Areas: What works best and how do we know?*, eds JP Beumer, A Grant & DC Smith, World Congress on Aquatic Protected Areas, Cairns.

Morcombe, M 2003, *Field guide to Australian birds*, 2nd Edition, Steve Parish Publishing Pty Ltd, Archerfield.

Mustoe, S 2011, *Status of turtles in Queensland after 2010 flood event: A review*, Prepared for Gladstone Ports Corporation, Applied Ecology Solutions, Belgrave Heights.

N

National Introduced Marine Pest Information System 2014, Marine Pest Interactive Map, viewed 29 May 2018, <http://www.marinepests.gov.au/nimpis>.

Neil, KM, Stafford, H, Rose, C & Thomas, R 2003, *Flora and Fauna Survey: Cairns Port Authority Ocean Disposal Site*, CRC Reef Research Centre and Department of Primary Industries and Fisheries, Cairns.

Neira, FJ & Potter, IC 1992, 'Movement of larval fishes through the entrance channel of a seasonally open estuary in Western Australia', *Estuarine, Coastal and Shelf Science*, vol. 35, pp. 213-224.

Neldner, VJ, Wilson, BA, Dillewaard, HA, Ryan, TS & Butler, DW 2017, 'Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland', Version 4.0, Queensland Herbarium, Queensland Department of Science, Information Technology and Innovation, Brisbane.

O

Oceania Maritime Consultants 2011, *Mapping and Assessment of Seagrass and Coral Reefs*, Prepared for Gladstone Ports Corporation Limited, Oceania Maritime Consultants Pty Ltd.

Odum, WE, McIvor, CC & Smith, TJ 1985, *The ecology of the mangroves of South Florida: a community profile*, University of Virginia, Charlottesville.

Olesen, B & Sand-Jensen, K 1994, 'Patch dynamics of eelgrass (*Zostera marina)* populations – shoot dynamics and biomass development', *Marine Ecology Progress Series*, vol. 106, pp. 147-156.

Oliver, J 1984, 'Intra-colony variation in the growth of *Acropora formosa*: extension rates and skeletal structure of white (zooxanthellae-free) and brown-tipped branches', *Coral Reefs*, vol. 3, pp. 139-147.

P

Parra, GJ 2005, *Behavioural ecology of Irrawaddy, Orcaella brevirostris (Owen in Gray, 1866), and Indo-Pacific humpback dolphins, Sousa chinensis (Osbeck, 1765), in northeast Queensland, Australia: a comparative study*, PhD thesis, James Cook University, Townsville.

Parra, GJ 2006, 'Resource partitioning in sympatric delphinids: Space use and habitat preferences of Australian snubfin and Indo-Pacific humpback dolphins', *Journal of Animal Ecology*, vol. 75, pp. 862-874.

Parra, GJ, Preen, AR, Corkeron, PJ, Azuma, C & Marsh, H 2002, 'Distribution of Irrawaddy dolphins, *Orcaella brevirostris*, in Australian waters', *Raffles Bulletin of Zoology*, vol. 10, pp. 141-154.

Pendoley, K & Bell, C 2014, *Gladstone Region 2013/2014 Marine Turtle Hatchling Orientation Monitoring Program*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Phillips, RC & Lewis III, RL 1983, 'Influence of environmental gradients on variations in leaf widths and transplant success in North American seagrasses (Zostera marine, eelgrass, *Thalassia testudinum*, turtlegrass, habitats)', *Marine Technology Society Journal*, vol. 17, pp. 59-68.

Piersma, T & Baker, AJ 2000, 'Life history characteristics and the conservation of migratory shorebirds', in *Behaviour and conservation*, eds WJ Gosling & LM Sutherland, Cambridge University Press, Cambridge, pp. 105-124.

Piersma, T 2007, 'Using the power of comparison to explain habitat use and migration strategies of shorebirds worldwide', *Journal of Ornithology*, vol. 148, pp. 45-59.

Pihl, L, Svenson, A, Moksnes, PO & Wennhage, H 1999, 'Distribution of green algal mats throughout shallow soft bottoms of the Swedish Skagerrak archipelago in relation to nutrient sources and wave exposure', *Journal of Sea Research*, vol. 41, pp. 281-294.

Pizzey, G & Knight, F 2007, *A Field Guide to the Birds of Australia*, 8th Edition, Collins, Sydney.

Platten, JR 2004, *Historical trends in recreational fishing catches in the Gladstone region*, Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management and Environmental Protection Agency.

Pollock, K, Marsh, H, Lawler, I & Alldredge, M 2006, 'Modelling availability and perception processes for strip and line transects: an application to dugong aerial surveys', *Journal of Wildlife Management*, vol. 70, pp. 255-262.

Pople, L, Reinhold, L & Limpus, C 2016, *Marine Turtle Nesting Population: Peak Island Flatback Turtles, 2015-2016 breeding season*, Department of Environment and Heritage Protection, Queensland Government, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Posey, MS, Alphin, TD & Powell, CM 1997, 'Plant and infaunal communities associated with a created marsh', *Estuaries*, vol. 20, pp. 42-47.

Pratchett, MS, Hoey, AS, Wilson, SK, Messmer, V & Graham, NAJ 2011, 'Changes in Biodiversity and Functioning of Reef Fish Assemblages following Coral Bleaching and Coral Loss.' *Diversity*, vol. 3, pp. 424-452.

Preen, A, Lee Long, W & Coles, R 1995, 'Flood and Cyclone related loss, and partial recovery, of more than 1000km^2 of seagrass in Hervey Bay, Queensland, Australia', *Aquatic Botany*, vol. 52, pp. 3-17.

Q

Queensland Gas Company 2009, *QCLNG Environmental Impact Statement Volume 5: Environmental Impacts of Shipping Operations & Ancillary Infrastructure, Chapter 08 Marine Ecology,* viewed 29 May 2018, <https://www.shell.com.au/about-us/projects-and-locations/qgc/environment/environment-management-assessment.html>.

Queensland Gas Company 2013, *QCLNG Whole of Project Migratory Shorebird Management Plan*, viewed 29 May 2018, <https://www.shell.com.au/about-us/projects-and-locations/qgc/environment/environment-management/management-plans/_jcr_content/par/expandablelist_db77/expandablesection_de.stream/1498172672385/632fd44828e2a9ba07a68023627cf9afc9113231ec8274a7d55db664fc126274/qclng-whole-of-project-migratory-shorebird-management-plan.pdf>.

Queensland Government 2016a, *Biodiversity Planning Assessment: Southeast Queensland*, version 4.1, Queensland Government, Brisbane.

Queensland Government 2016b, Line Fisheries Target Species and Fishing Gear, viewed 29 March 2018, <https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/fisheries-profiles/commercial-line-fisheries/fishing-gear>.

Queensland Herbarium 2016, *Regional Ecosystem Description Database (REDD)*, Version 10.0, viewed 11 January 2018, <https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/download/>.

Queensland Herbarium 2017, Census of the Queensland Flora 2017, viewed 11 January 2018, <https://data.qld.gov.au/dataset/census-of-the-queensland-flora-2017 >.

Quinn, RH 1992, *Fisheries resources of the Moreton Bay region*, Queensland Fish Management Authority, Brisbane.

R

R Development Core Team 2013, *R: a language and environment for statistical computing*, R Foundation for Statistical Computing, Vienna.

Ralph, PJ, Durako, MJ, Enriquez, S, Collier, CJ & Doblin, MA 2007, 'Impact of light limitation on seagrasses', *Journal of Experimental Marine Biology and Ecology*, vol. 350, pp. 176-193.

Rasheed, M, O'Grady, D, Scott, E, York, P, & Carter, A, 2017, *Dugong Feeding Ecology and Habitat Use on Intertidal Banks of Port Curtis and Rodds Bay – Final Report 2016*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns, 65 pp.

Rasheed, MA & Unsworth, RKF 2011, 'Long-term climate-associated dynamics of a tropical seagrass meadow: implications for the future', *Marine Ecology Progress Series*, vol. 422, pp. 93-103.

Rasheed, MA 2004, 'Recovery and succession in a multi-species tropical seagrass meadow following experimental disturbance: the role of sexual and asexual reproduction', *Journal of Experimental Marine Biology and Ecology*, vol. 310, pp. 13-45.

Rasheed, MA, McKenna, SA, Carter, AB, Coles, RG, 2014. Contrasting recovery of shallow and deep water seagrass communities following climate associated losses in tropical north Queensland, Australia. Marine Pollution Bulletin 83, 491–499.

Rasheed, MA, McKenna, SA, Taylor, HA & Sankey, TL 2008, *Long-term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone, October 2007*, Department of Primary Industries and Fisheries, Cairns.

Rasheed, MA, O'Grady, D, Scott, E, York, PH & Carter, AB 2017a, *Dugong Feeding Ecology and Habitat Use on Intertidal Banks of Port Curtis and Rodds Bay – Final Report*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) Publication 16/14, James Cook University, Cairns.

Rasheed, MA, Reason, CL, McCormack, CV, Chartrand, KM & Carter, AB 2012, *Port Curtis and Rodds Bay seagrass monitoring program, November 2011*, Fisheries Queensland, Cairns.

Rasheed, MA, Roder, CA & Thomas, R 2001, *Port of Mackay Seagrass, Macro-Algae and Macro-Invertebrate Communities, February 2001*, CRC Reef Research Centre, Townsville.

Rasheed, MA, Thomas, R, Roelofs, AJ & Neil, KM 2002, *Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002*, Department of Primary Industries, Cairns.

Rasheed, MA, Thomas, R, Roelofs, AJ Neil, KM & Kerville, SP 2003, *Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002*, Department of Primary Industries, Cairns.

Rasheed, MA, Wells, JN & Carter AB 2017b, *Seagrasses in Port Curtis and Rodds Bay 2016: Annual long-term monitoring*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 17/02, James Cook University, Cairns, 67 pp.

Reason, CL, Rasheed, MA, Carter, AB & Jarvis, JC 2017, Port Curtis Seagrass Seed Bank Density and Viability Studies - Final Report, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 17/40, James Cook University, Cairns, 36 pp.

Resource Assessment Commission 1993, *Values and Attitudes Concerning the Coastal Zone, Coastal Zone Inquiry Information Paper No. 4*, Australian Government Publishing Service, Canberra.

Reyes, JC 1991, *The conservation of small cetaceans: a review*, Prepared for the Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals, Bonn.

Reynolds, JE, Wells, RS & Eide, SD 2000, *The Bottlenose Dolphin: Biology and Conservation*, University Press of Florida, Gainesville.

Ricart, A.M, York, PH, Rasheed, MA, Pérez, M, Romero, J, Bryant, CV, & Macreadie, PI 2015, Variability of sedimentary organic carbon in patchy seagrass landscapes. Marine pollution bulletin, 100(1), 476-482.

Rogers, C 1979, 'The effect of shading on coral reef structure and function', *Journal of experimental Marine Biology and Ecology*, vol. 41, pp. 269-288.

Rollason, SN & Howell, S 2012, *Aquatic Conservation Assessments (ACA), using AquaBAMM, for the nonriverine wetlands of the Great Barrier Reef catchment*, Version 1.3, Department of Environment and Resource Management, Brisbane.

Rolls, RJ 2011, 'The role of life-history and location of barriers to migration in the spatial distribution and conservation of fish assemblages in a coastal river system', *Biological Conservation*, vol. 144, pp. 339-349.

Ross, GJB 2002, 'Humpback dolphins *Sousa chinensis*, *S. plumbea* and *S. teuszi*', in *The Encyclopaedia of Marine Mammals*, eds WF Perrin, B Würsig & HGM Thewissen, Academic Press, London, pp. 585-589.

Ross, GJB, Heinsohn, GE & Cockcroft, VG 1994, 'Humpback Dolphins', in *Handbook of Marine Mammals Vol. 5: The First Book of Dolphins*, eds SH Ridgway & R Harrison, Academic Press, London, pp. 23-42.

Ryan, DA, Brooke, BP, Bostock, B, Collins, LB, Buchanan, C, Siwabessy, J, Margvelashvili, N, Radke, L, Skene, D & Hamilton, L 2006, *Geomorphology and sediment transport in Keppel Bay, south-east Queensland, Australia*, Cooperative Research Centre for Coastal Zone, Estuary and Water Management, Indooroopilly.

S

Saayman, GS & Tayler, CK 1973, 'Social organisation of inshore dolphins (*Tursiops aduncus* and *Sousa*) in the Indian Ocean', *Journal of Mammalogy*, vol. 54, pp. 993-996.

Sandpiper 2012, *Gladstone Ports Corporation Migratory Shorebird Monitoring – Survey 5, Year 2, October 2012*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Sankey, TL & Rasheed, M.A 2011, *Gladstone Permanent Transects Seagrass Monitoring Sites – February and March 2011 Update*, DEEDI Publication, Fisheries Queensland, Cairns.

Sawynok, B, Parsons, W, Mitchell, J & Sawynok, S 2015, *Developing a fish recruitment indicator for the pilot Gladstone Healthy Harbour Report Card in 2015*, Infofish Australia, Frenchville.

Sawynok, B, Platten, J, Parsons, W & Sawynok, S 2014, *Gladstone Recreational Fishing Project Gladfish 2014 Nov 2013-Oct 2014. Assessing Trends in Recreational Fishing in Gladstone Harbour and Adjacent Waterways*, Infofish Australia, Frenchville.

Scott, MD & Chivers, SJ 1990, 'Distribution and herd structure of bottlenose dolphins in the Eastern Tropical Pacific Ocean', in *The Bottlenose Dolphin*, eds S Leatherwood & R Reeves, Academic Press, San Diego.

Sea Research 2013, *Changes in benthic communities on fringing coral reefs around Facing Island: August 2013*, Report prepared for Gladstone Ports Corporation, Brisbane.

Seagrasswatch 2015, *SeagrassWatch*, viewed 24 January 2018, <http://www.seagrasswatch.org/home_noG.html>

Sheaves, M, Johnston, R & Abrantes, K 2007, 'Fish fauna of dry tropical and subtropical estuarine floodplain wetlands', *Marine and Freshwater Research*, vol. 58, pp. 931- 943.

Sheppard, J, Preen, AR, Marsh, H, Lawler, IR, Whiting, S & Jones RE 2006, 'Movement heterogeneity of dugongs, *Dugong dugon* (Müller) over large spatial scales', *Journal of Experimental Marine Biology and Ecology*, vol. 334, pp. 64-83.

Sinclair Knight Merz 2004, *Port Curtis Integrated Monitoring Program: Sampling design and statistical methods package*, Prepared for Port Curtis Integrated Monitoring Program, South Brisbane.

Sinclair Knight Merz 2013, *Mangrove and Saltmarsh Monitoring: Literature Review,* Prepared for Gladstone Ports Corporation, South Brisbane.

SLR 2019a, *Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project – Environmental Impact Statement Terrestrial Noise and Vibration Assessment*

SLR 2019b, *Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project – Environmental Impact Statement Underwater Noise Assessment*

Small, M 1997, *Fish communities of a subtropical mangrove forest, with comparisons to adjacent mudflats and seagrass beds*, Central Queensland University, Rockhampton.

Sobtzick, S, Grech, A, Coles, R, Cagnazzi, D & Marsh, H, 2013, *Status of the dugong population in the Gladstone area. A Report for Gladstone Ports Corporation Limited for Project CA 20017: Monitoring of Dugongs*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication, James Cook University, Townsville, 37 pp.

Sobtzick, S, Hagihara, R, Grech, A, Jones, R, Pollock, K & Marsh, H 2015, *Improving the time series of estimates of dugong abundance and distribution by incorporating revised availability bias corrections*, Prepared for the Australian Marine Mammal Centre, Cairns.

Sobtzick, S., Cleguer, C., Marsh, H., Hagihara, R. & Centre for Tropical Water & Aquatic Ecosystem Research, 2017. *Distribution and abundance of dugong and large marine turtles in Moreton Bay, Hervey Bay and the southern Great Barrier Reef*. James Cook University, Townsville, Qld

Sousa, WP & Dangremond, EM 2011, 'Trophic Interactions in Coastal and Estuarine Mangrove Forest Ecosystems', in *Treatise on Estuarine and Coastal Science*, eds E Wolanski & D McLusky, Academic Press, Waltham, pp. 43-93.

Sozou, A, McKenna, S & Rasheed, M 2015, *Port of Karumba Long-term Seagrass Monitoring, November 2014*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Sperling, JB, Grigg, GC & Limpus, CJ 2010, 'Diving behaviour in two distinct populations of gravid flatback turtles, *Natator depressus*', *Australian Zoologist*, vol. 35, pp. 291-306.

Stewart, PM, Butcher, JT & Swinford,TO 2000, 'Land use, habitat, and water quality effects on macroinvertebrate communities in three watersheds of a Lake Michigan associated marsh system', *Aquatic Ecosystem Health & Management*, vol. 3, pp. 179-189.

Suntaggers (2018) Viewed 17 January 2018,< https://suntaggers.com.au>.Stolen, MK & Barlow, J 2003, 'A model life table for bottlenose dolphins (*Tursiops truncatus*) from the Indian River Lagoon system, Florida, U.S.A', *Marine Mammal Science*, vol. 19, pp. 630-649.

T

Taylor, HA & Rasheed, MA 2011, 'Impacts of a fuel oil spill on seagrass meadows in a subtropical port, Gladstone, Australia – The value of long-term marine habitat monitoring in high risk areas', *Marine Pollution Bulletin*, vol. 63, pp. 431-437.

Taylor, HA, Rasheed, MA & Carter, AB 2015, *Port of Weipa long-term seagrass monitoring, 2000 - 2014*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Thomas, R & Rasheed, M 2011, *Port of Hay Point Seagrass, Algae and Benthic Macro-invertebrate Survey – October 2010*, Department of Employment, Economic Development and Innovation, Cairns.

Thomas, R, Unsworth, RKF & Rasheed, MA 2010, *Seagrasses of Port Curtis and Rodds Bay and long term seagrass monitoring, November 2009*, Department of Employment, Economic Development and Innovation, Cairns.

Thompson, A & Dolman, AM 2010, 'Coral bleaching: One disturbance too many for near-shore reefs of the Great Barrier Reef', *Coral Reefs*, vol. 29, pp. 637-648.

Thompson, A, Costello, P & Davidson, J 2015, *Gladstone Healthy Harbour Partnership 2015 Report Card, ISP014: Coral*, Australian Institute of Marine Science, Townsville.

Thompson, A, Costello, P, Davidson, J, Murray, L, Schaffelke, B, Takahashi, M & Uthicke, S 2011, *Reef rescue marine monitoring program. Final report of AIMS activities - Inshore coral reef monitoring 2010*, Prepared for Reef and Rainforest Research Centre, Australian Institute of Marine Sciences, Townsville.

Thompson, A, Schaffelke, B, De'ath, A, Cripps, E & Sweatman, H 2010, W*ater quality and ecosystem monitoring programme. Reef Water Quality Protection Plan. Synthesis and spatial analysis of inshore monitoring data 2005-08*, Australian Institute of Marine Science, Townsville.

Threatened Species Scientific Committee (TSSC) 2013, *Conservation Advice for Subtropical and Temperate Coastal Saltmarsh*, Prepared for the Commonwealth Department of the Environment, Canberra.

Threatened Species Scientific Committee (TSSC) 2015a, *Conservation Advice: Numenius madagascariensis, Eastern Curlew*, Prepared for the Commonwealth Department of the Environment, Canberra.

Threatened Species Scientific Committee (TSSC) 2015b, *Conservation Advice for Calidris ferruginea, Eastern Curlew*, Prepared for the Commonwealth Department of the Environment, Canberra.

Threatened Species Scientific Committee (TSSC) 2016, *Approved Conservation Advice for Limosa lapponica menzbieri (Bar-tailed godwit (northern Siberian))*, viewed 1 March 2018, <http://www.environment.gov.au/biodiversity/threatened/species/pubs/86432-conservation-advice-05052016.pdf>

Tourism and Events Queensland 2016, *Gladstone: Fishing*, viewed 13 March 2016, <http://www.queensland.com/en-CA/Explore-Queensland/Gladstone-Region/Things-to-See-and-Do/Fishing>.

Triggs, B 2004, *Tracks, scats and other traces: A field guide to Australian Mammals*, Oxford University Press, South Melbourne.

Twaddle, H, French, K, Howe, M, Limpus, G, McLaren, M, Pople, L, Sim, E & Limpus, CJ 2015, *Marine Turtle Nesting Population: Peak Island Flatback Turtles, 2014-2015 breeding season*, Department of Environment and Heritage Protection, Brisbane, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Twaddle, H, Limpus, J, Pople, L, Wildermann, N & Limpus CJ 2014, *Marine Turtle Nesting Population: Peak Island Flatback Turtles, 2013-2014 breeding season*, Department of Environment and Heritage Protection, Brisbane, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

U

United Nations Educational, Scientific and Cultural Organisation & Intergovernmental Committee for the Protection of the World Cultural and Natural Heritage 1978, *Operational Guidelines for the implementation of the World Heritage Convention*, World Heritage Centre, Paris.

United Nations Educational, Scientific and Cultural Organisation & Intergovernmental Committee for the Protection of the World Cultural and Natural Heritage 2012, *Operational guidelines for the implementation of the World Heritage Convention*, World Heritage Centre, Paris.

Unsworth, RKF & Cullen, LC 2010, 'Recognising the necessity for Indo-Pacific seagrass conservation', *Conservation Letters*, vol. 3, pp. 63-73.

Unsworth, RKF, Rasheed, MA, Chartrand, KM & Roelofs, AJ 2012, 'Solar radiation and tidal exposure as environmental drivers of Enhalus acoroides dominated seagrass meadows', *PLoS ONE*, vol. 7, no. 3, pp. 1-8.

URS 2015, *GLNG LNG Facility Curtis Island – Shorebird Surveys*, viewed 29 May 2018, **https://www.santos.com/media/4246/20170216_glng-lng-facility-curtis-island-shorebird-surveys_0_final.pdf**

V

Vermaat, JE, Agawin, NR, Fortes, MD Uri, J, Duarte, CM, Marba, N, Enriquez, S & Van Vierssen, W 1997, 'The capacity of seagrasses to survive increased turbidity and siltation: The significance of growth form and light use', Ambio, vol. 26, pp. 499-504.

Vision Environment 2010, *PCIMP 2009 Intertidal and Coastal Monitoring*, Port Curtis Integrated Monitoring Program (PCIMP), Gladstone.

Vision Environment 2011, *Port Curtis Ecosystem Health Report 2008-2010*, Port Curtis Integrated Monitoring Program (PCIMP), Gladstone.

Vision Environment 2013, *Western Basin Dredging Disposal Project Water Quality Monitoring - Methodology Overview*, Vision Environment, Gladstone.

Vision Environment 2015a, *Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project Environmental Impact Statement. Reef and Nekton Baseline Data Collection, August 2015*, Vision Environment, Gladstone.

Vision Environment 2015b, *Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project Environmental Impact Statement. Macroinvertebrate Baseline Data Collection, October 2015,* Vision Environment, Gladstone.

Vision Environment 2015c, *EIS for Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project: Water Quality Monitoring June 2014 to June 2015*, Vision Environment, Gladstone.

Vision Environment 2015d, *EIS for Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project Marine Ecology - Coral and Fish 2015*, Vision Environment, Gladstone, Australia.

Vision Environment 2015e, *Port of Gladstone Biosecurity Monitoring Program 2015*. Vision Environment, Gladstone, Australia.

Vision Environment 2017, *Port of Gladstone East Banks Sea Disposal Site Macroinvertebrate Monitoring Program 2016/2017*. Vision Environment, Gladstone.

W

Walker, M 1997, *Fisheries Resources of the Port Curtis and Capricorn Regions*, Queensland Fisheries Management Authority, Brisbane.

Watling, JR, Robinson, SA, Woodrow, IE & Osmond, CB 1997, 'Responses of rainforest understorey plants to excess light during sunflecks', *Australian Journal of Plant Physiology*, vol. 24, no. 1, pp. 17-25.

Watson, RA, Coles, RG & Lee Long, WJ 1993, 'Simulation estimates of annual yield and landed value for commercial penaeid prawns from a tropical seagrass habitat, northern Queensland, Australia', *Marine and Freshwater Research*, vol. 44, pp. 211-220.

Waycott, M & McKenzie, LJ 2010, *Final report project 1.1.3 and 3.7.1 to the Marine and Tropical Sciences Research Facility: Indicators and thresholds of concern for seagrass ecosystem health for the Great Barrier Reef,* Reef and Rainforest Research Centre Limited, Cairns.

Waycott, M, Duarte, C, Carruthers, T J B, Orth, RJ, Dennison, WC, Olyarnik, S, Calladine, SA, Fourqurean, JW, Heck, KL, Hughes, AR, Kendrick, G, Kenworthy, WJ, Short, FT, Williams, SL 2009, Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences of the United States of America, 106(30), 12377-12381. **https://doi.org/10.1073/pnas.0905620106**

Wells, RS & Scott, MD 1999, 'Bottlenose dolphin - *Tursiops truncatus* (Montagu, 1821)', in *Handbook of Marine Mammals, Volume 6: The second book of dolphins and porpoises*, eds SH Ridgway & SR Harrison, Academic Press, San Diego.

Wells, RS & Scott, MD 2002, 'Bottlenose dolphins', in *Encyclopaedia of Marine Mammals*, eds WF Perrin, B Würsig, & JGM Thewissen, Academic Press, San Diego.

Wells, RS, Scott, MD & Irvine AB 1987, 'The social structure of free-ranging bottlenose dolphins on the west coast of Florida', in *Current Mammalogy*, ed HH Genoways, Plenum Press, New York, pp. 235-244.

WetlandCare Australia 2008, *Wetland Rehabilitation Guidelines for the Great Barrier Reef catchment*, Prepared for the Department of Environment, Water, Heritage and the Arts.

Wetlands International 2006, *Waterbird population estimates*, Wetlands International, Netherlands.

Whiting, SD 2008, *Movements and distribution of dugongs (Dugong dugon) in a macro-tidal environment in northern Australia*, Australian Journal of Zoology, 56: 215-222.

Wildlife Preservation Society of Queensland 2016, Species profile of Short-beaked echidna (*Tachyglossus aculeatus)*, viewed 12 January 2018, <http://wildlife.org.au/short-beaked-echidna/>.

Wildlife Unlimited 2013, Report for Migratory Shorebird Monitoring Port Curtis and the Curtis Coast Annual Summer Survey – 2013, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Wildlife Unlimited 2014, *Gladstone Ports Corporation Report for Migratory Shorebird Monitoring Port Curtis and the Curtis Coast Annual Summer Survey – 2014*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Wildlife Unlimited 2015, *Gladstone Ports Corporation Report for Migratory Shorebird Monitoring Port Curtis and the Curtis Coast Annual Summer Survey – 2015*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Wildlife Unlimited 2016, *Gladstone Ports Corporation Report for Migratory Shorebird Monitoring Port Curtis and the Curtis Coast Annual Summer Survey – 2016*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Wildlife Unlimited 2017, *Gladstone Ports Corporation Report for Migratory Shorebird Monitoring, Port Curtis and the Curtis Coast Annual Summer Survey – 2017*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Wildlife Unlimited 2018, *Gladstone Ports Corporation Report for Migratory Shorebird Monitoring, Port Curtis and the Curtis Coast Annual Summer Survey – 2018*, Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Wilson, A, MacFarlane, W & Murphy, J 2015, *Invasive plants and animals: Marine plants and animals*, Department of Environment and Heritage Protection, Brisbane.

Wilson, HB, Kendall, BE, Fuller, RA, Milton, DA & Possingham HP 2011, 'Analysing variability and the rate of decline of migratory shorebirds in Moreton Bay', *Conservation Biology*, vol. 25, pp. 758-766.

Wilson, S & Swan, G 2010, *A Complete Guide to Reptiles of Australia*, 3rd Edition, New Holland Publishers (Australia) Pty Ltd, Sydney.

Wirsing, AJ, Heithaus, MR & Dill, LM 2007, *Fear factor: do dugongs (Dugong dugon) trade food for safety from tiger sharks (Galeocerdo cuvier)?* Behavioral Ecology, vo. 153, pp. 1031-1040.

World Register of Marine Species 2018. *Dugongidae Gray, 1821*, viewed 22 February 2018, <http://www.marinespecies.org/aphia.php?p=taxdetails&id=196263>

X

Y

York, P, Davies, J & Rasheed, M 2014, *Long-term seagrass monitoring in the Port of Mourilyan – 2013*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

York, PH & Rasheed, MA 2017, *Seagrass Habitat of Cairns Harbour and Trinity Inlet: Annual Monitoring Report 2016*, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns.

Z

Zuur, AF, Ieno, EN & Elphick, CS 2010, 'A protocol for data exploration to avoid common statistical problems', *Methods in Ecology and Evolution*, vol. 1, pp. 3-14.

GIS base layer references

DigitalGlobe Web Map Service 2013, *World Imagery Base Map*, ESRI.

Gladstone Ports Corporation 2015, *Aerial imagery obtained from Gladstone Ports Corporation, July 2015* [8 September 2015].