C4

DREDGING AND DREDGE MOVEMENT

MARINE ECOLOGY

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GLOSSARY

Abundance	Relative numbers of animals, for a species or community, in a given area or sample size.
Ambient	Existing background conditions of the immediate surrounds prior to the development of the assessed proposal.
Amphipod	Small crustacean of the Order Amphipoda.
Ascidian	A class of sea squirts, typically occurring as benthic fauna attached to substrate.
Attenuation	Gradual loss in the intensity of light as it travels through water.
Avifauna	Collective grouping or generic reference to birds.
Bathymetric	Underwater depth and seabed topography.
Benthic	Pertaining to the seafloor or seabed.
Biodiversity / diversity	Refers to the variety of organisms (taxa) within the communities included in this assessment (i.e. number of fish or invertebrate species etc.). Elsewhere, may refer to the variation for other scales life components, such as genetic diversity.
Biomass	Total mass of living organisms, or of a particular subset of organisms, or organisms within a given area (e.g. seagrass biomass).
Biota	All living organisms, plants and animals.
Buffer	A zone separating two regions.
Community	The biotic component of a habitat; grouping of populations of different species living together or sharing a habitat.
Composition	The biological components comprising a community, taking into account the different species present and/or their abundance.
Crustacean	A class of predominantly aquatic/marine organisms which generally have a hard shell (e.g. crabs, prawns, lobsters).
Density	In relation to biota, extent or numbers of an organism within a given area (e.g. seagrass density).
Depauperate	Relatively devoid of biota, e.g. comparatively few obvious animals.
Dispersal	The movement or transport of animals and plants, particularly of juveniles and propagules, beyond their place of origin.
Distribution	The manner in which biota are spatially arranged; a species range or geographic extent.
Dredging	Excavation of subtidal bed sediments by mechanical means.
Echinoderm	From a phylum of marine animals with radial symmetry, includes starfish, sea urchins and sea cucumbers.
Ecological	Relating to the interactions between different organisms, or between organisms and their environment.
Ecosystem	Biotic and abiotic components of a broad environment functioning and interacting as an integrated system.
Epibenthic	Referring to organisms occurring on the surface of the seafloor or other substrata.
Epibiota	Organisms occurring on the surface of the seafloor or other substrata.
Epifauna	Fauna occurring on the surface of the seafloor or other substrata.
Epiflora	Flora occurring on the surface of the seafloor or other substrata.

Fauna	All of the animals found in an area.
Fisheries habitat	Natural and artificial habitats that support directly or indirectly the production, capture or culture of species of interest to fisheries.
Flora	All of the plants found in an area.
Germination	Growth of a seedling from a seed (e.g. new seagrass plant).
Habitat	The environment in which a plant or animal lives.
Heterogenous	Consisting of different elements or parts.
Homogenous	Consisting of similar elements or parts.
Hydrographic	Associated with mapping or describing the physical conditions characterising the ocean and other water bodies.
Indurated	Hardened or consolidated (with reference to indurated sands).
Infauna	Animals that live in the sediment.
Intertidal	The area along the coast below high tide and above low tide.
Invertebrate	Animals without backbones.
Larval	A juvenile form of animal, yet to undergo metamorphosis to adult form.
Macroalgae	Multicellular algae (seaweeds) that are visible to the human eye; green algae, red algae and brown algae.
Macro-invertebrate	Animals without backbones that are visible to the naked eye.
Mangrove	Salt tolerant trees which inhabit the intertidal zone on sheltered coastlines; their lower trunk and roots are periodically flooded by tides.
Megafauna	Animals that are large in size.
Micro-phytobenthos	Microscopic algae and cyanobacteria on the seabed.
Mitigation	Actions to alleviate, or reduce the severity of, disturbance.
Nutrients	Essential elements required by an organism for growth.
Pelagic	Pertaining to the water column.
Pest	A non-native species that has been introduced to a region and is considered problematic.
Photosynthetic	Undertakes the process carried out by plants, algae and some bacteria, whereby light energy is harvested by pigments (mostly chlorophyll) and utilised to convert carbon dioxide and water into organic molecules and oxygen.
Polychaete	Segmented marine worm from the Class Polychaeta.
Pore water	Water occurring between grains of sediment (i.e. interstitial).
Ramsar	Convention on Wetlands of International Importance Especially as Waterfowl Habitat, entered into force in 1975. A multilateral intergovernmental convention for the protection and management of internationally significant wetlands.
Richness	A measure of species/taxa diversity (e.g. the number of species present).
Rugosity	The degree of habitat complexity, taking into account changes in habitat height, slope and other physical characteristics. Indicative of amount of habitat available for colonisation, shelter, foraging etc.
Saltmarsh	An intertidal plant community complex dominated by herbs and low shrubs.
Seagrass	Flowering plant adapted to living submerged in seawater.
Sedimentation	The deposition or accumulation of sediment.
Seed bank	Dormant plant seeds stored in in the environment (e.g. viable seagrass seeds in sediment).
Senescent season	The dormant season for seagrass (and other plant) species that display seasonal growth, leaves and other plant parts may be shed.
Sessile	Animals that cannot move, fixed in one place.
Spawning	Common reproductive process for marine animals; the release or deposition of eggs or offspring, often in large numbers.
Substrate	The benthic habitat surface or material (e.g. sand, rock).
Subtidal	The area below the level of the lowest low tide; below the intertidal zone.
Suspended solids	Small solid particles occurring in suspension within the water column.
Turbidity / turbid	Optical measure of light-absorbing materials in a water sample; surrogate measure of suspended solids.
Urchin	Sea urchin; globular, spiny animals of the echinoderm phylum.

FOREWORD

The marine ecology assessment is presented in two parts. This **Chapter C4** provides the assessment for the Moreton Bay study area, where sand extraction operations are proposed to be undertaken. Chapter B10 addresses marine environments in the vicinity of the airport, where the majority of construction and operational activities will occur.

4.1
METHODOLOGY AND ASSUMPTIONS

4.1.1 Methodology

4.1.1.1 Nomenclature and terminology

For the purpose of this report the following terminology has been adopted:

The term study area refers to all tidal waters within the nominated marine ecology study area. The marine ecology study area for Moreton Bay is based on an area that is an approximate 15 km radius around the dredge area in northern Moreton Bay (**Figure 4.1a**)

- Dredge area refers to the Spitfire Realignment Channel (Moreton Bay) where capital dredging will be undertaken during construction to extract sand for reclamation purposes, it encompasses the:
  - Sand extraction area, which is the most likely dredge footprint for the Sunshine Coast Airport Expansion Project (the Project).
  - Spitfire Realignment Channel, which is the broader Spitfire Realignment Channel dredge area allocated for multiple projects, representing the ultimate combined dredge scenario footprint.
  - Note that for impact assessment, it is assumed that Port of Brisbane Pty Ltd (PBPL) will undertake capital dredging (already approved) of a 500 m wide channel at this location prior to the commencement of the Project construction. In this event, dredging would expand on PBPL's capital dredging work, such that the ultimate combined dredge footprint will be deeper (to approximately – 17.05 m lowest astronomical tide (LAT), as opposed to -16.5 m LAT if only the PBPL allocation was removed). The assessment, therefore, considers dredging outside the footprint of that already approved.
- The surrounding area refers to the intertidal and subtidal waters of northern Moreton Bay that are adjacent to the study area.

4.1.1.2 Assessment approach

Desktop assessments and field surveys were undertaken to describe the existing ecological characteristics of marine habitats, flora and fauna in northern Moreton Bay (**Table 4.1a**).

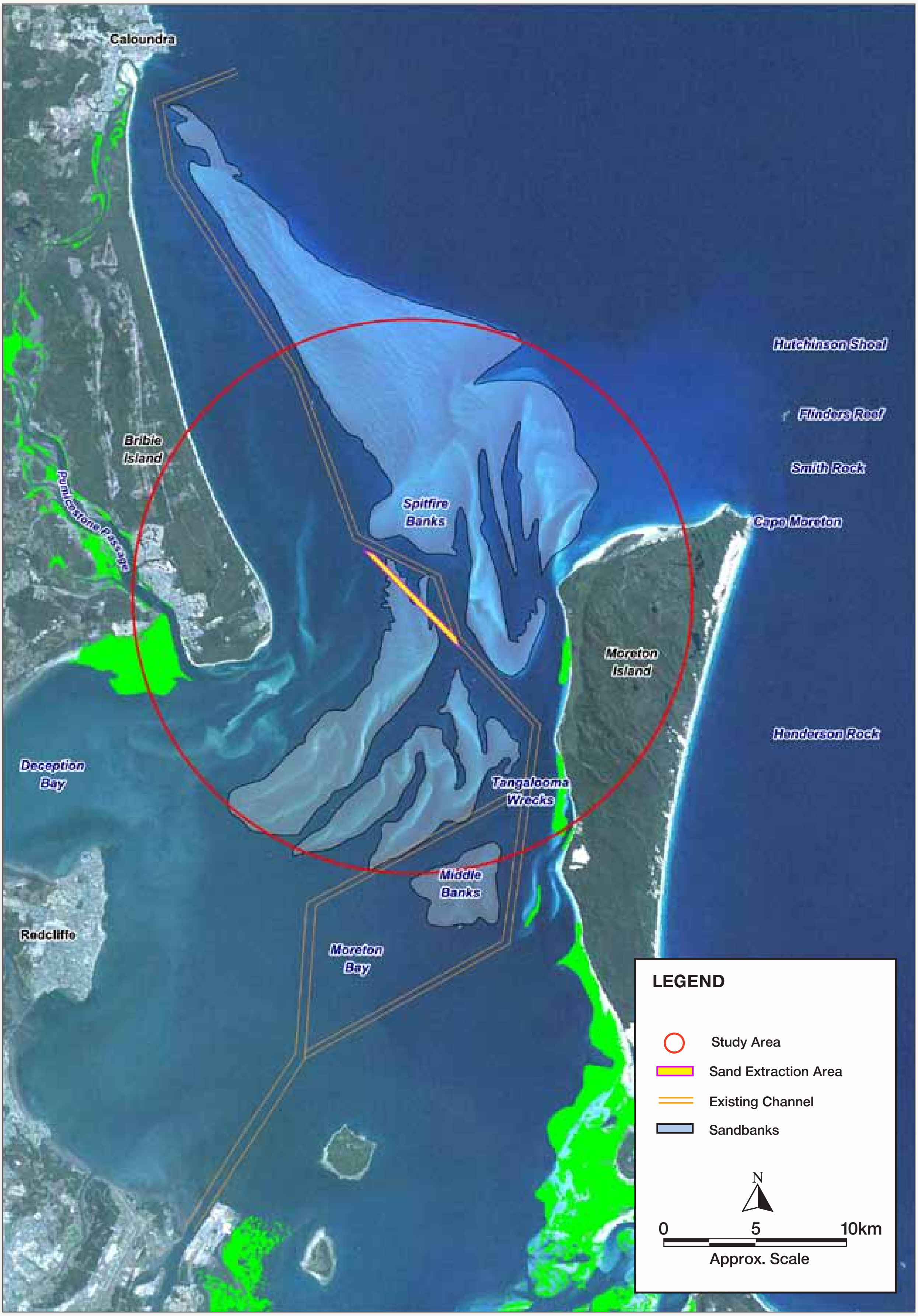
Key information sources reviewed during the desktop assessments included:

- Aerial photography
- Results from public database searches for species and communities of conservation significance, namely the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool, and the Department of Environment and Heritage Protection's (DEHP) Wildlife Online (refer **Appendix C4:A** and **C4:B**)
- Existing vegetation mapping including Ecosystem Health Monitoring Program (EHMP) seagrass maps (Healthy Waterways 2012), Regional Ecosystem maps (DEHP 2012), historical marine vegetation maps (from the Department of Agriculture, Fisheries and Forestry (DAFF) database), previous relevant seagrass mapping undertaken by BMT WBM (WBM 2005)
- Existing information on the ecological and fisheries values of the study area and surrounds, including data from the CHRIS database (DAFF 2012).

Table 4.1a Marine ecology components and assessment items

Component	Desktop	Field surveys
Marine vegetation communities (seagrass, saltmarsh, mangroves)	• Existing mapping • EHMP data • Other existing data and reports	• Seabed habitat survey (video) at dredge footprint
Unvegetated soft sediment marine habitats and epifauna communities	• Existing bathymetry mapping • Moreton Bay Sand Extraction Study • Other existing data and reports	• Seabed habitat and epifauna community surveys (sonar and video) at the dredge footprint
Reef habitats and communities	• Existing bathymetry mapping • Other existing data and reports	• Seabed habitat and epifauna community surveys (sonar and video) at the dredge footprint
Fish communities and fishery values	• Moreton Bay Sand Extraction Study • Commercial catch data	• No field surveys included
Marine mammals and reptiles	• Existing data and reports	• No field surveys included

Figure 4.1a: Marine ecology study area



A gap analysis was undertaken to assess the adequacy of information to complete the EIS. The key gap was the lack of contemporary, site-specific seabed habitat and epibenthic flora (seagrass, algae) and fauna community data for sites within, and adjacent to, the Project footprint. Field surveys were carried out to address these gaps as described below.

4.1.1.3 Seabed habitat mapping and epibiota surveys

Seabed habitat and epibenthos community surveys were carried out using a combination of:

- Initial classification and mapping of substrate types using acoustic (sonar) based methods
- Visual survey of seabed habitats and communities using an underwater video towed from the survey vessel.

Acoustic mapping survey effort over the sand extraction area is shown in **Figure 4.1b**. Survey lines were spaced in a 300 x 600 m grid formation over the dredge footprint and surrounds.

Acoustic mapping was conducted from the single hull survey vessel *Resolution II* with a Trimble Pro XRS differentially corrected GPS (dGPS). The differential correction of the positioning data was conducted in real-time using the Australian Maritime Safety Authority radio beacon at Ningi to provide sub-metre accuracy within the study area. The dGPS antenna was affixed to the top of the acoustic sounding pole to maintain the integrity of all collected survey data.

The survey was completed on 5 and 6 November 2012. Weather during the period was calm, with wind speeds rarely exceeding 10 kts, and seas of less than 0.5 m at all times. Vessel speed while conducting acoustic surveys were maintained at approximately 5.5 knots (11 km/h). To minimise the potential for aeration of the transducer resulting from propeller induced turbulence, the sounding pole was positioned 1 m wide of the outboard engine, with the transducer in front of the propeller at a depth of 0.8 m below the waterline. The pole was attached to a permanent transducer bracket specifically designed for survey work on *Resolution II*. This arrangement facilitated removal of the transducer from the water when the vessel was transiting to and from the study area, and a firm attachment point, free of turbulence for the transducer head.

Acoustic sounding and seabed classification was achieved using a 200 khz single beam Hondex Model 7300 echo sounder with a sonar beam width of 28 degrees. The echo sounder was interfaced to the Quester Tangent Corporation View Series 5 (Version R2.10) system which consists of hydrographic survey hardware and software components (**Figure 4.1c**) tailored to acoustic seabed discrimination based upon the shape of acoustic sonar returns from the seabed. The system records the characteristics of the reflected acoustic waveforms to generate habitat classifications, based upon the diversity of scattering and penetration of the acoustic signal from varying types of seabed. The process involves collection of acoustic data which are time stamped and geo-referenced using dGPS. The raw acoustic data were stored in real-time on a Toshiba Satellite Model U200 laptop computer running the QTC View Series 5 software.

Acoustic data analysis and mapping

The QTC suite of programs was used to process acoustic data (Locker and Wright 2003; Riegl and Purkis 2005; Preston et al. 2006). Raw data files were post-processed using the QTC Impact software package and all data were checked for correct time stamps, correct depths and correct signal strengths. Acoustic records from the marine ecology study area and the sand extraction area were combined for the backscatter analysis using the QTC Impact seabed classification software. This allowed comparison of sediments (and eventually habitat classes) between the two areas.

In the QTC Impact software (version R3.40) the acoustic echoes were digitised and normalised to a range between 0 and 1, before being subjected to further analysis.

These data were then reduced by generating Full Feature Vectors, referred to hereafter as acoustic records.

Figure 4.1c: Laptop and echo sounder (A) and the transducer head (B)

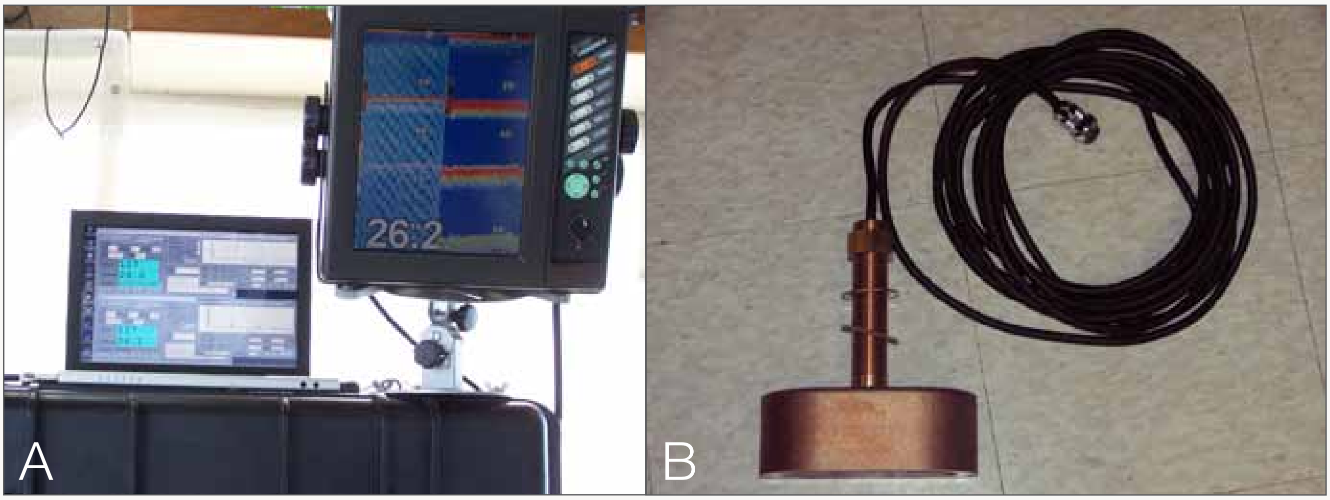
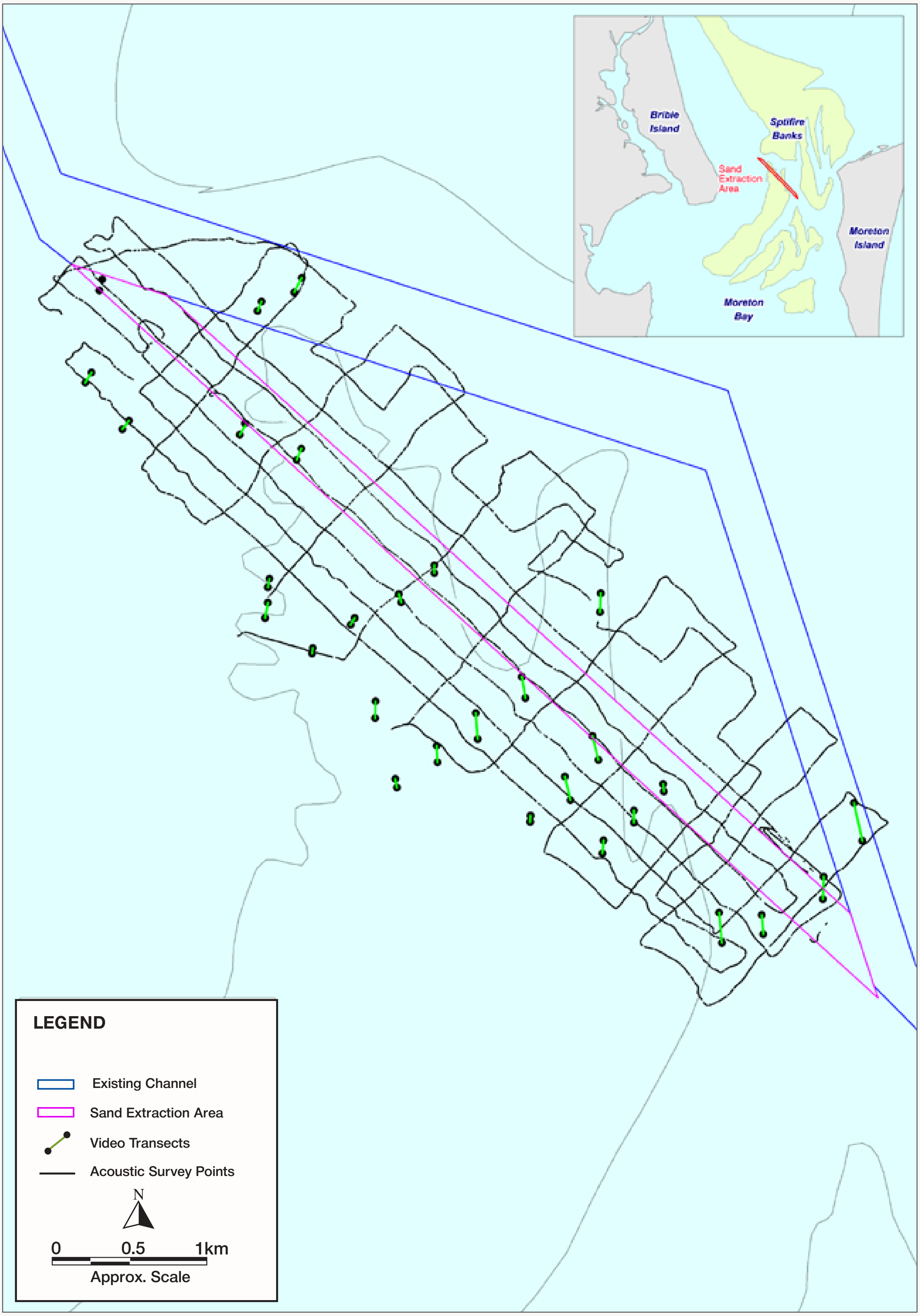


Figure 4.1b: Ecology sampling locations



Acoustic records were displayed on a bathymetry plot where the recorded depth was checked against the blanking (minimum recordable) depth and the maximum depths expected for the study area, based upon existing bathymetric information.

QTC Impact was used to classify acoustic signals (echograms) that returned from the seabed into statistically different acoustic classes. All acoustic records were subjected to Principal Components Analysis (PCA) to eliminate redundancies and noise. The first three principal components of each echo (called Q values) were retained, according to the theory that these typically describe 95 per cent of the information within each echo. Data points were then projected into pseudo three-dimensional space along these three components, where they were then subjected to cluster analysis to determine echoes of similar signature. In clustering, the user determines the desirable number of clusters (seabed classes) and also chooses which clusters to split and how often. Clustering decisions are guided by three statistics offered by the software package.

For each individual signal, the following data were exported from QTC Impact: latitude and longitude; depth (uncorrected for tidal or wave states); three PCA axes (called Q axes); a class category; a class assignment confidence value and a class probability value, which both range from 0 to 100 per cent. These indices may be useful for further determining the overall ‘quality’ of individual data points and classes. Records with confidence less than 95 per cent were removed from the analysis. For the purposes of data presentation and interpolation, each dataset has been reduced to a three column matrix consisting of a single x, y and geo-referenced seabed class category z.

A natural neighbour interpolation with median values was used to create benthic habitat maps of the study area using Vertical Mapper v3.1 through the MapInfo 10.0 platform. Mean values were used because habitat classes appeared to be serially ordinate based on sediment grain size. That is, class 2 and 4 habitats were often separated by class 3 habitats. Sonar data were interpolated using 0.1 m cell sizes and 0.1 m aggregation distances. For video data interpolations, cell sizes were 13.8 m and aggregations distances were 10.4 m.

Assessment of sediments and epifauna, and validation of acoustic data

The acoustically derived habitat categories do not, in isolation, provide information on the nature of the actual seabed conditions. The final classification of benthic habitat types was undertaken by ground-truthing and validating acoustic habitat classes using video analysis and qualitative investigations of particle size.

Indirect methods were used to classify benthic habitats developed by acoustic categories. This involved the following process:

- Generation of acoustic habitat classifications on each transect line using Vertical Mapper
- Undertaking video analysis at representative sites located on acoustic transect lines
- Using geographic information systems to overlay acoustic classes and video transects to check for correspondence or otherwise.

Video analysis

Seabed habitat communities of the sand extraction area were assessed using an underwater video camera on 7 November 2012. Video ground-truthing surveys were used to characterise each acoustic habitat class and validate the results of the acoustic classification and mapping, as well as describe epibenthic fauna communities. The sites selected for video transects encompassed the range of habitats previously identified by the acoustic methods to be separate classes. The locations of these sites are shown in **Figure 4.1b**.

Video transects were recorded at 29 sites surrounding the sand extraction area. At each transect, an underwater camera system was deployed by the passively drifting vessel for 3 – 4 minutes to film at least 50 m of sea floor. Video footage was observed on a computer monitor in real-time and recorded to hard drive. A van Veen grab was used to sample the seabed at selected sites to confirm sediment type.

Once collected, the video file for each transect was reviewed, noting the following features:

- Substrate type (e.g. soft sediment, consolidated reef)
- Approximate sediment grain size (e.g. silt, sand, rubble)
- The presence, general composition and abundance (i.e. dominant groups) of visually obvious biota, including epibenthic fauna (e.g. hydrozoans, sponges, ascidians etc.), epibenthic macroalgae and seagrass
- Other relevant features influencing seabed habitats (e.g. topography, evidence of trawling activity).

4.1.2 Assumptions and technical limitations

In terms of flora and fauna, this assessment focuses on conspicuous taxa present (or potentially present), especially marine plants (seagrass, macroalgae), and those that are considered to be of high environmental value for other reasons, such as high fisheries value or directly support fauna of high conservation or fisheries value (i.e. as a key habitat or food source).

The description of the existing environment provided herein is based primarily on a combination of information that was available to the authors at the time of writing, together with the results of surveys conducted specifically for the Project. It is recognised that additional data and knowledge relevant to the Project may reside elsewhere (e.g. unpublished data, grey literature).

For the assessment of impacts to marine ecological values, the assessment is guided, in part, by the outcomes of technical assessments included elsewhere in this EIS. Thus, it is also bound by the limitations and assumptions of the relevant chapters, particularly the modelling predictions presented for coastal processes and water quality (refer Chapter C3 – Coastal Processes and Water Quality).

4.1.3 Policy context and legislative framework

The following is a summary of federal and state legislation that is relevant to marine ecological aspects of the Project.

Federal:

- EPBC Act, which provides for the protection of Matters of National Environmental Significance (MNES). MNES of relevance to the Project include:
    - Wetlands of international importance (i.e. Moreton Bay Ramsar site)
    - Nationally threatened species and ecological communities (including marine turtles and whales)
    - Migratory species (including dugong, whale shark and several threatened marine megafauna species).

State:

- *Nature Conservation Act 1992* (NC Act), which provides for the protection of state listed threatened and near threatened flora and fauna species, which in the context of this Project includes marine turtles, whales, dolphins and dugong.
- *Fisheries Act 1994* provides for the use, conservation and enhancement of the community's fisheries resources and fish habitats. Of particular interest is the management of Fish Habitat Areas and the protection of fisheries habitats such as seagrass, mangroves and saltmarsh, and protection of fish stocks.
- *Environmental Protection Act 1994* (EP Act) provides for sustainable resource development while protecting ecological processes. The EP Act regulates environmentally relevant activities. The Environmental Protection (Water) Policy 2009 aims to achieve the object of the EP Act in Queensland waters by establishing environmental values and water quality objectives.
- The *Queensland Coastal Plan* Department of Environment and Resource Management (DERM), 2012) was prepared under the *Coastal Protection and Management Act 1995* in February 2012. The Coastal Plan consists of the State Policy for Coastal Management (SPCM), containing policies and guidance for coastal land managers on managing and maintaining coastal land. This policy has recently been replaced by the draft Coastal Management Plan (2013) which carries forward the policy outcomes from the State Policy for Coastal Management.
- The Coastal Protection State Planning Regulatory Provision (the Coastal SPRP) took effect on April 2013. Previously, the Draft Coastal SPRP had suspended the operation of the State Planning Policy 3/11: Coastal Protection (Coastal SPP). The Coastal SPRP provides outcomes for development assessment in the coastal management district.
- The single State Planning Policy (SPP) came into force December 2013, providing a single framework for considering a series of State Interests. The SPP is subordinate to the Coastal SPRP but must be considered in development assessment unless the provisions are adequately reflected in local planning schemes. Relevant State Interests include the biodiversity and the coastal environment.
- Sections and parts of the SPCM and Coastal SPRP that are relevant to marine ecology include:
    - Nature conservation, which covers biodiversity conservation, specifically conserving and managing a diverse range of habitats and biodiversity, the retention of native vegetation, and retention and management of riparian vegetation
    - Areas of high ecological significance, which states development and development infrastructure to be located outside of, and not have an impact on High Ecological Significance areas (including marine park zones, fish habitat areas and remnant vegetation), with some exceptions (note: development associated with an airport is an exception).

The relevance and consistency of the Project with the State Policy for Coastal Management and Coastal SPRP are outlined in Chapter B2 – Land Use and Tenure and Chapter A6 – Planning and Legislation Review.

4.2
EXISTING CONDITIONS

4.2.1 Introduction to marine habitats/values

The study area for the Moreton Bay dredging covers all marine environments within an approximate 15 km radius of Spitfire Realignment Channel, at the northern entrance of Moreton Bay. This includes northern Moreton Bay, and marine habitats between the eastern coast of Bribie Island and the north-western coasts of Moreton Island. Marine habitats within this area include pelagic waters outside Moreton Bay; semi-enclosed marine waters within Moreton Bay; subtidal soft sediment habitat; sandy beaches and shoals; rocky outcrops and artificial reefs; and vegetated habitats, primarily including seagrass communities. These habitats are described in the following sections in terms of the bio-physical characteristics, the values they support, and their current condition.

4.2.2 Marine protected areas

Declared protected marine areas within the study area include (**Figure 4.2a**):

- Commonwealth – Moreton Bay Ramsar site
- State – Moreton Bay Marine Park, Fish Habitat Areas.

Moreton Bay Ramsar site

Wetlands of international importance are listed as an MNES under Sections 16 and 17B of the EPBC Act. Such wetlands are commonly referred to as Ramsar wetlands. Parts of Moreton Bay Ramsar site are within the study area, but are positioned primarily near intertidal shores and estuaries, namely marine waters along the coasts of Moreton and Bribie Islands, and waters in Deception Bay and Pumicestone Passage. At its closest points, the Moreton Bay Ramsar site is located approximately 6 km to the east and west of the sand extraction area.

Key marine values justifying the inclusion of Moreton Bay as a Ramsar site include the following (EPA 1999):

- Moreton Bay is one of the largest estuarine bays in Australia
- Moreton Bay supports appreciable numbers of the vulnerable green and hawksbill turtles, the endangered loggerhead turtle, and is ranked among the top ten dugong habitats in Queensland
- It is a significant feeding ground for green turtles and is a feeding and breeding ground for dugong, the bay also has the most significant concentration of young and mature loggerhead turtles in Australia
- Moreton Bay supports over 355 species of marine invertebrates, at least 43 species of shore birds, 55 species of algae associated with mangroves, seven species of mangroves and seven species of seagrass
- In additional to these marine values, the bay is also recognised as a critical habitat for 43 shorebird species, including 30 migratory species (EPBC Act listed) (EPA 1999). Further details regarding the abovementioned marine flora and fauna are provided in **Section 4.2.8**, and in Chapter B8 – Terrestrial Fauna.

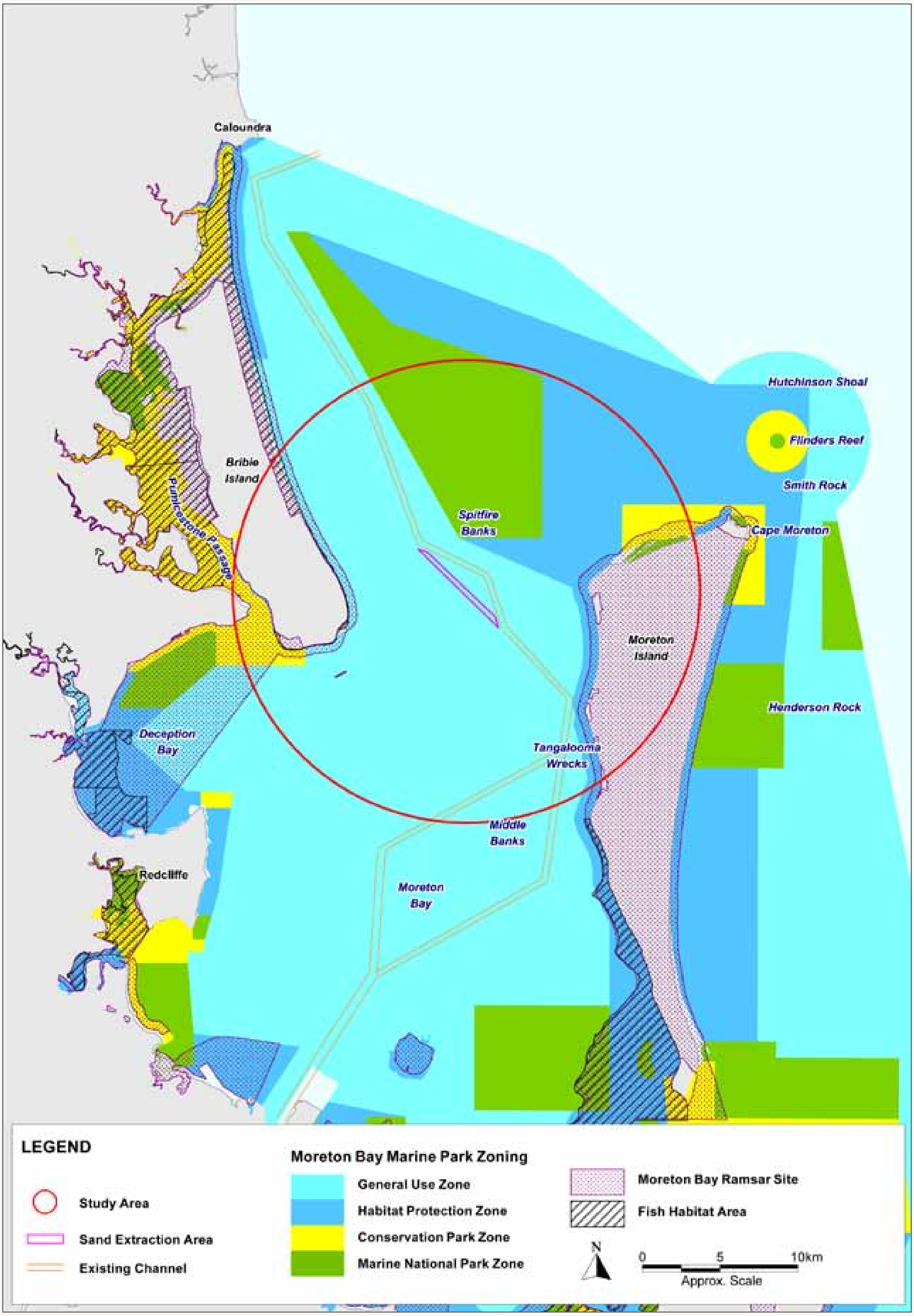
Moreton Bay Marine Park

Most marine waters of the study area are within the bounds of Moreton Bay Marine Park, which covers 3,400 km^2 stretching from Caloundra to the Gold Coast (DERM 2010). The marine park is managed using a zoning system declared under the Marine Parks (Moreton Bay) Zoning Plan 2008. There are four zone types in Moreton Bay Marine Park, each allowing different types of activities. A summary of zoned areas relevant to the Project is provided in **Table 4.2a**. The Marine National Park zone has the highest levels of protection. The closest area zoned as Marine National Park occurs west of the North-West Channel (MNP03), and includes parts of Spitfire Banks, Wild Banks, East Bank and North Banks. Other areas zoned as Marine National Park also occur in the study area (**Table 4.2a**) or surrounds, but are greater than 10 km from the sand extraction area.

Table 4.2a: Moreton Bay Marine Park zoning areas within the study area

Zone	Description	Relevant areas	Comments
Marine national park (green) zone	Highest level of protection ('no take'), all forms of take are prohibited, including fishing, collecting and extraction	MNP03 (includes parts of Spitfire Banks, Wild Banks, East Bank, North Banks) MNP06 (coastal lagoon adjacent on Moreton Island)	MNP03 located approximately 2.5 km to the north of the dredge footprint
Conservation park (yellow) zone	High conservation value for habitat and wildlife, limited recreational and commercial fishing permitted (no netting or trawling)	CPZ02 (southern Pumicestone Passage) CPZ04 (northern Moreton Island)	Areas in closest proximity to dredge footprint are CPZ02 (approximately 11 km west) and CPZ04 (approximately 9 km east)
Habitat protection (dark blue) zone	Protects sensitive habitats by keeping them generally free from potentially damaging activities (no trawling permitted)	HPZ02 (majority of northeast park area)	
General use (light blue) zone	Designated for both conservation and a wide range of activities (trawling permitted)	GUZ02 (remaining marine park in study area)	The Spitfire Channel and entire dredge area is wholly located within this zone

Figure 4.2a: Marine protected areas in the study area



Conservation Park Zones nearest to the sand extraction area include CPZ02, located approximately 11 km west at southern Pumicestone Passage and northern Deception Bay; and CPZ04 located approximately 9 km east on the northern coast of Moreton Island. CPZ02 incorporates habitats that are of high value to green turtles and dugongs, while CPZ04 provides a buffer between its adjacent marine national park and habitat protection zones.

Designated 'go slow' and 'no anchoring' areas are also located at various locations within the marine park. The designated areas nearest to the sand extraction area are two 'go slow' areas for turtles and dugongs located adjacent to western Moreton Island at Tangalooma Wrecks, and from Tangalooma Point to Moreton Banks.

Fish Habitat Areas

Fish Habitat Areas, which are managed under the Queensland *Fisheries Act 1994*, represent a form of multiple use marine protected area that limits certain activities that may affect fisheries habitat values. Four declared Fish Habitat Areas are located within or near the study area, as shown in **Figure 4.2a** and summarised in **Table 4.2b**. The closest Fish Habitat Area to the dredge footprint is located in Pumicestone Passage, approximately 12 km from the sand extraction area.

4.2.3 Seabed habitat

4.2.3.1 Acoustic mapping results

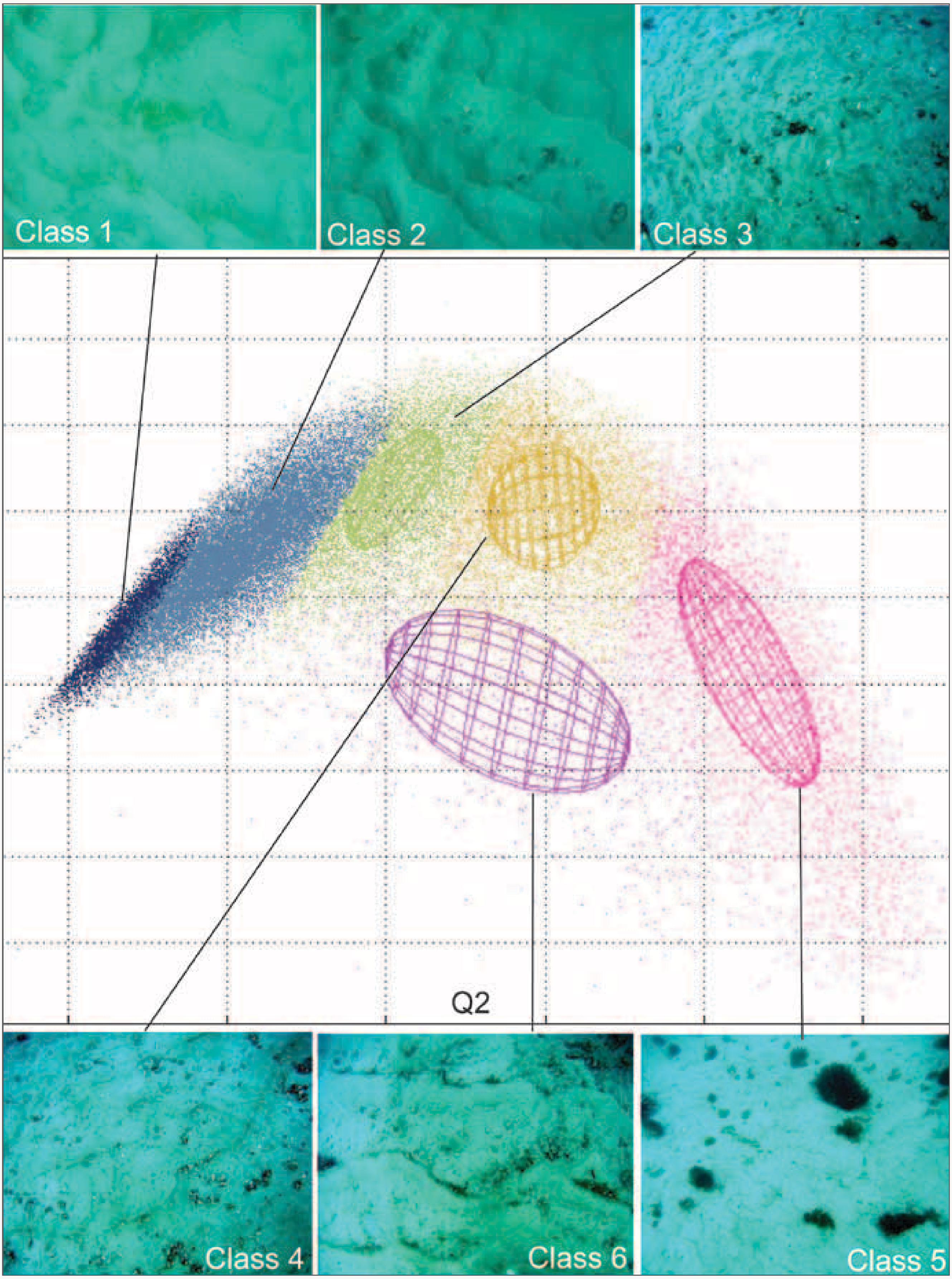
A total of 47,474 acoustic records (data points) were acquired for the combined dataset covering the Spitfire Realignment Channel. Based on five iterations per class and a maximum of 15 classes, cluster analyses revealed that the optimum number of seabed classes was six. Following the removal of anomalous data (i.e. records with confidence ratings less than 95 per cent), a total of 29,167 records remained from the combined dataset. PCA ordination of all acoustic records is shown in **Figure 4.2b**. In broad terms, data-points that are close together within each ordination (**Figure 4.2b**) are similar to each other, whereas data-points that are widely separated are dissimilar.

The data shows that class 1 (dark blue) and 2 (light blue) were the most similar classes, whereas class 1 and 5 (red) were the least similar to each other. Based on video observations and benthic grab observations, the acoustic habitat classes were mostly very similar to one another, and consisted largely of fine to medium sands with increasing fractions of coarse material present in higher classes (**Figure 4.2b**). Class 1 consisted of mostly fine sands, while class 2 consisted of fine to medium sands with shell grit. Class 3 contained fine to medium sands with occasional gravel. Class 4 habitats consisted of sand with some gravel

Table 4.2b: Summary of declared fish habitat areas in the study area vicinity (data courtesy DNPRSR 2013)

Fish Habitat Areas	Location	Area (ha)	Approximate distance from dredge footprint	Management level(s)	Key habitat features
Deception Bay	Caboolture River and foreshore, south to Deception Bay	1,512	24 km	A (>99 per cent of area) B(<1 per cent)	Sandy-mud foreshores, extensive intertidal flats, mangroves dominated by *Avicennia* and *Aegiceras*, samphire flats, ephemeral seagrass beds
Pumicestone Channel	Pumicestone Passage between mainland and Bribie Island, and most of Bribie Island foreshore	9,520	12 km	A (48 per cent of area) B (52 per cent)	Contains all of Moreton Bay's mangrove species, with shoreline dominated by *Avicennia*, *Ceriops*, *Aegiceras*, *Rhizophora*, patchy saltmarsh and seagrass beds, shoals
Kippa-ring	Southern end of Deception Bay	818	24 km	A	Ephemeral seagrass, extensive sand and mud intertidal flats and shoals, *Avicennia* dominated mangrove foreshore with samphire flats
Moreton Banks	South-western side of Moreton Island, south from Tangalooma Point	6,318	15 km	A	Extensive seagrass beds (prawn habitat) of *Zostera* and *Halophila*, mangroves, extensive public oyster grounds

Figure 4.2b: Two-dimensional PCA ordination showing clusters of acoustic classes and representative screen grabs over these habitats.



and occasional rubble (cobble). Class 5 habitats consisted of sand with gravel and some rubble, and class 6 habitats were similar to class 5 habitats, but were usually situated over high-relief areas, such as slopes and sand mounts.

4.2.3.2 Sediment distribution

Figure 4.2c shows patterns in the interpolated distribution of sediment classes over the sand extraction area. It was dominated by class 1 and 2 sediments over the shallower parts of the surveyed area, coinciding approximately with the large charted sandbank south of the Spitfire Channel. Class 1 sediments were more common in the shallowest southern part of this sandbank. The periphery of this sandbank was composed mostly of class 3 and 4 sediments. Bedforms consisting of small ripples to larger berms were present over much of this area, except where there were large patches of benthic micro-algae, the bed was mostly flat.

Patches of class 5 sediment interspersed with class 6 sediment were present in the southern extent of the surveyed area, in the Spitfire Channel. There were also areas of these two sediment classes in the north-western extent of the survey area and mid-way along the large northern projection of the sandbank.

This latter patch of class 5 and 6 sediment appeared to coincide with coarser material situated at the base of depressions, perhaps associated with previous sand extraction. These sediments had moderate semi-regular bedforms (sand ripples), but this was not necessarily a characteristic of the classes because other areas of class 5 sediment did not have obvious or regular bedforms. No areas of reef or large rocky outcrops were observed within the surveyed area.

Sediments appeared extremely homogeneous throughout the survey area, and class differences appear to represent subtle changes in the fraction of coarser material present in a matrix of fine to medium sands, as well as other changes in seabed habitat, including for example sediment compaction and rugosity. While highly resolving, the seabed classifications from acoustic methods describe very subtle changes that may not be biologically meaningful (see **Section 4.2.7** for more detail).

4.2.4 Seagrass and benthic algae

Seagrasses and other marine plants are protected under the *Fisheries Act 1994* due to their potential fisheries values. Seagrass also provides the primary food resource for threatened species such as dugong (*Dugong dugon)* (NC Act: Vulnerable) and green turtle (*Chelonia mydas)* (Vulnerable), as well as habitat for numerous sygnathids (e.g. pipehorses, pipefish) that are listed marine species under the EPBC Act (refer **Section 4.2.8**).

Dense, permanent seagrass beds do not occur in the northern tidal delta of Moreton Bay owing to the highly mobile substrate present and prevailing tidal flow currents. No known significant seagrass is located in the Spitfire Realignment Channel area, or immediately adjacent areas (**Figure 4.2d**), although small patches of sparse *Halophila ovalis* have been recorded there as follows:

- As described in further detail below, surveys undertaken as part of this EIS recorded occasional small patches of *H. ovalis*, typically with an estimated 1 per cent cover on transects where seagrass as observed. Seagrass matching this description was recorded in the northern reaches of the sand extraction area, as well as some adjacent sites. A greater coverage of *H. ovalis*, estimated to be approximately 15 per cent cover, was observed on only one transect, which happened to be located within the proposed sand extraction area.
- WBM (2005) – As part of surveys undertaken for the Port of Brisbane in 2005, BMT WBM (previously WBM) observed sparsely distributed seagrass in low abundance (*Halophila ovalis*) *on* the Western Banks within the Spitfire Realignment Channel. Specifically, *H. ovalis* was observed at 12 sites (approximately 15 per cent of sites) located between -5 and -15 m LAT as shown in **Figure 4.2e**. While no estimate of seagrass cover was made at the time, it was concluded cover was generally less than 10 per cent at each site, based on the low abundance of seagrass observed.

For the most recent surveys undertaken for this EIS, twelve of the 29 transects from the sand extraction area contained seagrass, with only one of these transects containing cover well above one per cent (**Figure 4.2f**). In most cases, seagrass consisted of a small patch similar to that shown in **Figure 4.2j (G)** in **Section 4.2.7**, observed once or twice over the length of the entire transect. Thus, seagrass cover over the length of each transect usually consisted of less than 1 per cent cover. However, in one transect, seagrass cover was much higher (refer area shaded green in interpolation **Figure 4.2f**) within a patch size of approximately 20 m. All seagrass within, and surrounding the sand extraction area consisted of *Halophila ovalis*, which is considered an early colonising and deepwater species in Moreton Bay, often with an ephemeral distribution that can fluctuate greatly annually and seasonally (Udy and Levy 2002).

Large patches of benthic micro-algae were commonly observed on shallower sandbanks throughout the sand extraction area. Benthic micro-algae varied from a dense, low-profile mat to sparse isolated areas of filamentous algae. Patches of benthic micro-algae were often visible from the sea surface in 5 – 7 m of water. Other commonly observed marine plants included *Sargassum* sp., *Caulerpa taxifolia*, *Halimeda* sp., and several other forms of unidentified green and brown macroalgae. Most macroalgae was found attached to small pieces of rubble and was more common in sediment classes 3-6 than it was in classes 1 and 2. Cover of macroalgae varied between 0 and 7 per cent throughout the sand extraction area.

The results are consistent with the findings of WBM (1995) and Udy and Levy (2002), who recorded seagrass at -12 m to -20 m LAT water depth, growing on subtidal sand in parts of northern and eastern Moreton Bay.

Figure 4.2c: Interpolated sediment classes

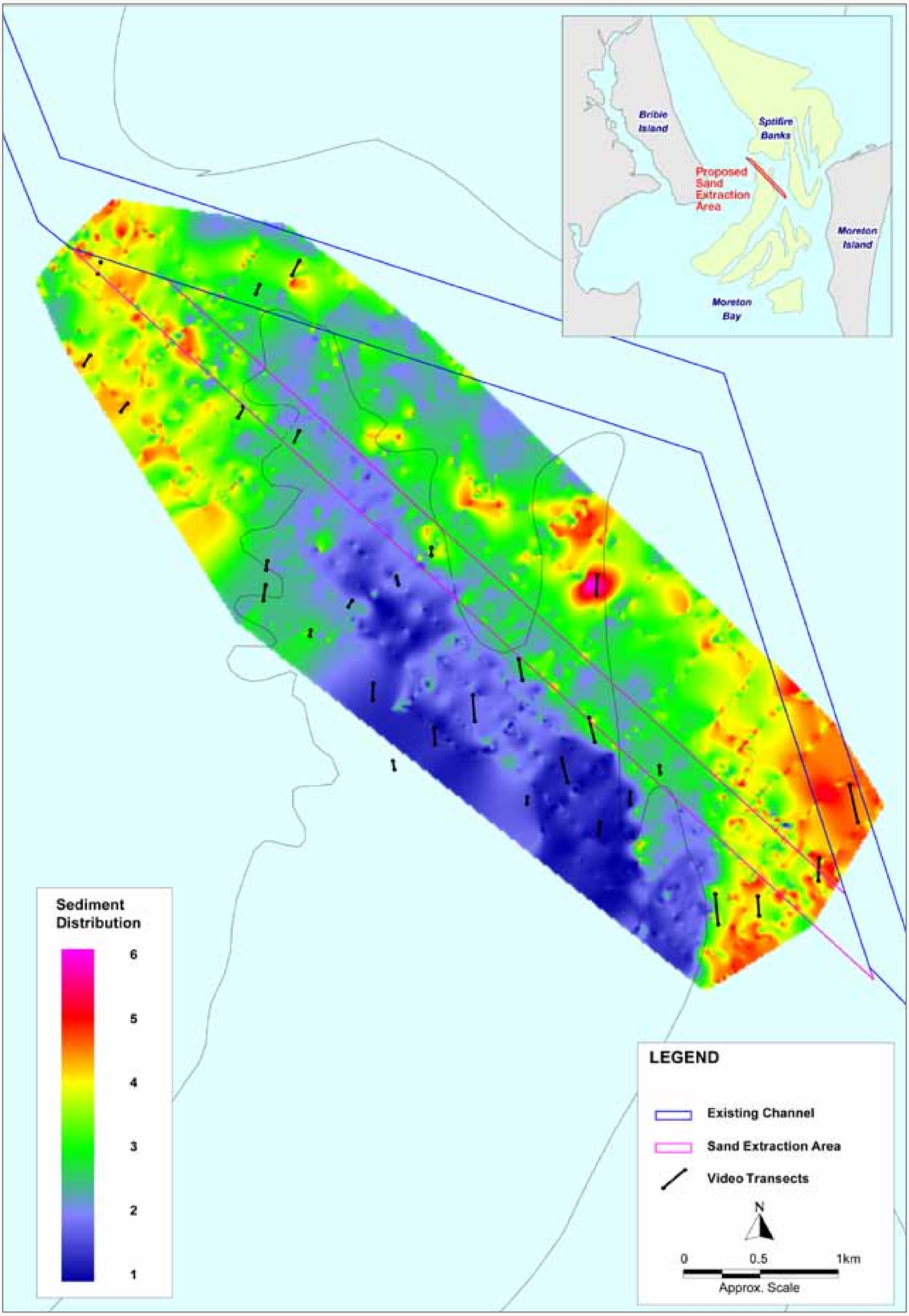


Figure 4.2d: Distribution and extent of seagrass meadows (supplied by QLD EPA, 2004 survey)

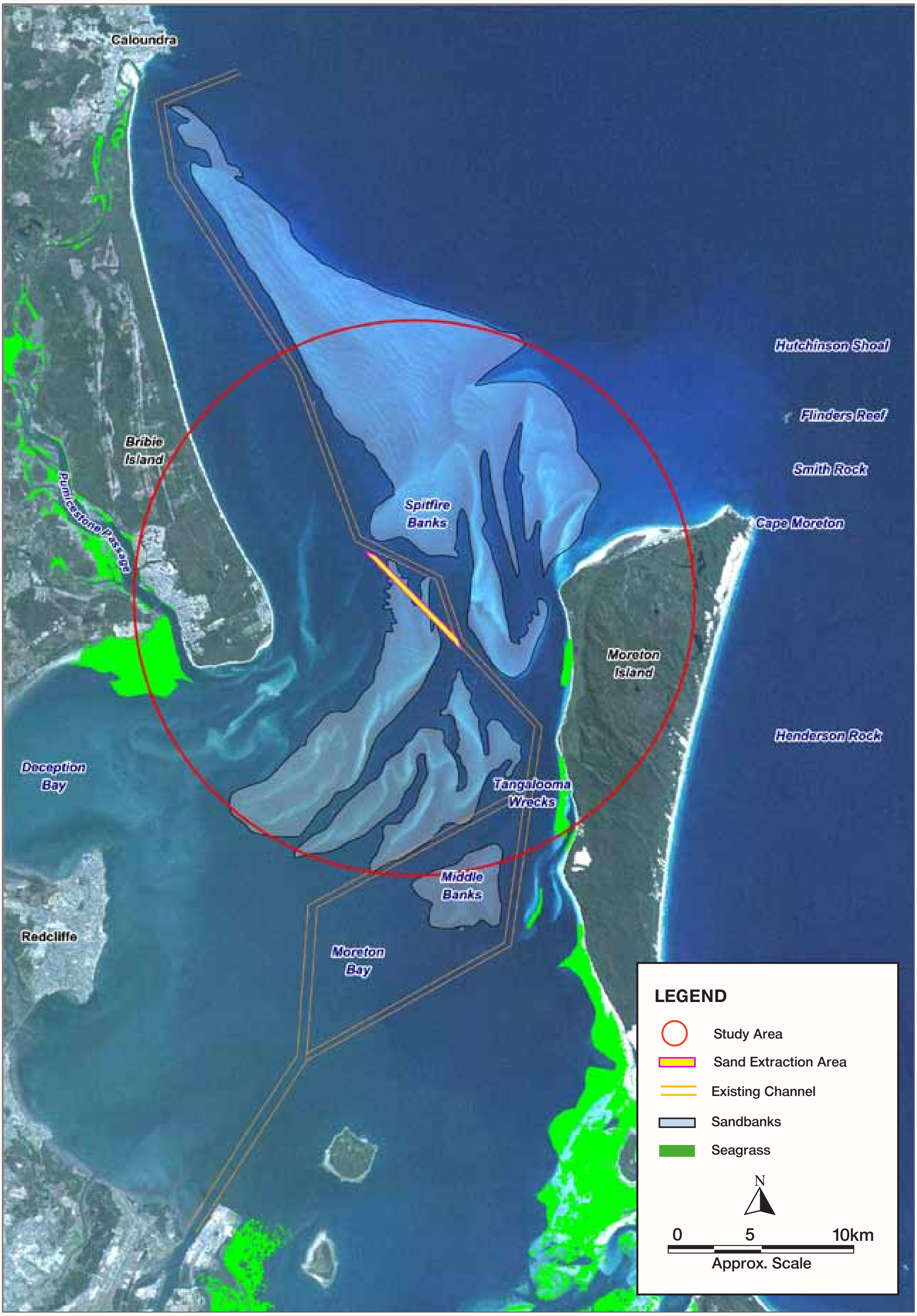


Figure 4.2e: Past seagrass observations within the dredge footprint (WBM 2005)

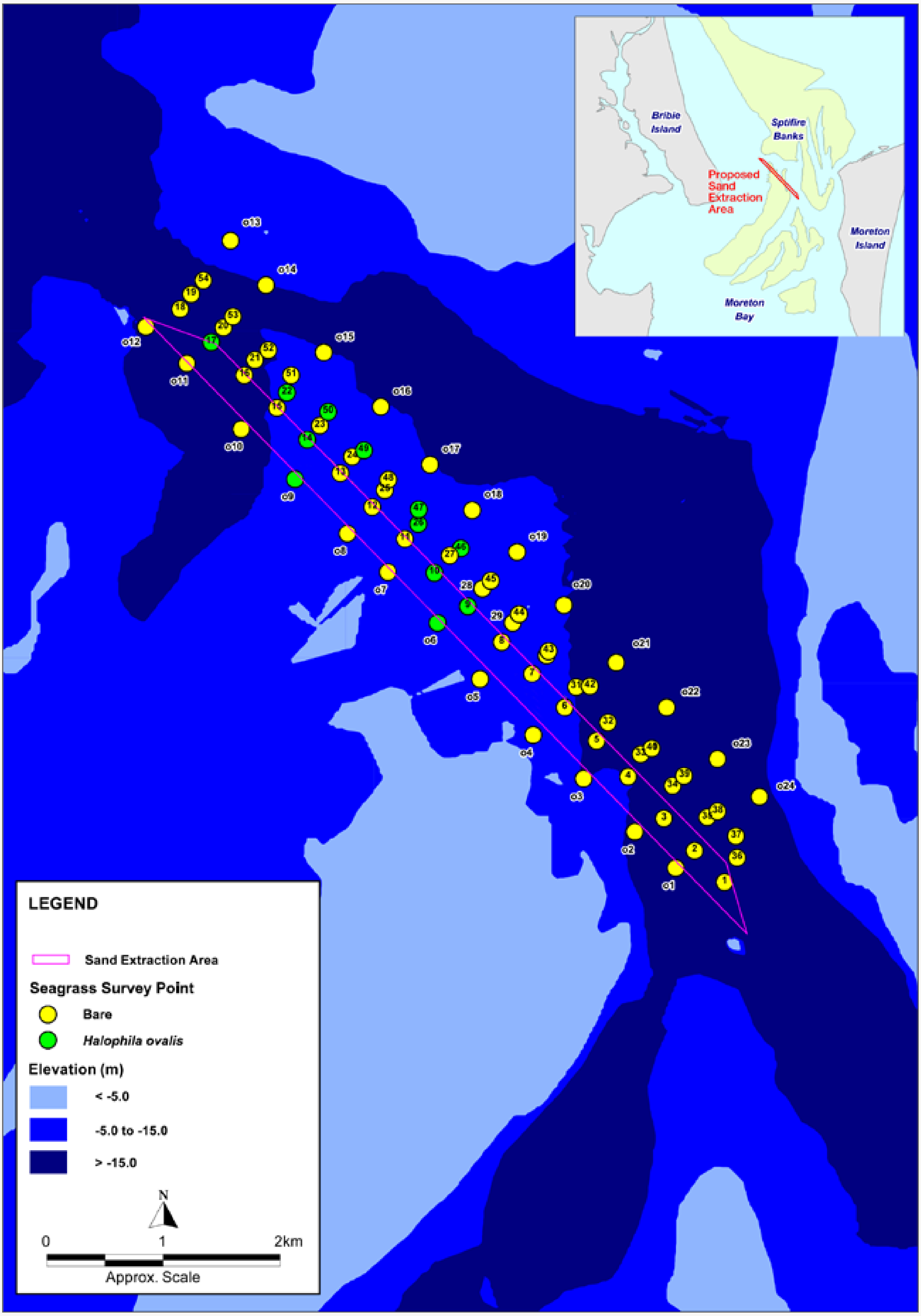
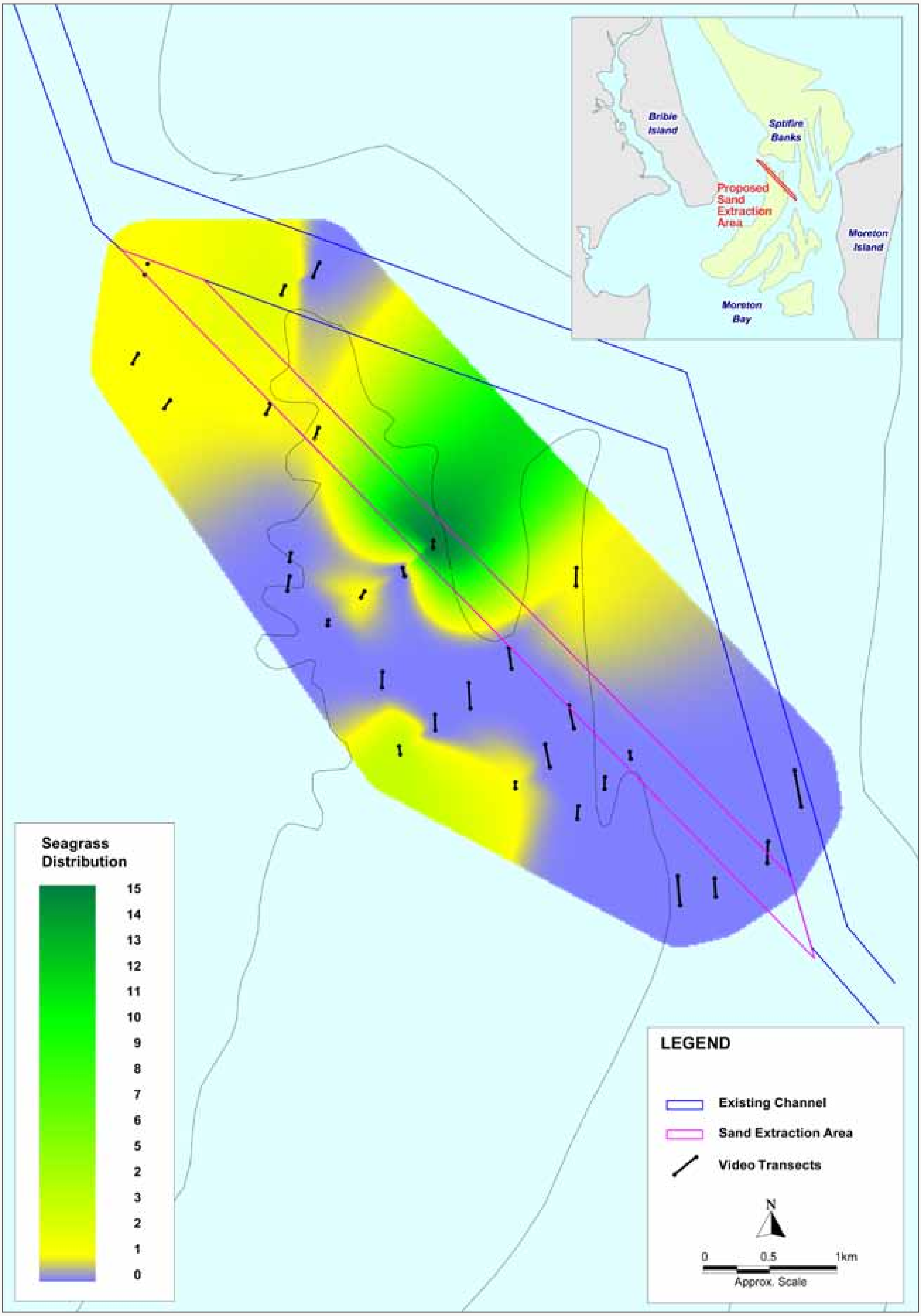


Figure 4.2f: Seagrass point-density distribution



In these deep environments, seagrasses were observed to form sparse isolated patches rather than contiguous meadows and are typically comprised of *H. ovalis* and/or *H. spinulosa*. Being close to their minimum light requirement (Udy and Levy 2002), these species are sensitive to medium to long term changes to light conditions, and are therefore usually ephemeral communities. These seagrass species have a range of adaptations that allow them to rapidly recolonise following disturbance. Similar seagrass communities were recorded further afield at Middle Banks, approximately 12 km south of Spitfire Realignment Channel, during surveys undertaken for the Brisbane Airport Corporation Parallel Runway Project (BAC 2007). At Middle Banks *H. ovalis* and *H. spinulosa* were recorded growing exclusively on shallow subtidal sand banks (from 4 to 10 m depth).

Given that seagrass and macroalgae are thought to only consist of isolated, sparse patches throughout the sand extraction area and immediate surrounds (under existing conditions of very low NTU/TSS), additional factors are likely to limit their establishment and/or persistence in this area. This would most likely be attributed to the high mobility of the substrate, and lack of consolidated substrata, which together limits opportunities for algal attachment and does not provide a stable environment for seagrass roots to take hold. Other factors may also contribute, such as relatively deep water depths (i.e. much of the area predicted to be impacted is already at, or near the depth limits for seagrass), or a limited availability of nutrients (i.e. very clean sands).

Given the sparse and isolated nature of the seagrass patches recorded at the sand extraction area and immediate surrounds, the seagrasses there are not recognised as directly providing critical habitat for threatened, or otherwise listed, fauna. Nevertheless, they would provide other locally valuable ecosystem functions, including the provision of habitat for fisheries and non-threatened fauna, seabed stabilisation and nutrient cycling.

Extensive and highly valuable seagrass meadows occur elsewhere in Moreton Bay, as shown in **Figure 4.2d**. Notable meadows within, or adjacent to, the broader study area include the following:

- Moreton Island – Numerous shallow water seagrass meadows occur adjacent to the western coast of Moreton Island. Towards the northern end of the island, notable seagrass beds are located approximately 7 km west of the sand extraction area
- Northern Deception Bay (15 km east of sand extraction area) – This meadow is a remnant of a once much more extensive seagrass meadow that occurred throughout Deception Bay (Hyland et al. 1989)
- Pumicestone Passage (> 15 km from sand extraction area) – A complex network of seagrass beds occurs throughout the length of Pumicestone Passage
- Moreton Banks (30 km south of sand extraction area) – Extensive meadows provide an important foraging ground for Moreton Bay's dugong population and sea turtles.

4.2.5 Reefs and hard substrata

No subtidal reefs, intertidal rocky shores or similarly hard substrata are present in the sand extraction area or the immediately adjacent environment. Areas of indurated sands may occur in places, particularly in the deeper channels outside the sand extraction area. These indurated sands do not provide a stable benthic substrate for reef-associated species such as corals, oysters or other encrusting fauna. However, based on observations elsewhere in Moreton Bay, indurated sand outcrops may provide some structural habitat values for 'reef-associated' fish species (Dr Darren Richardson, BMT WBM pers. obs., 1995).

Reefs do occur further afield towards the outer extent of the broader study area (**Figure 4.2g**), namely:

- Reefs (natural) – Small ephemeral coffee rock outcrops along the western coast of Moreton Island (Stephens 1978)
- Reefs (artificial) – Curtin Artificial Reef and Tangalooma Wrecks. Curtin Artificial Reef was established gradually from 1968 to 1998 and is located on a drop off from 15 – 25 m off the western coast of Moreton Island, in the Yule Roads Bulwer Wrecks area. It is comprised of approximately 32 vessels, car bodies, buoys, concrete pipes and tyres that have been sunk on an otherwise sandy bed. Tangalooma Wrecks is comprised of 15 vessels sunk off Tangalooma in a maximum depth of 10 m.

In terms of proximity to the sand extraction area, the nearest of these habitats (excluding small ephemeral coffee rock outcrops) is Curtin Artificial Reef, located approximately 6 km to the south-east, and Tangalooma Wrecks, located approximately 12 km south-east.

While these reefs are relatively small in area when compared to other habitat types present in the study area, they create local biodiversity hot spots. This is because they provide a more structurally complex habitat in an otherwise comparatively homogenous, sandy landscape. For example, these reef and rocky shore habitats act as an aggregation area for reef fish; they provide consolidated substrata for colonisation by macroalgae and sedentary invertebrates; and refuge, rest and foraging grounds for numerous mobile marine fauna (e.g. sharks, pelagic fish, turtles).

4.2.6 Mangroves and saltmarsh

Mangroves and saltmarsh communities are among the key primary producers in the wider Moreton Bay coastal zone, and also provide an important habitat for marine fauna, especially fish (including species of fisheries significance, refer **Section 4.2.9**) that depend on mangroves or saltmarsh as spawning, nursery, foraging and/or refuge habitat.

There are no mangroves or saltmarsh occurring in the sand extraction area or the immediately adjacent waters, and they are therefore highly unlikely to be affected by the proposed dredging works. The nearest of these communities is located in northern Deception Bay and Pumicestone Passage (**Figure 4.2h**), approximately 14 km from the sand extraction area.

Figure 4.2g: Distribution and extent of reefs and rocky shores

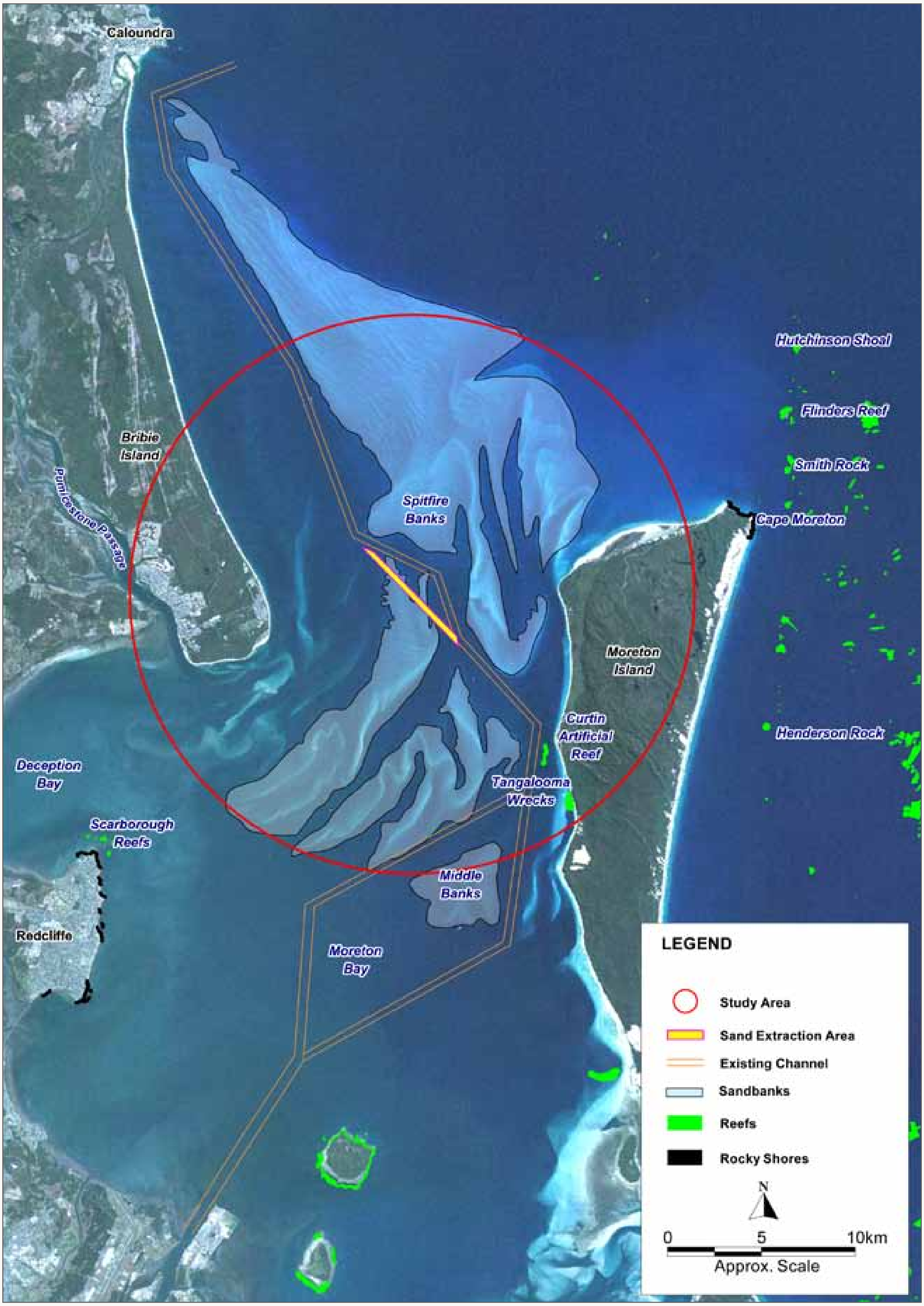
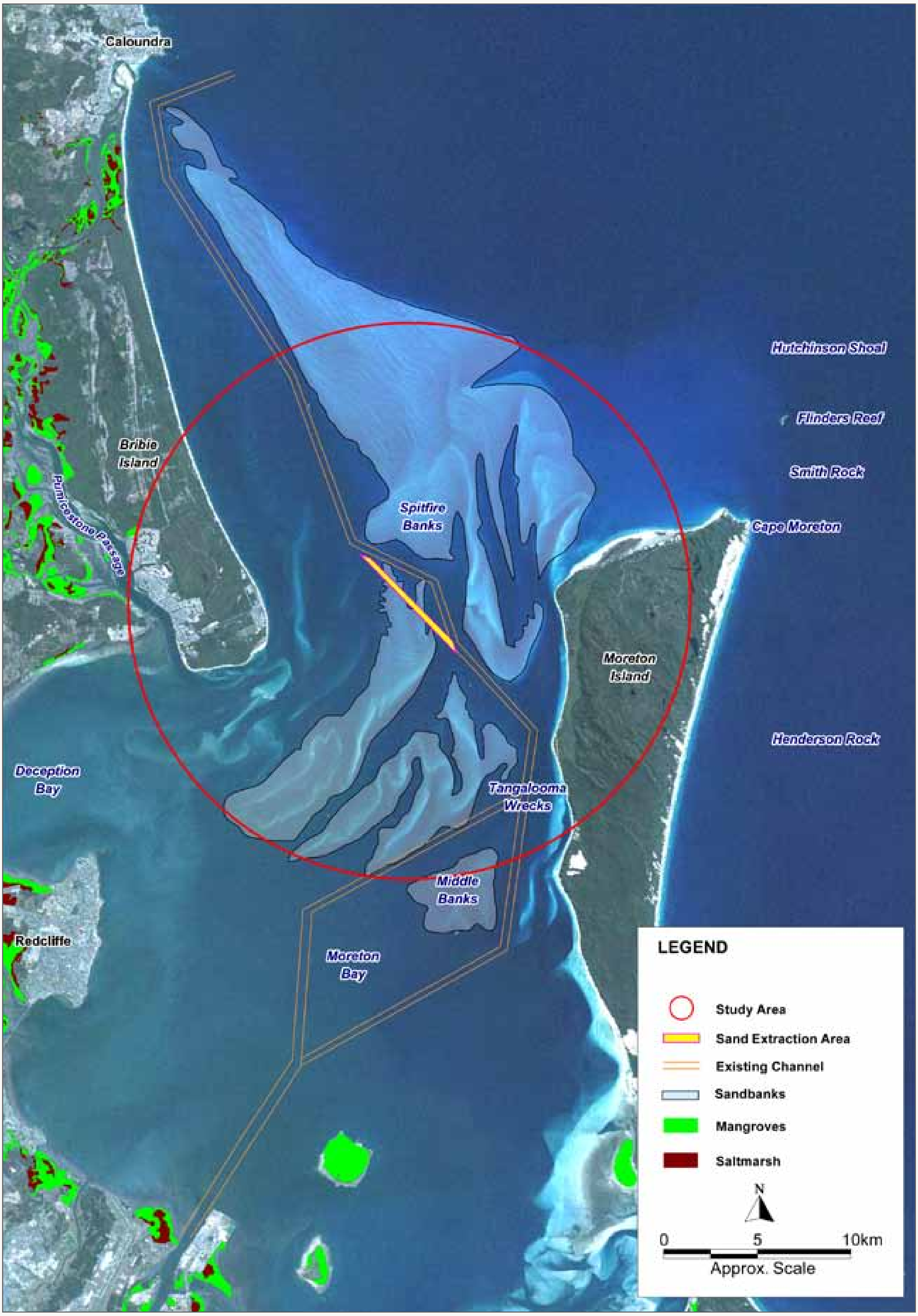


Figure 4.2h: Proximity of mangrove and saltmarsh vegetation communities to the study area (courtesy QLD Herbarium Regional Ecosystem mapping)



4.2.7 Invertebrates – epifauna and infauna

Epifauna include the animals living on or moving across the sediment surface, while infauna are the animals living within or burrowing through the surface layers of the sediment profile. All fauna referred to in this section are invertebrates within the size class known as macrofauna, which are those that would be retained on a 0.5 mm sediment sieve (i.e. larger than 0.5 mm).

4.2.7.1 Epifauna

The field surveys conducted for this EIS revealed that visually conspicuous epibenthic communities were sparse over much of the sand extraction area and immediate surrounds, although occasional patches of higher density assemblages were present in places. The highest fauna count was 1,006 individuals per transect (with a typical transect length of approximately 200 m), while three transects did not contain any individuals (**Figure 4.2i**). The highest counts of individuals were the result of large aggregations of small heart urchins (*Echinocardium cordatum*). Excluding one transect containing approximately 1,000 heart urchins, the average number of epibenthic animals was 13.9 individuals per transect.

Visible epibenthic fauna consisted of sea pens (*Pennatulacea*), stinging hydroids (*Hydrozoa*), sea anemones (*Cerianthidae*), sponges (*Porifera*), “lace corals” (*Bryozoa*), echinoderms, polychaetes, crustaceans, molluscs, and ascidians. Some of the more common and conspicuous taxa observed are shown in **Figure 4.2j**.

A total of 25 white rope ascidians (*Eudistoma elongatum*, **Figure 4.2j [A]**) were observed.

These were up to 50 cm in length, and were the largest non-motile taxon observed. A total of 35 cerianthid anemones (**Figure 4.2j [C]**), were observed, but these were present in only two of the 29 transects. Eight small black feather stars (Crinoidea, **Figure 4.2j [E]**) were seen from 5 transects. Stinging hydroids (c.f. *Sertularella* sp.) were observed in eight transects and were only observed once per transect. Most other taxa were recorded more than once on transects.

Although large epifauna were reasonably uncommon on video transects, grab samples frequently contained several heart urchins. The small size and burrowing nature of these animals means that they, and other small burrowers, were under-represented by video assessments. Despite underestimating small burrowing fauna, it was clear that epibenthic communities were very sparse, with the densest communities consisting of occasional pieces of rubble colonised by macroalgae, bryozoans, and sponges. No hard coral was observed in any of the video transects.

These results are consistent with past observations of epifauna in northern Moreton Bay. Davie and Hooper (1998) describe the clean sands of northern Moreton Bay as extremely species poor, in comparison to those elsewhere in Moreton Bay (i.e. at locations with a greater proportion of sedimentary fines and/or extensive seagrass meadows). Studies at similar sand banks at Western Banks (BAC 2007) likewise found epifauna communities to be relatively depauperate, and that the fauna present had a highly patchy distribution whereby the most abundant fauna species were present in isolated aggregations. These community characteristics are a response to the dynamic nature of the habitat, where the sand bed is actively mobile, continually changing under the influence of strong currents, ocean swell and waves (see Chapter C3 – Coastal Processes).

4.2.7.2 Infauna

The substrate of the sand extraction area and the immediately adjacent areas is predominantly an unconsolidated sandy environment, and provides the most extensive habitat within the vicinity of the dredging works that is likely to support a permanent resident fauna population (i.e. benthic invertebrate fauna). Detailed benthic fauna investigations were undertaken in 2003 (WBM 2004) at Spitfire Banks and other sand bank areas in northern Moreton Bay as part of the Moreton Bay Sand Extraction Study (MBSES). Key findings relevant to the Project are summarised below.

Community composition

At Spitfire Banks, benthic polychaetes, crustaceans, echinoderms and molluscs were all well-represented on all transects (**Figure 4.2k**). Polychaetes and crustaceans were the most abundant taxa, each representing approximately 33 per cent of total numbers. Molluscs were the most diverse group but each species had a low abundance. Haustoriid amphipods and deposit feeding worms from the family Spionidae numerically dominated the shallow substratums on most transect, although heart urchins dominate this substratum on one transect. No taxa or functional group consistently dominated deeper substrata (i.e. considerable variation between transects). However, on individual transects, deeper substrata were typically characterised by one or more of the following: heart urchins (Spatangoida), spionid worms (*Prionospio* spp. or *Spiophanes*), capitellid worms, or amphipods from the family Urothoidae.

Depth and related spatial patterns in benthic fauna

Benthic invertebrates are typically more diverse and occur in greater numbers at deeper water depths (i.e. to 20 m*)* (**Figures 4.2k and 4.2l**), possibly due to the relative stability of the substrate at deeper depths. Therefore a permanent change in depth at Spitfire Realignment Channel (as a result of capital and maintenance dredging) would likely result in changes in the numbers and dominance patterns of various species.

Patterns in recolonisation of macroinvertebrates

As the majority of macroinvertebrates live in the top 30 cm of the sediment profile, dredging can result in temporary defaunation of sediments. Experiments based on various dredging simulations found that recolonisation occurred, to a degree, at all sites within one week of dredging. Most taxa could be characterised as opportunistic and capable of colonising newly disturbed areas, a distinct advantage in sandy bank areas subject to strong currents and wave action. The dredging simulations did not result in major shifts in community structure: while abundances of all taxa declined immediately after dredging, a consistent subset of species remained numerically dominant.

Figure 4.2i: Total fauna density at survey transects (transect end points shown)

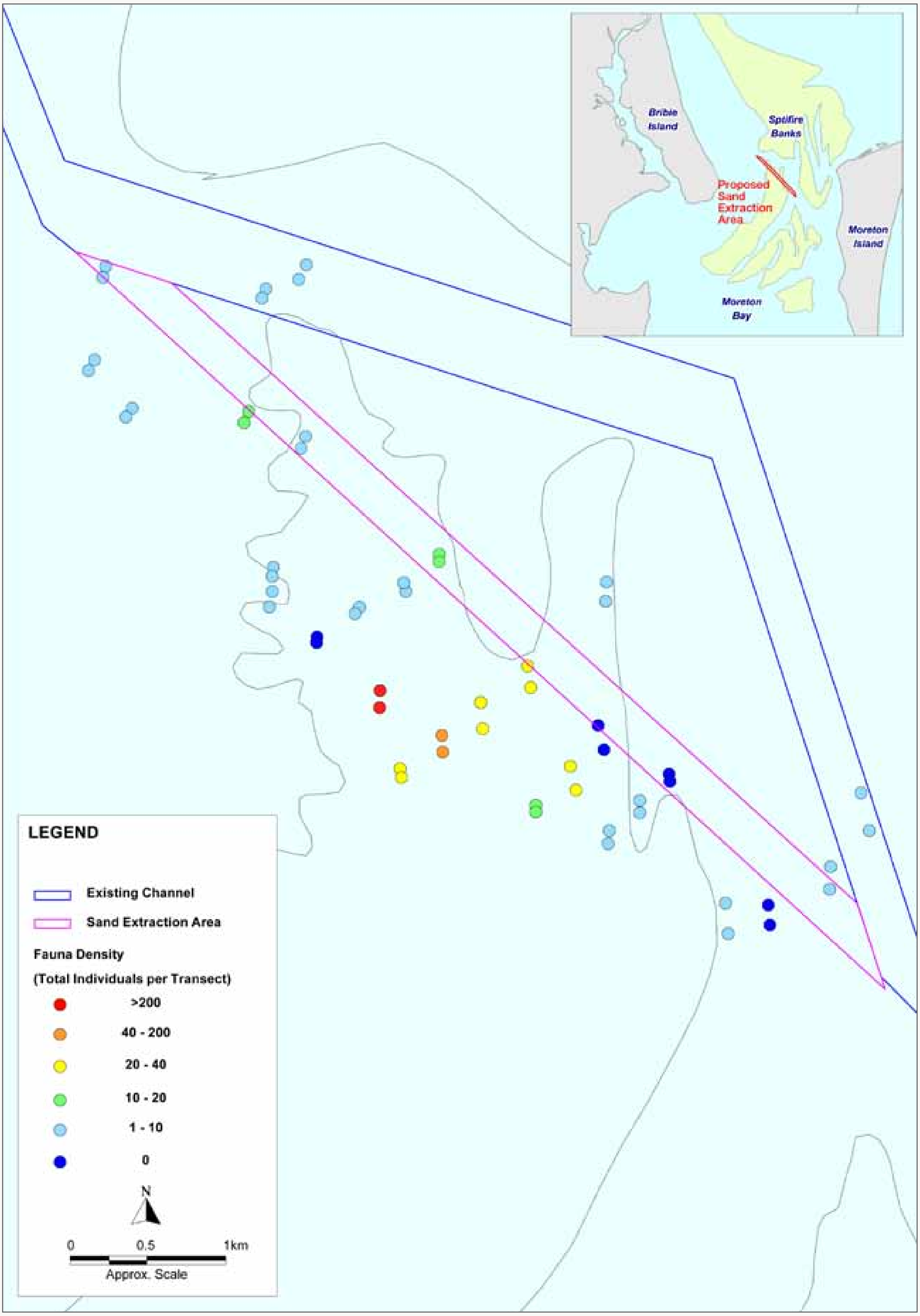


Figure 4.2j: White rope ascidians (Eudistoma elongatum) (A); heart urchin Echinocardium cordatum (B); small cerianthid anemone (C); red algae Hypnea spinella (D); benthic micro-algae and a black crinoid (E); sea star Luidia maculata (F); sparse Halophila ovalis over fine to medium sand (G) dense H. ovalis over sand, shell grit and rubble (H)

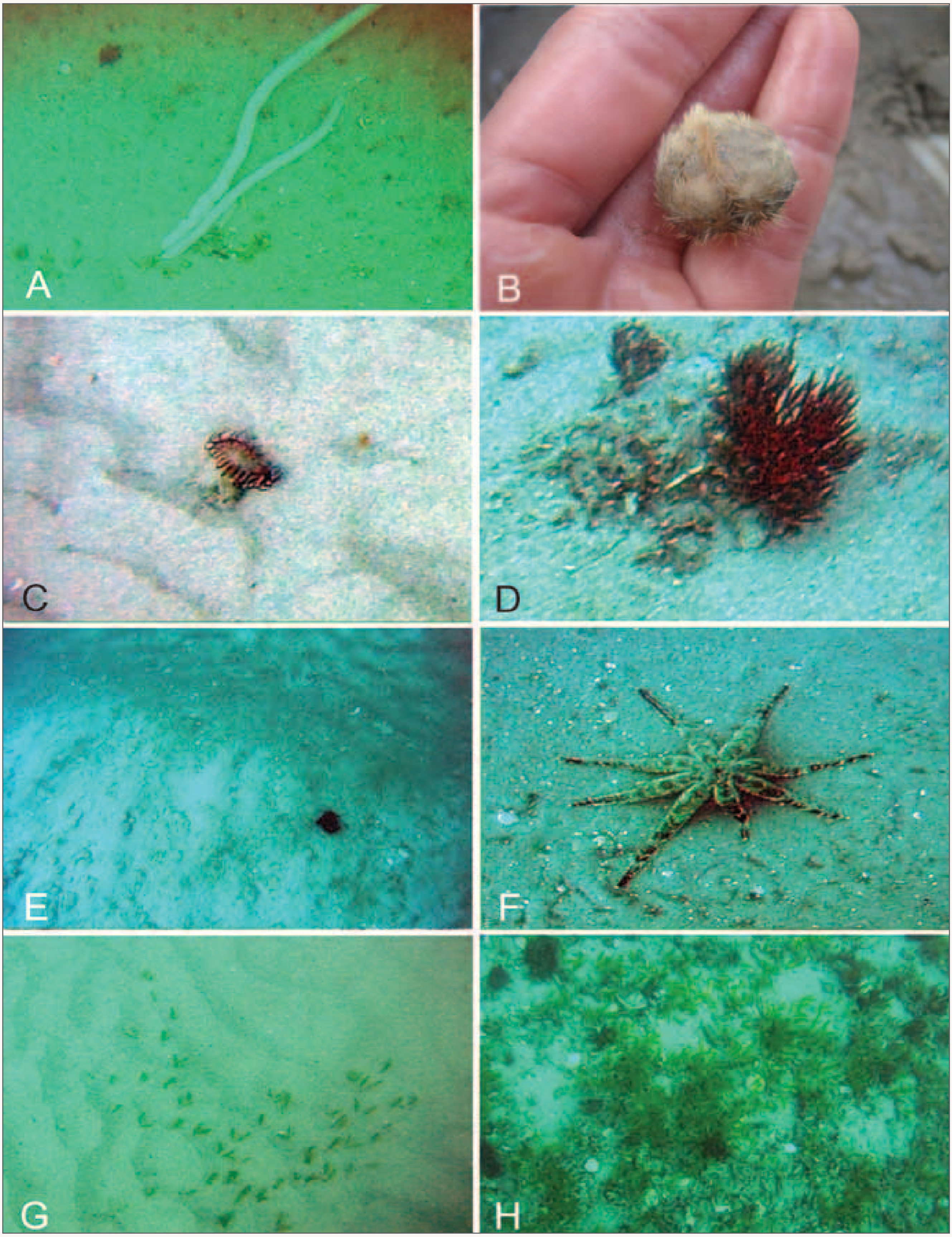


Figure 4.2k: Example of depth related patterns at four transects (A1, B1, C1, D1) for the abundance of broad benthic fauna taxa groups at Spitfire Channel

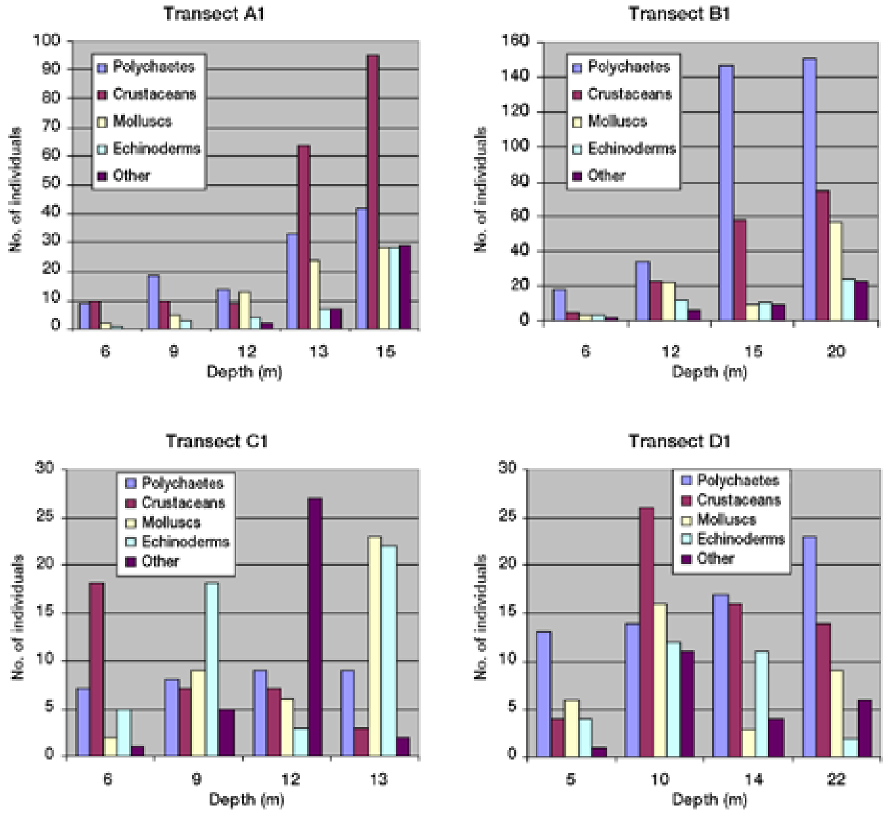
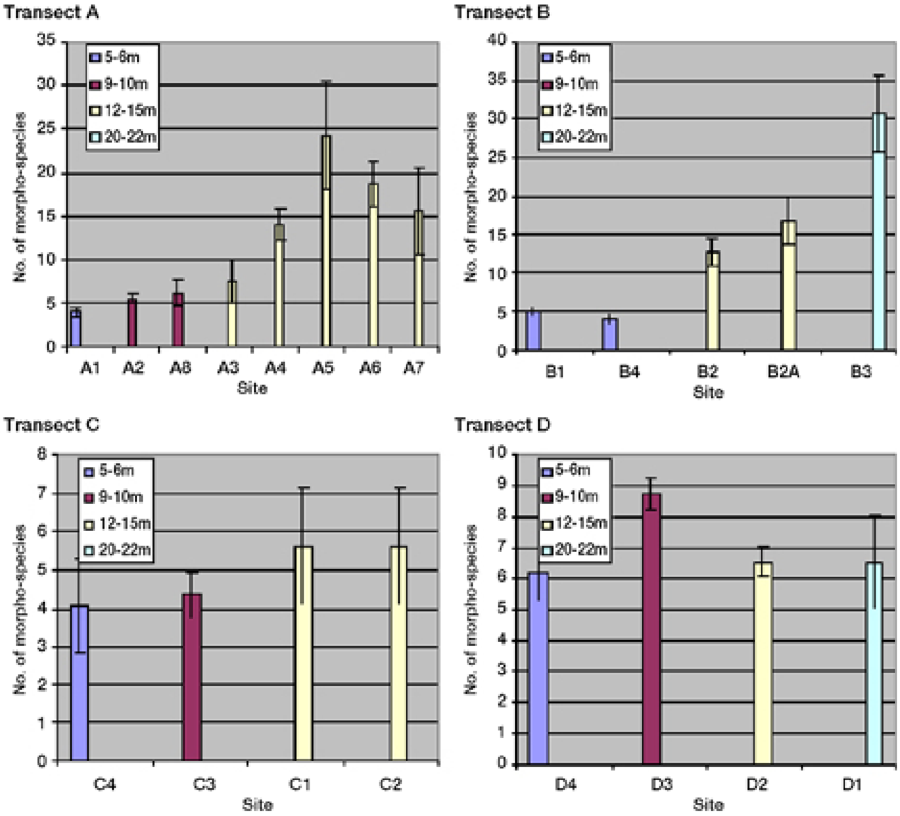


Figure 4.2l: Example of depth related patterns at two transects (A and B) for benthic fauna abundance (top) and richness (bottom) at Spitfire Channel

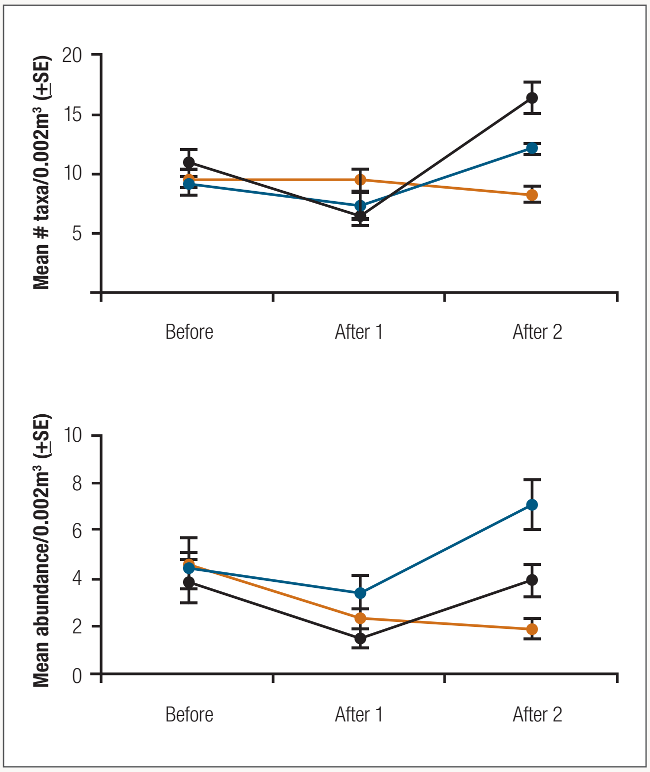


Subsequent colonisation peaks (abundance and richness increases, which in this study were observed to exceed baseline estimates) coincided with seasonal recruitment periods and, in WBM (2004), occurred approximately three months after the disturbance (**Figure 4.2m**).

In the context of the dredging works proposed for the Project, and their implications for benthic fauna, it should be noted that some dredging has previously been undertaken at the proposed sand extraction area by the Port of Brisbane (BMT WBM 2008). Also, the surface layers of sand banks within the northern tidal delta are highly dynamic as they experience strong currents and are exposed to ocean swells and, potentially, bay-generated waves (refer Chapter C3 – Coastal Processes and Water Quality). Despite this dynamic environment, the sandy substrate provides habitat for a range of benthic fauna such as heart urchins, crustaceans and molluscs, as well as isolated patches of very sparse seagrass and macroalgae. Some of the fauna are in turn prey species of fish and are therefore important for environmental and commercial reasons. While largely ephemeral, the patches of seagrass and macroalgae likely support a complimentary suite of invertebrate fauna, and provide an alternative habitat for transiting fish.

The MBSES (WBM 2004) found that benthic fauna communities in these active environments are in a constant state of flux, most likely in response to the natural physical disturbance and a range of biological processes (i.e. recruitment, migration, predation, competition, etc.).

Figure 4.2m: Example of (simulated) post-dredging benthic fauna recovery at Spitfire Banks; shown is mean number of taxa (top) and mean total abundance (bottom), time 'After 2' was approximately three months after the disturbance



Furthermore, benthic fauna species in these dynamic environments have adaptations that allow rapid exploitation and colonisation of disturbed areas, and therefore communities have a high degree of resilience to disturbance.

4.2.8 Listed and threatened marine fauna

The sand extraction area is not known to provide important resting, feeding or breeding areas, migratory pathways, or otherwise important areas for marine fauna species of conservation significance. However, numerous marine species of conservation significance are known or likely to occur in the broader study area. These include species of marine fish, mammals, reptiles and sea birds, as described below.

4.2.8.1 Marine fish

Six marine fish of conservation significance have been identified for the study area (**Table 4.2c**), of which five are listed threatened species. Both the green sawfish (*Pristis zijsron)* and black rock cod (*Epinephelus daemelii)* have highly restricted distributions, to northern Queensland and New South Wales respectively, and are unlikely to occur in the study area. The three threatened species most likely to occur are the great white shark (*Carcharodon carcharias)*, whale shark (*Rhincodon typus)* and grey nurse shark (*Carcharias taurus)*.

The whale shark (Vulnerable, EPBC Act) is a highly migratory species that tends to prefer offshore tropical and sub-tropical waters. This species is known to form seasonal feeding aggregations in the Coral Sea between November and December, although Ningaloo Reef is thought to present the only critical habitat in Australian waters (DSEWPAC 2012). There are occasional records of this species along Queensland's inshore coasts, although it is thought to represent a transient visitor. Whale sharks filter feed on nekton and plankton and its seasonal movements are thought to coincide with plankton blooms and changes in water temperature. Moreton Bay is not a known congregation site and any individuals transiting the wider area are considered more likely to pass to the east of Moreton Island than inside the bay itself.

Great white sharks (Vulnerable, EPBC Act) tend to occur from inshore rocky reefs and surf beaches to offshore oceanic waters (DSEWPAC 2012b), and sightings exist for open waters off the eastern coasts of Moreton and North Stradbroke Islands. It is possible that individuals may intermittently transit through the northern Moreton Bay area, however it is not known to represent a critical habitat or aggregation area for this species.

Grey nurse sharks are listed as Critically Endangered under the EPBC Act and Endangered under the NC Act. Most of the east coast population spends much of its time in New South Wales, in Queensland waters they are not known to number more than 30 individuals at any given time (Bennett and Bansemer 2004). Locations known as 'aggregation sites' are thought to be the most critical habitat for this species. All aggregation sites are rocky reefs, typically with caves, gutters or overhangs, and for Queensland include sites

Table 4.2c: Listed threatened and migratory marine fish potentially occurring in study area

Scientific name	Common name	Status		Local occurrence
		EPBC Act	**NC Act**	
Rhincodon typus	whale shark	Vulnerable, Migratory	Least concern	May occur in oceanic pelagic waters as transient visitor; sighted as far south as the Gold Coast
Pristis zijsron	green sawfish, narrowsnout sawfish	Vulnerable	Least concern	Unlikely, tropical species with historic distribution to southern QLD and northern NSW estuaries. Present-day distribution thought to be only as far south as Cairns
Carcharias taurus	grey nurse shark	Critically endangered	Endangered	East coast population concentrated in southern QLD and throughout NSW; known aggregation sites critical, favours rocky reefs with gutter, overhangs and caves
Carcharodon carcharias	great white shark	Vulnerable, Migratory	Least concern	May occur oceanic pelagic waters as transient visitor; sighted occasion off eastern North Stradbroke Island and Moreton island
Lamna nasus	porbeagle, mackerel shark	Migratory	Least concern	Species or species habitat may occur within area
Epinephelus daemelii	black rockcod	Vulnerable	Least concern	Primarily in NSW; may occur in southern QLD but records are rare

at Rainbow Beach, and off the eastern coasts of Moreton and North Stradbroke Islands. The nearest of these sites is approximately 20 km west of the sand extraction area.

The EPBC Act Protected Matters database also lists 30 sygnathid species (i.e. seahorses, pipehorses and pipefish) that are protected as Listed Marine species (i.e. non-threatened). Sygnathids are primarily associated with seagrass meadows and reef habitats, therefore the sand extraction area and immediate surrounds is unlikely to represent an important habitat for these species.

4.2.8.2 Marine mammals

There are nine threatened and/or migratory marine mammals that may occur within the study area (**Table 4.2d**). Threatened species are the key concern from a conservation perspective, and include three whales listed as Endangered or Vulnerable under the EPBC Act (blue whale (*Balaenoptera musculus)*, southern right whale (*Eubalaena australis)* and humpback whale (*Megaptera novaeangliae)*), as well as an additional two species listed as threatened or near threatened under the NC Act (dugong (*Dugong dugon)*, Indo-Pacific humpback dolphin (*Sousa chinensis)*). Each of these threatened species is discussed in further detail below in the context of the study area. Other EPBC Act listed mammals (i.e. listed marine species that are not threatened or migratory) that may occur in the area include minke whale (*Balaenoptera acutorostrata)*, short-beaked common dolphin (*Delphinus delphis)*, spotted dolphin (*Stenella attenuata)*, spotted bottlenose dolphin (*Tursiops aduncus)*, and bottlenose dolphin (*Tursiops truncatus)*.

Blue whale and southern right whale (both Endangered, EPBC Act) are considered to be transient visitors to the coastal waters of southern Queensland. Although blue whales are not known to utilise Queensland waters for ecologically important activities, they may transit oceanic areas while migrating to tropical breeding areas (Curtis and Dennis 2012).

Southern right whales generally occur offshore, but come in to shallow coastal waters to calve in winter. On the Queensland coast, small numbers have been observed inshore as far north as Hervey Bay (Curtis and Dennis 2012). When present in the broader region, it is unlikely either species ventures west of Moreton Island towards the sand extraction area, particularly given the shallower water depths.

The threatened (or near-threatened) marine mammals most likely to occur are the humpback whale, Indo-Pacific humpback dolphin and dugong. Humpback whales (Vulnerable under EPBC and NC Acts) are the most common species of whale in the region. Humpback whales visit the Moreton Bay Marine Park every winter and spring when migrating to and from their Antarctic feeding grounds. While they have a tendency to remain in oceanic waters on the eastern side of Moreton and Stradbroke Islands, occasionally individuals will enter Moreton Bay via the northern entrance (BMT WBM 2007) particularly if resting with a calf on their southern migration (late winter – early spring). The sand extraction area is not known to represent a key area for whales.

The near-threatened Indo-Pacific humpback dolphin is a tropical to sub-tropical species that extends as far south as the Queensland/New South Wales border, primarily inhabiting shallow coastal waters and estuaries. In South East Queensland known localities, and likely areas of highest

Table 4.2d: Listed threatened and migratory marine mammals potentially occurring in study area

Scientific name	Common name	Status		Local occurrence
		EPBC Act	NC Act	
Balaenoptera musculus	blue whale	Endangered Migratory, Other (marine)	Least concern	Unlikely, transient in offshore waters
Eubalaena australis	southern right whale	Endangered, Migratory, Other (marine)	Least concern	Generally offshore, though may calve in shallower coastal waters during winter
Megaptera novaeangliae	humpback whale	Vulnerable, Migratory, Other (marine)	Vulnerable	Common whale during winter-spring migrations
Balaenoptera edeni	Bryde's whale	Migratory, Other (marine)	Least concern	Species may occur in marine waters
Dugong dugon	dugong	Migratory, Other (marine)	Vulnerable	Common, most southern population, dense seagrass beds provide critical foraging habitat
Lagenrhynchus obscurus	dusky dolphin	Migratory, Other (marine)	Least concern	Species may occur in marine waters
Orcaella brevirostris	Irrawaddy dolphin	Migratory, Other (marine)	Least concern	Species may occur in marine waters
Orcinus orca	killer whale	Migratory, Other (marine)	Least concern	Species may occur in offshore marine waters
Sousa chinensis	Indo-Pacific humpback dolphin	Migratory, Other (marine)	Near threatened	Common, significant population in Moreton Bay and Brisbane River

numbers, occur in Moreton Bay and the Brisbane River, as well as at Tin Can Bay and Great Sandy Straight to the north (DSEWPAC 2013). It is therefore highly likely that this species regularly occurs in the study area. Hale et al. (1998) estimated there to be approximately 100 Indo-Pacific humpback dolphins in Moreton Bay (compared with 500 common bottlenose dolphins (*Tursiops truncatus*), although there were few sightings in northern Moreton Bay.

Moreton Bay supports the southernmost resident dugong (Vulnerable, NC Act) population on the east coast of Australia, estimated to comprise 600 – 800 individuals. Dugongs are most commonly associated with marine or estuarine areas that contain extensive seagrass beds, particularly Moreton Banks and Amity Banks. This is because in Moreton Bay they feed almost exclusively on seagrass, especially *Halophila ovalis*, supplementing this to a degree with macroinvertebrates such as ascidians (DNPRSR 2012). Due to the scarcity/absence of dense or extensive quality seagrass in northern Moreton Bay, dugongs are not abundant in this area. The closest important dugong feeding area to the sand extraction area is Moreton Banks, approximately 30 km to the south.

4.2.8.3 Marine reptiles

Six species of marine turtle are known to use Moreton Bay as a feeding ground, five of which are resident year round. All are considered threatened under both the EPBC Act and NC Act as listed in **Table 4.2e**. Moreton Bay is not an important turtle breeding area, with most turtles in the Bay believed to have originated from rookeries on the central and north Queensland coast and Islands, although turtle nesting is known to occur on the open beaches of eastern Moreton Island and Bribie Island (**Figure 4.2n**). The distribution and abundance of turtles within Moreton Bay is greatly influenced by the availability of suitable food resources.

The most abundant turtle species in Moreton Bay, the green turtle, feeds directly on seagrasses and algae, and highest abundances are centred on the important seagrass foraging areas at Moreton Banks (Limpus et al. 1994). Due to the scarcity/absence of high quality seagrass in northern Moreton Bay, green turtles are not abundant in this area. The closest important green turtle feeding area to the sand extraction area occurs at Moreton Banks, approximately 30 km to the south. Moreton Bay is an important feeding area for loggerhead turtles, which feed on molluscs, crustaceans, echinoderms, and jellyfish from seagrass and reef areas (Curtis and Dennis 2012; DSEWPAC 2012b). Sponges represent a large proportion of the diet of hawksbill turtles, although they also feed on seagrasses, algae, soft corals and shellfish. Other turtle species are uncommon in Moreton Bay.

Figure 4.2n: Location of known turtle nesting beaches

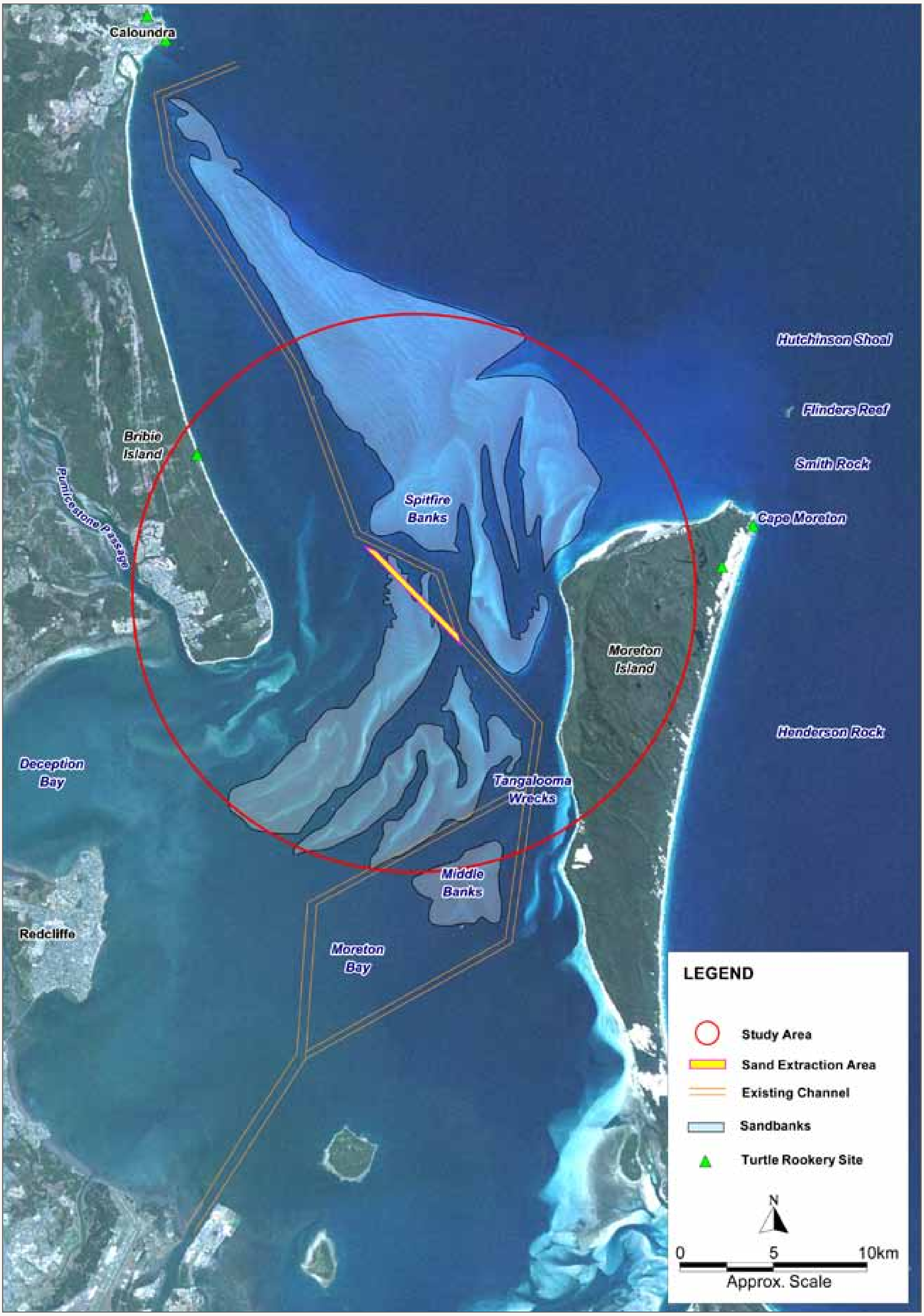


Table 4.2e: Listed threatened and migratory marine reptiles potentially occurring in study area

Scientific name	Common name	Status		Local occurrence
		EPBC Act	**NC Act**	
Caretta caretta	loggerhead turtle	Endangered, Migratory, Other (marine)	Endangered	Common in Moreton Bay and surrounding marine waters
Chelonia mydas	green turtle	Vulnerable, Migratory, Other (marine)	Vulnerable	Significant population in Moreton Bay, dense seagrass beds are an important food source, located approximately 20 km to the south of Spitfire Channel dredge area
Dermochelys coriacea	leathery turtle, leatherback turtle	Endangered, Migratory, Other (marine)	Endangered	Known to occur in Moreton Bay, though uncommon
Eretmochelys imbricata	hawksbill turtle	Vulnerable, Migratory, Other (marine)	Least concern	Reasonably common in Moreton Bay
Lepidochelys olivacea	olive Ridley turtle	Endangered, Migratory, Other (marine)	Endangered	Known to occur in Moreton Bay, though uncommon
Natator depressus	flatback turtle	Vulnerable, Migratory, Other (marine)	Vulnerable	Known to occur in Moreton Bay, though uncommon

It is likely that marine turtles that exist near the sand extraction area would be transient rather than resident, primarily due to the lack of optimal or perennial feeding resources in this exposed area. It is possible that the sparse seagrass assemblages may be used sporadically or occasionally by some marine turtles. Loggerhead turtles may also feed on jellyfish that occur in the vicinity of the sand extraction area.

The EPBC Act Protected Maters database also lists six species of sea snakes, which are protected as Listed Marine species (i.e. non-threatened).

4.2.8.4 Sea birds

Most avifauna species of conservation significance are addressed elsewhere in this EIS (Chapter B8 – Terrestrial Fauna). This section applies only to sea birds, or marine birds, which in this EIS is defined as ‘bird species that spend the majority of their life at sea’ and includes species of albatross, petrels and shearwaters.

An estimated eight species of sea bird, which are listed as threatened and/or migratory species under the EPBC Act, may occur in the study area. These species are listed, along with their respective conservation status, in **Table 4.2f.** Three are also listed as threated species under the NC Act. Note that both the southern giant petrel (*Macronectes giganteus)* and the Tristan albatross (*Diomedea exulans exulans)* are assigned a higher conservation status, being listed as Endangered under both the EPBC Act and NC Act.

The albatross and petrel species are primarily Southern Ocean species, but may visit Queensland waters in small numbers as rare visitors or vagrants in winter and spring (Curtis and Dennis 2012). As such, while the study area and surrounding waters do not represent a significant habitat for these species, it is possible that they may transit the area or, on a rare occasion, use the coastal waters to rest or forage. The shearwater species are not threatened, but are listed migratory species that transit the coastal waters of South East Queensland during their annual migration.

4.2.9 Fisheries values

While the potential impacts of the Project on commercial and recreational fisheries is addressed elsewhere in this EIS (Chapter C6 – Other Considerations), evaluation of fisheries data can be a useful tool from an ecological perspective. When combined with other information sources, it can indicate marine locations and/or species that are of high environmental value, but have not been identified by other methods elsewhere in the assessment.

A summary of the available information for commercial and recreational fisheries is provided below.

Commercial

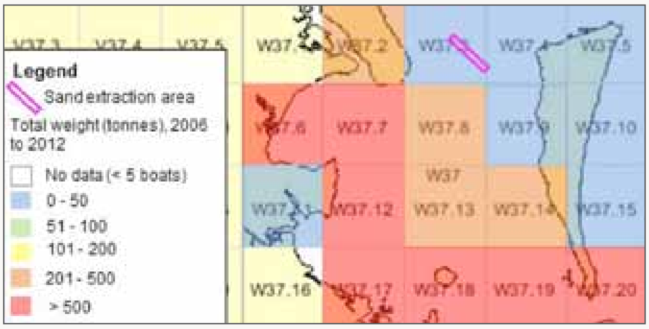
The northern Moreton Bay area contains important commercial fishing areas. The main commercial fishing activities are net fishing, trawling (targeting prawns) and crabbing using pots. Spanner crabs are commercially harvested from northern Moreton Bay and east of Moreton Island (WBM 2004). Blue swimmer crabs are commercially harvested from the northern Moreton Banks area, with areas west of the Moreton Bay Marine Park zone MNPO3 targeted (refer **Table 4.2a** and **Figure 4.2a**) (DERM 2007; WBM 2004). Trawling is typically undertaken in areas with a flat topography and few snags, such as the Moreton Bay central mud basin (BMT WBM 2007).

Table 4.2f: Listed threatened and migratory sea birds potentially occurring in study area

Scientific name	Common name	Status		Local occurrence
		EPBC Act	NC Act	
Diomedea exulans exulans	Tristan albatross	Endangered, Migratory, Other (marine)	**Endangered**	Rare, potential vagrants in small numbers
Fregetta grallaria grallaria	white-bellied storm-petrel	Vulnerable	Least concern	Rare, potential vagrants in small numbers
Macronectes halli	northern giant-petrel	Vulnerable, Migratory, Other (marine)	**Vulnerable**	Rare, potential vagrants in small numbers
Macronectes giganteus	southern giant-petrel	**Endangered**, Migratory, Other (marine)	**Endangered**	Rare, potential vagrants in small numbers
Pterodroma neglecta neglecta	Kermadec petrel	Vulnerable	Least concern	Rare, potential vagrants in small numbers
Thalassarche melanophris impavida	Campbell albatross	**Vulnerable**, Migratory, Other (marine)	Least concern	Rare, potential vagrants in small numbers
Thalassarche cauta	shy albatross	**Vulnerable**, Migratory, Other (marine)	Least concern	Rare, potential vagrants in small numbers
Calonectris leucomelas	streaked shearwater	Migratory, Other (marine)	Least concern	Annual migration along coast

Total commercial catch data was available for sites within the W37 grid over the years from 2006 to 2012, including the net, trawl, pot and line fisheries. These data are presented in **Figure 4.2o**, with the approximate location of the sand extraction area shown as a small pink rectangle at sites W37.3 and W37.4. Data from sites with less than 5 boats operating are not disclosed due to confidentiality concerns. Therefore, it should be noted that commercial catch from other sites and fisheries (especially those with less than 5 licences operating) are higher than reported here. Despite this, these data show some relative differences among sites within the W37 grid in terms of commercial catch. The sand extraction area is located in sites that contributed a small proportion of the total catch for grid W37 over this period (i.e. sites W37.3 and W37.4 each contributing less than 50 tonnes, primarily consisting of mullet). By comparison, much higher catches were recorded in the central (more southern) and western parts of Moreton Bay. Site W37.12, and sites W37.18 to 20, had the highest overall catches, with each recording in excess of 700 tonnes from 2006 to 2012 (**Figure 4.2o**).

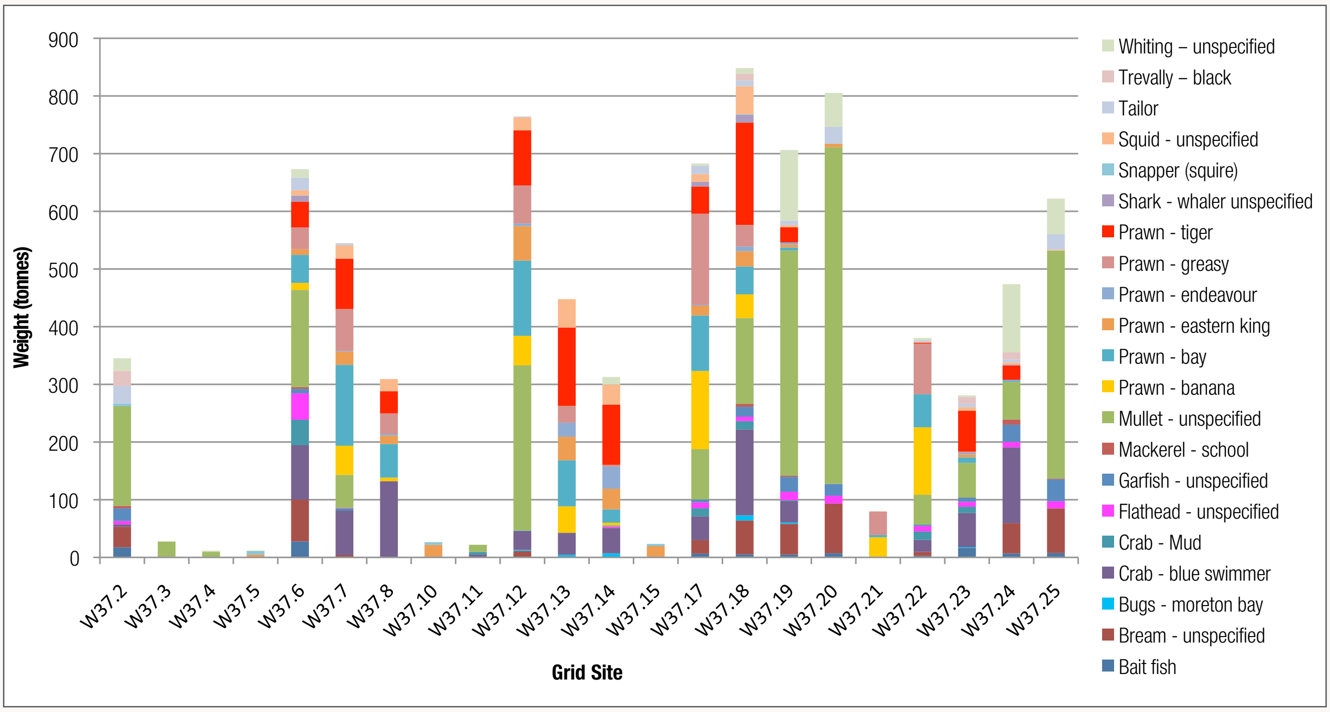
Figure 4.2o: Total commercial catch (tonnes) reported for sites in grid W37 between 2006 and 2012 (source: DAFF 2013)



For grid W37, between 2001 and 2005, total catches at the Moreton Bay grid sites were dominated by mullet, prawns (bay, tiger, greasy, banana, eastern king) blue swimmer crabs, bream, whiting and squid. Tailor, garfish, flathead, mud crab and bait fish made minor contributions to total commercial catch in grid W37, along with a range of other species (**Figure 4.2p**).

The ten highest overall contributors to total commercial catch for grid W37 between 2006 and 2012 are shown in **Table 4.2g**. Mullet, blue swimmer crabs, bay prawns and tiger prawns each contributed over 1,000 tonnes during this period, closely followed by greasy prawns and banana prawns. Mullet contributed the highest catch per unit effort by far, averaging 281 kg per day over this period. Bream produced the next highest catch per unit effort at 74 kg per day.

Figure 4.2p: Contributions to total commercial catch at sites within grid W37 between 2006 and 2012 (source: DAFF 2013)



Recreational

Recreational fishing activity typically focuses at least 7 km from the sand extraction area. To the east, the deep channel adjacent to the western coast of Moreton Island attracts predatory fish, while shallows support flathead and whiting, and Curtin Artificial Reef draws parrotfish, cod, sweetlip, snapper, bream and pelagic species. To the west, tailor, whiting, flathead and school mackerel are targeted off the southern point of Bribie Island (Australian Fish Finder 2012, Hooked in Paradise 2007). Nevertheless, recreational fishing does still occur within or adjacent to the sand extraction area, where channels, channel markers and/or navigation aids can support Spanish mackerel, northern bluefin tuna, cobia and trevally. The 'north-west 12' turning beacon, in particular, is close to the sand extraction area, however fishing intensity in this area is comparably low close to the main shipping channel due to necessity of frequently interrupting fishing to accommodate passing ships. Further afield, recreational fishing efforts also tend to concentrate at Pumicestone Passage, Scarborough Reefs, Tangalooma Wrecks and the eastern beaches of Bribie Island.

Table 4.2g: Top ten species contributing to total commercial catch between 2006 and 2012 in grid W37, and associated total licences, days fished and catch per unit effort (CPUE)

Common Name	Total Tonnes	Total Licences	Total Days Fished	CPUE (Kg/day)
Mullet – unspecified	3,628.9	482	12,896	281
Crab – blue swimmer	1,636.7	907	56,498	29
Prawn – bay	1,237.6	448	20,440	61
Prawn – tiger	1,198.3	470	29,222	41
Prawn – greasy	924.8	356	13,062	71
Prawn – banana	829.3	477	20,449	41
Bream – unspecified	611.2	436	8,313	74
Whiting – unspecified	576.5	402	8,495	68
Prawn – eastern king	431.7	444	14,581	30
Squid – unspecified	370.6	557	21,283	17

4.3
DESCRIPTION OF SIGNIFICANCE CRITERIA

A risk-based approach was adopted for assessing impacts to marine ecology values. This is based on the identification of potential impacting processes and characterising the significance and likelihood of environmental effects. This risk-assessment process is detailed in full in Chapter A9 – Environmental Impact Assessment Process. While the terminology used here for the levels of impact significance and likelihood are consistent with that used elsewhere in the EIS, for the purposes of this impact assessment these categories have distinct definitions specific to marine ecology. Discipline-specific definitions used in the marine ecology impact assessment are provided below in **Tables 4.3a to 4.3c** for:

- **Impact Significance**, which takes into account the overall degree of environmental effects in terms of intensity, geographic extent, anticipated duration and sensitivity of environmental receptors. Impact significance categories also take into account the legislative status of relevant matters of conservations concern, such as protected areas and threatened or migratory species.
- **Duration of Impacts**, which are incorporated into the impact significance.
- **Likelihood of Impact**, which assesses the probability of the impact occurring.

A qualitative risk rating is then calculated for each impacting process, determined from a combination of the relevant significance and likelihood scores, as shown in the risk matrix below (**Table 4.3d**).

Table 4.3a: Impact significance criteria used for marine ecology assessment

Impact Significance	Description of Significance
Very High	This impact is considered critical to the decision making process as it would represent a major change to the ecological character of the marine environment of the study area. This level of impact would be indicated by: • Complete loss of any habitat type presently supported by the study area; or • Substantial effects on ecosystem structure or function, such that many species become locally extinct; or • Major regional-scale changes to the ecological character of Moreton Bay Marine Park, Moreton Bay Ramsar site, Fish Habitat Areas; or • Major impacts to populations to commonwealth or state listed threatened species, such that their capacity to reproduce and recover is significantly affected; and • Lead to impacts that are irreversible or otherwise long term (i.e. greater than decades).
High	The impact is considered important to the decision making process as it would cause a detectable change to the values that underpin the ecological character of the study area. A high level of impact would be indicated by : • Measurable impacts to key ecosystem structure or functions, large changes in abundance of many species at spatial scales measured in 10's of kilometres; or • Mortality of a small number of individuals of internationally/ nationally threatened species, but no detectable change in population status and the capacity of populations to recover; or • Measurable loss in fisheries production at the local spatial scale, but no impacts at regional scales; and • Lead to impacts that are medium term (measured in years) or longer.
Moderate	While important at a state, regional or local scale, these impacts are not likely to be critical decision making issues. Moderate impact significance would be indicated by: • Measurable but small changes to supporting ecosystem components (e.g. habitat extent, water quality) and functions (e.g. fisheries production, fauna reproduction/recruitment) at scales measured in kilometres, but no impact at broader scales; or • Small changes in abundance of many species, or large changes in some species, at scales measured in kilometres; or • Loss of important life history functions of threatened species, or species of high fisheries or other significance, but no detectable change in their population status at a local spatial scale (i.e. capacity to recover); and • Impacts that are medium term (years) or shorter.
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. This would be indicated by: • Species of fisheries or conservation significance, or its habitat affected but no impact on local population status (e.g. stress or behavioural change to individuals); • Impacts tend to be short term or temporary and/or occur at local scale; • No effects to threatened species are expected, even at local spatial scales.
Negligible	Minimal change to the existing situation. This could include, for example, impacts at are below levels of detection, or impacts that are within the range of normal variation.

Table 4.3b: Categories used to define the duration of impacts

Relative duration of environmental effects	
Temporary	Days to months
Short term	Up to 1 year
Medium term	From 1 to 5 years
Long term	From 5 to 50 years
Permanent / irreversible	In Excess of 50 years

Table 4.3c: Categories used to define the likelihood of impacts

Likelihood of impacts (EIS categories)
Highly unlikely / Rare
Unlikely
Possible
Likely
Almost certain

Table 4.3d: Risk matrix

	Significance				
Likelihood	Negligible	Minor	Moderate	High	Very High
Highly unlikely / rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost certain	Low	Medium	High	Extreme	Extreme

4.4
ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION MEASURES

For the marine ecology values in the vicinity of the sand extraction area and surrounds, the primary impacting processes for the Project are associated with the construction phase only (i.e. dredging), and are broadly grouped into the following:

- Direct disturbance of benthic habitats and biota within the sand extraction area
- Indirect alterations to water quality and sedimentation in the vicinity of dredge plumes (i.e. increased turbidity and suspended solids)
- Direct or indirect interactions between the dredger and marine fauna, such as those relating to noise and vessel strike.

No operational impacts are anticipated as no works are proposed within the study area during the operational phase of the Project.

The above primary impacting processes have the potential to result in individual and cumulative environmental effects to marine ecology values. This section discusses potential impacts of the proposed dredging works on marine flora, fauna and their habitats. Risk ratings for each impacting process were determined based on criteria set out in **Section 4.3**.

Mitigation measures that would be incorporated into the Project to reduce the risk of impacts are also described. Note that an inherent mitigation aspect of the Project design, which is relevant to all aspects of this impact assessment, is that the chosen sand extraction area aligns with that of other past and approved existing dredge campaigns (i.e. Port of Brisbane). This reduces the need for multiple impacts elsewhere in Moreton Bay, or at alternative locations.

A summary of the results of the risk assessment and mitigation measures are provided in **Section 4.5**.

4.4.1 Direct effects of dredging

4.4.1.1 Potential Impacts

Habitats

In total, 2.01 km^2 of seabed occurs within the sand extraction area, which would be directly affected by sand extraction. Sand extraction from Spitfire Realignment Channel would result in the direct removal of benthic habitat and biota from within the sand extraction area. Water depth would also be increased to an anticipated -17.05 m LAT, based on the ultimate Spitfire Realignment Channel scenario. These effects would be localised, restricted to the sand extraction area.

The increase in water depth would represent a permanent change in habitat conditions as the proposed sand extraction area occurs in a shipping channel, which would be maintained by the Port of Brisbane. The following physical habitat responses are predicted:

- The greater water depth within the channel is expected to receive slightly lower light levels than at the completion of PBPL's dredging due to light attenuation with depth. This has the potential to adversely affect habitat conditions for micro-phytobenthos (benthic micro-algae) and seagrass communities within the sand extraction area
- Localised changes to bed stability on the batter slopes of the sand extraction area (see Chapter C3 – Coastal Processes and Water Quality)
- Highly localised change in the speed and direction of currents, primarily channelling local water currents at the northern and southern extents of the Spitfire Realignment Channel, where it meets other existing shipping channels. This is predicted to result in slightly increased scour at these locations, accompanied by a slight increase in sedimentation in the middle of the channel where current velocities would be expected to reduce (see Chapter C3 – Coastal Processes and Water Quality)
- Associated with the above hydrodynamic processes, a possible slight increase in the proportion of fine material in deeper, quiescent sections of the dredge area, although such materials may also be resuspended by passing ships.

Benthic fauna

As outlined in WBM (2004) and BAC (2007), recolonisation of benthic fauna to a dredged area may occur via several processes including:

- Passive recolonisation, involving the passive settlement of entrained or otherwise resuspended organisms
- Larval settlement by planktonic organisms
- Post-colonisation invasion of the dredged area by adult and juvenile fauna from neighbouring undisturbed areas.

Study results of small scale trials undertaken as part of the MBSES (as outlined in WBM 2004) indicated rates of recolonisation by organisms from larval dispersal and active colonisation in sand banks from adjacent areas are very high (in the order of hours to days). This can be attributed to the adaptation of faunal species to their highly mobile sand bank habitat. However, the size of disturbance is also a relevant factor; while recolonisation would occur in a short time frame, 'recovery' (in terms of comparable numbers of species and total individuals) of a large dredge footprint could be in the order of months and even possibly years.

It is expected that dredging of the sand extraction area would create benthic habitat conditions and communities that are similar to those found within the existing Spitfire Channel nearby and other existing navigation channels in northern Moreton Bay (see **Sections 4.2.3, 4.2.4** and **4.2.7**). Such communities are typically comprised of a suite of fauna found in adjacent undisturbed areas (WBM 1995). While most of the species currently inhabiting the sand extraction area can be expected to recolonise in time, there would likely be a shift in terms of which species are contributing the most to total fauna abundances (WBM 2004). It is also possible that benthic fauna richness and abundance may be greater post-recovery than occurs at present. For example, the MBSES found that deeper waters, which typically experience lower levels of wave energy than shallow waters, had richer and more abundant benthic fauna communities (WBM 2004).

Seagrass

Sparse patches of *Halophila ovalis* occur throughout the sand extraction area, although these deep-water seagrass assemblages do not form distinct meadows and are often ephemeral. It is considered highly unlikely that the entire sand extraction area would support contiguous seagrass meadows at any one time.

With respect to the small, sparse patches of deep water seagrass (*Halophila ovalis*) present in the sand extraction area, note that seagrass removal was previously approved for the Spitfire Realignment Channel (Port of Brisbane 2005) on the grounds of its low abundance (located at approximately 15 per cent of the sites sampled, with <5 per cent cover at individual sites; WBM 2005), ephemeral nature and marginal habitat value. The Project would involve a further deepening of the Spitfire Realignment Channel, below the current approved depth. This action is unlikely to have a further impact on local seagrass values on the basis that the dredging would result in seabed depths that are either at or beyond the light availability limits of seagrasses that occur in these environments.

Secondary effects

The risk of potential indirect flow-on effects to other marine ecology components is considered to be negligible. As the sand extraction area does not contain large or dense seagrass areas, the seagrass present is unlikely to provide an important refuge function for fish compared to the permanent dense and extensive seagrass meadows elsewhere in Moreton Bay (e.g. Moreton Banks, Amity Banks). Similarly, fish of fisheries significance in northern Moreton Bay area have flexible dietary and habitat requirements, and are unlikely to be adversely affected by dredging. The area is also not known to represent a significant feeding area for green turtles or dugongs (see **Section 4.2.8**). No reef communities or other features of high biodiversity value occur in the proposed sand extraction area.

In terms of protected areas, the sand extraction area is not within any protected areas, other than the General Use Zone of Moreton Bay Marine Park (i.e. where trawling and similar disturbances are permitted), therefore potential impacts to protected areas as a result of direct habitat removal or physical disturbance would not occur.

4.4.2.1 Mitigation measures

Habitat removal and physical habitat alteration within the sand extraction area is an inherent impact of any project that incorporates a marine dredging component. For the Project, considerable effort during the design phase of the Project went to the identification and selection of a sand extraction area that would minimise direct ecological effects to marine environmental values. This process is fully described in Chapter A3 – Options and Alternatives of this EIS. From an ecological perspective, important factors that were taken into consideration in the selection of the final sand extraction area were the:

- Limited presence and/or absence of key sensitive receptors (i.e. seagrass, reefs) in the area and likely extent of dredge plumes
- Highly mobile and dynamic nature of benthic habitats within and adjacent to the sand extraction area; thus these habitats and their inhabitant fauna are accustomed to a degree of physical sediment disturbance and therefore most likely to recover in a reasonable timeframe
- Additional relevant recommendations outlined in the MBSES (WBM 2005a,b) and the Cumulative Sand Extraction Assessment undertaken as part of this EIS (BMT WBM 2012) (e.g. minimising impacts to fisheries).

While the location and extent of physical habitat alteration and disturbance during dredging is unlikely to affect marine flora or fauna of conservation significance. Overall, these effects are considered to represent a minor impact for the construction phase of the Project, although these habitat alterations would persist over a long term duration and have high likelihood of occurrence.

4.4.2 Indirect effects due to water quality modifications

4.4.2.1 Potential impacts – plume-derived water quality alterations

As discussed in Chapter C3 – Coastal Processes and Water Quality, dredging would disturb and mobilise bed sediments, resulting in the following within the dredge plume:

- Increased suspended solids
- Sedimentation by suspended sediment (i.e. particles mobilised in the dredge plume settle on the seabed)
- Liberation of nutrients in pore waters and sediments.

Implications for marine ecology values are discussed below, with a particular focus on resultant light attenuation and sedimentation.

Reduced light levels

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

The numerical modelling supporting this assessment was based on a medium-large TSHD over a six week dredge campaign. This sized dredge is considered to have the highest plume production potential of those that could be contracted for the work. This provides a conservative assessment since it is considered most likely that a medium-sized TSHD would actually be used (i.e. lower plume production potential). Based on the modelled scenario (as discussed in Chapter C3 – Coastal Processes and Water Quality), it is expected that two to three dredge cycles would occur per day, and that plumes generated in each cycle would persist for periods measured in minutes to hours (i.e. dredge plume lasts approximately 90 minutes every eight hours). The actual locations affected by dredge plumes would vary, depending on the position of the dredger.

In the context of seagrass tolerances to low light, the following is noted:

- *Halophila ovalis*, the most common deepwater species in Moreton Bay (Udy and Levy 2002, WBM 2004, WBM 2005), is among the most sensitive species to light attenuation (Longstaff et al. 1999). This species can show signs of stress after several days of complete light attenuation and mortality within 30 days of complete attenuation (Longstaff et al. 1999).
- Some seagrass species are able to tolerate episodic pulses of high turbidity over an extended period. For example, Chaterand et al. (2012) conducted shading experiments to determine the effects of short pulses of low light (shading) conditions over 8, 12 and 16 week periods on the seagrass *Zostera mulleri*. No significant declines were observed in the shaded plots relative to controls over the 8 week measurement period. Notwithstanding this, there were significant differences between control and shaded plots which suggested that intermittent shading reduced the resilience of seagrass to major disturbances, such as flooding. No such studies have been conducted on *Halophila ovalis* to date.
- Seagrass growth and light requirements vary seasonally (Coles et al. 2004). For example, Preen (1992) examined seasonal differences in seagrass growth in Moreton Bay. Species such as *H. ovalis*, *H. spinulosa* and *Halodule uninervis* underwent a flush of seasonal growth after spring (e.g. exhibited by increases in shoot density), peaking in either aummer or autumn. Similarly, the above ground biomass for all seagrass species peaked in summer or autumn, when seagrass biomass and distribution tends to increase in response to optimal growth conditions (e.g. light availability). In contrast during the winter and spring months, seagrass biomass retracts and they presumably do not rely heavily on light availability during this time. This reflects somewhat the generalised seasons for growth and senescence of seagrass in broader Queensland (Chaterand et al. 2012), although in the tropics further north the growth season tends to coincide with the dry season (i.e. July to January). Comparatively, there is a significant lag for peak seagrass growth in subtropical Moreton Bay (i.e. summer/autumn).

Taking all of the above into account, the potential impacts of elevated TSS (and associated low light conditions) to seagrass in northern Moreton Bay are expected to vary seasonally, in response to physiological light requirements as discussed above. During winter, seagrass has lower light requirements, therefore impacts to seagrass as a result of light limitation would be expected to be less pronounced were dredging to be carried during winter. For instance, in winter there is a lower probability that plumes would adversely affect growth since it is not a peak seagrass growing season. Other effects may be observed, however, such as deterioration in the condition of existing shoots. During summer, particularly during calm weather periods, seagrasses require light for growth and reproduction, and are more sensitive to light limitation (Coles et al. 2004).

As discussed in Chapter C3 – Coastal Processes and Water Quality, modelling for both the summer and winter periods predict that the 80th percentile TSS above background level for the overall dredge campaign is expected to be less than 2.3 mg/L at all tested sites during both winter and summer periods, and that the 95th percentile TSS is expected to be less than 7.5 mg/L above background levels (refer **Figures 4.4a and 4.4b**). Note that the adopted modelling parameters are conservative and that dredge plumes are expected to be short-lived (typically 90 mins), with periods of seven hours or more between consecutive plumes. Given the combined low TSS and turbidity levels, albeit higher than the extremely low background levels, together with the short duration of individual plumes (some of which would occur at night), the comparably long periods of relief between plumes and the low occurrence of seagrass within the predicted plume extent, the predicted water quality alterations and associated reductions in light levels are expected to have a low impact on the surrounding seagrasses. Sub-lethal effects such as reduced biomass, leaf condition or shoot length are possible, and some mortality of seagrass could occur in the absence of mitigation.

In the unexpected event that seagrass mortality does occur, *Halophila ovalis* has adaptations that allow relatively rapid growth and recovery following disturbance (Duarte et al. 1997). Most notably, it can reproduce both sexually and asexually. Where some shoots or roots remain intact, vegetative growth through their rhizomes can allow significant recovery in a relatively short time frame (Coles et al. 2004). Where mortality is more extensive, recovery would be dependent on germination of seeds stored in the seed bank at that location, or on colonisation by propagules dispersed from elsewhere in Moreton Bay. The seeds are known to be able to survive in a dormant condition for at least two to three years and still remain viable (Campbell and MacKenzie 2004, Orth et al. 2006). Overall, the rate of recovery would be dependent on factors such as the location, magnitude and extent of disturbance, as well as the time of year and environmental conditions during the recovery period.

Existing channels in northern Moreton Bay are routinely dredged by the Port of Brisbane for navigation purposes. Initial capital dredging of sand banks was carried out for the Spitfire Realignment Channel in 2008. Turbidity monitoring suggested that plumes were very short lived and highly localised, reflecting the sandy nature of the dredged sediments (BMT WBM 2008). The results presented in **Section 4.2.4** show that seagrass continues to persist in the dredged footprint, in broadly the same areas and similar densities where it was recorded in 2005 prior to the 2008 dredging of Spitfire Realignment Channel by PBPL. This suggests that past dredging campaigns have not resulted in major long term effects to seagrass, consistent with the impact predictions above.

In terms of flow-on effects, it is noted that seagrass within the predicted extent of dredge plumes consists of small, isolated and sparse patches, and are unlikely to provide important areas for fauna of conservation significance and/or fisheries that are dependent on vegetated habitats. Given the above, and that major and/or long term impacts to seagrass are not expected as a result of dredging, detectable flow-on impacts to marine fauna communities are also not expected.

Sedimentation

Sedimentation resulting from the deposition of suspended solids from the dredge plume is predicted to occur for a worst-case scenario as shown in **Figure 4.4c**. Low-level sediment deposition is predicted to occur at some locations, extending considerable distances from the sand extraction area (greater than 10 km to the south), with the highest levels of sedimentation concentrated immediately adjacent to the northern and southern extents of the Spitfire Realignment Channel. At the locations of highest deposition, sediment deposition is typically estimated to reach a maximum of 2 mm per month within 13 km of the sand extraction area, although approximately 5 mm is predicted in naturally deep areas adjacent to the sand extraction area (refer to Chapter C3 – Coastal Processes and Water Quality). This deposition depth represents sediments that are unlikely to be resuspended, and can therefore be extrapolated to provide a cumulative estimate for the duration of the dredge program. With a maximum 32 week duration (for a small TSHD), the typical 2 mm per month deposition equates to a coarse total estimate of less than 2 cm. These depths are minimal in comparison to the naturally active movement of sediment in northern Moreton Bay through the processes of sand bank evolution (refer Chapter C3 – Coastal Processes).

As discussed in Chapter C3 – Coastal Processes, the northern Moreton Bay area is a highly dynamic system that experiences significant rates of sediment transport. Most parts of Moreton Bay's northern delta sand banks experience relatively high bed shear stresses due to the combined action of waves and currents and exhibit a highly mobile surface layer, which may be centimetres to metres thick. Where there are actively moving bed forms such as ripples and dunes, the active layer may (over time) involve thicknesses of up to five metres or more. Benthic species found here must therefore have adaptations that allow them to cope with mobile sediments and sedimentation.

Figure 4.4a: 20 per cent time exceedance (80th percentile) TSS concentration summer period (note: 'EPP EV Regions' identify the management intent for waters of high ecological value – refer to Chapter C3 for further detail)

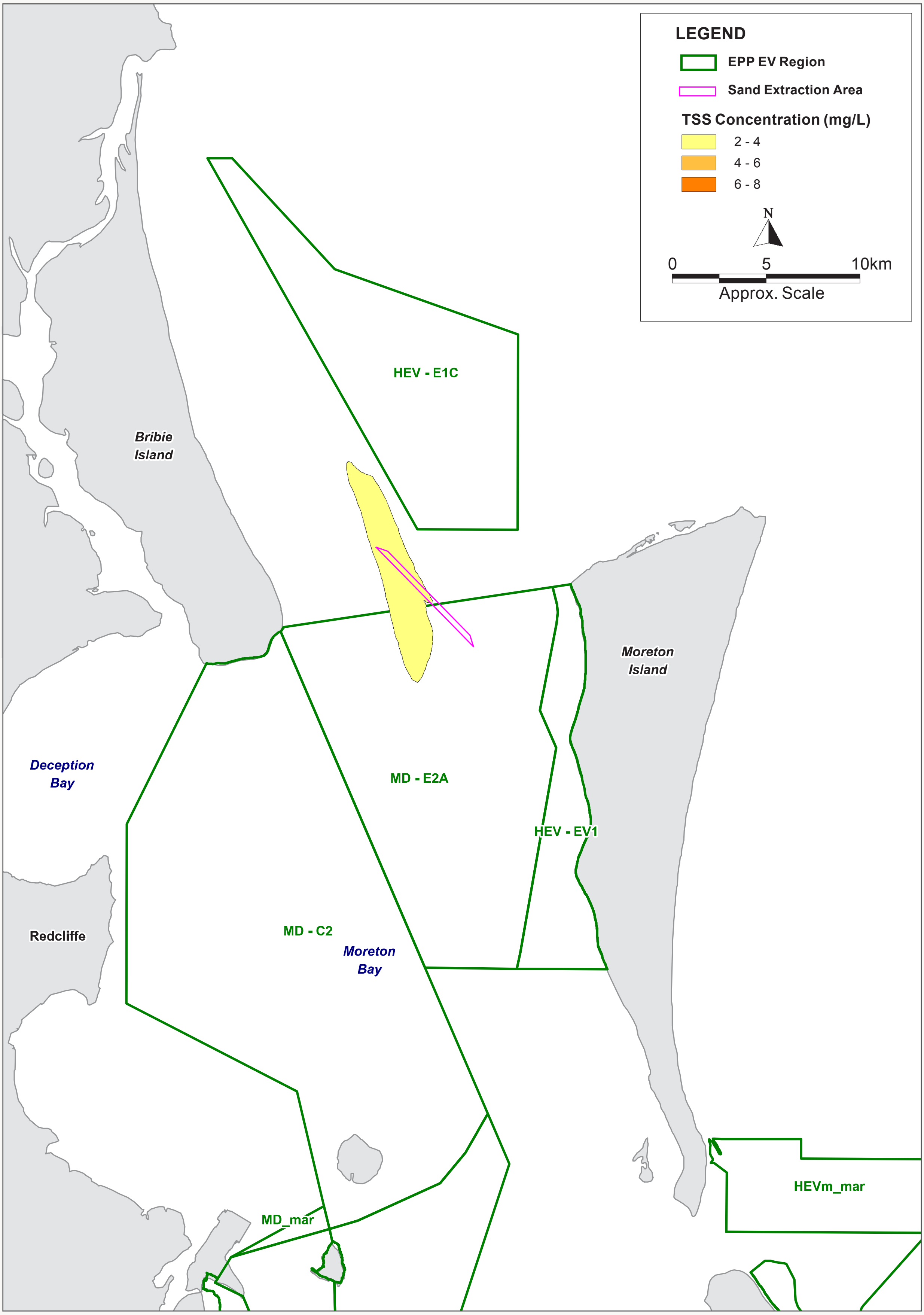


Figure 4.4b: 20 per cent time exceedance (80th percentile) TSS concentration winter period (note: 'EPP EV Regions' identify the management intent for waters of high ecological value – refer to Chapter C3 for further detail)

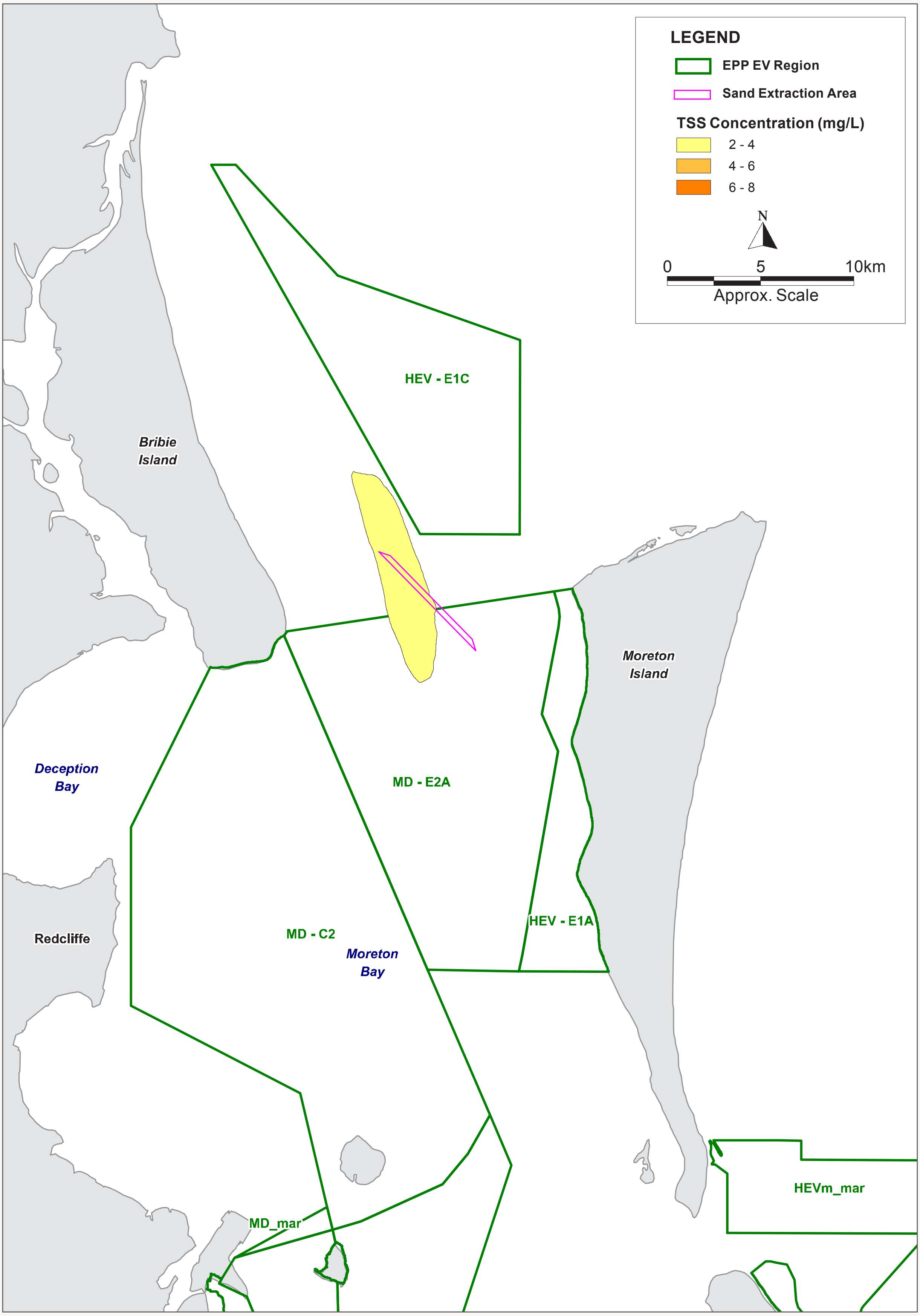
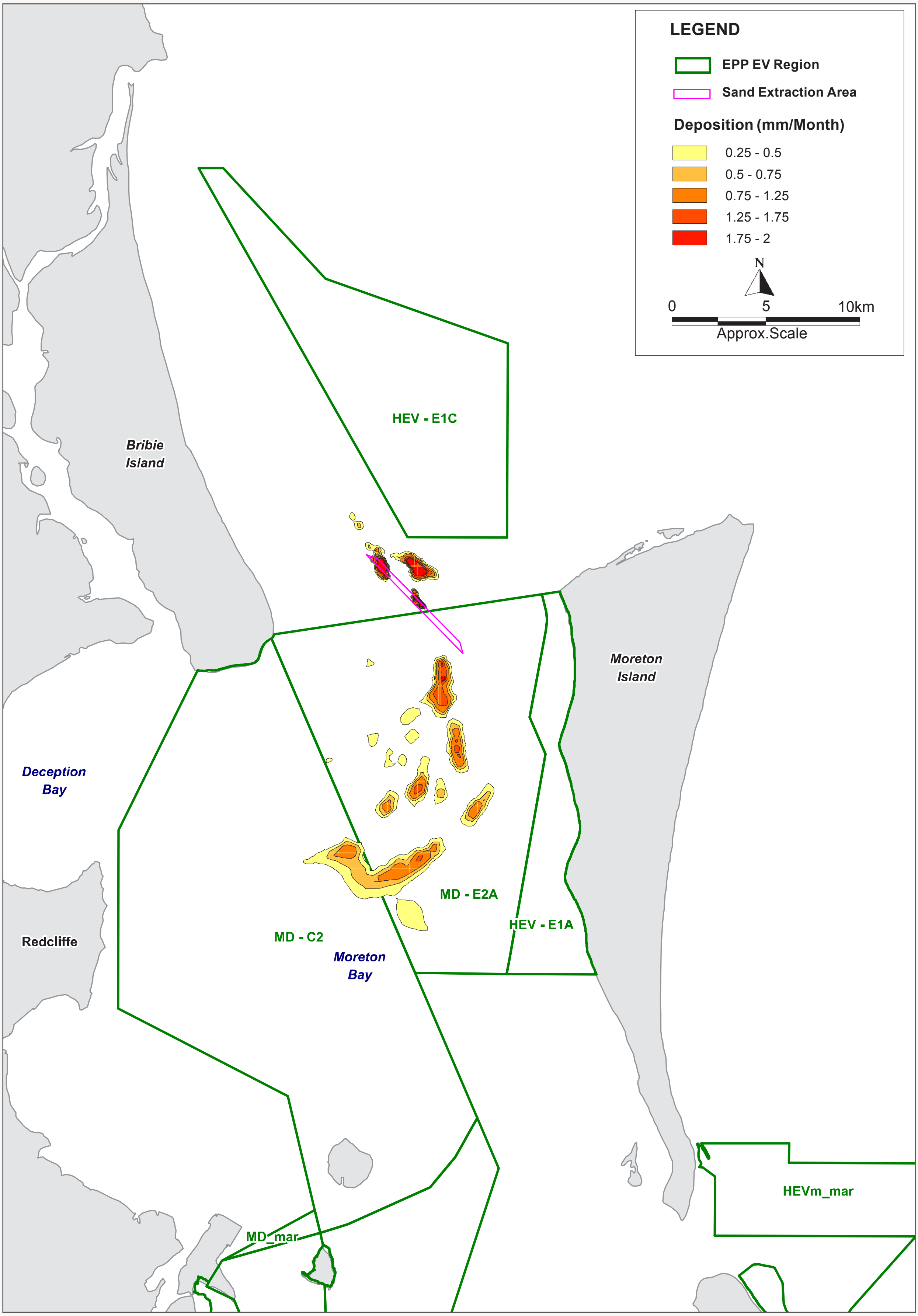


Figure 4.4c: Monthly dredge plume sediment deposition (mm/month)



Very sparse epifauna communities occur throughout the soft sediment habitats of the predicted sediment deposition zone and are partly comprised of filter feeders that entrap their prey (e.g. anemones, bryozoans, hydroids, ascidians). At sub-lethal levels of suspended sediment concentrations, some filter-feeders may benefit from the larger amount of suspended organic matter (i.e. food resources) contained within the dredged material, or released from benthic substrates disturbed by the dredger. However, it is unlikely that suspended sediment concentrations would reach levels that lead to interference or blocking of the respiratory and/or feeding structures of these animals.

If individuals of these sessile epifauna are small (i.e. less than 2.5 cm high) they could also be smothered in areas experiencing high levels of sedimentation, which could lead to stress or mortality. However, given the dynamic sedimentary environment, most epifauna (and infauna) species are mobile and capable of vertical migration through overlying sediment (Smith and Rule 2001). Based on the predicted low rate of sediment deposition over the duration of the dredge program, together with the existing communities being well-adapted to a highly mobile and dynamic sedimentary environment (noting past dredging in the sand extraction area in 2008), sedimentation is not expected to result in detectable fauna impacts.

Similar to the potential turbidity effects, seagrasses (while sparse) represent the benthic flora most likely to be affected by sedimentation, particularly as the species present, *Halophila ovalis*, is a low-growing species with leaves typically in the order of 1.5 to 4 cm high. This height limitation suggests that it can be prone to burial. However, *Halophila* species have adaptations that allow relatively rapid growth and recovery following disturbance (Duarate et al. 1997).

Based on sedimentation plots shown in Chapter C3 – Coastal Processes and Water Quality, it is expected that the highest rate of sedimentation would occur close to the northern and southern ends of the sand extraction area. Ephemeral deepwater seagrasses may be present at the time of dredging in these depositional areas. These seagrasses are predicted to experience deposition rates of up to 2 mm per month, which is considered minimal in the context of the natural sediment movement (i.e. sand bank mobility) in these areas. Nonetheless, if combined with elevated TSS levels it could result in cumulative stress to those seagrasses, particularly during winter months when seagrasses are less likely to adapt to (out-grow) sedimentation rates. Similar to reduced light levels, this stress could result in localised mortality, or a range of other community changes symptomatic of stress.

Other receptors potentially susceptible to plume-derived water quality modification

The predicted plumes and areas of water quality exceedences do not coincide with the known locations of other sensitive biotic receptors, such as corals and other reef communities. Similarly, dredge plumes resulting in detectable alterations to water quality and associated effects (e.g. light attenuation, sedimentation) are not predicted to extend to other habitat types present in the broader study area. Given the habitats and/or biota potentially directly affected by plume-derived water quality alterations are considered to be dynamic communities that are not of critical importance (e.g. as a food source) to species of high conservation or fisheries value, and that any direct effects are likely to be minor or negligible in nature, detectable flow-on effects to other fauna communities are not anticipated.

Plumes are not predicted to extend to within the bounds of Fish Habitat Areas or the Moreton Bay Ramsar site, although worst-case scenario modelling predicts that plumes may be detectable close to these areas near the eastern coast of Bribie Island (refer Chapter C3 – Coastal Processes). Any such occurrences are not expected to result in major impacts to fisheries habitat values supported by the Fish Habitat Area, or to the ecological character of the Ramsar site.

The primary issue of potential plume impacts is that dredge plumes resulting in detectable alterations to water quality and associated effects are predicted to extend from time to time over part of a Marine National Park (Green) Zone immediately north of the sand extraction area, namely the south-western corner of MNP03 (refer **Table 4.2a**, **Figure 4.2a** and Chapter C3 – Coastal Processes and Water Quality).

In general, the habitat and biological values of this Green Zone are considered to be very similar, if not almost identical, to those discussed throughout these sections for the broader northern Moreton Bay area. The primary difference being that the habitats in this managed Green Zone would be expected to be in a slightly better condition (i.e. less modified state) due to the exclusion of potentially adverse activities. This being said, given the dynamic, and potentially robust nature of the rest of northern Moreton Bay's soft sediment habitats, those differences may not be as great as what could be expected of habitats that are slower to recover.

Overall, the potential plume-derived impacts to the Green Zone is expected to consist of localised, low-level to negligible impacts to epibiota and infauna, within the vicinity of the predicted plumes. In most cases, it is expected that such impacts would not be detectable, or in the instance of ephemeral deepwater seagrasses for example, consist of localised, temporary changes to characteristics such as biomass reductions.

Flow-on effects to fauna of conservation or fisheries significance are not expected in green zone MNP03 to the north of the sand extraction area (refer **Figure 4.2a**).

4.4.2.2 Potential impacts – vessel or mechanically-derived spills

It is possible that chemical spills would occur on, or from the dredger, creating the potential for dredge-derived potential contaminants to be introduced to the marine environment. These could include, for example, hydrocarbons or other potential toxicants stored on board. Spills could occur either in the vicinity of the sand extraction area, or while the vessel is in transit between the sand extraction area and the pump-out site (note that similar impacts at the pump-out site, on the Sunshine Coast, are addressed in Volume B of this EIS). In the event that a spill occurs, it presents a toxicity risk to marine flora and fauna. The significance of such an impact is highly variable, depending on factors such as:

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

Spills of this nature are considered to be unlikely, and no more likely than typical for other large vessels using the surrounding shipping channel at any given point in time. Given their localised extent or potentially undetectable effects in the event that they do occur, they are considered to represent a low level of impact. Implementation of the mitigation measures listed below will further reduce the likelihood of such occurrences to highly unlikely.

Mitigation measures

Strategies that will be used to reduce water quality effects are listed below for:

Dredging

- A Dredge Management Plan has been developed for the Project (see Chapter E4 – Dredge Management Plan), which will be implemented throughout the duration of the works. A key component of this plan is a water quality monitoring program that will enable reactive and adaptive management of dredging operations to minimise water quality effects and, thus, effects to marine flora and fauna.

Even with the implementation of the above procedures, it remains likely that detectable water quality alteration and sedimentation will occur. However, the residual risks associated with these impacts is low as biological effects are considered minor, given the limited extent and/or absence of sensitive receptors (e.g. seagrass, corals) within the predicted zone of impact.

Spills

- Hazardous material handling procedures have been developed for the Project as part of the Dredge Management Plan (see Chapter E4 – Dredge Management Plan)
- Emergency spill response procedures will be implemented if/when required
- Relevant staff would be trained to ensure they have an appropriate level of competency for executing the above spills procedures
- The dredger would be required to comply with Port of Brisbane Port Procedures and Shipping Information, which sets out requirements for activities including refuelling and management of quarantine and sewage wastes.

With the implementation of the above measures, it is considered highly unlikely that spills, if they occur, will enter the marine environment. Note that spill and emergency response procedures will be outlined as part of Chapter E4 – Dredge Management Plan.

4.4.3 Direct interactions between dredger and megafauna

4.4.3.1 Potential impacts

Direct interactions between the dredger and marine fauna may arise in Moreton Bay by way of one or more of the following mechanisms, each of which are described in further detail below:

- direct contact or obstruction of fauna passage
- emissions of artificial noise from the dredger
- entrainment of fauna at the dredge head
- emissions of artificial light during night dredging.

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

During dredging, the dredger would be slow-moving, which would provide marine fauna time to evade the approaching vessel. Further, given the number of other large vessels that pass in the nearby shipping channel (e.g. in the order of one ship per hour), together with other regular smaller vessel movements (e.g. commercial charters, recreational), the dredger would represent a small proportion of the total number of boat movements expected to occur within the channels over the duration of dredging works. Together, this suggests that the likelihood of the dredger striking or obstructing the passage of marine fauna is low.

In the event such interactions occur, they would be restricted to areas within the sand extraction area, within the Port's shipping channels, and between the sand extraction area and the pump-out site, offshore from Marcoola.

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

Specific knowledge on the relative contributions of various noise sources to ambient noise levels is extremely limited, as is information on the effects of noise on marine megafauna in an Australian context. The Brisbane Airport Parallel Runway EIS (BAC 2007) notes that the physical structure of Moreton Bay does not promote conditions for extended noise propagation.

For example, it is thought that the shallow sand banks surrounding the sand extraction area would intervene and not facilitate underwater sound propagation. In this regard, unlike deep ocean basins where noise can travel long distances and add cumulatively to background levels, the shallow confined waters of Moreton Bay do not promote such extended propagation. For this reason, noise is likely to be limited to the near-field and therefore noise levels at a particular location would not persist or cause long-term changes to ambient levels.

In general, the most likely impact of underwater noise from the dredger for marine megafauna is the temporary avoidance of the dredger and immediate surrounds. The sand extraction area is not known to be an important feeding, calving area or migratory pathway for dolphins, whales, dugongs or other threatened and/or migratory species, such as humpback whale, great white shark and grey nurse shark. However, it is possible that waters near the sand extraction area may be used as a rest area by humpback whales, or the whales may transit the area to rest in other waters nearby. Given this, impacts to these species are not expected, other than behavioural avoidance.

If present in or near the sand extraction area during dredging, turtles are likely to exhibit a different response to noise than marine mammals. Turtles often remain stationary for long periods (feeding and resting), and based on observations of turtles exhibiting negligible response close to marine piling operations, GHD (2011) suggested that it cannot be assumed that turtles would voluntarily move away from dredging. As discussed below, mitigation measures would be implemented to further reduce the risk of dredging noise effects, as well as the risk of vessel strike by the dredger.

In terms of entrainment, it is possible for the suction at the dredge head to entrain fauna, potentially resulting in fauna injury or mortality. Of the marine megafauna, turtles are the group most likely to be affected by this process. Generally, turtles are highly mobile and would tend to avoid the dredger, typically returning to the surface to breath every few minutes. However, they can remain underwater for as long as two hours without breathing when they are resting. Queensland's foremost expert on sea turtles, Dr Col Limpus, suggests that sea turtles can use navigation channels as resting or shelter areas, and that there are recorded incidences of turtles being injured by TSHD dredgers. GHD (2005), citing personal communication from Dr Limpus, suggest that the numbers of turtles captured during dredging across all Queensland Ports is decreasing, with an average of 1.7 loggerhead turtles per year being captured across all ports. Furthermore, it was suggested that current research indicates that the impact of dredging on the overall viability of turtle populations is very low compared to the numbers killed by boat strikes, trawling, fishing, ingestion of marine debris and indigenous hunting.

Given the relatively low numbers of turtles impacted by dredgers compared to other activities, and the use of effective management and operational practices to reduce the potential for turtle capture, it is not considered that the proposed dredging would have a significant impact on turtle populations in the study area. Best practice dredging techniques would be used to further reduce risks to turtles (refer **Section 4.4.3.2**).

When the dredger is operated at night, its on-board lighting system will generate light emissions to the marine environment. Marine turtles are particularly sensitive to artificial lighting as they may become disorientated during nesting and hatching (Witherington 1992). However, no turtle nesting areas exist close to the dredging in Moreton Bay and there is a low incidence of turtle nesting elsewhere in the bay. Further, in the unlikely event that light from the dredger can be detected by emerging hatchlings (e.g. on the eastern coast of Bribie Island), the offshore position of the dredger at all times does not pose a risk for guiding hatchlings landward.

Artificial light is not known to have a major effect on foraging patterns of turtles, dolphins or dugongs. Given the rare occurrence of threatened seabirds in the study area, the risk of artificial lighting affecting these fauna is considered negligible. Mitigation strategies would however be undertaken to further reduce potential impacts (refer **Section 4.4.3.2**).

Seabirds are not expected to be directly affected by other direct dredging interactions, other than behavioural avoidance of the works area. Furthermore, direct interactions with the dredger are not expected to cause adverse impacts to the food resources for marine species of conservation significance. Overall, while interactions between the dredger and marine fauna are typically unlikely (although noise-related avoidance behaviour is more likely), they are considered to represent a minor impact, noting that the fauna most likely to be affected are generally species of high conservation significance. With the implementation of the best practice mitigation methods outlined below, it is expected that the likelihood of such interactions would be significantly reduced, resulting in low to negligible residual risk.

4.4.3.2 Mitigation measures

While the sand extraction area is not known to contain large numbers of marine megafauna, management strategies would be implemented throughout the course of the proposed dredging works in Moreton Bay to minimise the risk of interactions with the dredger. These management strategies are set out in Chapter E3 – Dredge Management Plan, and would include:

- Implementation of a Fauna Management Plan
- Implementation of megafauna exclusion zones (i.e. maintaining a given buffer distance between the dredger and megafauna) and associated reactive megafauna monitoring program (e.g. regular visual inspections of sand extraction area and dredge path)
- If visual monitoring for megafauna from the dredger detects megafauna within or headed towards exclusion zones, execute strategies to avoid interactions as required (e.g. stopping work in that area if megafauna, especially whales, are within or near exclusion zones; halt dredge vessel transit if potential to encroach on observed whales or their anticipated path)
- Operational procedures to minimise the risk of capture of turtles lying on the seabed, especially utilising tickler chains on the dredge head as a fauna exclusion device to reduce fauna entrainment and prevent fauna injury and mortality
- Ensure dredge suction is ceased prior to lifting the dredge head from the seabed
- Where it does not conflict with security and safety requirements, lighting on the dredger would aim for low wattage and/or directional light fixtures.

Together, these mitigation strategies would reduce the likelihood of interactions between the dredger and marine megafauna, such that the overall residual risk of potential impacts to marine megafauna is low for all related mechanisms (i.e. vessel strike, noise, entrainment and light).

4.4.4 Other matters

The following provides commentary on other matters that are not of key importance to the primary impacting processes discussed above.

Marine pests

While marine pests, if present, could be transported from the dredger to the marine environment, the Project is not considered to pose a notable risk in terms of the potential of introducing marine pests to Moreton Bay. This is based on the following:

- The dredge vessel remaining in South East Queensland for the duration of the dredging campaign
- As part of the Dredge Management Plan, appropriate measures would be in place during construction to reduce the potential for introducing marine pests from the dredger (e.g. compliance with antifouling, hull cleaning and ballast treatment requirements)
- The dredger would be operating in the vicinity of a shipping channel that accommodates numerous international vessels every day (i.e. contributes only a small proportion of local vessel traffic)
- Moreton Bay is not currently known to support populations of marine pests of concern that could be dispersed by the dredger to waters elsewhere.

Avoidance of fish spawning periods

Numerous fish and crustacean species may utilise the study area for spawning, however, the timing of spawning varies between species. For species of local fisheries significance, there is generally a broad window of peak spawning activity over the warmer spring and summer months (i.e. October to March). However, there are numerous exceptions.

For example, blue swimmer crabs (*Portunus pelagicus*) have two spawning periods during colder months, from August to October, then again in April. Others, such as stout whiting (*Sillago robusta*) can spawn throughout the year. As such, taking into account the extended six month duration of peak spawning activity and the occurrence of spawning throughout the remainder of the year, there is no true dredging window that would avoid fish spawning periods. While it is not known for certain, the sand extraction area is not likely to represent a critical site for spawning aggregations. Given their high mobility and the abundance of similar habitat in the surrounding area, spawning fish would likely avoid the sand extraction area while dredging is being undertaken. Rather, it is assumed that they would select alternative sites in nearby areas when spawning, foraging and other habitat utilisation activities coincide with dredging.

4.5
SUMMARY AND CONCLUSIONS

A summary of the outcomes of the risk-based assessment for each primary impacting process is provided **Table 4.5a**.

All processes potentially impacting the marine ecology values of the study area are relevant to the construction phase of the Project and include the:

- Removal and physical disturbance of benthic habitat
- Dredge plumes resulting in short term light attenuation and localised sedimentation
- Dredger interactions with megafauna, including risk of vessel strike, entrainment by dredge, behavioural modification (i.e. avoidance movements) or other noise impacts (i.e. masking communication)
- Potential localised water and/or sediment contamination as a result of vessel spills (i.e. introduction of hydrocarbons to the marine environment.

All of the above processes, if they occur, have the potential to result in effects to marine flora and/or fauna inhabiting the sand extraction area and adjacent surrounds, which may be expressed by way of fauna behavioural change, changes in the structure (i.e. composition or abundance) or distribution of biotic communities, as well as (unlikely) flow-on effects to values in the wider Moreton Bay area if food sources or other habitat values, for example, are altered.

Overall, these potential impacts were considered to be a medium risk to the marine ecology values of the study area without mitigation. However, with the implementation of the recommended mitigation measures it is anticipated that this rating would reduce to a low level of risk, given the resultant likelihood of effects would be unlikely or rare. The exception would be the removal or physical alteration of benthic habitats within the sand extraction area, which is inherent to any marine dredging operation. This risk has been minimised as far as possible by selecting a site location that is considered to have the least impact in this respect. Additionally, previous studies in the area indicate that benthic communities are extremely well adapted to their dynamic habitat and should recover, to a reasonable degree, within a relatively short time frame.

No impacts are expected as a result of the longer term operation of the Project.

Table 4.5a: Impact assessment summary table

Marine ecology	Initial assessment with mitigation inherent in the Preliminary Design in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment phase)			
Primary impacting processes	**Mitigation inherent in the design**	**Significance of impact**	**Likelihood of impact**	**Risk rating**	**Additional mitigation measures proposed**	**Significance of impact**	**Likelihood of impact**	**Residual risk rating**
Construction								
Removal and physical disturbance of benthic habitat/biota in sand extraction area (loss or change in benthic habitat and/or community structure at local 'footprint' scale)	Minimisation of direct ecological effects contributed significantly to the selection of dredging site	Minor	Almost certain	Medium	Nil	Minor	Almost certain	Medium
Turbid dredge plumes resulting in short term light attenuation and localised sedimentation (reduce light to photosynthetic biota, potential burial of benthic biota and/or changes to sediment characteristics, potentially in MPA Green Zone)	As above	Minor	Likely	Medium	Where practicable, dredging timed to minimise the potential likelihood for turbid plumes to impact sensitive receptors (i.e. seagrass senescent season) Management of dredge plumes through the implementation of a reactive monitoring program	Minor	Possible	Low
Risk of vessel strike, obstructing threatened species' passage or encouraging avoidance behaviour	As above – footprint avoids areas potentially containing important habitats and movement corridors	Minor	Possible	Low	Implement megafauna management plan. Visual checks from dredge vessel and implement strategies to avoid interactions	Minor	Unlikely	Low
Noise impacts from dredge operation displacing megafauna and other mobile marine species (cross-over with avoidance behaviour above) and/or masking, or otherwise interfering with, cetacean communication	As above	Minor	Likely	Medium	Implement megafauna management plan. Visual checks from dredge vessel and implement strategies to avoid interactions (i.e. stop work if megafauna sighted within a 300 m exclusion zone)	Minor	Possible	Low
Spills from dredge affecting water quality in vicinity of dredge operation and/or transit (i.e. introduce hydrocarbon contaminants)	Nil	Most likely minor, though highly dependent on nature of spill	Unlikely	Low	Develop hazardous material handling procedures. Implement emergency response procedures. Spill response training for staff	Minor	Highly unlikely	Negligible
Dredge entrainment resulting in fauna injury or mortality (e.g. turtles)	Sand extraction area selection avoids areas potentially containing important habitats and movement corridors	Minor	Possible	Low	Implement marine megafauna plan. Utilise tickler chains on dredge head. Ensure suction ceased prior to lifting dredge head	Minor	Unlikely	Low
Operational								
Nil operational impacts								

4.6
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