# Port Hedland Outer Harbour Development

## INTERTIDAL BENTHIC PRIMARY PRODUCER HABITAT SURVEY

- Revision 0 Final
- 15 September 2009
- WV03716-MV-RP-0020

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# Executive Summary

BHP Billiton Iron Ore is currently investigating a number of port development options in the Port Hedland region, including development of an Outer Harbour. The Outer Harbour development will increase export capacity and will include dredging and the development of a new jetty/wharf structure, berths and shiploading infrastructure. The terrestrial works include the development of a rail spur and loop from the existing BHP Billiton Iron Ore rail line, the construction of stockyards at Boodarie and an infrastructure corridor to transfer the ore to the shiploading facilities, and a causeway where the conveyor will cross West Creek to Finucane Island, parallel to the existing causeway.

This report details a survey conducted in December 2007 of the intertidal benthic primary producer habitat (BPPH) and the benthic primary producers (BPP) that inhabit areas in the vicinity of the proposed development. Two Guidance Statements (EPA 2001, 2004) provide advice to Proponents on assessing proposed developments that may negatively impact upon the suite of environmental services and ecological functions supported by the BPPH. Guidance Statement No. 1 (EPA 2001) specifically covers the mangroves of the Pilbara region, including the Port Hedland area. Guidance Statement No. 29 (EPA 2004) provides guidance on marine BPPH and the associated BPP such as seagrasses, corals, and in the intertidal zone, mangroves and salt marsh plants.

The survey was undertaken at sixteen sites, during which key characteristics of the vegetation and substrate were recorded, as well as the diversity and abundance of benthic fauna. The survey was undertaken specific to the proposed Outer Harbour Development, but also supports previous intertidal BPPH investigations undertaken for BHP Billiton Iron Ore (SKM 2007, 2009a).

The information gathered during the survey was used to aid in the interpretation of aerial photographs, and to confirm the vegetation classification map of the Port Hedland Industrial Area Management Unit produced by SKM (2009b) was accurate for the study area. The intertidal areas were found to be typical of arid zone coastlines of the north-west of Australia, and were characterised by dense stands of mangroves along seaward margins of tidal channels and creeks.

Seven species of mangrove were recorded during the field survey and while two of these species are locally rare and sparsely distributed in the harbour, all species are widespread throughout northern Australia and none are listed as threatened under the *Environment Protection and Biodiversity Act 1999* (EPBC Act) or the *Wildlife Conservation Act WA 1950*. Upper intertidal areas were a mosaic of samphires and other salt marsh plants, cyanobacterial mats and large areas of bare substrate. Benthic fauna was more diverse and abundant in areas where the substrate remained wetter for prolonged periods. The existing rail/road infrastructure has altered the hydrological regime in certain areas, which in turn appears to have altered the ecology of the mangrove forest in the near vicinity.

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# 1 Introduction

## 1.1 Project Overview

BHP Billiton Iron Ore's current port operations consist of processing, stockpiling and shiploading facilities at Nelson Point and Finucane Island (referred to as the Inner Harbour), located on opposite sides of the Port Hedland Harbour. BHP Billiton Iron Ore is currently investigating a number of port development options, including development of an Outer Harbour.

The Outer Harbour Development includes dredging and the development of a new jetty/wharf structure, berths and shiploading infrastructure. The terrestrial works include the development of a rail spur and loop from the existing BHP Billiton Iron Ore rail line, the construction of stockyards at Boodarie and an infrastructure corridor to transfer the ore to the shiploading facilities (**Figure 1-1**). This report provides information on habitat in the intertidal areas of the proposed development.

The intertidal areas are typical of arid zone coastlines of the north-west of Australia, and are characterised by dense stands of mangroves along seaward margins of tidal channels and creeks. Mangrove height and density typically decreases with distance from mean water level due to increased soil salinity and decreased tidal inundation. Upper intertidal areas are a mosaic of samphires and other salt marsh plants, cyanobacterial mats and large areas of bare substrate.

## 1.2 Purpose and Relevant Standards

This report presents the field survey results of those areas of the intertidal zone in the Port Hedland area that will, or could potentially be impacted, by the proposed Outer Harbour Development. The results of the field survey were used to create a vegetation classification map, and the ecological values of the vegetation classifications are discussed.

A portion of the proposed infrastructure corridor, required to support conveyors, access roads and utilities, will be established within the intertidal zone. Detailed engineering design and optimisation is currently being undertaken incorporating economic, technical, environmental and heritage factors.

The intertidal zone in and around the Port Hedland Harbour typically supports several types of benthic primary producer habitat (BPPH). Benthic primary producers (BPP) associated with these habitats (such as mangroves, salt marshes and cyanobacterial mats) are recognised as contributing important components of ecological functions and environmental services (EPA 2001, 2004).

Two Guidance Statements (EPA 2001, 2004) provide advice on the considerations that must be addressed by any proposed development that may negatively impact upon the suite of environmental services and ecological functions supported by the BPPH. Guidance Statement

No. 1 (EPA 2001) specifically covers the mangroves of the Pilbara region, including the Port Hedland area, and defines a Port Hedland Industrial Area Management Unit (the Management Unit) which is to be used for estimations of the effects of potential negative impacts on mangroves. The area of mangroves surveyed for this study lies entirely within the Management Unit. Guidance Statement No. 29 (EPA 2004) provides guidance on marine BPPH and the BPP such as sea grasses, corals, and in the intertidal zone, mangroves and salt marsh plants.

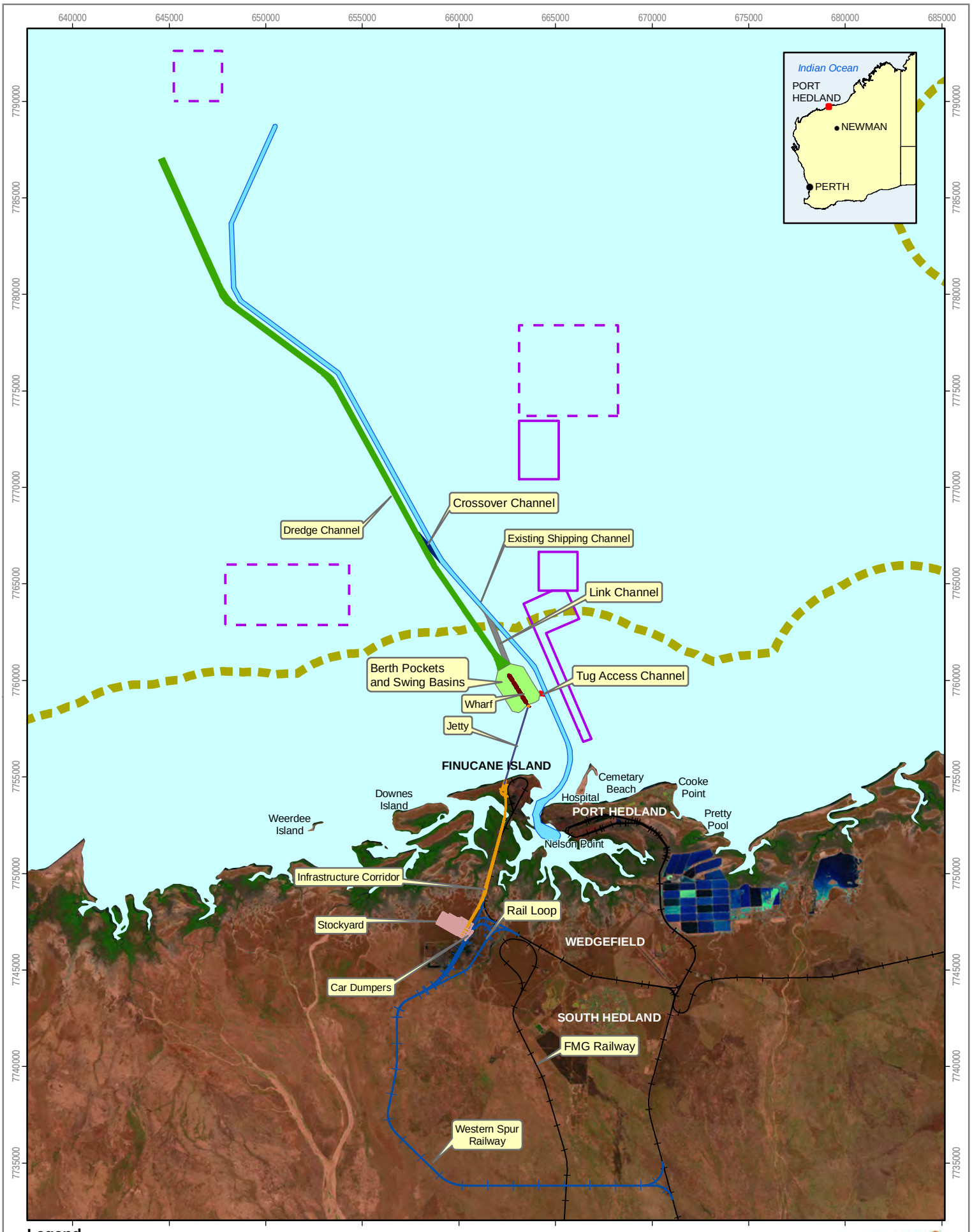
## 1.3 Study Objectives

The primary objective of this study was to conduct a field survey of BPPH and the associated BPP occurring in the intertidal zones of the study area to add to existing knowledge of mangrove habitat in the Management Unit. Particular focus was paid to areas likely to be disturbed by the proposed Outer Harbour Development construction activities, or potentially disturbed by already existing developments.

Secondary objectives were to:

- determine whether there are any locally rare species of mangroves present in, or near the area which may be impacted by the Outer Harbour Development;
- complete a comparative assessment of the 'environmental values' on scales ranging from local to regional, which encompasses as many of the ecological functions or environmental services that can be reasonably defined for each of the habitats and the associated BPP identified during the field survey; and
- provide sufficient baseline information to support the evaluation of engineering design options with respect to 'environmental' factors.

This study excludes a detailed impact assessment, which is provided in SKM (2009d).




**Legend**

- Spoil Ground (Existing)
- Spoil Ground (Proposed)
- Proposed Jetty
- Proposed Wharf
- Proposed Infrastructure Corridor
- Proposed Stockyards
- Proposed Western Spur Railway
- Existing Railways
- Proposed Departure Channel
- Proposed Berth Pockets and Swing Basins
- Proposed Link Channel
- Proposed Crossover Channel
- Existing Shipping Channel
- Proposed Tug Access Channel
- State/Commonwealth Jurisdiction Boundary

0 2.5 5
kilometres

Scale @ A4:1:250,000
Datum: GDA94
Map Grid: MGA94 Zone 50

bhpbilliton

Source:
Imagery: Landsat (2005)
Jurisdiction Boundary: AMBIS (2001)
Topography: Geoscience Australia, GEODATA Topo 250K V3

Figure 1-1 Project Overview

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# 2 Methods

Compared to other areas in the Pilbara region, the mangrove, salt marsh and tidal flats of Port Hedland are relatively well known. Many elements of the ecology, distribution and classification of these habitats have recently been described in detail through various studies undertaken by BHP Billiton Iron Ore (SKM 2007, 2009a, 2009b, 2009c). Other important references include:

- flora (Semeniuk et al. 1978; Paling et al. 2003);
- the influence of geology and geomorphology on the different intertidal habitats (Semeniuk 1993a, 1993b, 1994);
- vegetation associations (Beard 1975; Craig 1983; Semeniuk 2007; Paling et al. 2003); and
- fauna (Jones 2004).

Field surveys were undertaken to characterise the flora, fauna, and relative 'ecological values', with a focus on the areas where impacts associated with the Outer Harbour Development are likely to occur. Sixteen survey sites (**Table 2-1** and **Figure 2-1**) were selected to provide baseline information and to evaluate the data against the significant body of information already documented in previous studies, as referenced above. The field survey was conducted between 12 and 14 December 2007. The main primary producers of concern in this study (mangroves) were not considered to be strongly influenced by seasonal climatic factors.

## 2.1 Study Sites

The survey encompassed a number of sites located on Finucane Island, the upper intertidal area to the north-west of Boodarie, and on the southern bank of West Creek (either side of the existing causeway). Sites (**Figure 2-1**) were selected based on the following criteria:

- examination of literature and aerial photography to determine likely presence of locally rare flora;
- examination of aerial photography to determine the spatial distribution of vegetation associations and requirement for ground truthing of vegetation categories;
- intertidal areas likely to be affected by the project footprint (site SWCW2);
- intertidal areas that may already be affected by existing infrastructure (sites F8, F9, F10); and
- ease of access from road corridors.

Each of the study sites as shown in **Figure 2-1** were surveyed by informal line transects of varying length which were aligned parallel and perpendicular to shorelines. The alignment of transects enabled zonation patterns of BPP to be recorded and verified against those initially identified using aerial photography (as captured in 2007) and the vegetation classification system developed for the Management Unit (SKM 2009b).

## Table 2-1: Co-ordinate Locations of Survey Sites

| Area | Site Reference | Latitude | Longitude |
|---|---|---|---|
| Finucane Island | F1 | 20°18'20.000"S | 118°32'16.000"E |
| | F2 | 20°18'22.000"S | 118°32'28.200"E |
| | F3 | 20°18'9.700"S | 118°32'52.800"E |
| | F4 | 20°18'23.900"S | 118°32'19.800"E |
| | F5 | 20°18'27.300"S | 118°32'19.500"E |
| | F6 | 20°18'23.900"S | 118°32'13.300"E |
| | F7 | 20°18'7.700"S | 118°32'58.900"E |
| | F8 | 20°18'29.400"S | 118°33'27.900"E |
| | F9 | 20°18'34.900"S | 118°33'28.000"E |
| | F10 | 20°18'34.617"S | 118°33'25.961"E |
| North-west of Boodarie | B1 | 20°21'5.897"S | 118°31'0.601"E |
| South bank of West Creek | SWCW1 | 20°19'1.300"S | 118°33'22.400"E |
| | SWCW2 | 20°18'54.500"S | 118°33'18.000"E |
| | SWCW3 | 20°19.9.184"S | 118°33'18.854"E |
| | SWCE1 | 20°19.6.600"S | 118°33'23.500"E |
| | SWCE2 | 20°19'4.600"S | 118°33'28.900"E |

Datum: WGS84


Figure 2.1 - Proposed Infrastructure and Location of Intertidal Survey Sites

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The field survey documented the following information at each site:

- habitat and landform classification;
- substrate characteristics;
- flora species, composition, distribution and structure of communities;
- fauna species present;
- existing disturbance or anthropogenic influences;
- any unusual features; and
- geographic position (WGS84 datum).

## 2.2 Flora

The flora survey comprised a single field visit to 16 sites (**Figure 2-1**) to characterise the mangrove and salt marsh flora in terms of the several habitat and landform classification systems already produced for the Port Hedland area (SKM 2009b).

The survey focussed on the identification of mangrove species and habitats due to the significance of these in the context of the EPA's Guidance Statement No. 29 (EPA 2004) and Guidance Statement No. 1 on tropical arid zone mangroves of the Pilbara (EPA 2001). Field surveys recorded the species present, their height and condition, relative abundance, and any other relevant information.

Key references used for the identification of flora were Duke (2006) for mangroves, Johns (2006) for salt marshes, and Datson (2002) for samphires, supplemented with additional resources where available.

## 2.3 Fauna

There have been a significant number of studies documenting the flora of mangroves and salt marshes in the Port Hedland region, the fauna of these habitats is, by comparison, less well known.

At each of the sites surveyed for flora (**Figure 2-1**), the species and relative abundance of the large, conspicuous benthic fauna and the presence of any bioturbation (e.g. mounds, burrows, pellets) was recorded. Conspicuous benthic fauna and presence of bioturbation was not observed at all sites.

The aim was to provide a qualitative assessment of the large, conspicuous fauna that could be identified in the field by a trained observer (Dr J. Hanley) and to document which elements of this fauna were associated with each of the specific mangrove vegetation associations surveyed.

There is now a large body of literature on the ecology of fauna associated with mangroves and it is generally recognised that many species and genera present in the mangroves of north (Davie 1982,

1985; George & Jones 1982; von Hagen & Jones 1989; Hanley 1988, 1993a, 1993b, 1997; Hanley & Banks 1995; Hanley & Couriel 1992; Metcalf & Glasby 2008) and north-western (Hanley 1995; Wells 1983,1984) Australia are widely distributed throughout the Indo West Pacific region (Davie 2004; Frith et al 1976; Houbrick 1991; Reid 1986; Sasekumar 1974; Ng & Sivasothi 2001).

Earlier surveys of mangroves in the Management Unit (SKM 2007) revealed a generally low diversity of mangrove benthic invertebrate fauna when compared with areas both north and south of Port Hedland (J. Hanley pers. comm 2009).

These earlier surveys were not quantitative, but focussed on presence/absence of the large, conspicuous and generally widespread elements of the benthic invertebrate fauna associated with mangroves, including the large species of molluscs and crustaceans that are both easy to find and identify in the field (SKM 2007).

There is no single key reference that can be used for field identification of the mangrove fauna, and most field identifications require intimate knowledge of the information contained in a series of taxonomic publications on the crustacea, and mollusca. At a basic level, Jones (2004) provides a pictorial guide to the more common elements of the fauna in Pilbara mangroves, but the more detailed species list of fauna compiled by SKM (2007) and this report are based upon the taxonomic expertise of the field team that conducted the survey.

# 3 Survey Results

## 3.1 Finucane Island

Ten sites (F1 to F10) were surveyed on the southern side of Finucane Island, extending from the public recreation area on the western end (near site F6) to the BHP Billiton Iron Ore lease to the east (near site F8) (**Figure 2-1**). A small mangrove area located between the Finucane Island access road and existing rail line was included in the survey (sites F8, F9 and F10).

### 3.1.1 Site F1

The landward edge of mangroves at site F1 comprised a mixture of *Avicennia marina* and *Ceriops australis*, backed by a narrow zone of samphires (*Tecticornia halocnemoides*, *Muellerolimon salicorniaceum* and *Sporobolus virginicus*; **Plate 3-1a**). Note that *Ceriops australis* may have elsewhere been reported as *Ceriops tagal*, but Duke (2006) does not consider the latter species to occur on the Western Australian coast. *Ceriops australis* was abundant at this site and most specimens were laden with well-developed propagules (**Plate 3-1b**) with abscission collars evident, suggesting that the propagules were ready to be dropped.

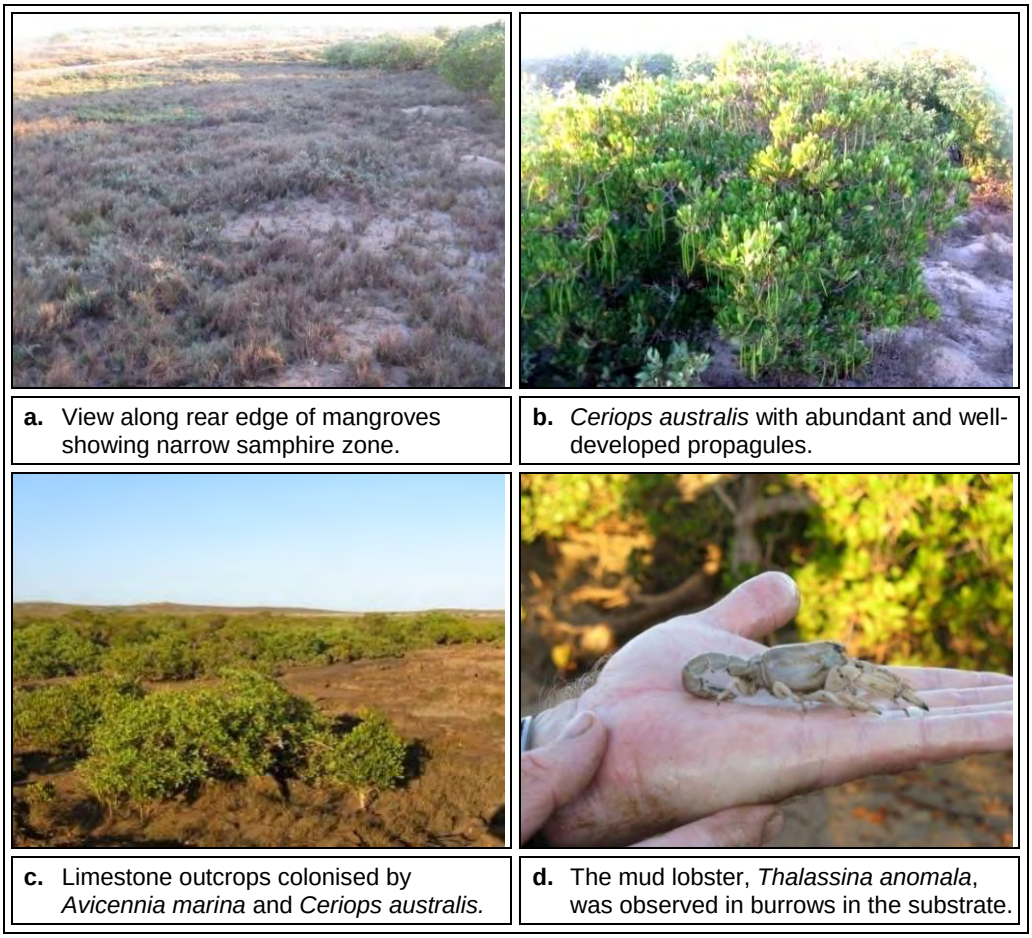
To the east edge of the mangroves are some outcrops of limestone platforms (**Plate 3-1c**). A substantial amount of debris (branches, tree trunks and leaf litter) was present in the area at the time of the survey and was potentially the remnant of tropical cyclone George, which caused widespread damage throughout the Port Hedland region in March 2007. Some large, mature and well-developed *Ceriops australis* trees were present in this area and again many were laden with propagules.

A list of the invertebrates recorded at the site is presented in **Table 3-1**, the majority of which are typical mangrove associates, including the mud lobster *Thalassina anomala* (**Plate 3-1d**). Crabs dominated the fauna in terms of diversity, and were found on the mud, under debris and in pools. Two sesarmid crab species (*Perisesarma* sp. and *Parasesarma* sp.) belong to genera that have not previously been recorded from Port Hedland, and the species differ from those recorded in mangroves further north (Hanley 1993) or listed as known from the Western Australian coast (Davie 2005).

## Table 3-1: Benthic Fauna Observed at Site F1

| Species | Abundance[1] |
|---|---|
| *Terebralia semistriata* (mud whelk) | common (mostly juveniles) |
| *Cerithidea largillierti* (mud whelk) | present |
| *Neosarmatium meinerti* (crab) | common |
| *Parasesarma* sp. (crab) | present |
| *Perisesarma* sp. (crab) | present |
| *Metapograpsus frontalis* (crab) | common |
| *Uca elegans* (crab) | present (drier margins, open areas) |
| *Uca mjobergii* (crab) | present |
| *Thalassina anomala* (mud lobster) | present |
| *Periopthalmus* sp. (mudskipper) | present |

[1] Present = 1-5 individuals recorded; common = 5-20 individuals recorded; abundant = greater than 20 individuals recorded



**a.** View along rear edge of mangroves showing narrow samphire zone.

**b.** *Ceriops australis* with abundant and well-developed propagules.

**c.** Limestone outcrops colonised by *Avicennia marina* and *Ceriops australis.*

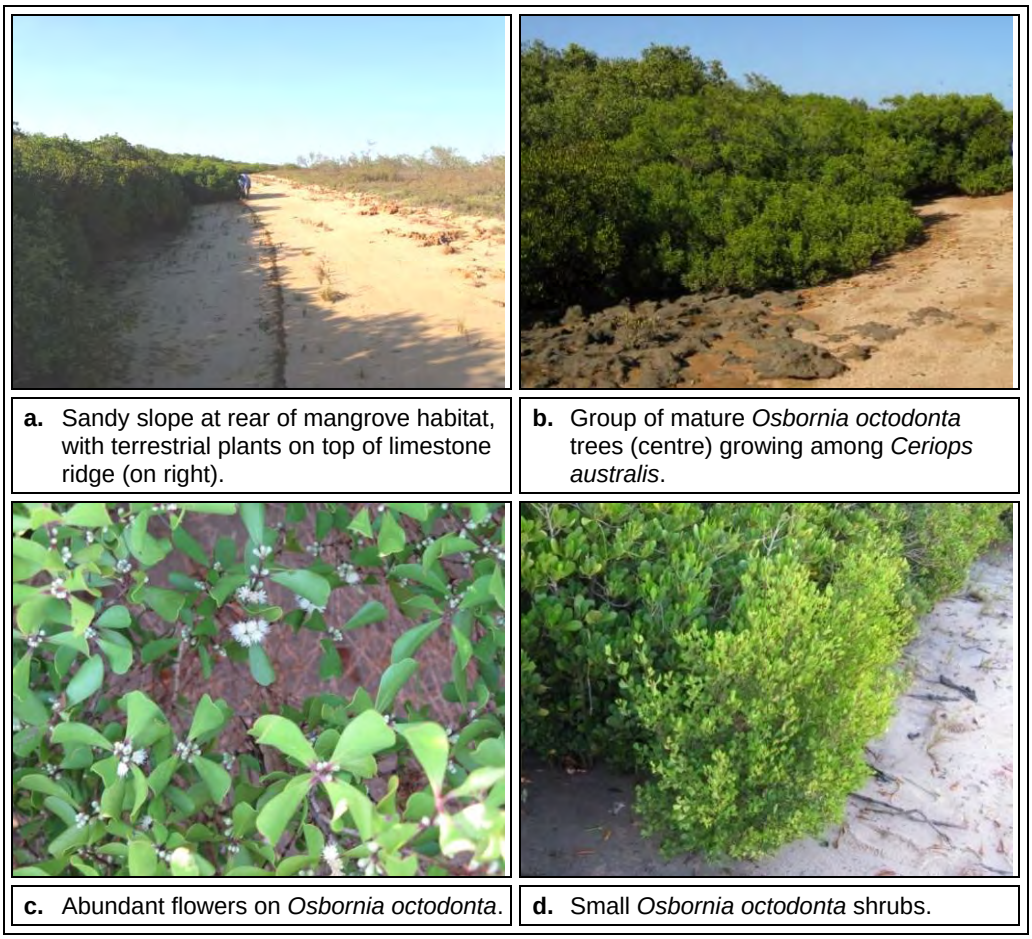
**d.** The mud lobster, *Thalassina anomala*, was observed in burrows in the substrate.

## Plate 3-1: Typical Habitat and Species at Site F1

### 3.1.2 Site F2

Site F2 was characterised by a dense band of mangroves backed by a steep sandy slope to the landward edge (**Plate 3-2a**). The salt marsh habitat that is typically found at high shore levels behind mangroves was absent at this site, presumably because the steep slope extends beyond the high tide level. The steep slope has most likely been created by the piling up of mobile sand over the top of a low-lying limestone ridge which was colonised by terrestrial vegetation (**Plate 3-2a**).

The mangrove forest at site F2 was dominated by *Ceriops australis*. A few individuals of the locally rare (J. Hanley, pers. comm. 2009) *Osbornia octodonta* were also present (**Plate 3-2b**), including one large tree in very healthy condition and covered in flowers (**Plate 3-2c**). Further east of this location were several smaller *Osbornia octodonta* shrubs (about 1 m high) (**Plate 3-2d**) and a small seedling. The *Osbornia octodonta* were growing at the base of a low sandy beach overlying limestone, which is the typical habitat for this species (Semeniuk 2007). The sparse distribution of *Osbornia octodonta* in this area is notable given the considerable area of suitable habitat and the flowers present on the large tree.



**a.** Sandy slope at rear of mangrove habitat, with terrestrial plants on top of limestone ridge (on right).

**b.** Group of mature *Osbornia octodonta* trees (centre) growing among *Ceriops australis*.

**c.** Abundant flowers on *Osbornia octodonta*.

**d.** Small *Osbornia octodonta* shrubs.

**Plate 3-2: Typical Habitat and Species at Site F2**

To the north-west of site F2, the landward edge of the *Ceriops australis* mangrove forest (**Plate 3-3a**) continued along the base of the steep sandy slope. A small *Osbornia octodonta* shrub (**Plate 3-3b**) and a few *Avicennia marina* trees were also recorded. A single *Aegiceras corniculatum* tree was recorded. This species superficially resembles *Osbornia octodonta* (**Plate 3-3c**) and the two species occupy similar habitats. The *Aegiceras corniculatum* tree was in flower (**Plate 3-3d**).

**a.** Landward edge dominated by *Ceriops australis*.

**b.** Small *Osbornia octodonta* shrub.

**c.** *Aegiceras corniculatum*, which superficially resembles *Osbornia octodonta*.

**d.** *Aegiceras corniculatum* in flower.

- **Plate 3-3: Typical Habitat and Species between Sites F2 and F3**

### 3.1.3 Site F3

Site F3 was located adjacent to the road to the western tip of Finucane Island (**Figure 2-1**). The area between the road and the mangroves lining the creek was a mosaic of *Avicennia marina* and salt marsh samphires, with some terrestrial vegetation present on low outcrops of limestone. Scattered tall, shrub-like *Avicennia marina* outliers lay close to the road causeway (**Plate 3-4a**).

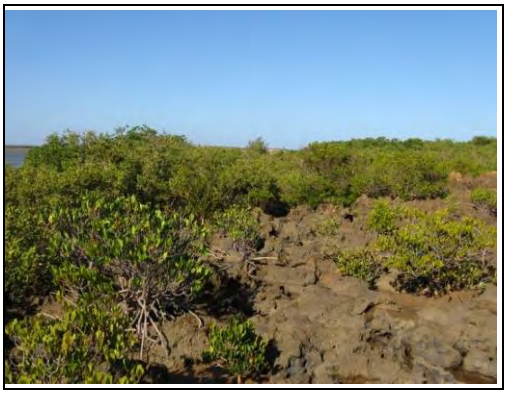
### 3.1.4 Site F4

At site F4 a shallow, broad, mangrove-lined channel breaks through the dune and leads into a small tidal pan fringed by mangroves. On both sides of the channel low *Avicennia marina* was backed by *Ceriops australis* (**Plate 3-4b**). The shallow water pools contained abundant small molluscs (probably *Cerithium* spp.) as well as fiddler crabs (*Uca* spp.), sesarmids crabs, and mudskippers (*Periopthalmus* sp.) (**Plate 3-4c**).

**a.** Samphire zone at site F3, viewed from the road looking west, with mangrove forest in distance.

**b.** Shallow, broad channel lined with mangroves at site F4. Vehicle tracks are evident.

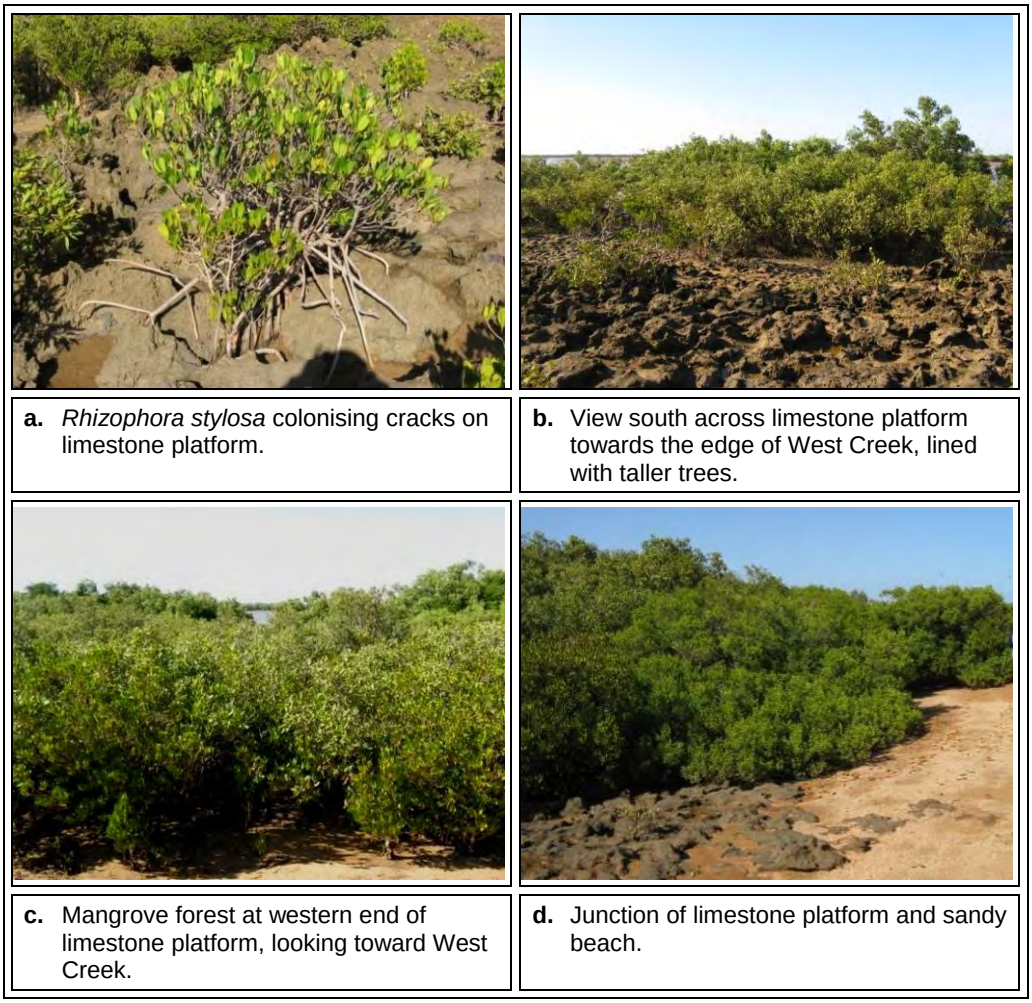
**c.** Edge of limestone platform between shallow channel and West Creek at site F4.



**d.** Limestone platform with scattered mangroves near F4

**Plate 3-4: Typical Habitat at Sites F3 and F4**

Nearby, a limestone platform acts as a barrier between the shallow channel and West Creek. The platform was colonised by *Avicennia marina*, *Rhizophora stylosa* and *Ceriops australis*, forming an open, low scrub with large bare areas of limestone between plants (**Plate 3-4c**–**d** and **Plate 3-5a–c**).



**a.** *Rhizophora stylosa* colonising cracks on limestone platform.

**b.** View south across limestone platform towards the edge of West Creek, lined with taller trees.

**c.** Mangrove forest at western end of limestone platform, looking toward West Creek.

**d.** Junction of limestone platform and sandy beach.

**Plate 3-5: Views of the Limestone Platform near F4**

Further west, the limestone platform merges with a sandy beach (**Plate 3-4d**). Cracks and crevices in the limestone platform were colonised by stunted mangroves. *Avicennia marina*, *Rhizophora stylosa*, *Ceriops australis* and *Aegialitis annulata* were observed growing intermingled with each other. A narrow fringe of tall mangroves were growing in front of the limestone platform, lining the bank of West Creek.

### 3.1.5 Site F5

At site F5, West Creek was lined with mangrove forest, typical of that found at similar shore heights through the Port Hedland Harbour region. The mangrove forest was characterised by tall, multi-stemmed *Avicennia marina* on the seaward margin with some tall *Rhizophora stylosa* trees to the landward margin intermingled among *Avicennia marina* (**Plate 3-6a-b**). Both species were at the beginning of their flowering phase at the time of the field survey. Substantial patches of

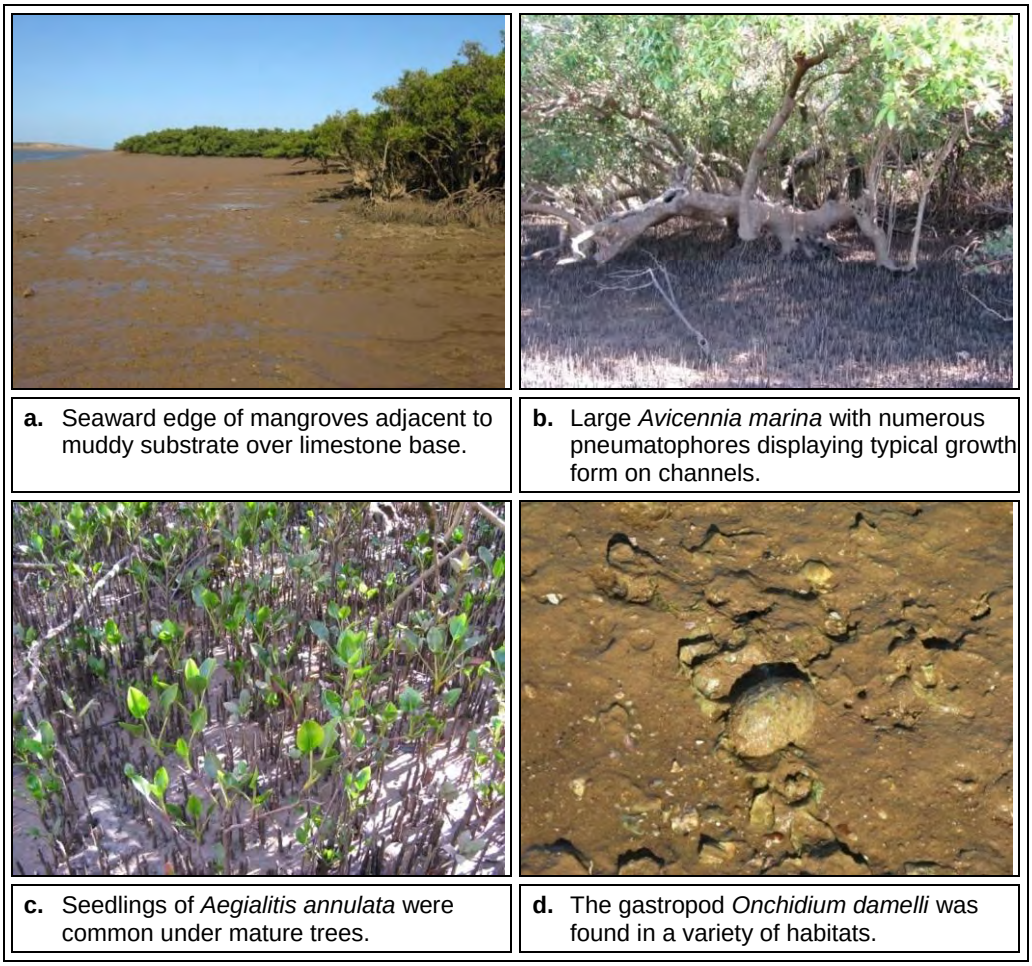
*Aegialitis annulata* formed an understory near the limestone platform that extends from site F4 (**Plate 3-6c**).

The benthic fauna observed at site F5 is listed in **Table 3-2**. Fauna included the gastropod *Onchidium damelli* (**Plate 3-6d**), and the dominant components were the fiddler crab *Uca flammula* and the oyster *Saccostrea cucculata*, which was often present as large clumps attached to pneumatophores. The collared kingfisher *Todiramphus chloris*, which utilises hollow trunks of *Avicennia marina* for breeding, was also observed at this site.

**Table 3-2: Benthic Fauna Observed at Site F5**

| Species | Abundance[1] |
|---|---|
| *Cerithidea largillierti* (mud whelk) | present |
| *Onchidium damelli* (mollusc) | present |
| *Saccostrea cucculata* (oyster) | abundant (in clumps attached to pneumatophores) |
| *Neosarmatium meinerti* (crab) | present |
| *Uca flammula* (crab) | abundant |
| *Perisesarma* sp.(crab) | present |
| *Periopthalmus* sp.(mudskipper) | present |

[1] Present = 1–5 individuals recorded; common = 5–20 individuals recorded; abundant = greater than 20 individuals recorded



**a.** Seaward edge of mangroves adjacent to muddy substrate over limestone base.

**b.** Large *Avicennia marina* with numerous pneumatophores displaying typical growth form on channels.

**c.** Seedlings of *Aegialitis annulata* were common under mature trees.

**d.** The gastropod *Onchidium damelli* was found in a variety of habitats.

- **Plate 3-6: Typical Habitat and Species at Site F5**

### 3.1.6 Site F6

The limestone platform described at site F4 extends to the eastern side of site F6, where it merges with a small sandy, sloping beach. Where these geological features merged, a dense stand of tall (i.e., greater than 3 m high) mangroves was observed (**Plate 3-7a-b**). A group of *Osbornia octodonta* trees were found in this vicinity, while further east scattered mature trees were intermingled among other mangrove species. At this site, *Osbornia octodonta* was generally found growing on the extreme landward edge of the mangrove forest.

The band of mangrove forest gradually narrows to the western side of site F6, where the sandy, sloping beach to the rear of the stand merges with a broad sandy beach on the bank of West Creek. Mangroves in this area were greater than 2 m in height and comprised a mixture of *Avicennia marina* and *Rhizophora stylosa* on the seaward edge, backed by mature *Ceriops australis* trees. The

landward edge of the mangrove forest was characterised by mature *Aegialitis annulata* that were heavily in flower at the time of the field survey. Scattered among this mixed association were several *Bruguiera exaristata*, a species which is locally rare (Semeniuk 2007), and this was the only site where the survey team noted the presence of this species.

**a.** Dense stand of mixed mangrove species along landward edge of mangrove forest.

**b.** Close-up view of mixed mangrove species association, showing large *Aegialitis annulata* trees.

- **Plate 3-7: Typical Habitat and Species at Site F6**

### 3.1.7 Site F7

Site F7 was located on the southern side of the road that extends to the western end of Finucane Island (**Figure 2-1**). At this site, there was no distinct boundary between the mangroves to the seaward side and the samphires to the landward side. The area was a mosaic of both vegetation types, with mangroves lining the numerous small tidal channels that traverse the broad tidal pan. Two mangrove species were recorded (*Avicennia marina* and *Ceriops australis*) and were interspersed among the samphires (predominantly *Tecticornia halocnemoides* and *Muellerolimon salicorniaceum*).

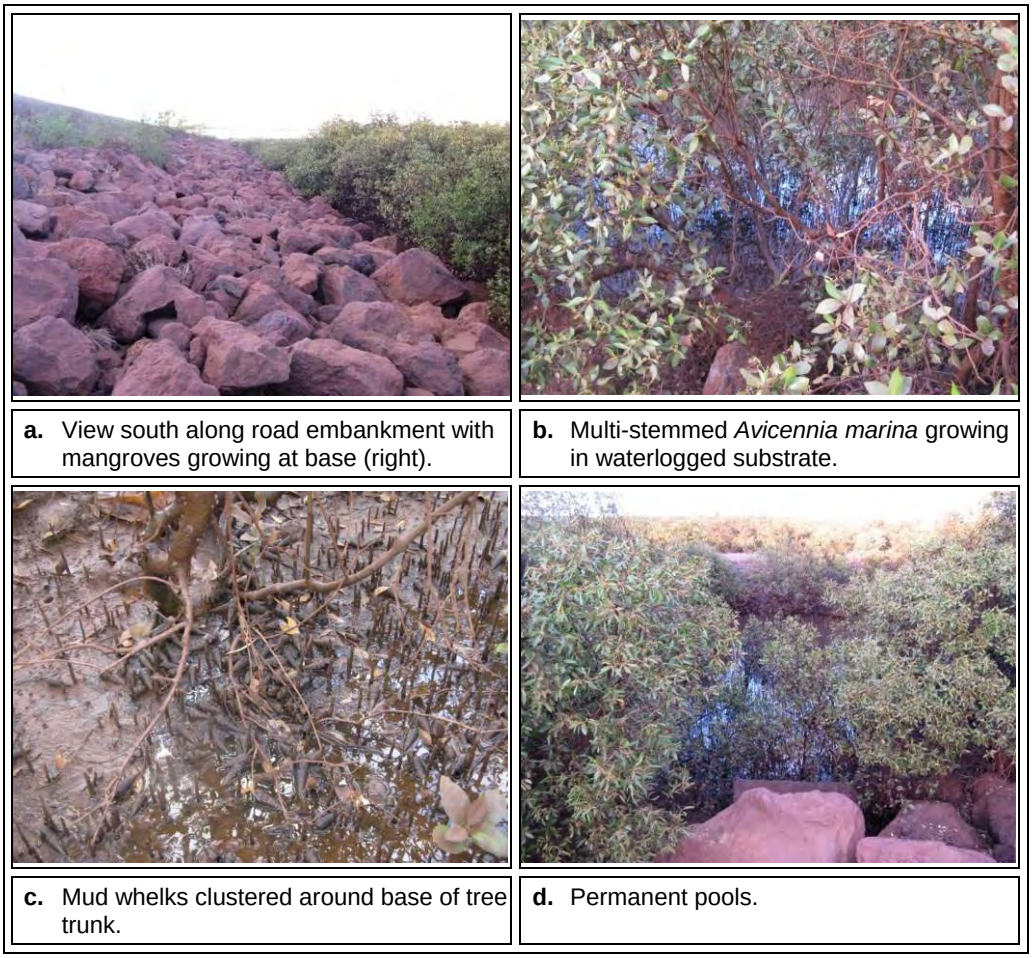
The height of the substrate varied across the site, with the result that some areas are regularly wetted by tides while other areas mostly remain dry. Numerous burrows of the crabs *Uca elegans* and *Neosarmatium meinerti* were present in wet substrate areas.

### 3.1.8 Site F8

Site F8 was located at the point of divergence between the existing road and rail lines on Finucane Island (**Figure 2-1**). The low lying area that is bounded by these transport routes is subject to tidal influence, and was colonised by a dense stand of *Avicennia marina* (**Plate 3-8a**). Where this area

broadens to the south, the mangroves present were tall (greater than 3 m), multi-stemmed and growing in waterlogged substrate (**Plate 3-8b**).

Abundant mud whelks (hundreds of individuals) of the species *Terebralia palustris*, *Terebralia semistriata* and *Terebralia sulcata* were recorded at the site. Live mud whelks were seen clustered around the edges of water pools and at the base of tree trunks (**Plate 3-8c**), while numerous dead shells were observed in a shallow pool of water (**Plate 3-8d**).



**a.** View south along road embankment with mangroves growing at base (right).

**b.** Multi-stemmed *Avicennia marina* growing in waterlogged substrate.

**c.** Mud whelks clustered around base of tree trunk.

**d.** Permanent pools.

- **Plate 3-8: Typical Habitat and Species at Site F8**

### 3.1.9 Site F9

Site F9 was located to the south of site F8, and was also within the area bounded by the existing road and rail lines on Finucane Island (**Figure 2-1**). This area has an altered hydrological regime as a result of physical barrier created by the railway embankment and two culverts through which all

tidal inflows and outflows are channelled. High tides flood the area and at low tide the substrate is exposed, however the constraint of water movement through the culverts apparently reduces flow speeds and increases the residence time of tidal water in the area. This is evidenced by the numerous mangrove pneumatophores, which are indicative of waterlogged substrate, and by the greater amounts of leaf litter and fine sediments when compared to similar mangrove habitat in the region. There may also be some seepage of freshwater (which is used to control dust on the nearby stockpiles) into this area.

Mangroves at this site comprised a stand of *Avicennia marina* ranging in height from 1 to 2.5 m and extending east to the railway embankment. At the time of the field survey, the substrate was very wet and heavily bioturbated. Five species of mud whelks were abundant here, at densities of approximately 5 to 10 individuals per square metre. The combination of fine sediments, surface water, and possibly more nutrients (from decomposing leaf litter) have created favourable conditions for benthic molluscs such as mud whelks, hence their high abundance in this area.

The benthic fauna at site F9 was considerably more diverse when compared with benthic fauna recorded by previous surveys of other areas of the harbour at similar shore heights (SKM 2007). In particular, a high diversity of molluscs (mud whelks and other molluscs) and crabs were observed, generally in large numbers. Many benthic fauna species recorded at this site (**Table 3-3**) were not recorded in mangrove habitat during surveys conducted elsewhere in the harbour previously (SKM 2007). The fauna assemblage recorded at site F9 was found to extend to the seaward edge of the mangrove habitat that is bounded by the existing road and rail lines, and was comprised of species typically associated with mangroves in tropical Australia (J. Hanley, pers. comm. 2009).

Several large species of mud whelk (**Plate 3-9a**) were highly abundant and particularly conspicuous due to their apparent absence from similar habitat elsewhere in the harbour (SKM 2007). In this area, three species of *Terebralia* mud whelks were commonly sighted in dense aggregations at the base of mangrove trees (**Plate 3-9b**), a behaviour that has been recorded elsewhere for *Terebralia* spp. (Crowe & MacMahon 1997, Pape et al. 2008). The mud whelk *Cerithidea largillierti* was also common but was not observed to aggregate on the mud surface as it appears to be restricted to lower trunks of the trees at low tide and migrating further up at high tide, presumably to avoid predators.

### Table 3-3: Benthic Fauna Observed at Site F9

| Species | Abundance[1] |
|---|---|
| *Terebralia semistriata* (mud whelk) | abundant |
| *Terebralia palustris* (mud whelk) | abundant |
| *Terebralia sulcata* (mud whelk) | abundant |
| *Telescopium telescopium* (mud whelk) | abundant |
| *Cerithidea largillierti* (mud whelk) | common |
| *Nerita balteata?* (mollusc) | present |
| *Nerita oualensis?* (mollusc) | present |
| *Littoraria articulata?* (mollusc) | present |
| *Onchidium damelli* (mollusc) | abundant |
| *Saccostrea cucculata* (oyster) | present; common in patches near MSL |
| *Neosarmatium meinerti* (crab) | common |
| *Parasesarma* sp. (crab) | abundant |
| *Perisesarma* sp. (crab) | abundant |
| *Metapograpsus frontalis* (crab) | common |
| *Uca flammula* (crab) | common |
| *Uca elegans* (crab) | present (drier margins, open areas) |
| *Scylla* spp. (crab) | present |
| *Clibanarius longitarsus* (hermit crab) | present |
| *Epixanthus dentatus* (crab) | present |
| *Thalassina anomala* (mud lobster) | common |
| *Periopthalmus* sp. (mudskipper) | common |

[1] Present = 1–5 individuals recorded; common = 5–20 individuals recorded; abundant = greater than 20 individuals recorded; MSL = mean sea level

**a.** *Terebralia semistriata*, grazing on leaf litter and algae, was abundant at this site.

**b.** Dense aggregation of mud whelks around the base of a mangrove tree.

**c.** The large sesarmid *Neosarmatium meinerti,* a nocturnal herbivore.

**d.** The mudskipper, *Periopthalmus* sp., constructs a u-shaped burrow.

**e.** The crab *Epixanthus dentata*, an ambush predator that feeds on other crabs.

**f.** Dense tangle of prop roots of *Rhizophora stylosa*.

- **Plate 3-9: Typical Habitat and Species at Site F9**

### 3.1.10 Site F10

Site F10 was situated on the western side of the causeway (**Figure 2-1**) in the area of mangrove habitat that, unlike site F9, has unrestricted incoming tidal flow and is not enclosed by existing infrastructure. Sites F9 and F10 were at similar shore heights.

In comparison to site F9, site F10 comprised small pools of water, a drier substrate, more sand, less leaf litter, and more bioturbation at the time of the survey (**Plate 3-10a-b**). The benthic fauna found in this area is listed in **Table 3-4** and was notably species-poor compared to that observed to the east of the causeway at and near site F9.

The fiddler crab *Uca flammula* was abundant and many burrows were evident. The climbing mud whelk, *Cerithidea largillierti*, was also present at this site. The large mud whelks that were abundant on the east side of the causeway were completely absent at this site, although the grazing pulmonate gastropod, *Onchidium damelli*, was common. Some mud whelks were observed to the north-north-east of site F10 in an area where the *Avicennia marina* formed a closed canopy that extends over a wetter substrate, and they were more common between this area and the upper culvert.

**Table 3-4: Benthic Fauna Observed at Site F10**

| Species | Abundance[1] |
|---|---|
| *Cerithidea largillierti* (mud whelk) | present |
| *Onchidium damelli* (mollusc) | common |
| *Neosarmatium meinerti* (crab) | present |
| *Parasesarma* sp.(crab) | common |
| *Uca flammula* (crab) | abundant |
| *Thalassina anomala* (mud lobster) | present |
| *Periopthalmus* sp. (mudskipper) | present |

[1]Present = 1–5 individuals recorded; common = 5–20 individuals recorded; abundant = greater than 20 individuals recorded.

Although this site has unrestricted incoming tidal flow, it appears to have an altered hydrological regime as a result of the existing infrastructure, which in turn appears to have had an effect on the local ecology. Evidence for this include: large *Avicennia marina* trees with numerous pneumatophores (**Plate 3-10c**), surface pools of water (**Plate 3-10d**), waterlogged substrate (**Plate 3-10e**), fine mud and the presence of mud whelks only in the vicinity of the upper culvert outflow. It is likely that the embankment creates a dam-like effect, restricting outgoing tidal flow through the culvert. The net result is water retained on the tidal flat on the unrestricted side of the culvert for a prolonged period of time at low tide (**Plate 3-10f**).

**a.** Relatively dry, sandy substrate at site F10.

**b.** Heavily bioturbated substrate at site F10.

**c.** Numerous pneumatophores of *Avicennia marina* trees.

**d.** Pool of water on tidal pan with mud whelks, including some dead shells.

**e.** Waterlogged substrate with mud whelks.

**f.** Flooded tidal pan retaining water at low tide.

- **Plate 3-10: Typical Substrate and Hydrological Conditions at Site F10**