Proposed Outer Harbour Development
Port Hedland

MARINE TURTLE TOWED VIDEO SURVEYS 2009-10

- Rev B
- 27 May 2010

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Limitation Statement

The sole purpose of this report and the associated services performed by Sinclair Knight Merz (“SKM”) is to detail the towed video field surveys undertaken to detect marine turtles offshore of Port Hedland. The survey was undertaken in accordance with the scope of services set out in the contract between SKM and the Client (FAST JV). That scope of services, as described in this report, was developed with the Client, BHP Billiton Iron Ore and Pendoley Environmental.

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Executive Summary

BHP Billiton Iron Ore proposes to expand their iron ore operations in the Pilbara by developing a new port. This proposed development is known as the Port Hedland Outer Harbour Development (Outer Harbour Development). The proposed Outer Harbour Development is located on the coast near Port Hedland in the Pilbara region of Western Australia.

The Outer Harbour Development will involve the construction of infrastructure (jetty and wharves) and dredging, to allow ship access to the infrastructure for loading of iron ore. The estimated dredge volumes for these activities are up to 54 Mm^3, with spoil to be disposed into three proposed offshore spoil grounds.

Dredging and disposal activities in this region have been identified as a potential risk to marine turtles. Desktop and field studies have identified the flatback turtle (*Natator depressus*) as the species with life stages most reliant on the marine and intertidal habitats in the vicinity of the proposed development, in particular the ‘internesting’ period of the life stage. This is the stage in between the successive egg clutches of a breeding season when a turtle departs the beach before returning to the beach to lay subsequent clutches. Recent studies have observed that during the internesting phase, flatback turtles will undertake resting dives to the seabed floor for up to half an hour, increasing susceptibility to dredging and disposal activities.

Satellite tracking of four flatback turtles on Cemetery Beach from the 2008-09 summer season indicated that one turtle repeatedly surfaced in the existing shipping channel adjacent to the proposed berth pocket dredging. None of the nine turtles tracked in the 2009-10 survey were observed to frequent this location; however the 2009-10 data was not available until after the design and implementation of the towed video survey had been completed.

A Draft Marine Turtle Management Plan (BHP Billiton Iron Ore 2009) has been prepared for the proposed Outer Harbour Development which outlines management strategies and monitoring programs that will be adopted to mitigate potential impacts associated with the construction phase of the development.

A towed video survey was proposed with the objective of determining the presence, and abundance, of flatback turtles on the seabed in areas within or adjacent to the proposed dredging and spoil disposal areas.

Towed video surveys were undertaken during the period 16–18 December 2009, during the flatback turtle internesting season. The surveys were undertaken in the existing shipping channel immediately to the east of the proposed Outer Harbour Development berth pockets. In addition, video tows were conducted in and adjacent to the proposed Spoil Ground 3 and the proposed jetty alignment linking Finucane Island to the wharf.

A total of 25 transects covering approximately 10 km linear distance were completed in the three areas without detecting the presence of marine turtles. Underwater visibility was extremely poor in all areas surveyed, primarily due to tidal, wind and shipping actions causing re-suspension of sediments, and spoil disposal activities at Spoil Ground One, to the east of the existing shipping channel.

Whilst analysing video footage, marine scientists also classified benthic habitat. Habitat classifications linked to time, date and GPS location were recorded every second of footage capture, with almost 30, 000 data points recorded across the 25 transects. Bare sand was the most commonly recorded benthic category (present at approximately 75% of data points) followed by filter feeders (present at ~25% data points) and algae (present at ~5% data points). Hard coral was present at <0.01% of data points. The slopes of the existing shipping channel supported macroalgae and filter feeders, with minimal numbers of hard and soft coral; the maintained base of the shipping channel consisted of bare sand or sand with rubble.

After completion of the survey, it was concluded that using video tows as a method to record the presence of marine turtles during internesting is not suitable under visibility conditions experienced in Port Hedland. It is estimated that water visibility of at least 5 m in the vertical plane would be required to render this technique effective – conditions that are very uncommon in this region and difficult to predict in advance for scheduling of field surveys.

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1. Introduction

1.1. Project Overview

BHP Billiton Iron Ore exports iron ore from port facilities in Port Hedland, Western Australia. The 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 now embarking on a development program at their Western Australian iron ore operations and is investigating a number of proposed port development options, one of which is to develop an Outer Harbour at Port Hedland.

The proposed Outer Harbour Development will be a new port facility near Port Hedland with an export capacity of approximately 240 Mtpa of iron ore. Construction will be in stages (referred to as Stages 1–4). Stage 1 of the Outer Harbour Development will take approximately three years to construct.

1.2. Project Description

The marine infrastructure for the new offshore loading facility will be constructed on Finucane Island. The new jetty and wharf will extend nominally 4 km offshore in a northerly direction, adjacent to the existing inner harbour shipping channel. The new iron ore loading facility will be capable of berthing and loading vessels up to 320,000 deadweight tonnes (DWT).

The key components of the offshore maritime infrastructure comprise the following:

- an abutment (on Finucane Island), jetty and wharf accommodating 8 berths;
- mooring and associated mooring dolphins;
- associated transfer stations, ore conveyors and shiploaders;
- dredging for berth pockets, basins and channels; and
- aids to navigation.

The construction of the proposed Outer Harbour Development will require dredging to enable vessel access to the proposed wharf infrastructure. Dredging operations will include the creation of new:

- berth pockets;
- swing basins;
- arrival and departure basins;
- link channel to the existing inner harbour shipping channel;

- departure channel; and
- tug access channel linking the existing channel to the wharf head area.

The new departure channel will be approximately 34 km in length. The basins, berth pockets and up to 3 km of the new departure channel will be located in State waters, with the remainder of the departure channel being in Commonwealth waters. The total volume of dredged material is estimated to be approximately 54 Mm^3, including an allowance for over-dredging. There is a range of material types in the proposed dredging footprint, thus requiring the use of a trailing suction dredger (TSD) for softer material, while harder materials will first require cutting/crushing using a cutter suction dredger (CSD). Geotechnical studies completed to date have identified no areas in the dredging footprint that would require marine blasting operations for material extraction.

1.3. Potential Impacts to Marine Turtles from the Outer Harbour Development

During preparation of the Public Environmental Review (PER), marine turtles were identified as one of the marine environmental factors that may be exposed to at least a ‘medium’ risk of impact from the Port Hedland Outer Harbour Development. The identified aspects that may cause impacts to turtles included:

- vessel collision;
- entrainment by dredges;
- burial by spoil disposal;
- light (affecting navigation);
- noise (affecting behaviour); and
- hydrocarbon spills and waste disposal.

A key component in mitigating and managing the potential risks to marine turtles is gaining an understanding of the habitats likely to be used by turtles in the vicinity of the proposed Outer Harbour Development.

1.4. Existing Information

Pendoley Environmental were contracted to undertake desktop and field investigations to determine the range of marine turtle species present in the Port Hedland region, their relative abundances, the life stages represented and potential project related risks (Pendoley Environmental 2009). The desktop study identified the summer season (from early November to February) as the period during which turtles would be congregating in the Port Hedland region in the greatest numbers and at the most vulnerable life stage cycles (e.g. nesting/internesting females and hatchlings). The desktop review identified three regionally significant species of marine turtles likely to be present in the Port Hedland region:

- flatback turtles (*Natator depressus*);
- green turtles (*Chelonia mydas*); and
- hawksbill turtles (*Eretmochelys imbricata*).

The study identified the following turtle life stages to be at risk from the proposed Outer Harbour Development:

- **nesting and internesting female flatback turtles** during the summer breeding season;
- **juvenile and adult marine turtles** of all species that forage, rest or pass through the area; and
- **post-hatchling flatback turtles** that may utilise nursery habitat in the Port Hedland region.

Flatback turtles are capable of laying multiple (up to four) clutches of eggs during the nesting season, which typically peaks between November and January for this species in the Port Hedland region, predominantly at Cemetery Beach. The period between laying clutches of eggs is known as the internesting period and is typified by females remaining in proximity to the nesting beach and conserving energy (Pendoley Environmental 2009). Typically, female turtles will not feed during this time, while eggs are developing for the next clutch, and when diving may rest on the seabed for periods of up to 30 minutes at a time (J Oates, pers. comm. 25 May 2010). This behaviour increases susceptibility to dredging and disposal activities. Post-internesting, the flatback turtles undergo migration to foraging grounds, with soft corals and jellyfish identified as likely food sources based on isotopic studies (Pendoley Environmental 2010).

Satellite tracking undertaken on four flatback turtles during the internesting period as part of the Pendoley Environmental study in 2008-09 showed that one turtle repeatedly surfaced in or near to the existing shipping channel to the west of Cemetery Beach (**Figure 1-1**), while the other turtles appeared to utilise the near shore habitat to the north-east of Cemetery Beach. The tracking units used in the 2008-09 study were only capable of showing the surface location of turtles and could not indicate dive duration or depths.

Examination of habitat maps modelled by Sinclair Knight Merz (SKM 2009a) determined that the area visited by the turtle around the existing shipping channel in 2008-09 was primarily bare sediment, with the potential for hard substrate with or without benthic primary producers (BPPs) on the slopes of the channel. The base of the shipping channel was modelled to be bed rock/rubble, and is maintenance dredged approximately every three to four years. This type of habitat may offer areas of refuge for the internesting turtles suitable for conserving energy and avoiding predators.

In the 2009-10 study, satellite tracking units with Time Depth Recorders (TDR) were used, capable of measuring the percentage time spent at relative depths when turtles dive underwater, within six hour blocks. However, they did not log individual time-series dive profiles, which give a better indication of whether turtles are undertaking resting dives to the bottom of the seafloor. However, previous studies of internesting flatbacks using other satellite tracking units have shown that the turtles have been found to rest on the seabed floor for about half an hour and usually no longer than an hour (J Oates, pers. comm. 25 May 2010). The bathymetry of the area visited by the tracked flatback turtles will be overlaid with the 2009-10 dive depth data within the six hour blocks to analyse what percentage of time was spent at the seabed. This component of the 2009-10 data analysis had not been undertaken at the time of writing.

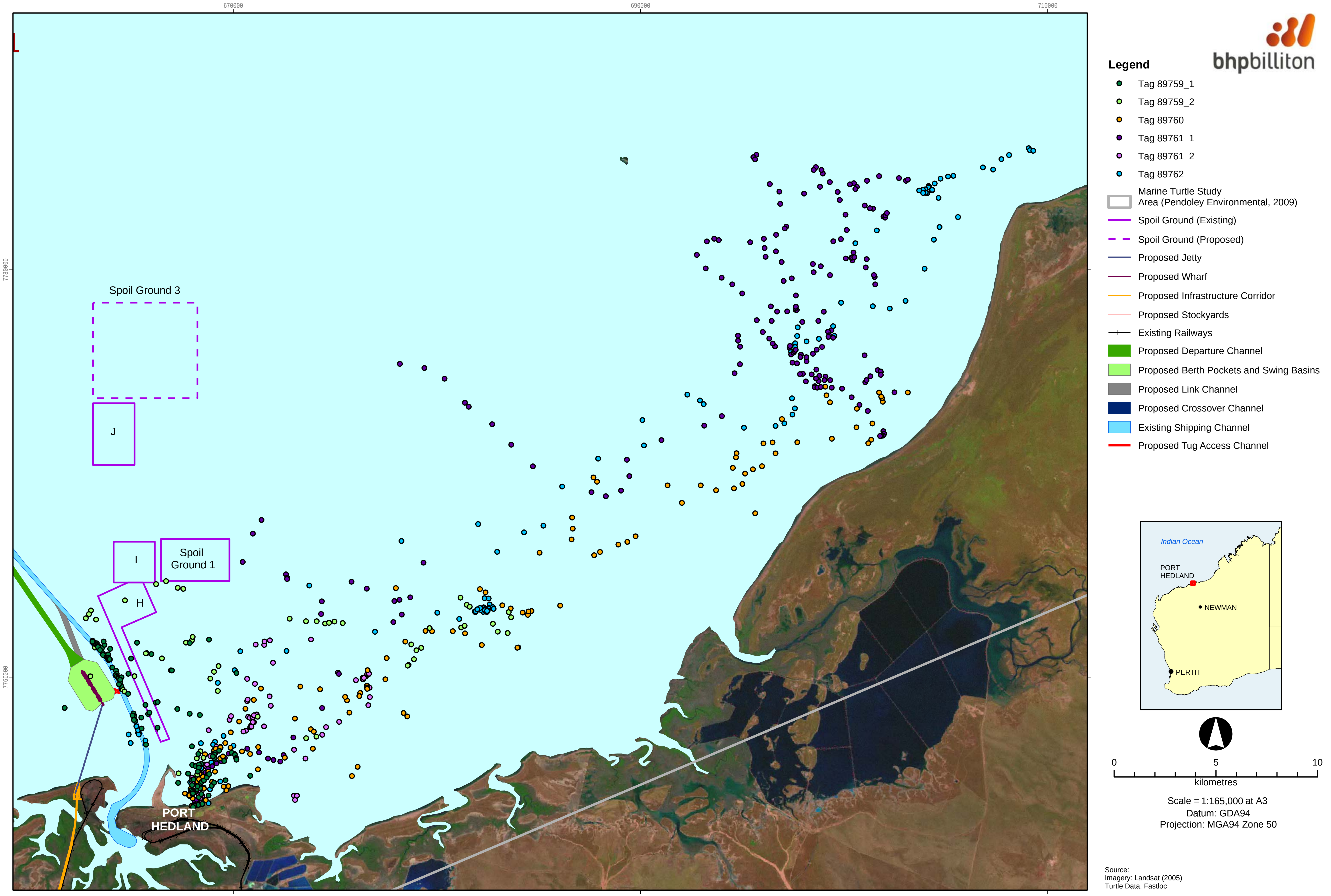
1.4.1. Rationale of Towed Video Survey

Desktop and field data collected in the 2008-09 summer season suggested that the seabed within or adjacent to the proposed Outer Harbour Development dredge footprint may be used by female flatback turtles during the internesting period.

A workshop was held in September 2009 (prior to 2009-10 satellite data being available) to discuss project related risks to marine turtles, including during the flatback internesting period and potential management measures that could be implemented during dredging activities to mitigate these risks. The workshop involved representatives from BHP Billiton Iron Ore, FASTJV, Pendoley Environmental and SKM. Participants agreed that a towed video survey could improve knowledge of internesting female flatback habitat preference, including abundance and density. This information could potentially be used to understand the potential risk of dredging activities during the internesting period.

Participants acknowledged that unpredictable and generally poor water clarity in the Port Hedland region was likely to reduce the effectiveness of towed video surveys, but it was still worthwhile undertaking the study during the nesting season, when female flatback turtles are known to internest and aggregate in the area.

The towed video study was not aimed at identifying turtles in other ‘at risk’ life stages described in **Section 1.4**.



Source:
Imagery: Landsat (2005)
Turtle Data: Fastloc

Figure 1-1 Movements of Four Satellite Tracked Flatback Turtles During the 2008-09 Internesting Period

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2. Methods

2.1. Video Capture

A high resolution underwater video camera transmitted footage of the seabed to a 15 inch television monitor on board the vessel *Serious Fun*. During recording, video footage was encoded with latitude and longitude coordinates every second using a Furuno GP-37 differential global positioning system (DGPS) and saved to a portable hard drive recorder. The height of the video camera was manually controlled by scientists on the vessel to avoid collisions with objects and to maintain vision of the seabed. Video height above the seabed was generally limited to <1 m, resulting in a transect width of approximately 1 metre. Water clarity was poor due to wind and tidal conditions, shipping activity and offshore disposal of inner harbour dredge material to Spoil Ground One.

For each transect, the vessel *Serious Fun* was positioned at the desired start point based on wind and tidal conditions. The vessel was then allowed to drift, at approximately 1 knot. As turtles could be disturbed by the noise of the vessel engines during positioning, transects ran for a minimum of 10 minutes to minimise the impact of any potential initial disturbance. Transect 21 was the exception, stopped after approximately five minutes due to shipping movements.

2.2. Video analysis

Video footage was analysed in real-time using video analysis software, which allowed the user to assign qualitative substrate and biota attributes to the GPS position of the camera while the video footage was recorded. The benthic habitats along the video transects were described using broad substrate and biota descriptions and were recorded into spreadsheets each second. If a habitat description was not altered by the observer, the preceding description was recorded by default. The substrate and biota attributes are defined in **Appendix A** and are consistent with classifications used for other subtidal surveys of the area, including those used to develop benthic habitat maps (SKM 2009a and SKM 2009b). Biota cover was also assigned one of the density classifications described in **Appendix A**.

Habitat data points were then tabulated to show the proportion of habitat types in each transect (**Table 3.1**) and overlaid on existing and proposed developments to illustrate the dominant habitat types and densities (**Figure 3-1** and **Figure 3-2)**. All video footage has been retained and can be re-examined at a future stage if necessary.

2.3. Transects

From 16–18 December 2009, footage from 25 towed video transects was captured in three areas offshore of Port Hedland related to the proposed Outer Harbour Development. A description of the capture approach in each area is provided below, transect locations are shown in **Figure 2-1** and transect lengths are provided in **Table 3.1**.

Shipping channel

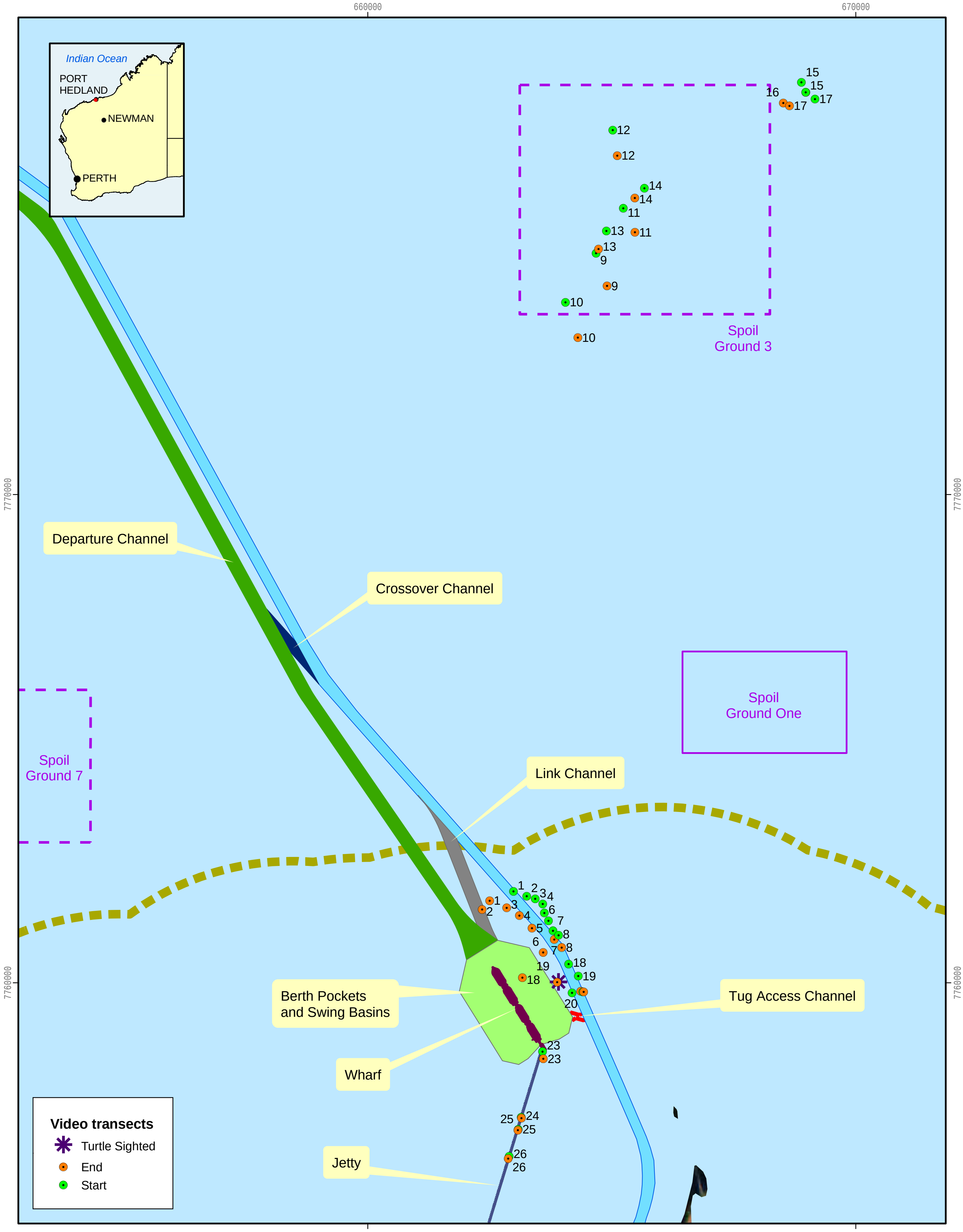
The base of the existing channel is maintained at a constant depth by regular dredging and is likely to support minimal biota or structural complexity; so it was considered more appropriate to capture transverse transects across the existing channel adjacent to the proposed wharf head dredge footprint. This approach captured any variation in biota and complexity on the channel slopes and undredged seabed with increasing distance (and depth) from shore. As the habitat preference/ requirement of the internesting flatbacks was not known, this approach provided the greatest chance of covering different habitat types that might support resting turtles. A total of twelve transects were captured along the shipping channel (1-8; 18-21).

Spoil Ground 3

Transects in spoil ground 3 were positioned to cover as much area as possible. Poor visibility was experienced along the first six transects (9-14) within the spoil ground. As conditions were not conducive to capturing footage of turtles it was decided to conduct the final three transects (15-17) to the north-east of spoil ground 3 so that concurrent ground truthing of the seabed could be undertaken. Ground truthing in this area was required to support habitat modelling (SKM 2009a), as bathymetric data was not captured at the time of light detection and ranging (LiDAR) surveys due to cloud cover.

Jetty Footprint

Four transects (23 – 26) were conducted along the alignment of the proposed jetty, each covering less ground than at other locations due to slack tide and wind conditions at the time. Although this area will not be dredged, it was opportunistically investigated as time permitted.



Legend

- ☐ Spoil Ground One (Existing)
- Spoil Ground (Proposed)
- 🟩 Proposed Departure Channel
- 🟩 Proposed Berth Pockets and Swing Basins
- ■ Proposed Link Channel
- ■ Proposed Crossover Channel
- ■ Existing Shipping Channel
- Proposed Tug Access Channel
- Proposed Jetty
- Proposed Wharf
- Proposed Infrastructure Corridor
- State/Commonwealth Jurisdiction Boundary

PRELIMINARY

0 1 2
kilometres

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bhpbilliton

Source:
Australian Maritime Boundaries (AMB)
© Commonwealth of Australia (GA), 2006
Imagery: Landsat 2005
Topography: GEODATA Topo 250K V3
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Figure 2-1 Location of towed video transects Offshore of Port Hedland, December 16-18 2009

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3. Results

3.1. Marine Turtle Observations

No turtles of any species were observed on video footage during the towed video surveys. One turtle was observed on the surface between the proposed berth pockets dredge footprint and the existing shipping channel (**Figure 3-1**) but could not be identified as it was distant from the vessel.

3.2. Benthic Habitat Observations

Video footage was observed and classified by marine scientists in real-time, recording a total of 29,734 points of habitat data along the 25 towed video transects (**Table 3.1**). Based on an assumption that the video footage captured a band approximately 1 m wide, the survey covered approximately 10, 500 m^2 of seabed across the 25 transects.

The classified video transects point data was displayed to show the distribution and density of habitat classes (**Figure 3-1** and **Figure 3-2**). Almost 75% of the area covered during video tows consisted of bare substratum (sand) with no visible attached biota. Of the area that contained biota (~26% of total area), four classifications were recorded: 'filter feeders'; 'algae'; 'hard coral' and 'soft coral' (**Table 3.1**). Biota also occurred as mixed assemblages, as shown in figures and tables in this section.

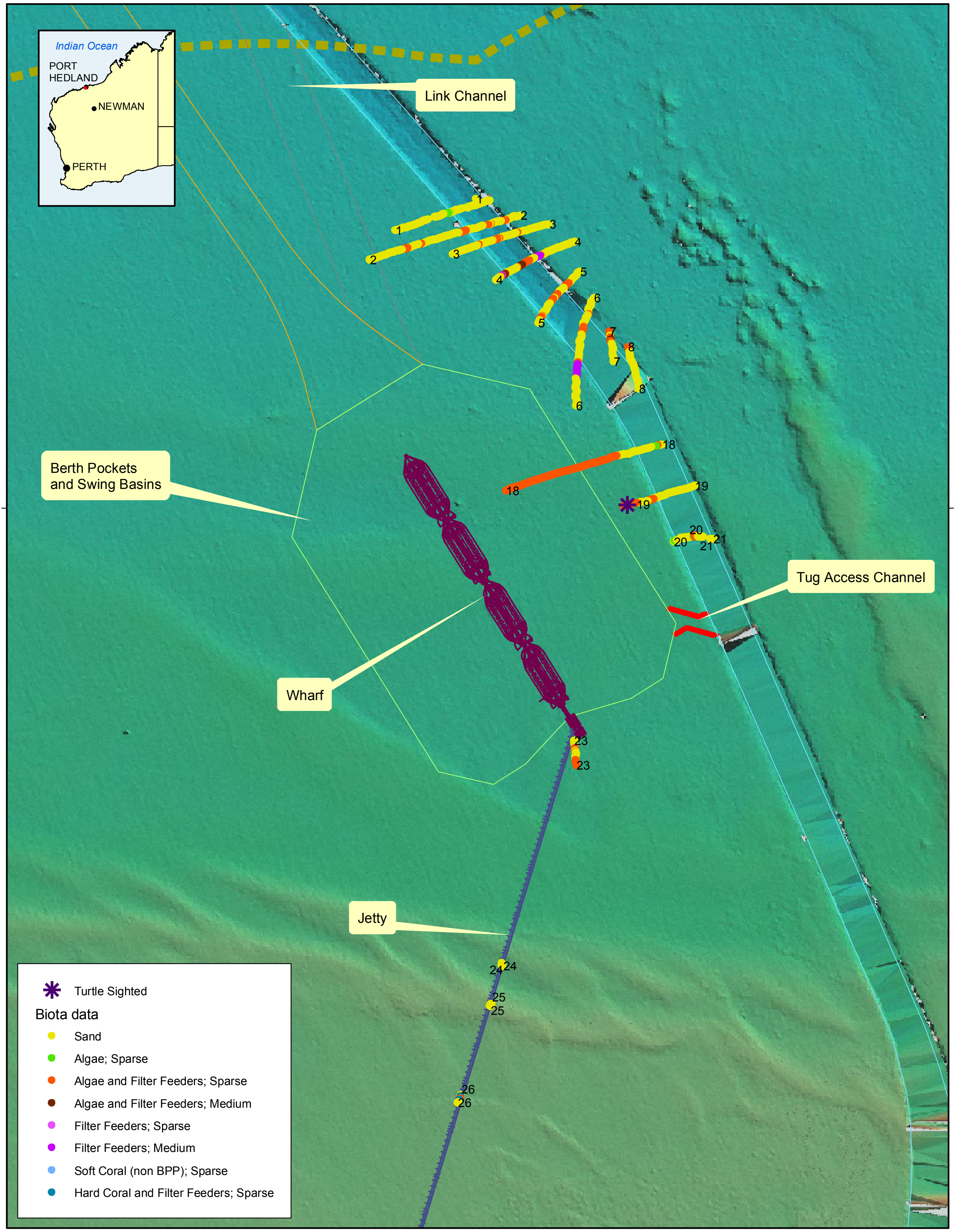
When biota was recorded (at ~26% of total data points), filter feeders were by far the most common classification, recorded 97% of the time (either solely or in mixed assemblages); followed by algae (~19 %); hard coral (<3%) and soft coral (<1%).

The soft coral, algae and hard coral classifications consisted of hermatypic species attached to consolidated hard substrate and are defined as BPPs. The filter feeder classification comprised communities of ahermatypic, heterotrophic invertebrates (animals which absorb prey/food for energy) that are predominately non-photosynthetic and are not defined as BPPs. The majority of biota found along transects was sparse in coverage as defined in **Appendix A** (5-25% biota cover).

The distribution of benthic habitat classes in the three surveyed areas was consistent with field observations and modelling undertaken during the proposed Outer Harbour Development benthic habitat surveys (SKM 2009a).

Table 3.1 Video analysis point data for biota classes (number of video points recorded per biota classification)

Transect	Biota Classes							No Biota	Video Points	Transect Distance (m)
	Filter Feeders	Algae	Algae and Filter Feeders	Hard Coral	Hard Coral and Filter Feeders	Soft Coral	Soft Coral and Filter Feeders	Sand	Total	
1		66						1095	1161	525
2	35		230					1677	1942	955
3	11		120					1253	1384	614
4	188		329				12	1051	1580	528
5	222		103					1017	1451	396
6	442		110					1495	1938	657
7			176					325	501	185
8	116							626	742	261
9	954							513	1467	707
10	1358							200	1558	765
11								1279	1279	546
12	491		4					1085	1580	533
13								1493	1493	404
14								1036	1036	286
15								1137	1137	221
16								1257	1257	510
17								1119	1119	542
18	1150	10	13					356	1529	988
19	257							812	1069	450
20	1	138	157					1334	1630	180
21								136	136	21
23	605					2		991	1598	150
24								340	340	20
25								360	360	18
26	97			7	201			142	447	54
Total	**5927**	**214**	**1242**	**7**	**201**	**2**	**12**	**22129**	**29734**	**10516**



Legend

- Spoil Ground (Proposed)
- Proposed Tug Access Channel
- Proposed Jetty
- Proposed Wharf
- State/Commonwealth Jurisdiction Boundary
- Proposed Departure Channel
- Proposed Berth Pockets and Swing Basins
- Proposed Link Channel
- Proposed Crossover Channel
- Existing Shipping Channel

PRELIMINARY

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bhpbilliton

Source:
Australian Maritime Boundaries (AMB)
© Commonwealth of Australia (GA), 2006
Imagery: Landsat 2005
Topography: GEODATA Topo 250K V3
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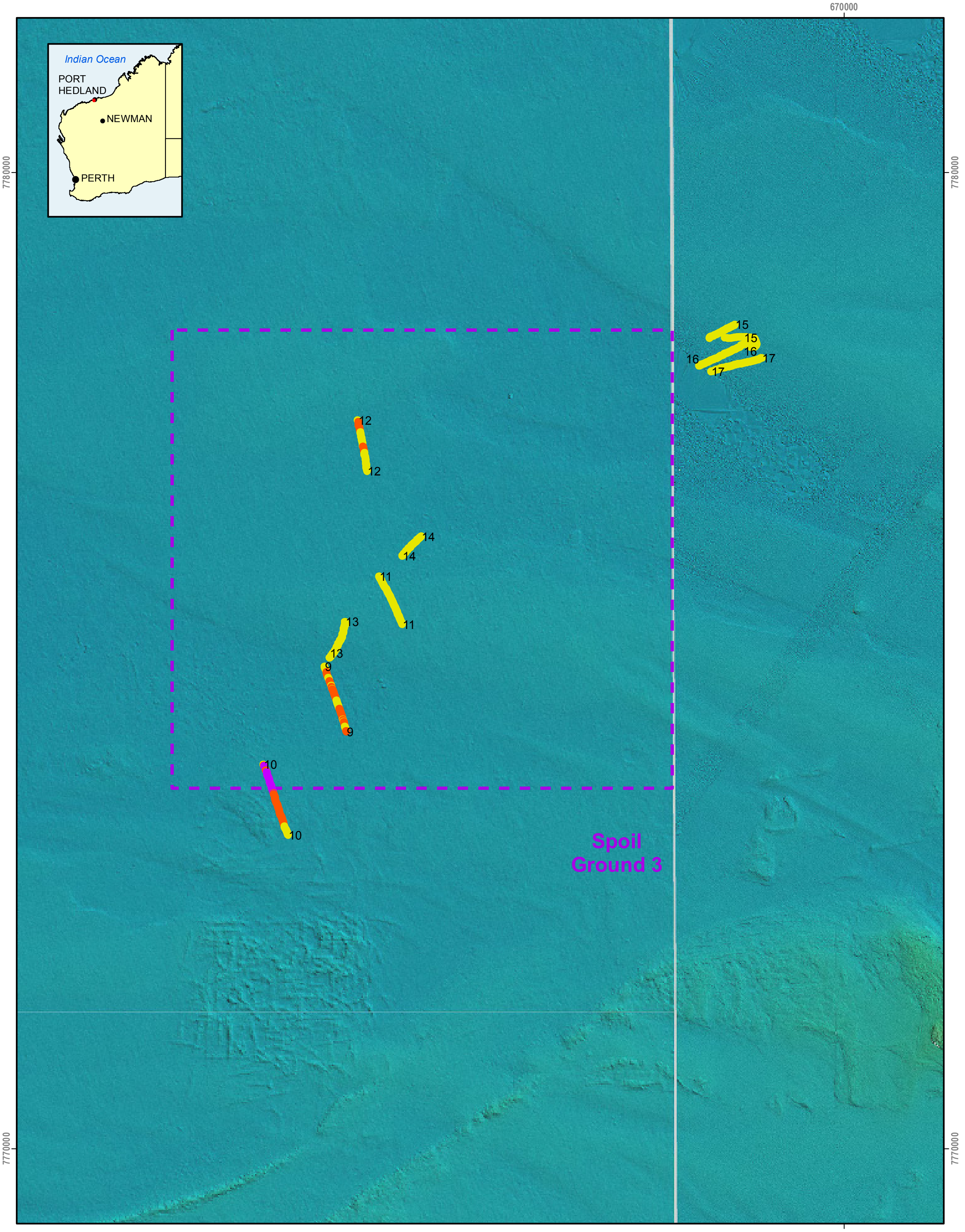
Figure 3-1 Habitat Classifications Along Transects in Existing Channel and Proposed Jetty Alignment



Legend

- - Spoil Ground (Proposed)

Biota data

●	Sand	●	Algae and Filter Feeders; Medium
●	Algae; Sparse	●	Filter Feeders; Sparse
●	Algae and Filter Feeders; Sparse	●	Filter Feeders; Medium
		●	Soft Coral (non BPP); Sparse
		●	Hard Coral and Filter Feeders; Sparse

PRELIMINARY

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metres

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bhpbilliton

Source:
Australian Maritime Boundaries (AMB)
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Figure 3-2 Habitat Classifications Along Transects in and Adjacent to Proposed Spoil Ground 3

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4. Discussion

The towed video survey did not detect the presence of internesting female flatback turtles or improve knowledge of their habitat preference during this phase of their life cycle. Using video tows to detect turtles on the benthos during the flatback turtle nesting season may prove successful in areas with predictably good water clarity, but this is not the case in the Port Hedland region. As water clarity in this region can rapidly deteriorate from factors including wind and tidal movements, it is extremely difficult to predict days when visibility will be adequate to attempt towed video surveys, and this will be further limited to the flatback turtle nesting season. These difficulties are compounded in the areas of interest by shipping movements re-suspending material in the existing channel and spoil disposal from the Inner Harbour dredging activities at Spoil Ground One.

The findings of this study indicate that towed video methods are likely to be unviable for detecting marine turtles in the Port Hedland region due to the limited periods of necessary water clarity. Time Depth Recorder (TDR) units with GPS capability are recommended for all future studies to determine the sub surface movements and habitat preference (structural complexity) of internesting turtles.

Whilst the towed video survey was not successful in capturing footage of turtles on the seabed, it did confirm the presence of predicted benthic habitats as modelled by SKM during early environmental investigations (SKM 2009a). This increases confidence in the prediction of benthic habitats in areas that have not, or will not, be ground truthed by divers or video transects.

5. References

Pendoley Environmental (2009) *Port Hedland Outer Harbour Development: Marine Turtle Habitat Usage Within The Port Hedland Region Of Western Australia*. Report prepared for SKM/BHP Billiton Iron Ore.

Pendoley Environmental (2010) *Port Hedland Outer Harbour Development: Stable Isotope Preliminary Study*. Report prepared for BHP Billiton Iron Ore.

Sinclair Knight Merz (2009a) *Port Hedland Outer Harbour Development: Marine Benthic Habitat Survey*. Report prepared for BHP Billiton Iron Ore.

Sinclair Knight Merz (2009b) *RGP6 Port Facilities Selection Phase Study: Benthic Primary Producer Subtidal Habitat Mapping*. Report prepared for BHP Billiton Iron Ore.

Appendix A SKM Marine Habitat Classifications

Consolidated (Reef) substrate	**Any substrate predominantly made up of particles of cobble size (>64mm diameter) or larger.**
Biotic dominated	A habitat in which one or more groups of biota cover >5% of the reef
Abiotic rocky reef	Reef with <5% biota
Reef Substrate	
Rock (unbroken)	Unbroken rock substrate
Boulder	Particles >256mm
Cobble	Particles 64-256mm
Reef Profile	
High Profile	>4m rise over 2m; a hard or solid substrate with slopes greater than 70 degrees, including vertical walls, overhangs etc.
Medium Profile	1-4m rise over 2m; a hard or solid substrate with slopes between 30 and 70 degrees
Low Profile	A hard or solid substrate with slopes between 2 and 30 degrees.
Flat	<1m over 2m; a hard or solid substrate with slopes of less than 5 degrees
Obscured reef	No hard substrate was visible due to a superficial sand/gravel layer but biotic components such as sessile invertebrates and macroalgae, which require a solid substrate for attachment, were present.
Unconsolidated (Sediment) substrate	**Any substrate predominantly made up of particles of pebble size (<64mm diameter) or smaller.**
Biotic sediment	Biota covers >5% of sediment
Abiotic sediment	Biota covers <5% of sediment
Sediment	
Flat	Sediment with undulations < 25cm high
Ripples	Sediment with undulations 25 - 75cm high
Waves	Sediment with undulations > 75cm high
Particle Size	
Pebble	Particles 4-64mm
Gravel	Particles 2-4mm; used to describe conspicuous grains of sediment, including biogenic particles such as shells and coral rubble
Sand	Particles 63um-2mm
Mud	Particles <63um

Biota classes	
Algae	
Coralline algae	Encrusting
Membrane, thin sheets	20mm-20cm; Red algae membrane (Rmem), Green membrane (Gmem), Brown membrane (Bmem) (e.g. *Lobophora* spp. , *Padina* spp.)
Turfing, fine feathery	<20mm; Rturf, Gturf, Bturf (e.g. Turfing algae)
Foliaceous, bushy	<20cm; Rfoli, Gfoli, Bfoli (e.g. Gfoli = *Caulerpa* spp.)
Lobed, flattened and rounded	<20cm; Rlobe, Globe, Blobe (e.g. BLOBE = *Dictyopteris* spp.)
Fleshy or ball-like	<20cm; Glump (e.g. Codium spp.)
Branching, large canopy species	>20cm; RBranch, GBranch, BBranch (e.g. BBranch = *Sargassum* spp.)
Seagrass	Can be separated into genus e.g. Halophila, Posidonia, Zostera, Amphibolis
Hard Coral	Where possible further distinction based on morphological structure can be made (adapted from English *etal*. 1997)
Branching	At least 20 branching (e.g. *Seriatopora hystrix*)
Digitate	No 20 branching (e.g. *Acropora digitifera*)
Tabular	Horizontal flattened plates (e.g. *Acropora hyacinthus*)
Encrusting	Major portion attached to substrate as a laminar plate (e.g. *Porites vaughani*)
Foliose	Coral attached at one or more points, leaf-like appearance e.g. *Turbinaria* spp.)
Massive	Solid boulder or mound (e.g. *Favites* spp.)
Submassive	Tends to small columns, knobs or wedges
Other Invertebrates	Excluding hard coral. The presence of soft corals, sponges, ascidians, gorgonians (sea fans), hydroids, sea whips, sea pens.
Density of biota	
Very Dense	Total biota cover > 75% - no substrate visible.
Dense	Total biota cover 50-75% - some substrate is visible.
Medium	Total biota cover 25-50% - substrate is clearly visible but biota dominates the image frame.
Sparse	Total biota cover 5-25% - substrate dominates the image frame
Very Sparse	Total biota cover 1-5% - only used to record presence of biota which is ecologically important with very sparse densities (i.e. seagrass, hard coral)
No biota	Total biota cover <5% - no significant macro-biota