Power and Water Corporation

Report for Bathymetric and Benthic Survey of the Proposed East Point Outfall

Part Three Benthic Survey

January 2009

Photo: Large mobile waves at site A7 up to 6 m high, visibility to 8 m in this image.

Contents

Table Index

Figure Index

Appendices

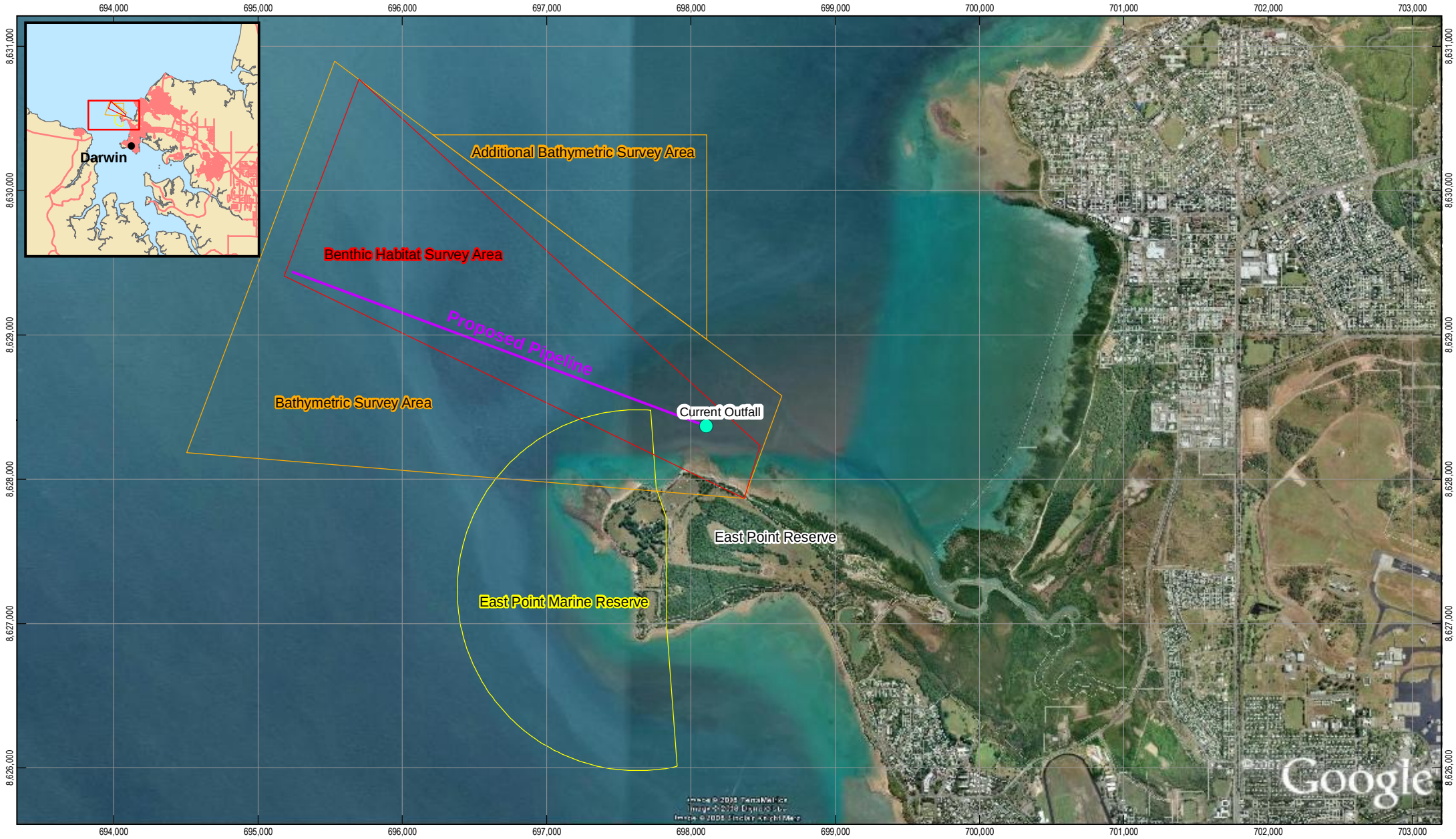
1. Introduction

1.1 Project Background

Power and Water Corporation (PWC) have announced the Larrakeyah Outfall Closure Plan. This plan includes the closure of the Larrakeyah outfall and the upgrade of the Ludmilla (East Point) outfall by 2011. This upgrade requires studies of the East Point area including environmental investigations to determine a suitable pipeline alignment.

GHD Pty Ltd (GHD) was commissioned by PWC to undertake a bathymetric and benthic survey of the East Point survey area (Figure 1), and a bathymetric survey of the Larrakeyah outfall. The benthic survey was undertaken from 4 November to 10 November 2008 following the bathymetric survey of the area.

PWC nominated a proposed pipeline alignment (Figure 2) during a workshop held on 5 November 2008. The proposed pipeline alignment extended northwest from the existing outfall in a straight line to an area known as 'Outfall Option 5' (A8, on Figure 2). This corridor was approximately three kilometres long. The benthic survey concentrated survey sites along this alignment as well as in adjacent habitats, at reference sites from the 2007 survey work (GHD, 2007), and around the harbour at East Point Marine Reserve, South Shell Island and Weed Reef (Figure 3).



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

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LEGEND

- Proposed Pipeline Alignment
- Benthic Habitat Survey Area
- Bathymetric Survey Area
- East Point Marine Reserve

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Proposed East Point Outfall, Bathymetic and Benthic Survey

Job Number 43-21461
Revision A
Date 02 FEB 2009

The Bathymetric & Benthic Study Area

Figure 1

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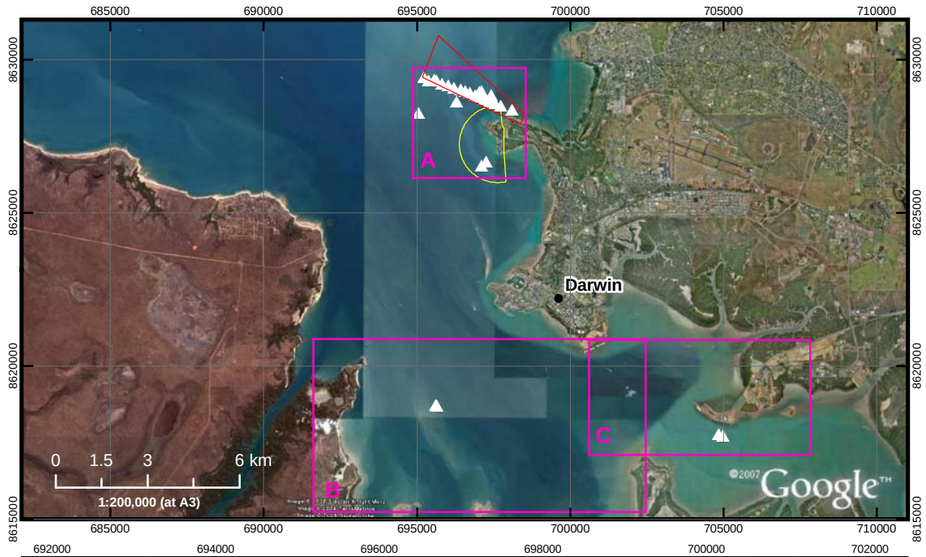
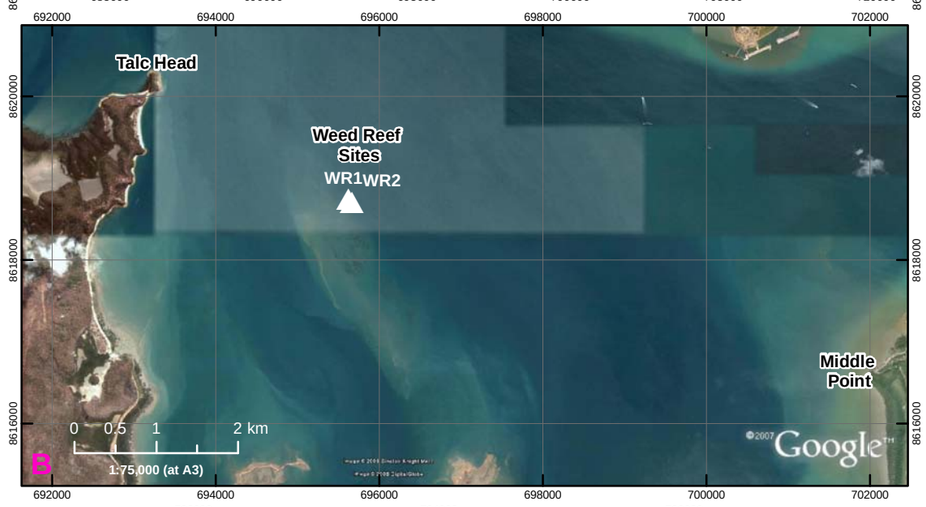
Level 5, 66 Smith Street Darwin NT 0800 **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** **W** www.ghd.com.au

Data source: Benthic Habitat Survey Area Data from PowerWater Corporation, Bathymetric survey area data from PowerWater Corporation, Northern Territory Coastline data from Northern Territory Government, Reserve Data from GHD, Imagery Obtained from Google Earth Pro, WARNING Google Earth Imagery is not Orthorectified Created by:sdwoodger





Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

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LEGEND

- Benthic Survey Sampling Sites
- Benthic Habitat Survey Area
- East Point Marine Reserve

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Proposed Pipeline Alignment and Survey Sites Figure 2

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Data source: Benthis Habitat Survey Area supplied by PWC. Sample sites created by GHD. Imagery obtained from Google earth Pro. WARNING Google Pro imagery is not orthorectified. Created by:bmcginley., sdwoodger

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Metres

Geographic Coordinate System
Horizontal Datum: Geocentric Datum of Australia 1994

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LEGEND

- South Shell Island
- Weed Reef
- Benthic Habitat Survey Area
- East Point Marine Reserve

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Proposed East Point Outfall, Bathymetic and Benthic Survey

Job Number 43-21461
Revision A
Date 02 FEB 2009

The Darwin Harbour Study Area

Figure 3

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Level 5, 66 Smith Street Darwin NT 0800 T 61 8 8982 0100 F 61 8 8981 1075 E W www.ghd.com.au

Data source: Benthic Habitat Survey Area Data from Power and Water Corporation, Bathymetric survey area data from Power and Water Corporation, Reserve Data from GHD, SS1-2 and WR1-2 points from GHD, Imagery Obtained from Google Earth Pro, WARNING Google Earth Imagery is not Orthorectified Created by: sdwoodger

2. Methods

2.1 Timing of the Surveys

The surveys were carried out during neap tide conditions between the 4th November 2008 and the 9th November 2008. Underwater visibility at the survey sites ranged from one to five metres and was sufficient to conduct accurate surveys.

2.2 Preferred Pipeline Corridor Benthic Transect Surveys

A total of eight sites were surveyed at 400 m intervals along the proposed pipeline alignment (Sites A10 through to A8 on Figure 2). At each site four 20 m long transect tapes were established approximately parallel to the shoreline (Figure 4). Each transects were positioned over an area of 50 m x 10 m of marine habitat.

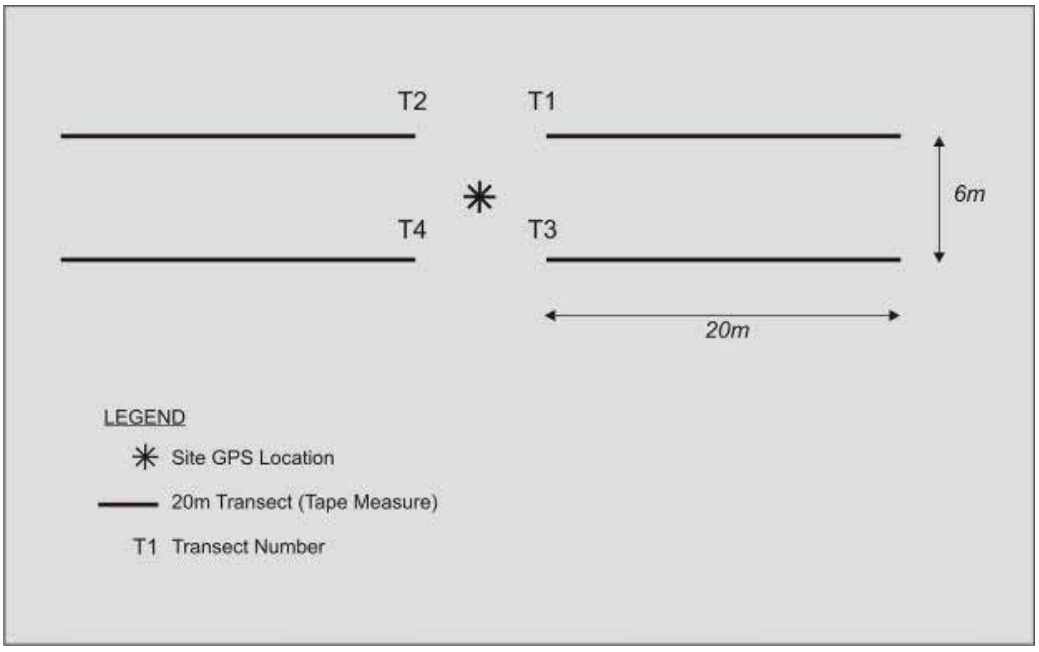

Figure 4 Benthic transect basic set up.

Benthic organisms were counted in a 20 m x 1 m transect centred on each tape. A record was kept of the number of encounters with different species in each major benthic group. Percentage cover of benthic organisms was calculated by determining the length of the tape intercepted by benthic organisms. Intercept lengths for all colonies of a species or benthic group along each transect were totalled and converted to a percentage cover measurement.

The following benthic organisms or groups of benthic organisms were recorded:

- All algae;

- All seagrasses;
- Sponges;
- Hydroids;
- All hard corals identified to species level (or to growth form if more appropriate);
- All soft corals;
- Gorgonians;
- Bryozoans and
- Ascidians.

These techniques have been used in many surveys of marine benthic habitats in the Australian region (Mapstone *et al*., 1989; Ayling and Ayling, 1995, 2002; GHD, 2006).

Spot checks between sample sites

Spot checks were carried out between sites along the proposed pipeline alignment (S1 – S9). At each spot check site an estimate was made of benthic organism density and diversity. Spot checks were also carried out at any major depth discontinuity along the pipeline route.

2.3 Reference Sites

2.3.1 Adjacent Sand Habitat (northern diversion sites)

Two adjacent sand habitat reference sites (B2 and B3) were surveyed 200 m north and parallel to the proposed pipeline alignment. No permanent sites were established at sand habitat sites.

Each of the sites was established as four 20 m long transects oriented and surveyed using the same methods as for sites along the pipeline corridor. Both sites were selected at depths similar to those of the adjacent sites (A2 and A3) on the proposed pipeline alignment.

The sites were selected to identify habitat in areas close to the East Point Marine Reserve adjacent to the proposed pipeline alignment.

2.3.2 East Point Marine Reserve Reef Habitat

Permanently marked reef reference sites were established and surveyed at two sites within the southern section of the East Point Marine Reserve.

Each of these sites was established as four 20 m long transects oriented and surveyed using the methods used along the pipeline corridor. One site was established in the shallow sub-tidal zone close to the shore, and the second in deeper water toward the outer reserve boundary.

These sites (EPR1 and EPR2) were chosen to allow comparison between the marine benthic habitat within the proposed pipeline alignment and the marine reserve to the south. The sites were set up as permanent sites. They are likely to be useful as baseline and operational monitoring sites for future outfall upgrades.

2.3.3 Darwin Harbour Reef Habitat

Two pairs of distant reference sites were surveyed on fringing reefs at South Shell Island and Weed Reef. The methods described above were used for the sand habitat and reef reference sites.

Permanent transects were established in 2005. These sites have been surveyed for numerous programs since 2005. Each site had four 20 m long transects.

These distant reference sites were selected as they have been monitored in the past, providing a historical basis for comparison. These sites are considered to be beyond the range of any impacts resulting from construction and operation of the proposed extension to the Ludmilla outfall. It is noted that these sites may not be immune to other sources of contamination in the harbour.

2.3.4 2007 Survey Sand Habitat

Two 2007 survey sand habitat reference sites (Outfall 3 and Outfall 6) were surveyed during the present program in areas over 10 m deep to the south of the preferred pipeline route. This was to allow comparison of marine habitats physically similar to those along the pipeline. These sites were surveyed in a previous survey commissioned by PWC (GHD 2007) and allow comparison between the 2008 and the 2007 sites.

Permanent Transect Construction

Permanent transects were marked by driving half or one metre lengths of 12 mm reinforcing rod into the substratum at 5 m intervals along each 20 m transect. The survey tape was stretched tightly between the stakes close to the substratum. The finished level of the reinforcing rod was 250 mm from the marine bottom surface in water shallower than 6 m, and 600 mm in water deeper than 6 m. Placement of the rods allows for future monitoring. The rods reduce spatial variability and improve the power to detect real change in the marine community between successive surveys. Transects were numbered one to four and marked using cable ties at the start of each transect (Figure 5).

Figure 5 **Cable ties on a Weed Reef site indicating the start of transect 4 facing left and transect 3 facing right**

2.4 Analysis

Means and standard deviations were calculated for the cover and density of major benthic groups for each group of transects at each site (Table 3).

Statistical analysis of the marine benthic fauna was conducted using Primer ver. 6 (Clarke, 2001). Cluster and multidimensional scaling (MDS) analyses were performed to find the “natural groupings” of samples. This shows which samples are more similar to each other than to other samples. The cluster and MDS analyses represent groupings of samples with a similar faunal composition.

The cluster and MDS were based on a similarity matrix produced using the Bray-Curtis similarity co-efficient, with a square-root transformation. Transformations are required for datasets where more common fauna could potentially out weigh the rarer fauna when determining similarity between samples. Applying a transformation defines a balance between the contribution of common and rarer fauna.

An Analysis of Similarities (ANOSIM) was used in conjunction with the cluster and MDS to provide a significance value ($p=0.05$) for differences between sampling locations. A significance value of less than 5% ($p < 0.05$) gives a greater confidence level in the results achieved.

3. Results

Data collected during the survey are summarised and presented in (Table 1, Table 2 and Table 3). Raw data are presented in Appendix A.

Photographic plates showing a representative selection of benthic organisms and the general substrate types along the preferred pipeline corridor are included in the following Section.

Table 1 Summary of Pipeline Route and Reference Site Substratum and Communities

Site	Depth (mAHD)	Substratum type	Algae % cover	Seagrass % cover	Benthic % cover	Benthic density (per m^2)	Diversity (no. of species)
Preferred pipeline corridor							
A10	-2.551	Fine rippled sand	0	0	0	0.03	2
S3	-3.174	Fine rippled sand	0	0	nr	0	0
A2	-5.192	Sand with some mobile sand waves	0	1.1	0	0.64	6
S4	-6.315	Fine rippled sand with some mobile sand waves	0	0	nr	0.01*	2
A3	-6.539	Mobile sand with large sand waves	0	0	0	0.05	3
S5	-9.639	Smooth silty mud with worm and crustacean holes	0	5	nr	0*	1
A4	-11.404	Smooth silty mud with worm and crustacean holes	0	0	0.19	0.04	3
S6	-13.242	Smooth silty mud with worm and crustacean holes	0	0	nr	0.01*	2
A5	-13.055	Smooth silty mud with worm and crustacean holes	0	0	0.68	0.3	9
S7	-13.787	Smooth silty mud with worm and crustacean holes	0	0	nr	1.0*	10
A6	-15.058	Smooth silty mud with some low sand waves	0	0	0.64	1.06	12
S8	-13.921	Smooth silty mud with worm and crustacean holes	0	0	nr	0.5*	7
A7	-13.901	Sand and pebbles with silt and some sand waves	0	0	0.34	0.73	11
S9	-7.868	High system of large mobile sand waves	0	0	nr	0*	0
S1	-12.033	High system of large mobile sand waves	0	0	nr	0*	0
A8	-12.37	Smooth sand and pebbles with some silt	0	0	0.25	1.11	20
Northern pipeline diversion							
B2	-6.653	Fine rippled sand with some sand waves	0	0	0	0.45	3
B3	-5.757	Smooth sand with a few sand waves	0	22.2	0	0.53	11
S2	-6.143	High mobile sand waves	0	0	nr	0	0
Sand habitat reference sites							
OUT3	-14.333	Smooth silty sand with low flat rock patches	0	0	5.8	5.21	35
OUT6	-12.908	Sand waves with flat sand and low rock between	0	0	8.2	5.26	54
Reef habitat reference sites							
EPR1	N/A	Broken shallow reef slope	0.5	0	56.5	>10*	106
EPR2	N/A	Sand with numerous reef patches	1.7	0	20.5	>10*	102
SS	N/A	Reef slope with some sand patches	4.5	0	46.0	>10*	92
WR	N/A	Shallow reef slope	0.9	0	64.3	>10*	91

Percentage cover figures are means from groups of four 20 m line intercept transects at each site. Epibenthic density records mean number of organisms per square metre from four 20x1 m transects at each site. * indicates estimated density only. nr = not recorded. EPR = East Point Reserve; SS = South Shell Island; WR = Weed Reef.

N/A – accurate depth data is not available for these sites, as they were outside the area of the detailed bathymetric survey.

Table 2 Summary of Pipeline Route and Reference Site Benthic Community Percent Cover

Site	Sponge cover	Soft coral cover	Bryozoan cover	Ascidian cover	Hard coral cover	Acroporidae cover	Fungiidae cover	Pectiniidae cover	Merulinidae cover	Faviidae cover	Poritidae cover
Preferred pipeline corridor											
A10	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0.1	0	0	0	0	0	0	0
A5	0.5	0.2	0	0	0	0	0	0	0	0	0
A6	0.6	0	0	0	0	0	0	0	0	0	0
A7	0.3	0.1	0	0	0	0	0	0	0	0	0
A8	0.2	0.1	0.1	0	0	0	0	0	0	0	0
Northern pipeline diversion											
B2	0	0	0	0	0	0	0	0	0	0	0
B3	0	0	0	0	0	0	0	0	0	0	0
Sand habitat reference sites											
OUT3	3.6	1.5	0	0.4	0	0	0	0	0	0	0
OUT6	7.4	0.8	0	0	0.1	0	0	0	0	0	0
Reef habitat reference sites											
EPR1	12.9	0	0	0.7	42.3	0.9	2.1	11.0	6.0	12.5	2.7
EPR2	15.0	1.7	0.8	0.4	1.0	0	0	0.1	0	0.2	0.1
SS	12.9	2.2	0	0.5	25.0	0.9	0.9	14.5	0.8	1.1	4.5
WR	5.4	8.7	0	0.2	48.5	6.7	7.3	23.2	2.1	3.1	3.2

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Percentage cover figures are means from groups of four 20 m line intercept transects at each site. EPR = East Point Reserve; SS = South Shell Island; WR = Weed Reef.

Table 3 Pipeline Route and Reference Site Benthic Organism Abundance

Site	Sponges	Hydroids	Hard coral	Soft coral	Bryozoan	Ascidian
Preferred pipeline corridor						
A10	0	0	0	0	0	0
A2	0	0	0	0	0	0.54
A3	0	0	0	0	0	0
A4	0	0	0	0.01	0	0
A5	0.15	0	0	0.1	0.03	0.03
A6	0.73	0	0	0.09	0.16	0.08
A7	0.53	0	0	0.03	0.08	0.09
A8	0.59	0.15	0	0.08	0.06	0.11
Northern pipeline diversion						
B2	0	0	0	0	0	0.29
B3	0.13	0.05	0	0.01	0	0.15
Sand habitat reference sites						
OUT3	2.11	0.25	0	2.79	0.03	0.04
OUT6	4.2	0.11	0.39	0.25	0	0.31

Benthic density records mean number of organisms per square metre from four 20x1 m transects at each site.

3.1 Description of the Preferred Pipeline Route

3.1.1 A10 to A3

The substrate of the inshore CH 0 - 800 m (A10-A3) of the preferred pipeline corridor was fine rippled or consolidated sand with very low benthic diversity (Figure 6). A species of solitary ascidian (Figure 7) was the only common benthic organism encountered (Table 3). Patches of the seagrass *Halophila decipiens* covered around 1% of the sand substratum at site A2 (Figure 8).

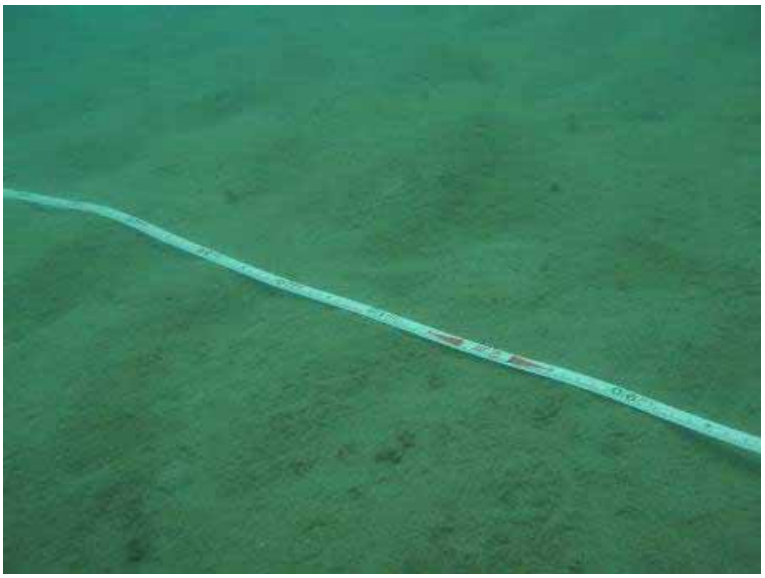

Figure 6 Sandy substrate type along the inner 800m of preferred pipeline corridor (site: B2)

Figure 7 **A species of solitary ascidian was the only common benthic organism encountered between sites A10 to A2.**

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Figure 8 **Approximately 1% of the substratum at site A2 was the seagrass *Halophila decipiens*.**

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3.1.2 A3 to A4

A major depth discontinuity about CH 700 - 1300 m (between sites A3 and A4) along the proposed pipeline alignment marked the point where a wide dune of mobile sand crossed the route. These sand waves are evident on the bathymetric survey (Part Two – Bathymetric Report). The large mobile sand waves run from the northern edge of East Point north up toward Nightcliff. There were no benthic organisms recorded on the mobile sand wave.

3.1.3 A4 to A7

West (seawards) of the sand wave system recorded at sites A3-A4 the depth increased rapidly and the substratum became increasingly muddy with deep, easily re-suspended silt covering the bottom. From approximately CH 1300 - 2700 m (A5 through to half way between A6-A7) along the proposed pipeline alignment the bottom was smooth soft sandy mud with some embedded pebbles and numerous worm and crustacean holes (Figure 9). This mud habitat supported a low diversity benthic community dominated by small communities of sponge species with occasional gorgonians, bryozoans and ascidians also present (Figure 10, Figure 11, Table 1 and Table 3). Mean densities of benthic organisms in this habitat ranged from 0.5 – 1.0 per square metre (Table 1).

Figure 9 Silty substrate type observed within the deeper basin of the preferred pipeline corridor (site: A6)

Figure 10 Large bryozoans overgrown by sponges along the proposed pipeline alignment within the deep mud habitat

Figure 11 A large sponge buried in the mud substratum along the proposed pipeline alignment

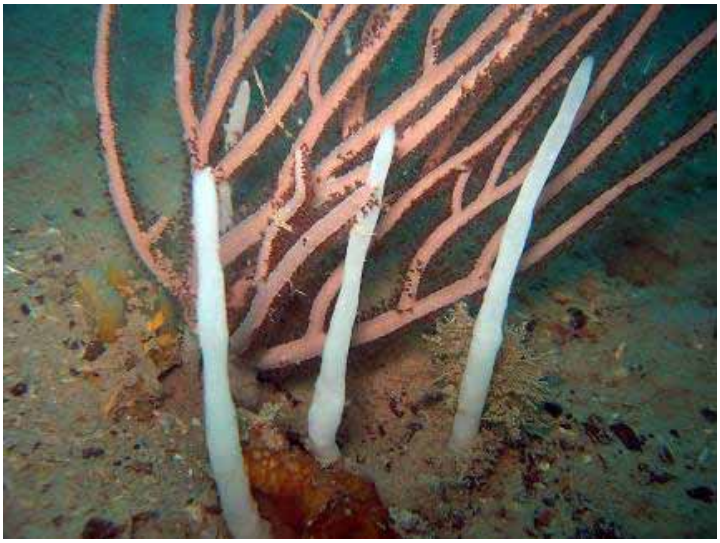

Figure 12 Gorgonians, sponges and bryozoans in the deep mud habitat

3.1.4 A7

Approximately 2700 m along the preferred pipeline corridor the depth began to decrease and the substratum became firmer and more sandy with numerous small pebbles and a low silt content (Figure 13). This habitat supported a low density benthic community dominated by sponges with some gorgonians, bryozoans and ascidians (Table 3).

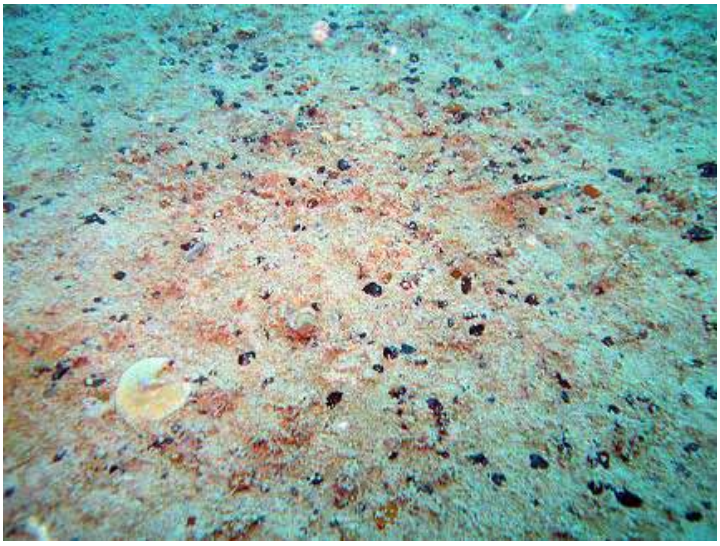

Figure 13 Pebbly sand substrate type on seaward side of deeper basin (site: A7)

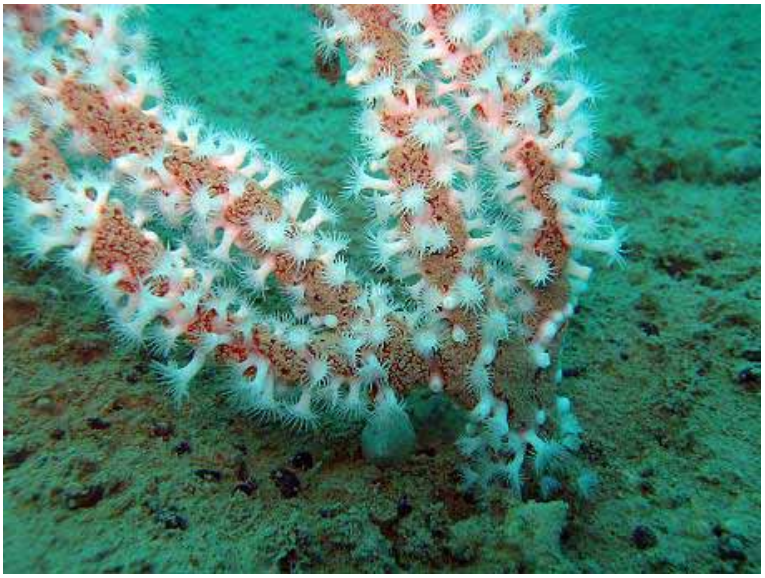

Figure 14 Zoanthids growing on sponges in the sand pebble habitat along the outer proposed pipeline alignment

3.1.5 A7 to A8

Approximately four large mobile sand wave systems between 3 and 5 m high crossed the proposed pipeline alignment over CH 2700 - 3085 m that show up as distinct features on the bathymetric map (Part Two – Bathymetric Report). These mobile sand waves did not support any benthic organisms (Table 1). Figure 15 shows the top of a smaller sand wave observed at site A7. It should be noted, that the sand waves observed between A7 and A8 were significantly larger than the one pictured in Figure 15.

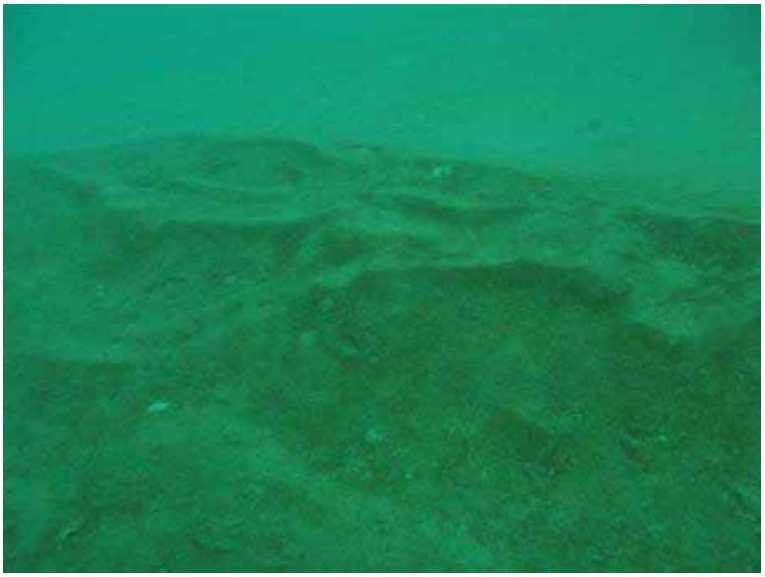

Figure 15 Sand wave observed at site A7

3.2 Description of Adjacent Sand Sites

The sand sites (B2 and B3) adjacent to the proposed pipeline alignment sites (A2 and A3) recorded habitat similar to the inshore 800 m of the proposed pipeline alignment. The substratum was fine rippled or consolidated sand with very low benthic diversity (Table 3). A species of solitary ascidian was the only organism encountered at site B2. A very low abundance of sponges, hydroids and soft corals were encountered at site B3 (Table 3).

Patches of the seagrass *Halophila decipiens* covered 22% of the sand substratum at adjacent sand site B3 and less than 1% of the sand substratum at site A2. This seagrass species needs stable sand and light in order to survive. It is anticipated to be prevalent throughout the inshore area to the north of the proposed pipeline alignment. This species is a grazing resource for animals such as Dugongs, and is known as a fast coloniser able to quickly recolonise following a linear disturbance such as a pipeline instalment. Please see section 4.1 for more information regarding seagrass.

3.3 Description of the 2007 Sand Habitat Reference Sites

The two 2007 reference sites (OUT3 and OUT6) were approximately 450 m and 1200 m south of the proposed pipeline alignment. These sites supported a richer benthic community than the sand sites along the proposed pipeline alignment. These sites had some low sand waves with consolidated sand and low rock basement patches between them (Figure 16). There was moderate benthic diversity along the peaks of the sand waves (Figure 17). Both sites had moderate densities of benthic organisms averaging five per square metre, with sponges and gorgonians being most abundant. There was moderate benthic diversity at both sites with an average of about 40 species recorded per site (Table 1).

Figure 16 Exposed rock basement between sand waves at Outfall 6

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Figure 17 Large sponge garden along the peaks of the sand waves at Outfall 6

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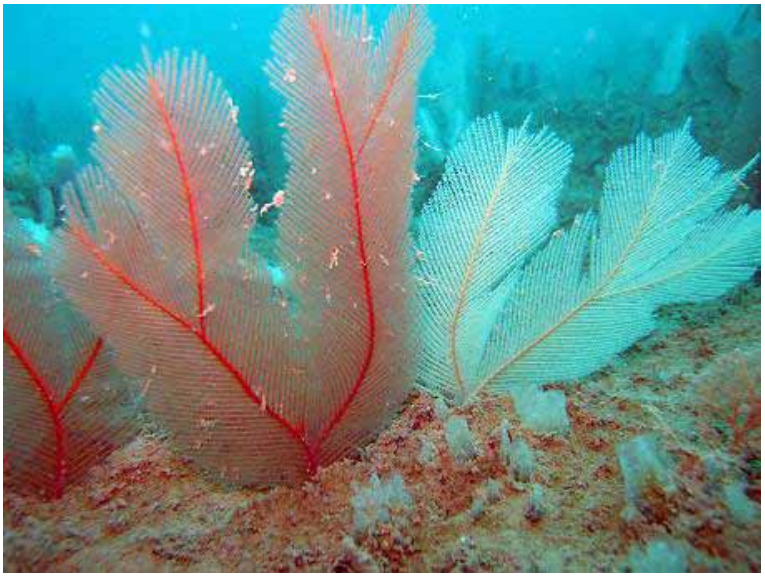

Figure 18 Gorgonian sea fans and sponges at the inner sand habitats Outfall 3

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Figure 19 Gorgonians, sponges and crinoids at Outfall 3

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3.4 Description of the East Point Reserve Reference Sites (EPR1 and EPR2)

The first East Point Reserve reference site (EPR1) was located on the shallow reef slope and was dominated by hard corals, which covered over 40% of the substratum (Figure 20). The families Faviidae and Pectiniidae were the most abundant coral families and accounted for more that half of the cover of hard corals recorded. Sponges were also common with a diverse range of species covering a total of 13% of the substratum. Combined benthic abundance was very high with almost 60% cover and an estimated density of over 10 organisms per square metre. Benthic diversity was very high with over 100 species recorded in the four transects.

The deeper East Point Reserve site (EPR2) had numerous reef patches on a sand substratum and supported a benthic community dominated by a diverse array of sponges (Figure 21 and Figure 22). The sponges covered 15% of the substratum, and accounted for almost three quarters of the overall benthic cover. Hard corals were rare at this site and only covered 1% of the substratum. Benthic diversity was very high at the site with over 100 species recorded.

Figure 20 Hard corals and sponges in the shallow East Point Marine Reserve site (EPR1)

Figure 21 Sponges and soft corals in the outer East Point Marine Reserve site (EPR2)

Figure 22 Numerous sponges and gorgonians in the outer East Point Marine Reserve site (EPR2)

3.5 Description of the Distant Reef Reference Sites

Two distant reef reference locations were surveyed with two sites recorded on the shallow reef slope at South Shell Island and two sites on the shallow reef slope at Weed Reef. All these sites had a high benthic cover dominated by hard corals and were similar to the shallow East Point Reserve site (Table 1 and Table 2). Pectiniid corals were dominant at South Shell (Figure 23 and Figure 24) and Pectiniid and Acroporid corals dominant at Weed Reef (Figure 25 through to Figure 28). Benthic diversity was high in these reef sites with over 90 species recorded at each site during the surveys.

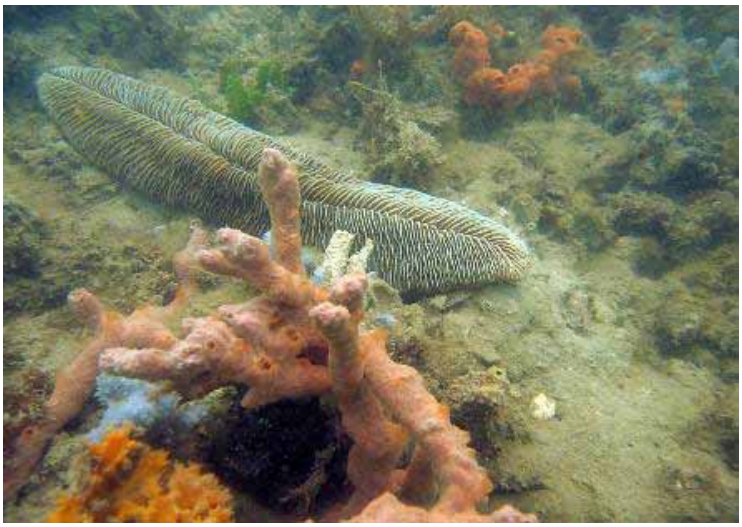

Figure 23 Sponges and fungiid coral at South Shell Island.

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Figure 24 The pectiniid coral *Mycedium elephantotus* was common at South Shell Island.

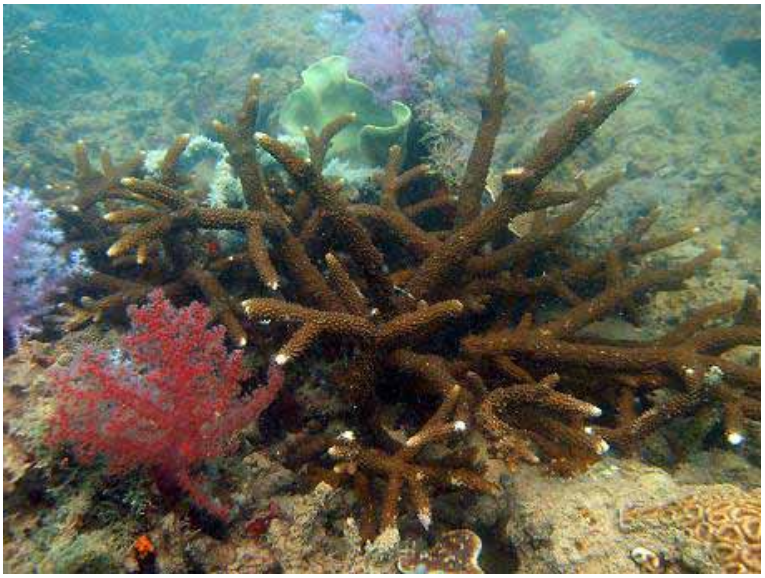

Figure 25 Staghorn *Acropora* coral with sponges and soft corals at Weed Reef

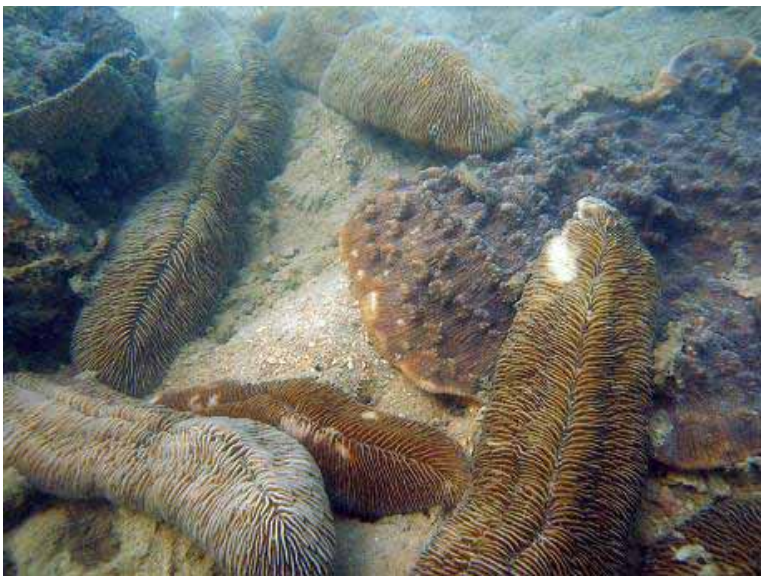

Figure 26 Pectiniid and fungiid corals at Weed Reef

Figure 27 Pectiniid hard corals dominated the Weed Reef sites.

Figure 28 Soft corals, sponges and gorgonians at Weed Reef

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3.6 Incidental observations

Incidental observations of mobile marine fauna were limited to two individual turtle sightings. The turtle sightings occurred within the East Point Marine Reserve at monitoring site EPR1. Both individuals were identified as green turtles (*Chelonia mydas*), one small (approximately 40 cm) and one medium size (approximately 60 cm). These species are relatively common within Darwin Harbour with many nesting sites in the NT, mostly concentrated from the western end of Melville Island to near the Queensland boarder (Chatto, 1998). Discussions with local dive operators indicated that they are commonly seen around the East Point area.

3.7 Community comparison between the proposed pipeline alignment and reference sites

The data analysis indicates that the proposed pipeline alignment has a significantly lower diversity, percent cover and density than all other sites surveyed. This includes the adjacent sand habitat sites (B2 and B3) and the 2007 sand habitat reference sites (Outfalls 3 and 6).

The mean data presented in Section 3.7.1 show the total benthic diversity, percentage cover and mean density at each location. The MDS and cluster analysis in Section 3.7.2 show the statistical relationship, or lack there of, between the sites along the proposed pipeline alignment, as well as the sand habitat reference sites (B2 and B3) and the reef sites (East Point Marine Reserve, South Shell Island and Weed Reef).

3.7.1 Diversity, Cover and Density of the Benthos

The graphs presented in Figure 29 to Figure 33 provide a summary of the data in Tables 1 to 3. The graphs show mean total benthic diversity per location, mean percentage cover at each location and mean density at each location. Error bars are standard errors. Locations have been grouped as follows:

- Pipeline = preferred pipeline corridor (n=8 sites);
- Sand ref. = 2007 sand habitat reference sites (n=2);
- EPR deep = East Point Reserve 2, deep reference site (n=1);
- EPR reef = East Point Reserve 1 reef slope site (n=1);
- Distant reef = Distant reef reference sites at South Shell and Weed Reef (n=4).

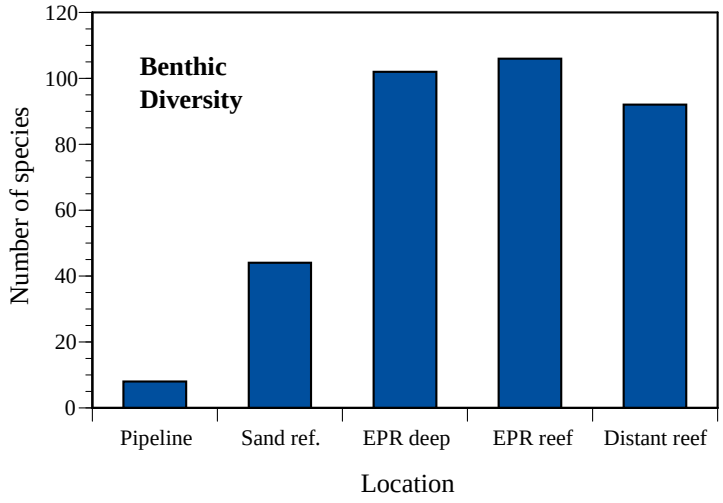

Figure 29 Benthic Diversity Comparison Graph

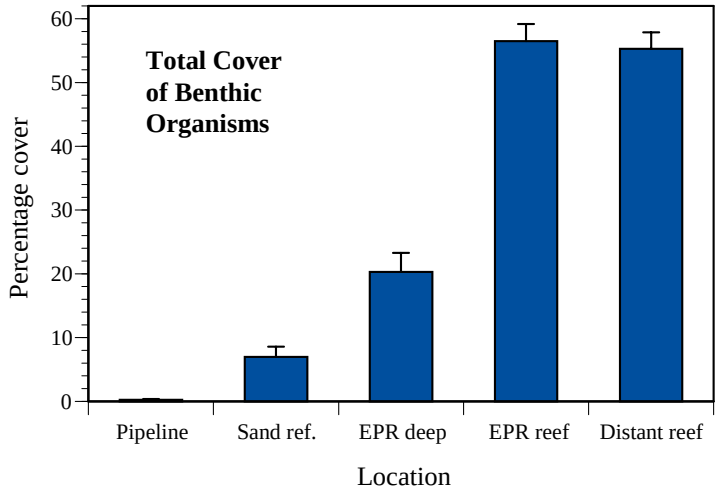

Figure 30 Total Benthic Cover Comparison Graph

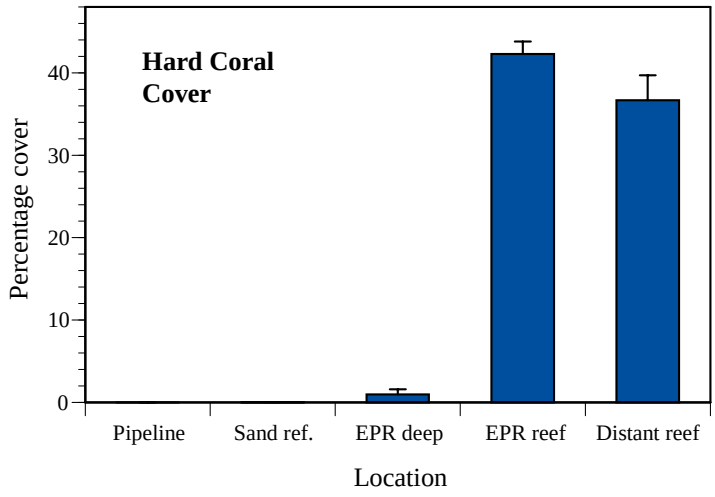

Figure 31 Hard Coral Cover Comparison Graph

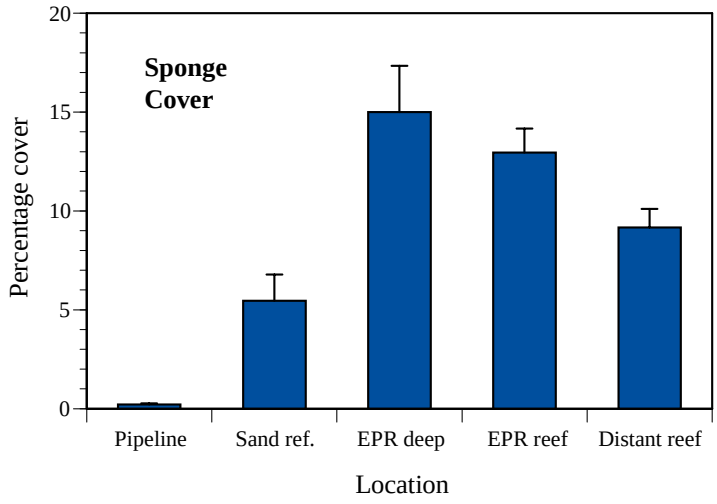

Figure 32 Sponge Cover Comparison Graph

3.7.2 Multidimensional Scaling (MDS) and Analysis of Similarity (ANOSIM)

There are clear differences among the sites in terms of diversity, cover values and organism densities, with the communities along the proposed pipeline route having low values for all three parameters. What these parameters do not demonstrate is whether the different sites are in some way unique, or tend more to being replicates of one another, though some are less diverse than others.

How distinct the communities are one from another is determined analysing the levels of similarity among the communities. Percentage similarities of the faunas of the different sites were determined using data on cover of the faunal groups found at each site. 100% similarity would mean two sites were identical, and 0% similarity would mean that the sites were completely different. Two methods are used to display the patterns of similarity among the different sites.

One is a diagram generated by Multidimensional Scaling (MDS) showing each site as a dot. The sites that have high levels of similarity to each other form groups of dots that are separated from other groups. Each of the separated groups of dots are composed of sites that have a higher levels of similarity to each other than sites in other groups. Figure 33 demonstrates that the sites fall into two major groups at the 60% level of similarity. These are referred to as Group 1 and Group 2. Group 1 contains the pipeline and adjacent sand habitats, while Group 2 is composed of sites from the East Point, South Shell and Weed Reefs. Most of the 2007 sand habitat reference sites (outfalls 3 and 6) fall between the two groups, seemingly exhibiting similarities to both groups.

The Group 1 sites are more ambiguously split at the 80% similarity level with one group containing all the pipeline sites and sand habitat sites except one transect from site B3. Site B3 within the sand habitat is separate from the within the 60% similarity group of Group 1, but is clearly ungrouped from the remainder of the sites.

At the 80% similarity level there are three sub-groups within Group 2:

- The deeper water East Point sites;
- Most of the South Shell sites (excluding 2 transects from SS1); and
- All Weed Reef sites, the shallow reef East Point sites and the two transects from the South Shell 1 (SS1) site.

The second depiction of relationships among the sites is use of a cluster analysis and diagram showing a branching structure beginning with a single stem composed of all sites at the top (with an overall low similarity to each other). The branches separate the sites into groups with higher similarity to one another than to other groups of sites. This in turn is subdivided into more groups of sites with even higher levels of similarity to one another. Figure 34 shows that this depiction of the site similarities displays a Group 1 and Group 2 diverging at approximately the 50% similarity level. Group 2 contains the East Point sites, the Weed Reef and South Shell sites, as was the case with the MDS diagram. Group 1 contains the pipeline and adjacent sand habitats along with the 2007 sand habitat reference sites, which were largely separated from the pipeline and sand habitats in the MDS diagram (Figure 33). All but one of the 2007 sand habitats and three of the adjacent sand habitats are separated from the pipeline sites at approximately the 85% level of similarity, leaving a sub-cluster composed mostly of pipeline sites.

Both depictions of the patterns of similarity of the sites suggest that the pipeline and adjacent sand sites are different from the reef habitats, and to a lesser extent from the 2007 sand reference sites. The pipeline sites overlap to some extent with the other sand habitats, but in the main appear to form a distinct grouping. As well as being supported by the photographic, visual evidence of differences

between the two groups of sites, the reliability of the similarity pattens is in accord with the statistical evidence.

Statistical analysis made use of the R-statistic, ranging from 0 (no difference between sites) to 1 (no similarity between sites). Comparison of Group 1 with Group 2 from the cluster analysis yields a Global R-statistic of 0.976 (p=0.001) indicating a significant difference between the two groups. The Global R-statistic from a comparison of Groups 1 and 2 from the MDS analysis again indicated a significant difference between the groups (Global R=0.842, p = 0.001). Tests involving pair-wise comparisons of all sites (Table 4) indicate that the pipeline sites are significantly different from the adjacent sand habitats ($p<0.05$), with greater differences ($p<0.001$) from the three reef locations and the 2007 habitat reference sites.

The similarity analyses demonstrate that the benthic communities at the pipeline sites are:

- Closely aligned with, but significantly different from those of the adjacent sand habitat; and
- Differ greatly from the reef sites and the 2007 sand habitat reference sites.

The basis of the similarity between the pipeline sites and the adjacent sand sites seems to be associated with both communities having low levels of sponge, soft coral and ascidian cover. The differences are that:

The adjacent sand communities have cover at a slightly higher levels than the pipeline communities;

- The pipeline communities have a very low level of bryozoan cover; while
- The adjacent sand communities have a low level cover of hard coral.

The parameters used to assess the communities are suggestive of the site on the pipeline route maintaining a degraded community possibly extracted from that found in the less physically disturbed adjacent sand habitats. The pipeline communities are unlikely to be unique

Table 4 Pairwise test of all locations (R-statistic)

R-Statistic	Pipeline	Sand Habitat	East PT	South Shell	Weed Reef	2007 sand habitat reference sites
Pipeline	-	0.332*	0.985**	1**	1**	0.913
Sand Habitat	-	-	0.895**	1**	1**	0.594**
East PT	-	-	-	0.182	0.448**	0.671**
South Shell	-	-	-	-	0.515**	0.994**
Weed Reef	-	-	-	-	-	1**
2007 sand habitat reference sites	-	-	-	-	-	-

Note: (*) significance level less than 0.05, (**) significance level is 0.01

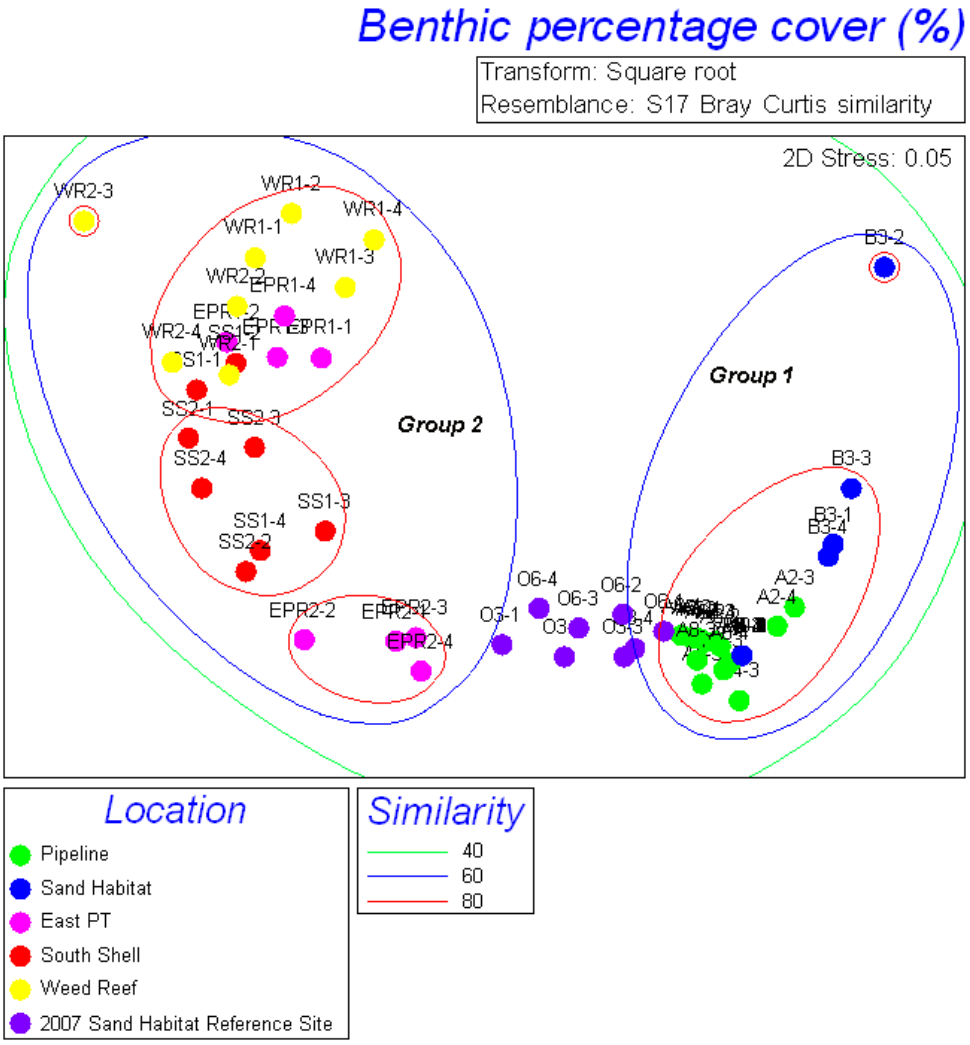

Figure 33 MDS analysis of fauna percentage cover (stress = 0.04)

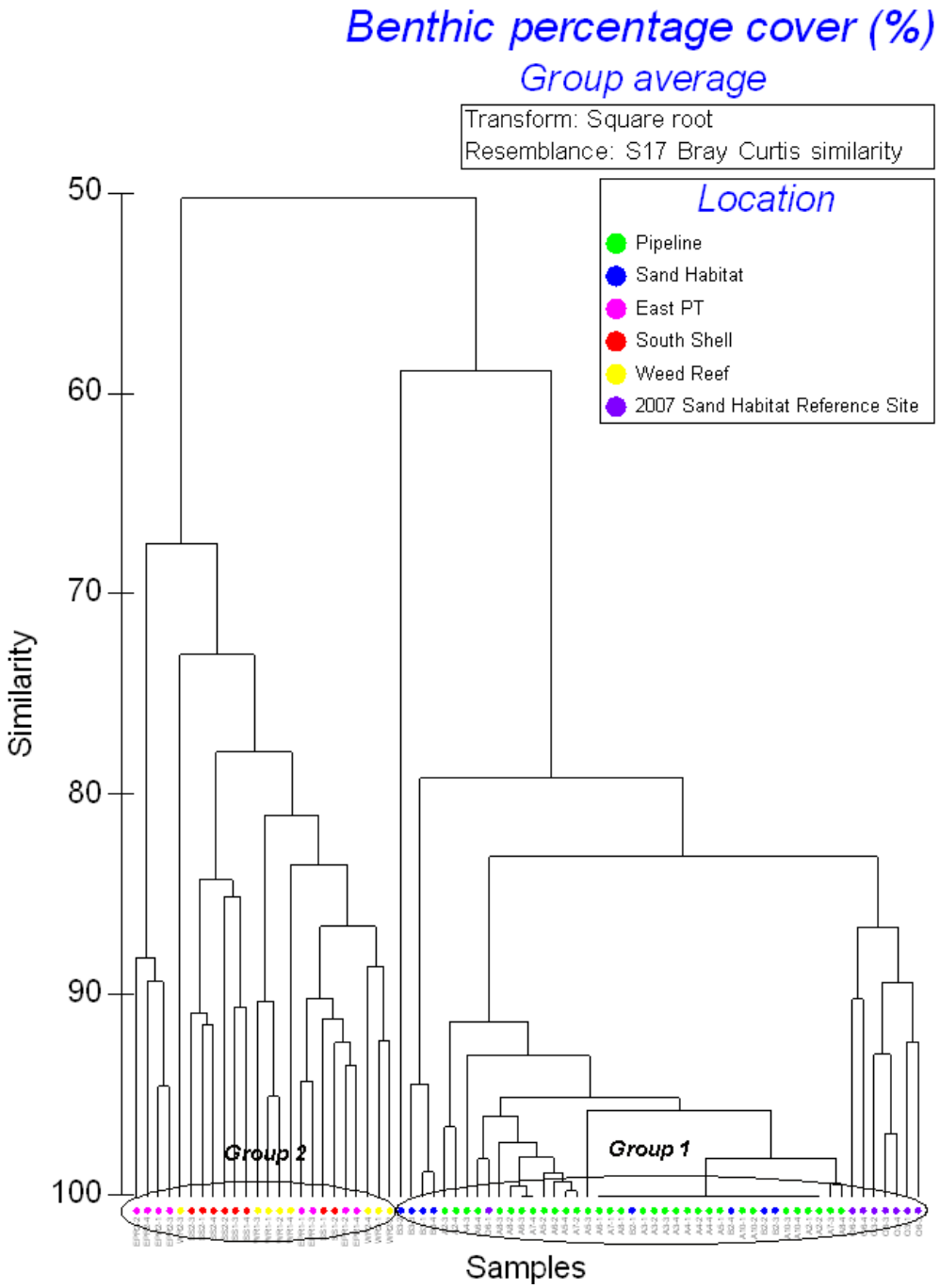

Figure 34 Cluster analysis of fauna percentage cover

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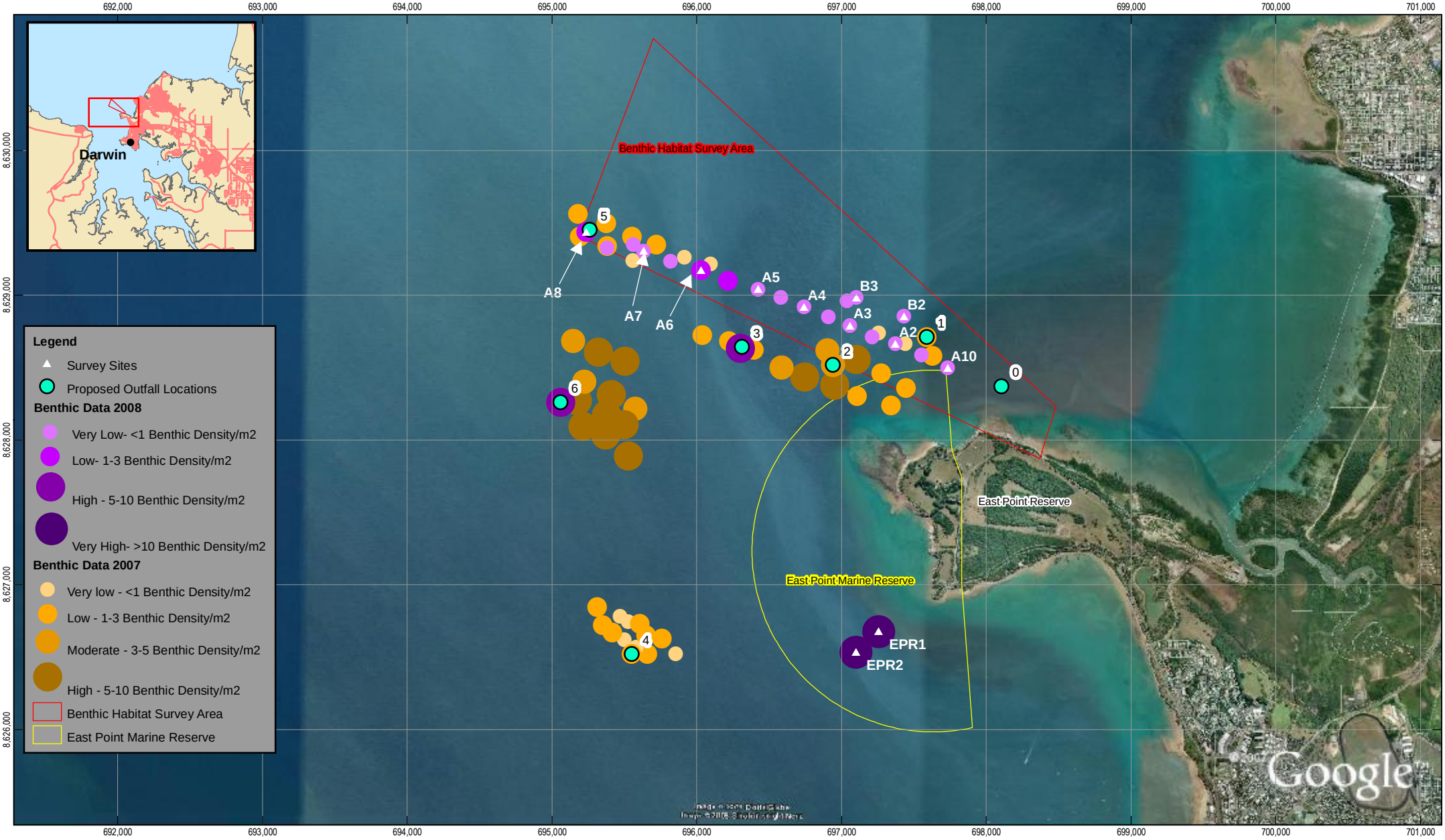
3.8 Comparison with GHD (2007) Findings

The report titled *Survey of Benthic Habitats in the Vicinity of the East Point Sewage Outfall* (GHD 2007) discusses the results of a drop camera survey of benthic habitats adjacent to the East Point outfall during February 2007. This survey was a qualitative assessment focusing on alternative outfall locations in the area immediately to the south west of the current preferred alignment.

Two sites surveyed during the 2007 survey (Outfalls 3 and 6) were incorporated into the current (2008) survey. Figure 3.3 of the 2007 report (GHD, 2007) illustrates benthic habitat distribution and density estimates. This figure indicates that Outfall 6 (OUT6) is characterised by a 'High' density of benthic organisms, while Outfall 3 (OUT3) is characterised by a 'Moderate' density of benthic organisms. Quantitative benthic density data collected in 2007 (GHD, 2007) indicate that Outfall 3 (5.21 organisms per m^2) has a lower diversity than Outfall 6 (5.26 organisms per m^2) although the difference is minor (Table 1).

Figure 36 presents the benthic habitat density at each site for the 2008 survey (represented by the purple colour) and the qualitative assessment made during the 2007 survey (represented by the orange colour). The low density of benthic organisms in the proposed pipeline alignment contrasts with the higher densities of adjacent habitats.



1:35,000 (at A4)

0 162.5 325 650 975 1,300

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

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PowerWater

Power and Water Corporation
Proposed East Point Outfall, Bathymetic and Benthic Survey

Job Number 43-21461
Revision A
Date 02 FEB 2009

Benthic Density Estimates

Figure 35

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Level 5, 66 Smith Street Darwin NT 0800 T 61 8 8982 0100 F 61 8 8981 1075 E W www.ghd.com.au

Data source: Benthic Habitat Survey Area Data from PowerWater Corporation, Benthic Survey Sites and 2008 - 2007 Data from GHD , Northern Territory Coastline data, Cadastre Data and Roads Data from Northern Territory Government, Reserve Data from GHD, Imagery Obtained from Google Earth Pro, WARNING Google Earth Imagery is not Orthorectified

Created by: sdwoodger

4. Discussion

4.1 Benthic Cover Comparisons

The proposed pipeline alignment was characterised by sand and mud habitats with low to very low benthic diversity and abundance compared to sand and reef locations in the Darwin Harbour region.

Patches of the seagrass *Halophila decipiens* covered less than 1% of the sand substratum at site A2 and 22% of the sand substratum at Northern diversion site B3. This species needs stable sand and light in order to survive. It is anticipated to be prevalent throughout the inshore area to the north of the proposed pipeline alignment. Animals such as dugongs feed on this species. It is a fast coloniser and would quickly recolonise following a linear disturbance such as a pipeline instalment.

Darwin Harbour does not maintain a large population of dugong (Bayliss 1986). Surveys reveal that the Northern Territory's larger populations are located in the Gulf of Carpentaria and to the northwest of the Tiwi Islands (Bayliss 1986; Bayliss and Freeland 1989; and Saalfeld 2000). Populations are found in shallow coastal areas where seagrass beds occur. Within Darwin Harbour small areas of seagrass that dugongs are known to exploit are located adjacent to Mandorah, Casuarina Beach and Fannie Bay (Acer Vaughan, 1993). McKinnon *et al*. (2006) recorded a number of sightings in Darwin Harbour, but provided no quantitative information on abundance in the harbour or relative to the remainder of the Northern Territory population. It is unlikely that any substantial population of dugong is feeding on the small seagrass patch at the B3 site.

Rich benthic communities dominated by sponges and gorgonians occurred in both sand reference sites, which is consistent with the GHD 2007 survey results. In comparison the sand-living communities surveyed along the pipeline corridor were relatively sparse and had a low diversity.

All the reef reference communities supported rich benthic communities at least an order of magnitude higher in benthic density and diversity compared to the communities recorded along the proposed pipeline alignment.

4.2 Water Movement Indications

The large sand wave systems observed at site A3 and between A7 and A8 (Part Two – Bathymetric Report) are likely to be deposited along current lines. It seems likely that the fine muddy sediments observed in the deep basin between A4 and A7 are deposited in a slack current eddy generated by East Point. If current measurements and modelling being undertaken by Charles Darwin University (CDU) support this suggestion, the deeper basin may not provide optimal dilution and mixing for the proposed outfall. It may be preferable to extend the pipeline beyond this deeper basin, into the sand wave system between A7 and A8. Visually, this sand wave area appeared subject to stronger currents.

5. Conclusions and Recommendations

5.1 Conclusions

The benthic habitats along the proposed pipeline alignment are less diverse and have few organisms than the other sites surveyed. The proposed pipeline sites are representative a benthic habitat of considerably lower conservation significance than the other sites surveyed. The lack of reef structure, along with the high tidal currents results in large areas of mobile sand waves, making benthic colonisation difficult.

From an ecological perspective there appears to be fewer constraints within the footprint of the proposed pipeline alignment. It is likely that the introduction of a solid structure in this generally unconsolidated environment may provide an anchor point for colonisation and lead to an increase in the density of benthic organisms.

The area to the south of the proposed pipeline alignment, including the East Point Marine Reserve, showed considerably higher diversity, density and percent cover than the proposed pipeline alignment. Appropriate environmental management practices seem likely to prevent significant impact during construction. These communities should be considered during hydrodynamic modelling, outfall location selection and baseline monitoring in order to predict and monitor potential impacts during operation.

5.2 Recommendations

GHD recommends that PWC take the following into consideration:

- Undertaking new ocean outfall modelling based on the bathymetric survey data collected during this project;
- Undertaking baseline ecological studies once the final pipeline route has been established;
- Establishment of permanent benthic transects for ongoing monitoring;
- Undertaking tidal velocity and direction studies at the deep hole adjacent to East Point along the proposed pipeline alignment; and
- Consider undertaking a bathymetric survey in the early dry season to further understand the movements, if any, of the sand waves recorded during this project.

6. References

Acer Vaughan. 1993. *Darwin Port expansion Environmental Impact Statement*. Report for Department of Transport and Works, Northern Territory Government.

Acer Vaughan. 1993. *Darwin Port expansion Environmental Impact Statement: Supplementary Report*. Report for Department of Transport and Works, Northern Territory Government.

Ayling A.M. and Ayling A.L. 1995. A preliminary survey of benthic communities on fringing reefs in the middle Cairns Section. Unpublished report submitted to the Great Barrier Reef Marine Park Authority.

Ayling A.M. and Ayling A.L. 2002. Long term monitoring program for marine benthos in the vicinity of Keswick Island development (Whitsunday Island Group): baseline survey, Unpublished report to the Great Barrier Reef Marine Park Authority. 18 pp.

Ayling A.M. and Ayling A.L. 2005. The Dynamics of Cairns Section Fringing Reefs: 2004. Unpublished report to the Great Barrier Reef Marine Park Authority. 82 pp.

Bayliss, P. 1986. *Factors affecting aerial survey of marine fauna, and their relation to a census of dugong in the coastal waters of the northern Australia*. Australian Wildlife Research 13:27-32.

Bayliss, P. and Freeland, W. J. 1989. *Seasonal patterns of distribution and abundance of dugongs in the western Gulf of Carpentaria*. Australian Wildlife Research 16: 141-149.

Chatto, R, 1998. A preliminary review of the locations of marine turtle nesting in the Northern Territory. In *Marine turtle conservation and management in northern Australia* (eds R Kennett, A Webb, G Duff, M Guinea and G Hill) pp 33-40.

GHD 2006. Survey of Benthic Habitats in the Vicinity of the East Point Sewage Outfall. Report for Power and Water Corporation.

McKinnon et al. 2006. *Darwin Harbour: Water Quality and Ecosystem Structure on a Tropical Harbour in the Early Stages of Urban Development*, Pp 433-459 in Wolanksi. E. (ed.) The Environment in Asia Pacific Harbours, Springer Netherlands.

Mapstone B.D., Choat J.H., Cumming R.L. and Oxley W.G. 1989. The fringing reefs of Magnetic Island: benthic biota and sedimentation - a baseline survey. Unpublished report to the Great Barrier Reef Marine Park Authority. 88 pages.

Saalfeld, W.K. 2000. *Distribution and abundance of dugong in the coastal waters of the Northern Territory*. Technical report, Parks and Wildlife Commission of the Northern Territory.

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Appendix A

Raw Data

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Site	Transect	Sponge	Gorgonians	Pyura	Ascidian	Anemone	Sea pen	Bryozoan	Crinoid	Sabellid	Hydroid	Solitary coral	Seagrass	Total benthos	Site means	sd	Diversity
A10	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0.01	0.03	2
A10	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
A10	3	0	0	0	0	0	0	0	0	0	0	0	0	0			
A10	4	0	0	0	0	0	0	0	0	0	0	0	0	0			
A2	1	0	0	16	0	0	0	0	0	0	0	0	0	16	0.60	0.18	4
A2	2	0	0	6	0	1	1	0	0	0	0	0	0	8			
A2	3	0	0	8	0	0	0	0	1	0	0	0	1	10			
A2	4	0	0	13	0	0	0	0	0	0	0	0	1	14			
A3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0.06	3
A3	2	0	0	0	0	1	0	0	1	0	0	0	0	2			
A3	3	0	0	0	0	0	0	0	0	0	0	0	0	0			
A3	4	0	0	0	0	0	1	0	1	0	0	0	0	2			
A4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.05	3
A4	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
A4	3	0	0	0	1	0	0	0	0	1	0	0	0	2			
A4	4	0	0	0	0	1	0	0	0	0	0	0	0	1			
A5	1	3	4	0	1	0	0	0	0	0	0	0	0	8	0.30	0.08	9
A5	2	4	0	0	1	0	0	1	0	0	0	0	0	6			
A5	3	2	3	0	0	0	0	1	0	0	0	0	0	6			
A5	4	3	1	0	0	0	0	0	0	0	0	0	0	4			
A6	1	14	3	0	3	0	0	3	0	0	0	0	0	23	1.06	0.18	12
A6	2	12	1	0	1	0	0	2	1	0	0	0	0	17			
A6	3	13	1	0	2	0	0	4	0	0	0	0	0	20			
A6	4	19	2	0	0	0	0	4	0	0	0	0	0	25			
A7	1	2	1	0	3	0	0	1	0	0	0	0	0	7	0.73	0.37	11
A7	2	8	0	0	1	0	0	0	1	0	0	0	0	10			
A7	3	20	1	0	0	0	0	2	0	0	0	0	0	23			
A7	4	12	0	0	3	0	0	3	0	0	0	0	0	18			
A8	1	20	1	0	1	0	0	2	1	0	2	0	0	27	1.11	0.26	20
A8	2	9	2	0	4	0	0	2	4	0	5	0	0	26			
A8	3	7	2	0	4	0	0	0	2	0	5	0	0	20			
A8	4	11	1	0	0	0	0	1	3	0	0	0	0	16			
B2	1	0	0	11	1	0	0	0	4	0	0	0	0	16	0.45	0.26	3
B2	2	0	0	5	0	0	0	0	1	0	0	0	0	6			
B2	3	0	0	5	0	0	0	0	5	0	0	0	0	10			
B2	4	0	0	1	0	0	0	0	3	0	0	0	0	4			
B3	1	3	0	0	0	1	0	0	1	0	0	0	1	6	0.53	0.21	11
B3	2	3	1	0	2	1	0	0	3	0	0	0	1	11			
B3	3	2	0	2	2	0	0	0	2	0	0	0	1	9			
B3	4	2	0	1	5	0	0	0	3	0	4	0	1	16			
O3	1	63	88	0	1	0	0	0	0	0	12	0	0	164	5.21	2.09	35
O3	2	38	54	0	2	0	0	1	0	0	6	0	0	101			
O3	3	19	61	0	0	0	0	1	0	0	0	0	0	81			
O3	4	49	20	0	0	0	0	0	0	0	2	0	0	71			
O6	1	51	2	0	4	0	0	0	0	0	2	8	0	67	5.26	1.73	54
O6	2	118	0	0	8	0	0	0	0	0	6	3	0	135			
O6	3	55	16	0	5	0	0	0	0	0	1	8	0	85			
O6	4	112	2	0	8	0	0	0	0	0	0	12	0	134			

Site	Transect	Sponge	Gorgonians	Pyura	Ascidian	Anemone	Sea pen	Bryozoan	Crinoid	Sabellid	Hydroid	Solitary coral	Seagrass	Total benthos
A10	mean	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	sd	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
A2	mean	0.00	0.00	0.54	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.03	0.60
	sd	0.00	0.00	0.23	0.00	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.03	0.18
A3	mean	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.05
	sd	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.06
A4	mean	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.04
	sd	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.05
A5	mean	0.15	0.10	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.30
	sd	0.04	0.09	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.08
A6	mean	0.73	0.09	0.00	0.08	0.00	0.00	0.16	0.01	0.00	0.00	0.00	0.00	1.06
	sd	0.16	0.05	0.00	0.06	0.00	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.18
A7	mean	0.53	0.03	0.00	0.09	0.00	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.73
	sd	0.38	0.03	0.00	0.08	0.00	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.37
A8	mean	0.59	0.08	0.00	0.11	0.00	0.00	0.06	0.13	0.00	0.15	0.00	0.00	1.11
	sd	0.29	0.03	0.00	0.10	0.00	0.00	0.05	0.06	0.00	0.12	0.00	0.00	0.26
B2	mean	0.00	0.00	0.28	0.01	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.45
	sd	0.00	0.00	0.21	0.03	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.26
B3	mean	0.13	0.01	0.04	0.11	0.03	0.00	0.00	0.11	0.00	0.05	0.00	0.05	0.53
	sd	0.03	0.03	0.05	0.10	0.03	0.00	0.00	0.05	0.00	0.10	0.00	0.00	0.21
O3	mean	2.11	2.79	0.00	0.04	0.00	0.00	0.03	0.00	0.00	0.25	0.00	0.00	5.21
	sd	0.93	1.40	0.00	0.05	0.00	0.00	0.03	0.00	0.00	0.26	0.00	0.00	2.09
O6	mean	4.20	0.25	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.11	0.39	0.00	5.26
	sd	1.80	0.37	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.13	0.18	0.00	1.73
PIPE	mean	0.25	0.04	0.07	0.04	0.01	0.00	0.04	0.02	0.00	0.02	0.00	0.00	0.49
	sd	0.11	0.02	0.03	0.04	0.01	0.01	0.02	0.02	0.00	0.02	0.00	0.00	0.15
REF	mean	3.16	1.52	0.00	0.18	0.00	0.00	0.01	0.00	0.00	0.18	0.19	0.00	5.24
	sd	1.36	0.88	0.00	0.08	0.00	0.00	0.01	0.00	0.00	0.20	0.09	0.00	1.91

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Site	Transect	Sponge	Gorgonians	Pyura	Didemnum	Anemone	Sea pen 1	Bryozoan	Crinoid	Sabellid	Hydroid	Solitary coral	Seagrass	Total benthic
A10	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	2	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	3	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	4	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	3	0	0	0	0	0	0	0	0	0	0	0	65	0
A2	4	0	0	0	0	0	0	0	0	0	0	0	25	0
A3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	2	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	4	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	3	0	0	0	3	0	0	0	0	12	0	0	0	15
A4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	2	23	0	0	0	0	0	0	0	0	0	0	0	23
A5	3	0	16	0	0	0	0	0	0	0	0	0	0	16
A5	4	15	0	0	0	0	0	0	0	0	0	0	0	15
A6	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	2	11	0	0	0	0	0	0	0	0	0	0	0	11
A6	3	6	0	0	0	0	0	0	0	0	0	0	0	6
A6	4	34	0	0	0	0	0	0	0	0	0	0	0	34
A7	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	2	17	0	0	0	0	0	0	0	0	0	0	0	17
A7	3	0	4	0	0	0	0	0	0	0	0	0	0	4
A7	4	6	0	0	0	0	0	0	0	0	0	0	0	6
A8	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	2	4	0	0	0	0	0	0	0	0	0	0	0	4
A8	3	11	0	0	0	0	0	3	0	0	0	0	0	14
A8	4	0	2	0	0	0	0	0	0	0	0	0	0	2
B2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
B2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
B2	3	0	0	0	0	0	0	0	0	0	0	0	0	0
B2	4	0	0	0	0	0	0	0	0	0	0	0	0	0
B3	1	0	0	0	0	0	0	0	0	0	0	0	225	0
B3	2	0	0	0	0	0	0	0	0	0	0	0	990	0
B3	3	0	0	0	0	0	0	0	0	0	0	0	365	0
B3	4	0	0	0	0	0	0	0	0	0	0	0	195	0
O3	1	142	58	0	8	0	0	0	0	0	22	0	0	230
O3	2	61	32	0	17	0	0	0	0	0	5	0	0	115
O3	3	34	22	0	4	0	0	0	0	0	0	0	0	60
O3	4	47	6	0	5	0	0	0	0	0	0	0	0	58
O6	1	56	0	0	0	0	0	0	0	0	0	0	0	56
O6	2	133	0	0	0	0	0	0	0	0	0	0	0	133
O6	3	107	56	0	0	0	0	0	0	0	0	0	0	163
O6	4	292	5	0	0	0	0	0	0	0	0	3	0	300

Site	Transect	Sponge	Gorgonians	Pyura	Didemnum	Anemone	Sea pen 1	Bryozoan	Crinoid	Sabellid	Hydroid	Solitary coral	Seagrass	Total benthic
A10	mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	sd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2	mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00
	sd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00
A3	mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	sd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4	mean	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.19
	sd	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.38
A5	mean	0.48	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68
	sd	0.57	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
A6	mean	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64
	sd	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
A7	mean	0.29	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
	sd	0.40	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
A8	mean	0.19	0.03	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.25
	sd	0.26	0.05	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.31
B2	mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	sd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B3	mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.19	0.00
	sd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.58	0.00
O3	mean	3.55	1.48	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	5.79
	sd	2.43	1.09	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	4.03
O6	mean	7.35	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	8.15
	sd	5.09	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	5.09
PIPE	mean	0.20	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.14	0.26
	sd	0.25	0.07	0.00	0.01	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.19	0.28
REF	mean	5.45	1.12	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.17	0.02	0.00	6.97
	sd	3.76	1.23	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.26	0.04	0.00	4.56

Appendix B

Sample Collection Species List

As provided by NTMAG

GHD Pty Ltd
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Fisheries Permit Number: 2008-2009/S17/2703

STN_FIELD_	REGO_NO_	CLASS	ORDER_	FAMILY_	GENUS_	SPECIES_	AUTHOR_	WORKING_NA
A5	Z005635	Demospongiae	Haplosclerida	Phloeodictyidae	Oceanapia			
A7	Z005652	Demospongiae	Poecilosclerida	Raspailiidae	Trikentrion	flabelliforme	Carter, 1882	
A7	Z005653	Demospongiae	Poecilosclerida	Raspailiidae	Endectyon?	sp.		
A7	Z005654	Demospongiae	Poecilosclerida	Raspailiidae	Endectyon?	sp.		
A7	Z005655	Demospongiae	Poecilosclerida	Raspailiidae	Raspailia (Raspailia)	phakellopsis	Hooper, 1991	
A7	Z005656	Demospongiae	Poecilosclerida	Raspailiidae	Raspailia (Raspailia)	phakellopsis	Hooper, 1991	
A7	Z005657	Demospongiae	Hadromerida	Hemiasterellidae	Axos	flabelliformis	Carter, 1879	
A7	Z005661	Demospongiae	Halichondrida	Halichondriidae	Ciocalypta	oscitans	Hooper et al, 1997	
B3	Z005658	Demospongiae	Hadromerida	Clionidae	Spheciospongia?			
EPR1	Z005636	Demospongiae	Verongida	Pseudoceratinidae	Pseudoceratina	verrucosa	Bergquist, 1995	
EPR1	Z005637	Demospongiae	Verongida	Pseudoceratinidae	Pseudoceratina	verrucosa	Bergquist, 1995	
EPR1	Z005638	Demospongiae	Poecilosclerida	Microcionidae	Clathria?	sp.		
EPR1	Z005639	Demospongiae	Poecilosclerida	Tedaniidae	Tedania?			
EPR1	Z005640	Demospongiae	Poecilosclerida	Tedaniidae	Tedania?			
EPR1	Z005641	Demospongiae	Dictyoceratida	Dysideidae	Dysidea	sp.		CRRF2089
EPR1	Z005642	Demospongiae	Dictyoceratida	Dysideidae	Dysidea			CRRF2089
EPR1	Z005643	Demospongiae	Dictyoceratida	Dysideidae	Dysidea			CRRF3071
EPR1	Z005644	Demospongiae	Dictyoceratida	Dysideidae	Dysidea			CRRF3071
EPR1	Z005645	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Thalysias)	reinwardti	Vosmaer, 1880	
EPR1	Z005646	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Thalysias)	reinwardti	Vosmaer, 1880	
EPR1	Z005647	Demospongiae	Halichondrida	Dictyonellidae	Acanthella	cavernosa	Dendy, 1922	
EPR1	Z005648	Demospongiae	Poecilosclerida	Microcionidae	Clathria	sp.		
EPR1	Z005649	Demospongiae	Halichondrida	Axinellidae	Reniochalina	stalagmitis	Lendenfeld, 1888	
EPR1	Z005650	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Wilsonella)	cf. tuberosa	(Bowerbank, 1875)	
EPR1	Z005651	Demospongiae	Halichondrida	Dictyonellidae	Stylissa	flabelliformis	(Hentschel, 1912)	
EPR2	Z005659	Demospongiae	Poecilosclerida	Raspailiidae	Ceratopsion			0122
EPR2	Z005660	Demospongiae	Poecilosclerida	Raspailiidae	Ceratopsion			0122
Outfall 6	Z005662	Demospongiae	Halichondrida	Axinellidae	Axinella			1270
Outfall 6	Z005663	Demospongiae	Halichondrida	Axinellidae	Axinella	aruensis	(Hentschel, 1912)	
Outfall 6	Z005664	Demospongiae	Halichondrida	Axinellidae	Axinella	aruensis	(Hentschel, 1912)	
Outfall 6	Z005665	Demospongiae	Halichondrida	Axinellidae	Phakellia			0131
Outfall 6	Z005666	Demospongiae	Halichondrida	Axinellidae	Phakellia			0131
Outfall 6	Z005667	Demospongiae	Poecilosclerida	Raspailiidae	Ectyoplasia	tabula	(Lamarck, 1814)	
Outfall 6	Z005668	Demospongiae	Poecilosclerida	Raspailiidae	Ectyoplasia	tabula	(Lamarck, 1814)	
Outfall 6	Z005669	Demospongiae	Halichondrida	Halichondriidae	Halichondria	tyleri	(Bowerbank, 1873)	
Outfall 6	Z005670	Demospongiae	Halichondrida	Halichondriidae	Halichondria	tyleri	(Bowerbank, 1873)	
Outfall 6	Z005671	Demospongiae	Poecilosclerida	Raspailiidae	Ceratopsion			0122
Outfall 6	Z005672	Demospongiae	Poecilosclerida	Raspailiidae	Ceratopsion			0122
Outfall 6	Z005673	Demospongiae	Hadromerida	Hemiasterellidae	Axos	flabelliformis	Carter, 1879	
Outfall 6	Z005674	Demospongiae	Hadromerida	Hemiasterellidae	Axos	flabelliformis	Carter, 1879	
Outfall 6	Z005675	Demospongiae	Poecilosclerida	Raspailiidae	Raspailia (Raspailia)	phakellopsis	Hooper, 1991	
Outfall 6	Z005676	Demospongiae	Poecilosclerida	Raspailiidae	Raspailia (Raspailia)	phakellopsis	Hooper, 1991	
Outfall 6	Z005677	Demospongiae	Spirophorida	Tetillidae	Paratetilla?	sp.		
Outfall 6	Z005678	Demospongiae	Spirophorida	Tetillidae	Paratetilla?	sp.		
WR1	Z005679	Demospongiae	Halichondrida	Axinellidae	Reniochalina	stalagmitis	Lendenfeld, 1888	
WR1	Z005680	Demospongiae	Halichondrida	Axinellidae	Reniochalina	stalagmitis	Lendenfeld, 1888	
WR1	Z005681	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Wilsonella)	cf. tuberosa	(Bowerbank, 1875)	
WR1	Z005682	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Wilsonella)	cf. tuberosa	(Bowerbank, 1875)	
WR1	Z005685	Demospongiae	Dictyoceratida	Dysideidae	Dysidea			CRRF3071
WR1	Z005686	Demospongiae	Dictyoceratida	Dysideidae	Dysidea			CRRF3071
WR1	Z005688	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Thalysias)	abietina	(Lamarck, 1814)	
WR1	Z005690	Demospongiae	Halichondrida	Dictyonellidae	Acanthella	cavernosa	Dendy, 1922	
WR1	Z005691	Demospongiae	Halichondrida	Dictyonellidae	Acanthella	cavernosa	Dendy, 1922	
WR1	Z005693	Demospongiae	Haplosclerida	Petrosiidae	Petrosia?			
WR2	Z005683	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Thalysias)	reinwardti	(Bowerbank, 1875)	
WR2	Z005684	Demospongiae	Poecilosclerida	Tedaniidae	Tedania?			
WR2	Z005687	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Thalysias)	abietina	(Lamarck, 1814)	
WR2	Z005689	Demospongiae	Poecilosclerida	Microcionidae	Clathria (Thalysias)	abietina	(Lamarck, 1814)	
WR2	Z005692	Demospongiae	Halichondrida	Dictyonellidae	Acanthella	cavernosa	Dendy, 1922	

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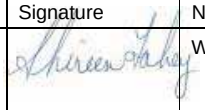
1	O Glade Wright A Ayling K Rope	S Fahey		W Freeland		03.02.2009