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Analysis of Macro-benthic Communities and sediment particle size analysis from Port Curtis samples – February 2015

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Analysis of macro-benthic communities and sediment particle size analysis from Port Curtis samples– February 2015

A Report for Aurecon Group

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KEY FINDINGS

This report presents the results of an analysis of the macro-invertebrate communities and sediment characteristics from samples supplied from six deep water locations within Port Curtis. Samples were collected by Aurecon Group and processed by the TropWATER laboratory in Cairns. The analysis was conducted to provide an indication of the benthic macro-invertebrate diversity and density in the vicinity of planned dredging activities for the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication.

Key findings include:

1. The benthic macro-invertebrate communities from the samples were typical of communities found in offshore and nearshore subtidal areas elsewhere in Queensland.

2. Benthic macro-invertebrate communities at all six locations were dominated by filter feeding and suspension feeding species such as polychaetes, bryozoans and bivalves, similar to recent studies of benthic communities in Port Curtis.

3. Medium to coarse sands dominated the samples across all six locations surveyed with nil to negligible fine fractions recorded in the samples.

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1 INTRODUCTION

In preparation for the planned Channel Duplication capital dredging project, Aurecon engaged the Seagrass Ecology Group at James Cook University's Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) to analyse sediment samples for macro-benthic identification and diversity, as well as an analysis of the sediment particle size for reporting for the dredge footprint and dredge material placement areas associated with the Channel duplication project. These works form part of the geotechnical and geochemical sampling and reporting required for the Channel Duplication Environmental Impact Statement (EIS). Samples were collected by Aurecon in late February 2015 and sent to the laboratory at James Cook University for analysis.

This report details the results of the benthic macro-invertebrate and sediment components of the geotechnical and geochemical surveys conducted in February 2015 by Aurecon.

The objectives of the analysis reported here were to:

- Characterise the benthic macro-invertebrate communities from the supplied samples and provide estimates of density and diversity,

- Analyse the sediment particle size from the samples within the dredge footprint and dredge material placement areas, and;

- Discuss the implications of the survey results for overall diversity of the survey area.

2 METHODS

Samples were collected by Aurecon Group in February 2015 from six of the borehole locations within the dredge footprint. Samples were collected with a grab (SEAS GS7L-SS Grab Sampler) at ten replicate sites in each of the six locations, with a total of 60 samples collected.

2.1 Benthic habitat sites

The grab samples were frozen prior to being sent to the TropWATER lab in Cairns where samples were sieved to 2mm. A representative sample of sediment was extracted from each sample. Organisms in the >2mm fraction were sorted, identified and quantified (Figure 1). Organisms were identified to at least family level with the total number of individuals and number of different taxa in each family recorded.

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Figure 1. Sampling from the boat using the grab sampler; contents of one sample; example of fauna found.

2.2 Sediment particle size analysis for fine fraction

The methods for this project were based on the samples containing high fractions of fine sediments and were to be run using the Malvern Mastersizer 2000. Initial processing indicated that most sediment samples were dominated by medium to coarse sands and fractions of shell. Running coarse sediment through the Mastersizer may cause damage to the machine as well as reduce the quality of the output and reliability of the data (see Section 4.3 of this report). Two locations (BH14 and BH29) had samples which could not be run in the Malvern Mastersizer 2000 due to sediment size and were run using the Rapid Sediment Analyser which allows for coarser fraction analysis.

2.2.1 Samples analysed on the Malvern Mastersizer 2000

Samples from sites BH3, BH30, BH45 and BH63 were analysed using the Malvern Mastersizer 2000. The Malvern Mastersizer 2000 is a laser diffraction particle size analyser with a lens range of 0.02-2000 µm. Sediment samples were sieved to separate the <1.4 mm and the >1.4 mm fractions as this is the upper limit for sediment grain sizes to be reliably and safely analysed using this method. This instrument separates particles into 100 bin size classes which range from < 2 µm to 2000 µm (Table 1). The particles within each bin size class are given as a percentage of the total sample volume. The grain size analyses reported here is the average of three successive laser diffraction runs.

2.2.2 Samples analysed on Rapid Sediment Analyser

The Rapid Sediment Analyser (RSA) uses the differential rate of sedimentation of particles suspended in a water column to yield the percentage of size fractions. Samples are dried and then split into representative subsamples and put through the RSA which takes account of the sediment density, water column height and temperature, and calculates a grain size distribution.

Table 1. Particle size fractions bins used for samples analysed on the Malvern Mastersizer 2000 and the Rapid Sediment Analyser.

Coarse sand	Medium sand	Fine sand	Coarse silt	Medium silt	Fine silt	Clay
1000- 2000 µm	250- 500 µm	63-250 µm	31-63 µm	15.6-31µm	2-15.6 µm	<2 µm

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3 RESULTS

A total of 60 benthic habitat and sediment grabs were assessed from six locations in the survey area. Macro-invertebrate results were generally similar to a recent study of the deep water benthic macro-invertebrate community in the broader Gladstone region (McKenna et al. 2014). Reports from the field team during sample collection suggest the samples were taken primarily in areas with large amounts of rock and rubble. The presence of finer materials such as muds and silts may not have been detected in the samples due to limitations of the grab collection method in areas of high rubble and rock content. In areas where there are high amounts of rock and rubble, coarser sediment may wedge the grab open; allowing finer sediments to fall out of the grab on retrieval and hard surfaces will also limit the penetration of the grab once on the bottom.

The mean number of taxa and mean number of individuals per m^2 was calculated from the area of the grab (0.04472 m^2). As there was uncertainty in the number of grabs collected at each site, a range in the estimated densities as opposed to a single per m^2 calculation is reported (Table 2). Care should be taken in the interpretation of these results when comparing to other macro-invertebrate and sediment analyses studies conducted in Gladstone or nearby areas. The method of sample collection used in this study (grabs) is different to those of other referred studies (sled tows) and are unlikely to be directly comparable (see Section 4.3 of this report).

3.1 Estimates of benthic macro-invertebrate density and diversity

The six sites were dominated by a mixture of polychaete or sipunculid worms with encrusting and erect bryozoans, bivalves and gastropods (Table 2). Sites BH3 and BH30 were the most diverse locations with the greatest total number of taxa recorded (209 and 156, respectively; Table 2). The BH14, BH29 and BH63 sites were generally similar with total numbers of taxa ranging from 127 – 156 (Table 2). Site BH45 had the lowest total number of taxa (107) recorded at any location (Table 2).

Figure 2. Examples of the types of benthic macro-invertebrates found.

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Table 2. Total number of taxa found in the six benthic community locations sampled, and the mean number of individuals (standard error) per m^2 found in each of the six benthic community locations. Sites BH3, BH29, BH30 are the range in mean number of individuals per m^2 for 2-3 grabs; site BH14 is the range in mean number of individuals per m^2 for 1-3 grabs; and sites BH45 and BH60 are mean number of individuals per m^2 for one grab.

Taxonomic Group		Benthic Community Location											
		BH3		BH14		BH29		BH30		BH45		BH63	
		Taxa	Individuals	Taxa	Individuals	Taxa	Individuals	Taxa	Individuals	Taxa	Individuals	Taxa	Individuals
Annelidia	Polychaete	47	130 (19) - 195 (29)	16	63 (20) - 188 (59)	41	154 (46) - 231 (69)	39	141 (41) - 211 (61)	42	568 (89)	40	318 (67)
Sipuncula	Unsegmented worm	9	12 (3) - 18 (4)	84	0	8	22 (17) - 34 (25)	7	6 (2) - 9 (3)	3	16 (8)	6	18 (6)
Ectoprocta	Encrusting bryozoan	23	156 (32) - 234 (48)	15	34 (6) - 101 (19)	19	86 (13) - 130 (20)	30	148 (30) - 222 (45)	16	233 (49)	14	250 (50)
	Erect bryozoan	5	8 (5) - 12 (7)	4	4 (2) - 11 (5)	13	51 (30) - 76 (44)	7	13 (6) - 19 (9)	10	36 (19)	7	20 (11)
	Motile bryozoan	0	0	0	0	0	0	0	0	0	0	1	13 (13)
Cnidaria													
Anthozoa													
Zoantharia	Solitary coral	4	4 (2) - 6 (3)	0	0	3	2 (1) - 3 (2)	3	4 (2) - 6 (3)	8	25 (10)	12	89 (36)
Alcyonaria	Gorgonian	0	0	0	0	0	0	4	5 (2) - 8 (3)	1	2 (2)	0	0
	Sea pen	0	0	1	1 (1) - 2 (2)	0	0	0	0	0	0	2	7 (5)
	Soft coral	7	5 (2) - 8 (3)	0	0	2	1 (1) - 2 (1)	3	2 (2) - 3 (2)	2	4 (3)	1	2 (2)
Hydrozoa	Hydroid	12	30 (12) - 45 (18)	0	0	7	30 (15) - 45 (23)	13	73 (27) - 110 (40)	0	0	5	253 (186)
Echinodermata	Asteroid	0	0	0	0	0	0	0	0	1	2 (2)	0	0
	Crinoid	1	1 (1) - 1 (1)	0	0	0	0	0	0	0	0	0	0
	Ophiuroid	10	75 (38) - 113 (57)	1	1 (1) - 2 (2)	9	13 (4) - 20 (6)	10	45 (18) - 67 (28)	7	34 (17)	1	2 (2)
Arthropoda													
Crustacea	Brachyuran	8	6 (2) - 9 (3)	0	0	1	1 (1) - 1 (1)	9	10 (4) - 15 (6)	1	2 (2)	4	9 (5)
	Penaeid prawn	1	1 (1) - 1 (1)	0	0	0	0	0	0	0	0	0	0
	Carid shrimp	4	4 (2) - 7 (3)	1	1 (1) - 2 (2)	1	1 (1) - 1 (1)	5	4 (2) - 7 (3)	0	0	3	7 (3)
	Barnacle	22	72 (19) - 108 (28)	0	0	11	25 (13) - 37 (19)	11	34 (17) - 50 (26)	1	2 (2)	1	2 (2)
	Other decapod	0	0 (0) - 0 (0)	0	0	1	1 (1) - 1 (1)	2	4 (3) - 6 (4)	1	2 (2)	1	2 (2)
Isopoda	Isopod (sea lice)	2	1 (1) - 2 (1)	0	0	1	1 (1) - 1 (1)	1	1 (1) - 1 (1)	0	0	0	0
Mollusca	Bivalve	31	55 (6) - 83 (9)	1	1 (1) - 4 (4)	22	41 (10) - 61 (14)	33	61 (17) - 92 (25)	3	7 (3)	6	13 (9)
	Gastropod	23	29 (9) - 44 (13)	4	3 (2) - 9 (7)	15	14 (4) - 21 (6)	12	10 (3) - 16 (5)	10	22 (6)	33	94 (26)
	Nudibranch	0	0	0	0	1	1 (1) - 2 (2)	0	0	1	2 (2)	0	0
Vertebrata	Fish	0	0	0	0	1	1 (1) - 1 (1)	0	0	0	0	1	2 (2)

3.2 Sediment Particle Size Analysis

Medium or coarse sands dominated samples across all benthic habitat locations with only negligible fine fractions detected and no samples classified as muds (Table 3). Laboratory observations indicated samples collected from BH30, BH45 and BH63 had a high proportion of medium to large (> 2mm) rocks and shell, though further analysis of the > 2 mm fraction was beyond the scope of this study. Additional processing of the larger fraction sizes is available should further detail be required.

Although there are minor variations in the details of sediment grain size distributions between samples from each site, they are generally very similar in their dominant characteristics. The percent sand in the samples ranged from 84 to 100%, silt ranged from 0 to 14% and clay ranged from 0 to 2% of the total sample (Table 3). The majority of samples contained a considerable medium sand fraction (peaking at 82% at site BH29). Sediment at sites BH14, BH29 and BH45 was nearly exclusively dominated by sand with only one site each at BH29 and BH45 containing <1% silt (Table 3). Site BH3 and BH30 had silt ranging from 0.1 to 9% of the total sample while site BH63 typically had <1% silt.

3.3 Site Characterisation

The six locations can be characterised based on the benthic macro-invertebrate community composition and dominant sediment types found from the grab samples as follows:

Site BH3
Site BH3 was dominated by polychaete worms with bivalves and encrusting bryozoans/gastropods. The sediment was characterised as medium sands with a minor component of finer fractions.

Site BH14
Site BH14 was dominated by sipunculids (unsegmented worms) with encrusting bryozoan and gastropods/erect bryozoans. The sediment was characterised as coarse sands with no mud component.

Site BH29
Site BH29 were dominated by polychaetes with bivalves and encrusting bryozoans. The sediment was medium sands with no mud component.

Site BH30
Site BH30 were dominated by polychaetes with bivalves and encrusting bryozoans. The sediment was generally characterised as medium sands with a minor component of finer fractions.

Site BH45
Site BH45 was dominated by polychaetes with encrusting bryozoan and erect bryozoan/gastropods. The sediment was characterised as medium sands with no mud component.

Site BH63
Site BH63 was dominated by polychaetes with gastropods and encrusting bryozoan. The sediment was characterised as fine to medium sands with variable but minor component of mud.

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Table 3. Particle size summary of sediment samples at 10 sites within each of the six benthic community locations (BH3, BH14, BH29, BH30, BH45 and BH63).

Benthic Community Location	Site #	Coarse Sand %	Medium Sand %	Fine Sand %	Coarse Silt %	Medium Silt %	Fine Silt %	Clay %	Mean Grainsize (µm)
Sediment grain size (µm)		1000- 2000	250- 500	63-250	31-63	15.6-31	2-15.6	<2	
BH3	1	22	56.3	18.3	1.0	0.5	1.9	0	181
	2	14.3	54.2	25.3	1.5	1.2	3.3	0.2	313
	3	12.6	57.1	27	1.3	0.6	1.4	0	312
	4	10.3	50.8	35.7	0.7	0.8	1.7	0	410
	5	5.8	40.6	39.8	2.2	2.1	7.7	1.8	227
	6	23.8	52.2	20.5	1.1	0.5	1.8	0	346
	7	10.2	45.3	36.2	2.3	1.5	4.0	0.6	243
	8	11.4	53.9	29.8	1.2	0.9	2.6	0.3	280
	9	16.3	56	23.2	1.5	0.8	2.2	0.1	307
	10	16.8	56.2	22.8	1.4	0.6	2.2	0.1	310
BH14	1	71.5	27.5	1.1	0	0	0	0	486
	2	79.1	19.7	1.3	0	0	0	0	522
	3	56.8	41.7	1.5	0	0	0	0	430
	3a	80.7	17.3	2	0	0	0	0	523
	4	87.4	11.7	0.8	0	0	0	0	673
	5	89.5	8.8	1.6	0	0	0	0	562
	6	83.7	16.3	0	0	0	0	0	589
	7	88.9	10.3	0.7	0	0	0	0	584
	8	85.4	13.6	1	0	0	0	0	565
	9	83.8	15.1	1.1	0	0	0	0	457
	10	88.3	11.4	0.2	0	0	0	0	580
BH29	1	18.4	77.2	4.4	0	0	0	0	344
	2	20.9	76.2	3	0	0	0	0	349
	3	26.4	69.4	4.1	0	0	0	0	375
	4	24.9	69.2	6	0	0	0	0	352
	5	15.2	81.6	3.3	0	0	0	0	344
	6	22.1	75.2	2.7	0	0	0	0	349
	7	0	13.3	86.4	0.4	0	0	0	330
	8	20	76.7	3.3	0	0	0	0	353
	9	15.2	79.9	4.9	0	0	0	0	330
	10	11.7	82.8	5.4	0	0	0	0	313

Benthic Community Location	Site #	Coarse Sand %	Medium Sand %	Fine Sand %	Coarse Silt %	Medium Silt %	Fine Silt %	Clay %	Mean Grainsize (µm)
Sediment grain size (µm)		1000- 2000	250- 500	63-250	31-63	15.6-31	2-15.6	<2	
BH30	1	4.7	37.8	45.9	2.1	2.5	6.3	0.8	199
	2	8	50.3	35.9	1.1	1.3	3.2	0.2	256
	3	6	45	39.5	1.7	1.8	5.5	0.6	226
	4	15	49.5	30.6	1.3	1	2.5	0.1	283
	5	13.6	52.8	28.8	1.3	0.9	2.5	0.1	287
	6	24.9	46.7	21.3	1.8	1.2	3.6	0.4	328
	7	19.6	54.9	20.7	1.1	0.8	2.8	0.2	319
	8	8.6	50	26	1.9	2.8	9.3	1.4	230
	9	15.2	59.1	24.4	1.2	0.2	0	0	271
	10	9.8	58.4	31.7	0	0	0	0	302
BH45	1	10.5	65.4	24.1	0	0	0	0	322
	2	12.2	61.2	26.7	0	0	0	0	319
	3	8.5	61.8	29.7	0	0	0	0	305
	4	15.1	58.9	26	0	0	0	0	329
	5	13.6	60.8	24.8	0.7	0.1	0	0	321
	6	13.7	61.1	25.2	0	0	0	0	326
	7	19	59.1	21.9	0	0	0	0	350
	8	12.6	65.8	21.6	0	0	0	0	332
	9	16.6	61.1	22.4	0	0	0	0	338
	10	13.8	65.4	20.8	0	0	0	0	337
BH63	1	3.4	48.8	46.2	0.6	1	0	0	250
	2	1.8	45.1	52.6	0	0	0.6	0	240
	3	1.8	42.6	54.5	0.3	0.9	0	0	231
	4	2.5	53.6	43.9	0	0	0	0	264
	5	1.2	38.7	58.8	0.2	1	0.1	0	219
	6	0.5	40.9	58.6	0	0	0	0	232
	7	2.4	47.2	50.4	0	0	0	0	247
	8	1.4	40.7	56.8	0.3	0.9	0	0	225
	9	14.1	39.1	46.9	0	0	0	0	285
	10	2.3	48.2	48.4	0.2	0.3	0.5	0	247

4 DISCUSSION

4.1 Benthic macro-invertebrate communities

The benthic macro-invertebrate communities at all six locations were dominated by filter feeding and suspension feeding species such as polychaetes, bryozoans and bivalves, similar to recent results from the broader Gladstone area and Abbot Point (McKenna et al. 2014; McKenna et al. 2013a). The majority of areas sampled in broader Port Curtis region in November 2013 were dominated by open substrate with a low to medium density of benthic communities in both the inner port area (inside Facing Island) and the outer port (outside Facing Island) (McKenna et al. 2014). Medium densities of habitat-forming benthos and benthic invertebrates were also found in the Gatcombe and Golding cutting Channel Duplication project footprint during that survey (McKenna et al. 2014). While the diversity of taxa found in this study is generally comparable to studies conducted in Abbot Point and Gladstone, direct comparison of the density is difficult due to the different methods used for sample collection (see Section 4.3 of this report).

Impacts to benthic animals and habitat caused by disposal of dredge material is influenced by many factors such as the volume of sediment, the disposal method and characteristics of the dredge material, and the site-specific conditions of the location (Bolam 2011; Cole et al. 1999). Filter-feeding organisms such as those dominating the sites in this survey are particularly at risk of smothering and congestion of feeding mechanisms by elevated suspended materials (Erftemeijer and Lewis III 2006; Cruz-Motta and Collins 2004). Anaerobic conditions within the benthos associated with decaying benthic animals and mass emigration from the affected area are also potential causes of declines in benthic macro-invertebrates following burial (Dauer 1984). However, rapid recovery of polychaete assemblages within dredge disposal areas has been reported for communities composed of opportunistic species with fast maturation rates, allowing for rapid colonisation of disturbed habitats, or substantial adult populations in surrounding areas which can act as sources for immigration (Dauer 1984). Rapid recovery (between 14 and 84 days) of polychaetes has been observed at several locations within offshore dredge material placement areas (DMPA) (Cruz-Motta and Collins 2004; Jones 1986; McCauley et al. 1977). Other possible mechanisms for recovery following burial include the capacity to burrow back to the surface, although this is dependent on the depth of the disposed material (Newell et al. 1998; Maurer et al. 1979), the characteristics of the sediment, including organic carbon and sand content, and the trophic group (Bolam 2011). Studies of vertical migration have shown poor recovery for polychaetes; however oligochaetes and gastropod molluscs did show recovery by vertical migration depending on the depth of the deposited sediment (Bolam 2011). The organic content of the deposited sediment can also have an impact on vertical migratory success, with increased organic content detrimentally affecting migratory success (Bolam 2011). As identification to the species level was not within the scope of this study, further analysis would be required to determine the usefulness of this recovery mechanism for the different taxa found in Gladstone.

Previous studies of benthic communities in 2002 and 2013 have found benthic macro-invertebrates existing in proximity to maintained channels, port facilities and the existing DMPA (McKenna et al. 2014; Rasheed et al. 2003). The continued presence of these assemblages in 2013 following dredge disposal may indicate that macro-invertebrate communities at these locations are somewhat resilient to previous dredge material placement (McKenna et al. 2014).

4.2 Sediment analysis

The sediment composition within the survey area was generally similar to that previously described from the middle shelf of the Great Barrier Reef (Belperio 1983; Maxwell 1968) and other Queensland locations such as Townsville (Cruz-Motta and Collins 2004) and Abbot Pt (McKenna et al. 2013a). The middle shelf zone consists of poorly sorted silts and sands, and gravel particle sizes of a mix of terrigenous (mostly silt-

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sized) and carbonate shell hash (sand and gravel) (McKenna et al. 2013a). Sands found in these samples were mainly quartz sand of a relatively homogenous composition with very small fractions of carbonate.

The particle size distribution in the majority of samples analysed contained a considerable medium sand fraction (peaking at 82%), with nil to negligible fine fractions. Sediment at all sites was nearly exclusively dominated by sand with silt typically comprising <1%.

4.3 Potential limitations of the data

Due to the differences in sampling methods and scale, this study is not directly comparable to previous assessments of benthic macro-invertebrate communities and assessment of any changes from previous assessments is not possible, however it is useful in assessing potential differences between the six sites surveyed and as an overall indication of the diversity of benthic taxa. Previous studies conducted by TropWATER in Gladstone (McKenna et al. 2014) and other Queensland locations (McKenna et al. 2013b; McKenna et al. 2013a; Rasheed and Taylor 2008; Rasheed et al. 2001) to investigate the benthic macro invertebrate communities have utilised a camera towed behind a vessel and a sled net integrating large areas of the seafloor. In these studies, the camera and sled system was towed for 100 metres at each site on a sled with a net (600 mm width, 250 mm depth) (see McKenna et al. 2014 for more detail). The determination of community type and density from the sled-tow method is likely a more accurate representation of the benthic community diversity as it allows for a substantially greater area to be sampled at each site. This is important for areas where there is a relatively sparse distribution of benthic life. Grab sampling, as used in this study, provides a small isolated sample with a significantly reduced area and consequently much of the diversity of the benthic community may not be fully represented.

For the sediment analysis the majority of samples were comprised of coarser material such as shell, and not spherical but rather plate-like. The non-spherical shapes in the biogenic sediments produces divergence in the grain size output of replicate samples because the laser in the Malvern Mastersizer 2000 may view a grain of non-spherical shape from different angles and estimate a range of sizes for the same grain in repeat samples and measurements. Thus, the outputs from multiple replicates of the same sample are highly variable and the output quality of the particle size analysis is reduced. Other analysis options to better deal with samples of this nature such as using a Rapid Sediment Analyser (RSA) were outside of the scope of this project, but could be applied to the samples if required to give a better estimate of grain size. We did use the RSA method for two of the sites (BH45 and BH63) where the course fractions of the sediment were so high that the Mastersizer could not be used without the risk of causing significant damage to the apparatus.

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