University of
Western Australia

UWA Marine Research Group

CHARACTERISING THE MARINE BENTHIC HABITATS OF THE PROPOSED SOUTHERN SEAWATER DESALINATION PLANT (SSDP) SITE:

INTERPRETATION FROM UNDERWATER TOWED VIDEO & MAP INTERPOLATION

Report: MRG 2008-1

Report to:

KBR

AUSTRALIA

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Document Information

REPORT NO.	MRG 2008-1
TITLE	*Characterising the benthic marine habitats of the proposed Southern Seawater Desalination Plant (SSDP) site: Interpretation from underwater towed video and map interpolation*
DATE	14 February 2008
JOB	BDSP 2
CLIENT	Kellogg Brown & Root Pty Ltd (KBR)
USAGE	This report identifies underwater benthic habitats from towed video and identifies the distribution of seagrass and benthic biota across the proposed SSDP site. Distributions were derived from interpolating point sample data collected and supplied by UWA Marine Research Group, using ArcMap 9.2.
PRECIS	In total, 156.9 minutes of geo-referenced video footage were recorded and described. Substrate, biota and seagrass data collected using towed video were imported into ArcGIS 9.2 as a point layer. Ordinary kriging was used to interpolate the data into continuous surfaces for substrate type, biota and seagrass density.
KEYWORDS	Binningup Desalination Benthic Seagrass Invertebrate Macro-algae

Version-Date		Released by	Purpose
1.0	27 Dec 07	UWA Marine Research Group	KBR Review
1.1	17 Jan 08	UWA/KBR	Amalgamation of video footage and mapping reports
1.2	14 Feb 08	UWA/KBR	Final Report

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1.0 EXECUTIVE SUMMARY

The Water Corporation of Western Australia proposes to construct both ocean intakes and ocean outlets that enter the sea near Binningup, Western Australia to supply seawater to and to remove wastewater from a desalination plant being planned in the area.

Detailed towed video surveys were undertaken to map seabed habitats using geo-located towed video in December 2007. The survey area was located to include the proposed location of the pipeline and covered an approximate area 1,200 m west to east from the shore and 800 m north to south. Only an 800 x 800 m was eventually surveyed, being restricted to 300-400 m offshore.

The seabed in the survey area consisted of a sand veneer over limestone rock, which outcrops as pavement and reef. These elements formed the substratum for impoverished and sparse communities of seagrass, seaweeds and sessile benthic invertebrate-covered reef, seagrass on sediment and extensive unvegetated sediment. There was a large amount of submerged detritus (unattached seagrass and algal wrack).

Only three classes of substrata (sediment, sediment and reef, reef) and four benthic habitat types (vegetation, sessile invertebrates, vegetation and sessile invertebrates, and no biota) were delimited in the towed video footage. The reef and sediment classes intergraded and were not accurately interpolated from our spatial models. This reflects the ephemeral nature of the exposed reef and extent of sediment and defines this area as highly disturbed from the perspective of a marine benthic organism's ability to recruit, colonise and persist on both reefs (invertebrates and seaweeds) and unvegetated sediment (seagrasses). Biota were not always obvious because of the presence of detritus on sediments and the large volumes of detritus indicate also the highly disturbed nature of this region.

Habitats along this stretch of the Western Australian coastline north and south of Bunbury and south of Mandurah some 10s to 100s of kilometres from the Binningup survey area are reported to be similar, although some of these other areas look less physically disturbed and have a richer, more abundant flora and fauna.

2.0 INTRODUCTION

In December 2007, Kellogg Brown & Root Pty Ltd (KBR) approached the University of Western Australia (UWA) Marine Research Group requesting a re-visiting of the video surveying of marine benthic habitats for the proposed site of the Southern Seawater Desalination Plant (SSDP) off the coast of Binningup, Western Australia. A survey had previously been conducted in September 2007 by Fugro Survey Pty Ltd; however data from this survey was not detailed enough to address the needs around the ocean outfall. Fugro's survey work had provided a larger regional scale benthic habitat map and the new UWA survey was designed to supplement this map with a detailed substrate and biota map in the vicinity of the proposed ocean outfall.

The goal was to map a region 800 m north-south and 1,200 m east-west from the coast to the south of Binningup (Appendix A). This sampling was modified as the boat and divers were not able to work in waters shallower than 5m due to swell action associated with a storm that crossed the coast on the last day of survey. The survey area was modified to a 800 by 800 m grid without including the two north south transects nearer to the shore nor the extension of the east-west transects to the beach (see Appendix A)

This report documents the processing of video footage (Appendix B), the amount of substrate and biota and observed in video and the quality of the imagery, then the methods of mapping and interpolation from the video points, concluding with the production of spatial maps for substrates (Appendix C), biota (Appendix D) and seagrasses (Appendix E). The resulting distribution of major substrates and biota are then placed into a regional context and conclusions and recommendations made from this specific mapping exercise.

3.0 FIELD SURVEY

The new survey work was conducted between 4 and 6 of December 2007 by UWA, and aimed to produce a finer scale, more targeted benthic habitat map of the proposed SSDP site to compliment Fugro's large scale map. Survey work consisted of a gridded towed video design of the target area. This grid consisted of towed video transects every 200 m, equating to 5 transects running north-south and 7 transects running east-west. (Appendix A and B) This design was to provide the most comprehensive video coverage of benthic habitats surveyed. Data gathered would provide the biological input required for a decision on the suitability of this site for the proposed desalination plant.

4.0 VIDEO PROCESSING

Underwater towed video imagery was analysed by D.r Grey Coupland and Dr. Justin McDonald at the University of Western Australia's marine ecology labs. Analysis of footage is used to create a database of substratum and biological benthos characteristics for any subsequent habitat modelling and mapping. Drs Grey Coupland and Justin McDonald are both qualified marine scientists with over 10 years experience working on Australia's benthic marine communities. They have worked extensively on the marine communities of Western Australia for the last 5 years.

The video footage was then used to develop continuous surfaces of the distribution of seagrass and benthic biota across the site by interpolating point samples collected in the December survey.

The video interpretation was then inputted into ARC MAP by Brenton Chatfield.

5.0 METHODS

5.1 VIDEO INTERPRETATION

Video observation and interpretation took place in two phases. Firstly, habitat characterisation was carried out. Characterisation involved viewing segments of the video to develop a series of biotic and abiotic criteria from which to describe the benthic habitats (Table 1).

Table 1. Categories used to interpret video footage. Note: not all categories are assigned in the resulting data. Categories are established prior to analysis of the footage and are based upon what may be expected to occur in this region.

Substrate	Macroalgae	Seagrass	Sessile invertebrates	Video comments
Hard (reef/rock)	Undifferentiated	Undifferentiated	Undifferentiated	Start of tape
Can't discern	Mixed brown algae	*Amphibolis*	Sponges	End of tape
Fractured/Fissured/Broken	Mixed red algae	*Zostera/ Heterozostera*	Ascidians	Start line
Unbroken	Mixed green algae	*Halophila*	Bryozoa	Fish in frame
Cobbles	*Ecklonia*	*Posidonia*	Hydroids	Some of veg cover is drift
Boulders/small outcrops	*Sargassum*	*Thalassodendron*	Soft corals, gorgonians	Single frame analysis
Soft (sediment)	*Caulerpa*		Hydroids	
Can't discern	*Scytothalia*		Hard corals	
Coarse gravel	Epiphytes		Sea whips	
Fine gravel	*Codium*		*Tethya*	
Sand			Black coral	
Fine sand (silt/clay)			*Pyura*	

The second phase involved viewing the video and describing habitats in as much detail as possible given the quality of the footage. In order to devise a comprehensive map and a detailed account of the benthic habitats, interpretation was required of all the footage recorded. This entailed viewing every frame and recording every change in habitat, however small.

Video footage was first converted and saved into a digital format to provide a backup of the video tapes. Footage was then closely observed and whenever a change in any biotic or abiotic category was observed, footage was paused and a description made using the assigned categories and specifically designed software that had been modified and updated since the previous video analysis. All geo-referenced video frames were described in detail (Figure 1), and were entered into a database for subsequent analysis. Density of biota coverage was also described and recorded where this was possible.

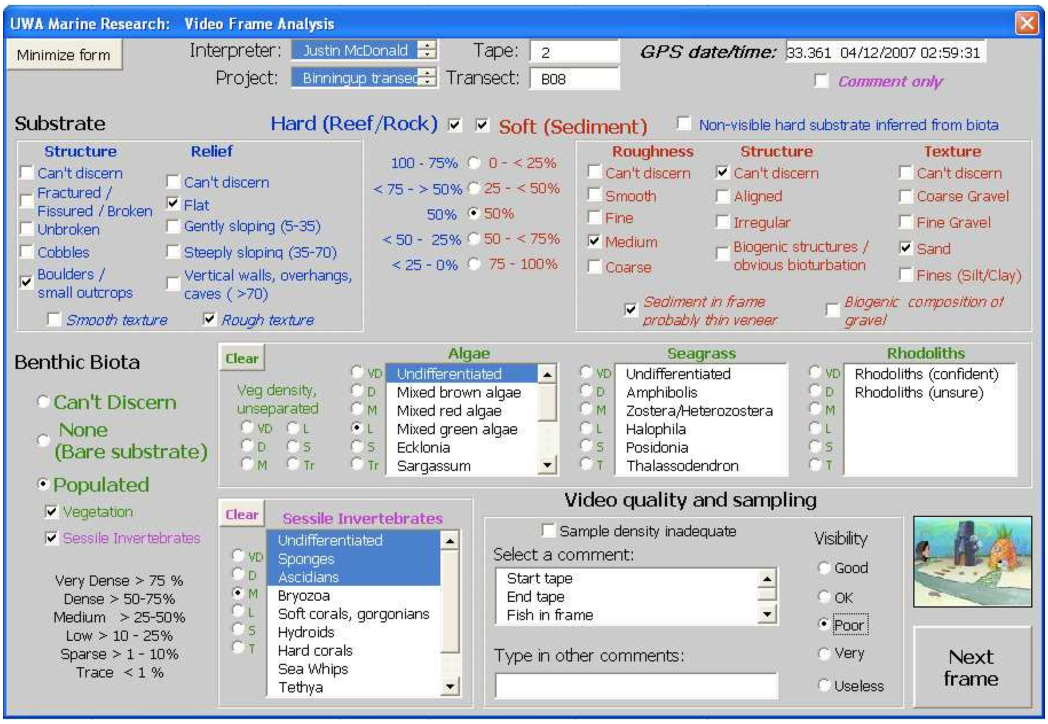

Figure 1. Screen capture illustrating the on-screen form that the observer completed for all 9,416 seconds (156.9 minutes) of footage examined.

5.2 Map Interpolation

Following the interpretation of the video footage from the geo-referenced video frames, all point sampling data were entered into ArcMap 9.2 as a point layer using the 'Add XY data' tool and exported as a shape file.

Indicator kriging (Cressie 1993) was used to interpolate the sampled point data to create continuous surfaces across the study area. Kriging is a geostatistical method that uses the value at each sample point in conjunction with the measured spatial autocorrelation (derived from a semi-variogram) to develop a predictive map of the observed data. The dataset was randomly divided into 2 parts (a 70/30 split), with 70% of the data (training data) used to develop the interpolated surfaces, while the remaining 30% of data (testing data) was used to evaluate the accuracy of the interpolated surfaces (i.e. by comparing the known values to the interpolated values).

Using the Geostatistical Wizard ('Geostatistical Analyst' extension) in ArcMap 9.2, probability maps (5m grid cell showing the probability of occurrence) were derived for each category of substrate type (sediment, sediment and reef or reef), biota type (vegetation, vegetation and sessile invertebrates, sessile invertebrates, no biota or video uninterpretable), and seagrass density (dense, medium, low, trace or no seagrass) using a spherical model with up to 16 neighbours for the training data.

The accuracy of the probability maps was assessed in two parts. First, the ability of the indicator kriging to determine whether each category was present or absent was determined from the measured area under the curve (AUC value) of receiver-operating characteristic plots (ROC plots) (Hanley and McNeil 1982, Zweig and Campbell 1993, Fielding and Bell 1997). An AUC value of 1 indicates that the model can discriminate perfectly between presence and absence, while a score of 0.5 indicates that the model cannot discriminate any better than by chance alone. AUC scores > 0.9 are considered excellent, between 0.8-0.9 as good; 0.7-0.8 as fair; 0.6-0.7 as poor and AUC values < 0.6 indicate the model is unable to discriminate better than by chance (Araújo *et al.* 2005).

The second part of the evaluation process determined how accurately the models predicted the habitat based on calculating the percentage of correctly predicted presences (sensitivity), the percentage of correctly predicted absences (specificity) and the overall predictive accuracy. A threshold or cut off value must be determined before sensitivity and specificity can be calculated from the predicted probabilities and Pfair was chosen as it minimizes the difference between sensitivity and specificity (i.e. it balances the number of false positive and false negative predictions).

Using the threshold value, the probability map of each category was converted to a binary (presence/absence) map and then a single map for each of substrate, biota and seagrass density was created by 'adding' the relevant presence/absence maps together. If multiple categories were found to occur at the same location, an average of the values was used, e.g. if both dense seagrass and low seagrass were predicted to occur, medium seagrass was assigned.

6.0 RESULTS

6.1 VIDEO

In total, 156.9 minutes (9,416 seconds) of geo-referenced video footage (Figure 2) was analysed and subsequent data recorded. Results provide an indication of the spatial coverage of the assigned variables.

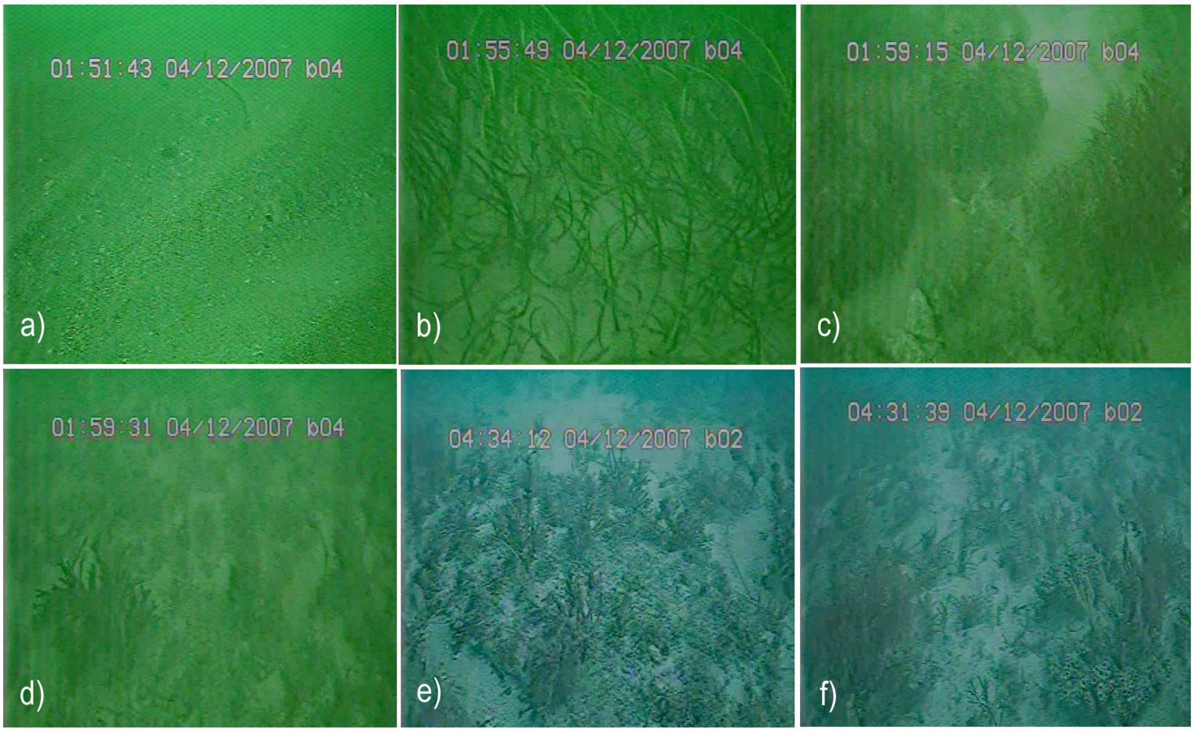

*Figure 2. Screen capture illustrating the various biota categories assigned to benthos a) bare sand, b) seagrass (*Posidonia*) c) undifferentiated algae, d) undifferentiated algae and* Codium*, e) undifferentiated invertebrates, sponges and ascidians f) undifferentiated invertebrates and hard corals.*

The major abiotic substratum categories identified, according to the length of time spent over each substratum type were: sediment, sediment over reef, and reef, with boulders and small outcrops common across the reef habitat (Table 3).

Table 3. Proportion of video frame in each (A) Substrata and (B) Biotic category. Proportions are relative to minutes of video footage where habitat could be described.

(A) Primary substrate	Proportion of Substratum %
Soft sediment (sand)	85.5
Sediment overlying reef	14.2
Reef	0.2

(B) Primary biota	Proportion of biota %
Invertebrates	29.7
Macro algae	28.3
Bare sand	27.6
Seagrass	14.4

The major biotic groups included were macro-algae/invertebrate, bare sand (bare sand indicates an absence of obvious benthic biota), then seagrass. Mixed macro-algae/invertebrate assemblages dominated benthic habitats assessed. Algal habitat comprised 39% of the video footage, with invertebrate assemblages recorded from 41% of the benthic habitat filmed (Table 3).

Abiotic substrate categories

Substrate categories were defined as either soft (sediment) or hard (reef/rock). Reef not covered by sand comprised only 0.2% of the abiotic substrata identified from video footage. Reef with overlying sand comprised 14.2% of the footage, with much of this habitat characterised by boulders or small outcrops, or as fractured or broken. Soft substratum i.e. sand habitat, however, comprised the vast majority of all substratum habitats characterised, (85.5%).

Biotic categories

Flora

The algal biota was likely to be mixes of red, green and/or brown, but it was often too difficult to discern the specific types of algae due to the video quality. As such, most of the algae were described as 'undifferentiated'. The green algae *Codium* was, however, discernable in 6.4% of the algae assemblages due to its distinctive morphology.

The seagrasses recorded were either *Posidonia angustifolia* or *Posidonia coriacea*. *Posidonia angustifolia* was the most abundant species, comprising 98.7% of all seagrass recorded (Table 4). *Posidonia coriacea* was only recorded in small patches.

Table 4. Proportion of minutes of video footage descriptions in each (A) Seagrass and (B) Sessile invertebrate categories where the benthos occurred.

(A) Seagrass	Proportion of seagrass %
Posidonia angustifolia	98.7
Posidonia coriacea	1.3
(B) Sessile invertebrates	**Proportion of invertebrates %**
Undifferentiated	43.5
Sponges	25.2
Ascidians	24.9
Hard corals	5.0
Bryozoa	1.3
Hydroids	0.1

Fauna

It was often too difficult to discern some of the specific types of fauna due to the video quality. Consequently, fauna were often described as 'undifferentiated' (43.5%) to ensure that types of fauna were not missed or incorrectly identified. Of the invertebrates that were identified, the predominant sessile invertebrates were sponges (25.2%) and ascidians

(24.9%). These two groups often occurred together. Table 4 identifies all the sessile invertebrates recorded and the proportions of each group relative to the total sessile invertebrate fauna identified.

6.2 MAPPING

Indicator kriging was able to discriminate whether a category was present or absent with excellent ability (AUC value > 0.9) for all habitat categories (Table 5). The distribution of each category was also very accurately predicted with all but 1 category being predicted with greater than 90% accuracy (Table 5). The poorest predictive accuracy was seen for low density seagrass, but this still had an overall accuracy of 88.5%. These results indicate that the interpolated maps for substrate type (Appendix C), biota (Appendix D) and seagrass distribution (Appendix E) can be considered to be an accurate and reliable representation of the habitat structure in the study area.

Table 5: Categories of Substrate, Biota and Seagrass and the accuracy with which each could be interpolated using indicator kriging. AUC indicates the ability of the indicator kriging to discriminate between whether a category was present or absent (0.6-0.7 is poor, 0.7-0.8 is fair, 0.8-0.9 is good, >0.9 is excellent), sensitivity measures how often the category was correctly predicted to be present and specificity measures how often the category was correctly predicted to be absent.

Habitat	Category	AUC	Sensitivity	Specificity	Overall Accuracy
Substrate	Sediment	0.995	96.5	96.6	96.5
	Sediment and Reef	0.995	96.6	96.6	96.6
	Reef	0.994	100	98.9	98.9
Biota	Vegetation	0.985	95.3	94.7	94.8
	Vegetation and Sessile Invertebrates	0.994	96.7	96.7	96.7
	Sessile Invertebrates	0.998	100	99.5	99.5
	No Biota	0.988	95.1	95.3	95.3
	Video Uninterpretable	0.999	98.1	98.2	98.2
Seagrass	Dense	0.984	94.4	94.6	94.6
	Medium	0.956	91.8	91.9	91.8
	Low	0.919	88.6	88.5	88.5
	Trace	0.962	91.3	92.2	92.2
	No Seagrass	0.989	94.3	94.4	94.4

7.0 DATA LIMITATIONS

The accuracy of any maps constructed using these data and how well they represent the actual distribution of benthos is directly linked to the quality of the video footage provided. The changing quality of the video may lead to some inconsistent observations of benthic habitat presence or absence. Of the 156.9 minutes of video footage collected, 21% was unusable such that classification of benthic habitat was not possible. Poor quality footage was an artefact of weather conditions and subsequent water turbidity due to suspended particles at the time of collection.

Table 6 identifies video quality for the 156.9 minutes described and Figure 6 a-d provides examples of the quality of footage collected. Colour of the imagery recorded was green which presented problems with viewing and interpreting the footage, particularly when attempting to identify among red, green and brown alga.

Table 6. Quality of video footage and proportion of footage assigned to each category relative to the 156.9 minutes of video analysed.

	footage quality (% of footage)				
	ok	**poor**	**very poor**	**useless**	**total footage (minutes)**
transect					
B01	0	47	37	16	14.0
B02	30	15	42	13	19.4
B03	0	8	92	0	13.2
B04	6	62	5	27	19.6
B05	0	41	25	35	22.4
B06	11	79	9	4	8.7
B07	0	27	69	5	16.1
B08	0	36	65	0	15.4
B09	0	25	66	9	13.6
B10	0	1	10	89	14.5
all transects	5	33	41	21	156.9

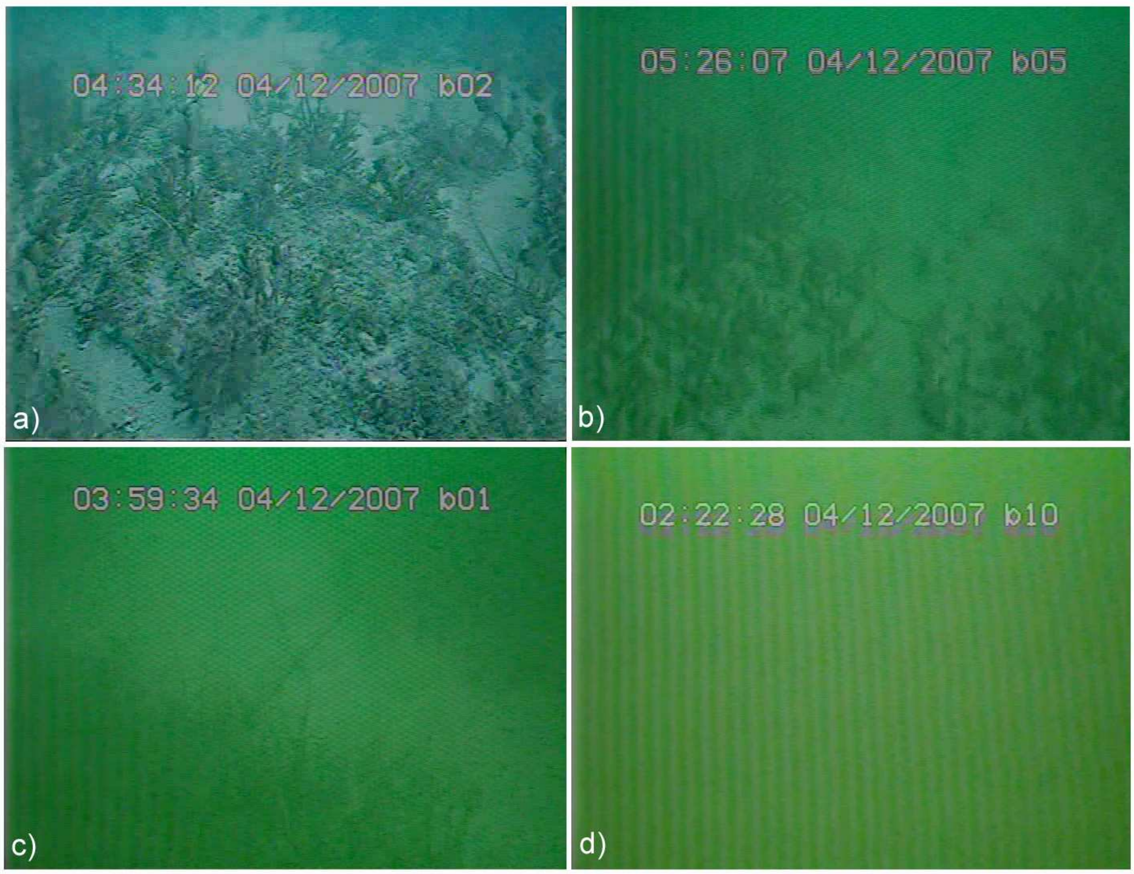

Figure 3. Screen captures illustrating the video quality categories assigned to the video footage examined a) ok quality, b) poor quality, c) very poor quality d) useless.

8.0 Regional Context

The area towed and mapped from video is a highly disturbed nearshore environment characterized by moving sands and bare subtidal pavement. Seagrass cover is greatest 900 m offshore, but these meadows do not have high shoot density and are very patchy in their distribution, The meadows offshore are clearly occurring on sand whereas closer inshore a mosaic of seagrass, seaweed and sessile benthic invertebrates was observed on relatively low relief reef and pavement. The mosaic of seaweeds and benthic invertebrates is most developed on reefs 300 -500 m offshore. Where we had reasonable images closer inshore there was extensive pavement bare of invertebrates and seaweeds suggesting that the pavement gets covered and scoured by shifting sands frequently. Further south, at the southern Bunbury wastewater treatment outfall, Cambridge and Kendrick (2000) found more diverse and more established benthic communities. Below are more detailed descriptions of the classes of substrata mapped and their association to specific biota with a regional context

Unvegetated sediment

Unvegetated sediment was the most extensive substrate observed from the videos. They were characteristically extensive but small patches of sediment were observed between and on pavement and reef. Large north-south trending ripples were common in video as was large amounts of unattached seagrass and algal detritus (wrack).

Seagrass and algal detritus (wrack) accumulations were observed inshore over unvegetated sediments. This detritus can be important for both nutrient cycling and juvenile fauna. It has been estimated to account for 15-19% of nutrient recycling (Kirkman and Kendrick 1997). It can drift at least 10 km and may take over 400 days to decompose, therefore providing habitat to abundant invertebrates, juvenile fish and shorebirds (Kirkman and Kendrick 1997), Reef pavement and elevated reef

Reef habitats ranged from limestone pavement partially covered by sand to ridges and gullies with topography of as much as 2 m, Limestone pavement was the most common substratum after unvegetated sediment and was bare of macroscopic biota inshore whereas offshore had variable coverage of seaweeds, sponges, ascidians, hydroids, bryozoa and in some places hard corals. A few patches of seagrass occurred in sandy hollows on the reef and this contrasts strongly to the reported high abundance of seagrasses, especially the species *Amphibolis antarctica* and *A. griffithii,* reported from the Bunbury Wastewater Treatment Plant outfall south of Bunbury (Cambridge and Kendrick 2000). Ridges and gullies had more diverse communities of seaweeds and sessile invertebrates. Similar assemblages have been recorded from south of Mandurah (Montgomery 1995) and Walker *et al.* (1994) and south of Bunbury (Cambridge and Kendrick 2000).

Seagrasses

The ribbon weeds, *Posidonia angustifolia* and *Posidonia coriacea,* were the only seagrasses observed from video. The region was species poor suggesting that those seagrases that were not observed either do not successfully recruit or cannot persist through frequent physical disturbances caused by storms in the region. Seagrass species diversity and extent were greater further south at Bunbury (Cambridge and Kendrick 2000).

A recent summary of the influence of waves and currents on Western Australian seagrasses indicated that some species of *Posidonia* (*Posidonia ostenfeldii* complex including *Posidonia coriacea*) are tolerant of wave disturbance as they have strongly reinforced leaves (Carruthers *et al.* 2007). *Posidonia coriacea* is an early successional species colonising mobile sediments and once established it both modifies the sediment and acts as a trap for finer sand and silt particles. It is subsequently colonised by *Posidonia angustifolia* and *Amphibolis* species (Kendrick *et al.* 2008). Interestingly, we did not observe *Amphibolis* species in this survey, although the more extensive beds and meadows were *Posidonia angustiflolia*. Smaller, more delicate species (e.g. *Heterozostera* spp., *Halophila ovalis*) were not observed, but they are present in these areas during the calmer summer months and lost or have restricted distributions during the winter storms.

Biota associated with benthic habitats

The reef pavement and ridges and gullies provide shelter for mobile fauna and attachment sites for sessile invertebrates. The Western rock lobster, *Panulirus cygnus*, can be found seasonally on these reefs (Jernakoff *et al.* 1987). The rocky outcrops were also covered with large ascidians such as *Herdmonia momus*, encrusting and large upright sponges although these were generally not as large as reported by Cambridge and Kendrick (2000), as well as temperate hard or stony corals such as *Turbinaria* and *Coscinarea*. The sponges and ascidians are filter feeders and are characteristic of areas with both strong water motion and high detrital or phytoplankton loads in the water column. These assemblages were similar but less abundant and more species poor than those reported by Cambridge and Kendrick (2000), Montgomery (1995) and Walker *et al.* (1994)

9.0 Conclusions and Recommendations

- The seabed in the survey area consisted of macroalgae and sessile invertebrate covered reef pavement and ridges, seagrass on sediment offshore and large areas of mobile unvegetated sediments and detritus (floating seagrass and algae).
- Unvegetated sediments were concentrated in the inshore and central sectors of the survey area.
- Extensive seagrass beds were observed starting at 900 m offshore although they were sparse and patchy.
- Seagrasses patches were not observed closer than 700 m from the beach. Light did not appear to be limiting in either environment, and the major difference seemed to be the benthic shear associated with the seas and ocean swells.
- There was a northwest-southeast trend in the distribution of reef starting in the south at 300 m offshore and 600m offshore in the northern sector mapped.
- The area mapped was highly disturbed with large areas of reef pavement devoid of biota and where biota occurred they occupied a small proportion of the total reef surface. Sediment sheets and megaripples were observed midshore suggesting sediment was highly mobile,
- The area had similar reef and seagrass communities to those reported further north and south although the diversity and abundance of organisms in this region appeared to be poorer.

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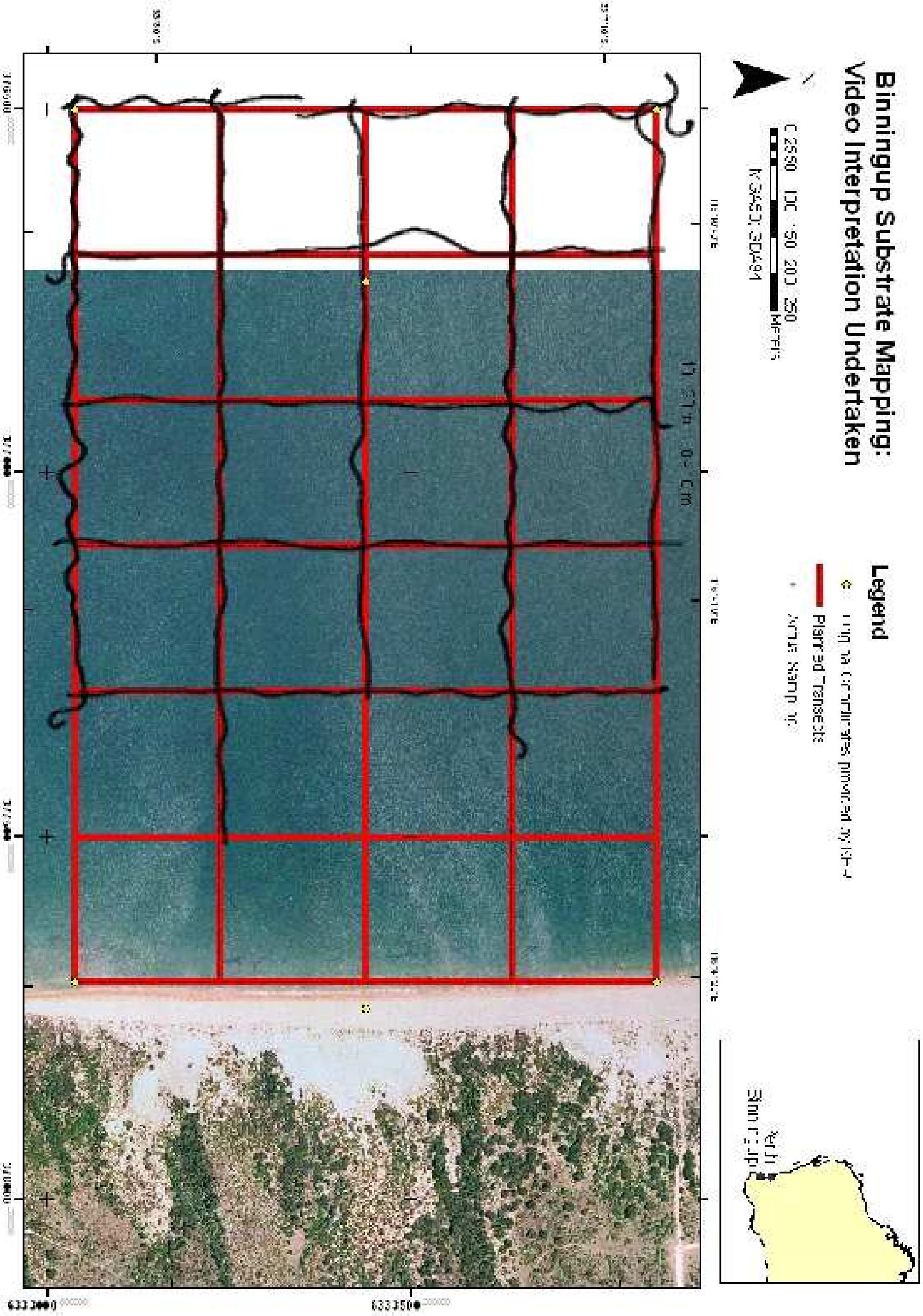
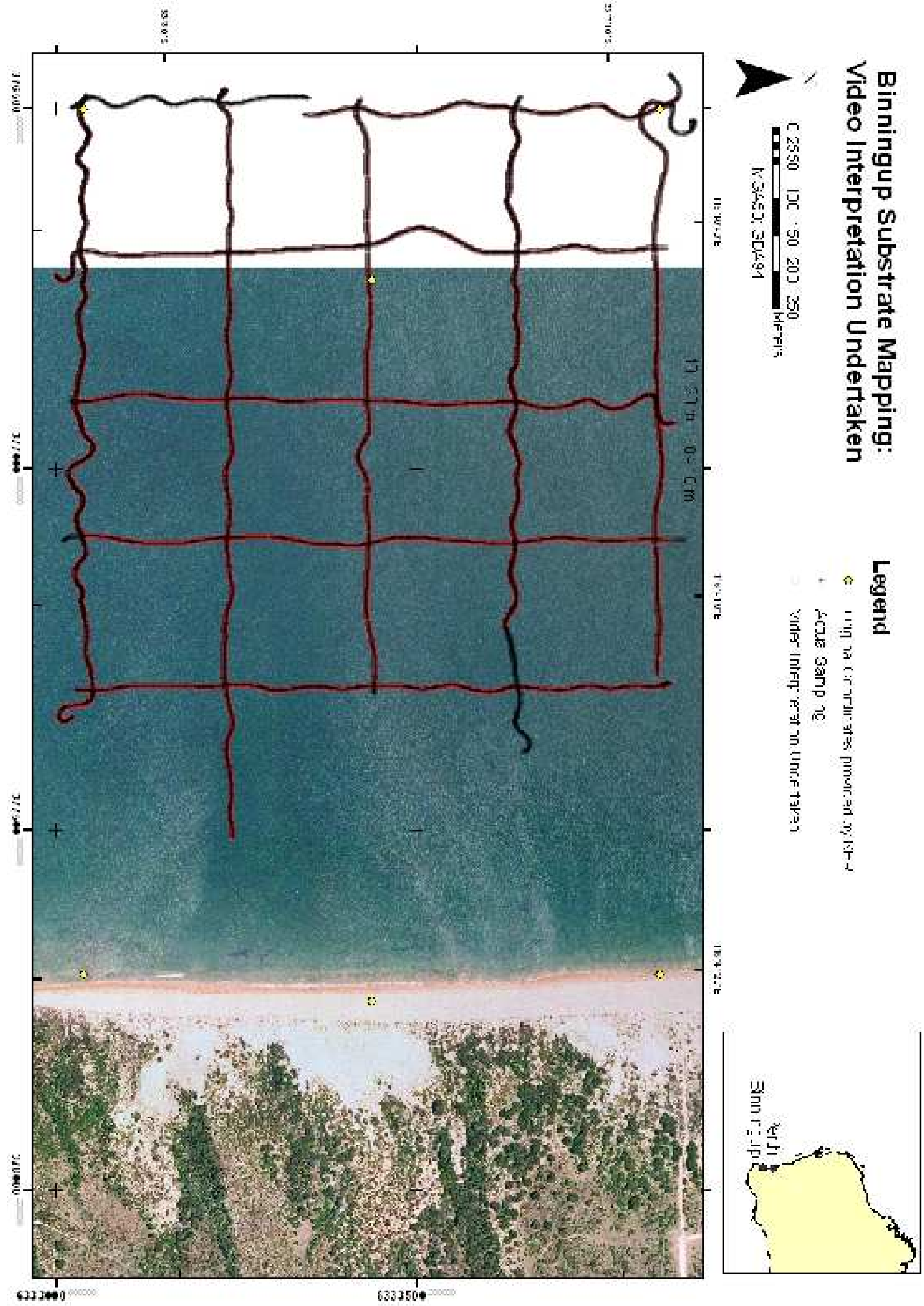
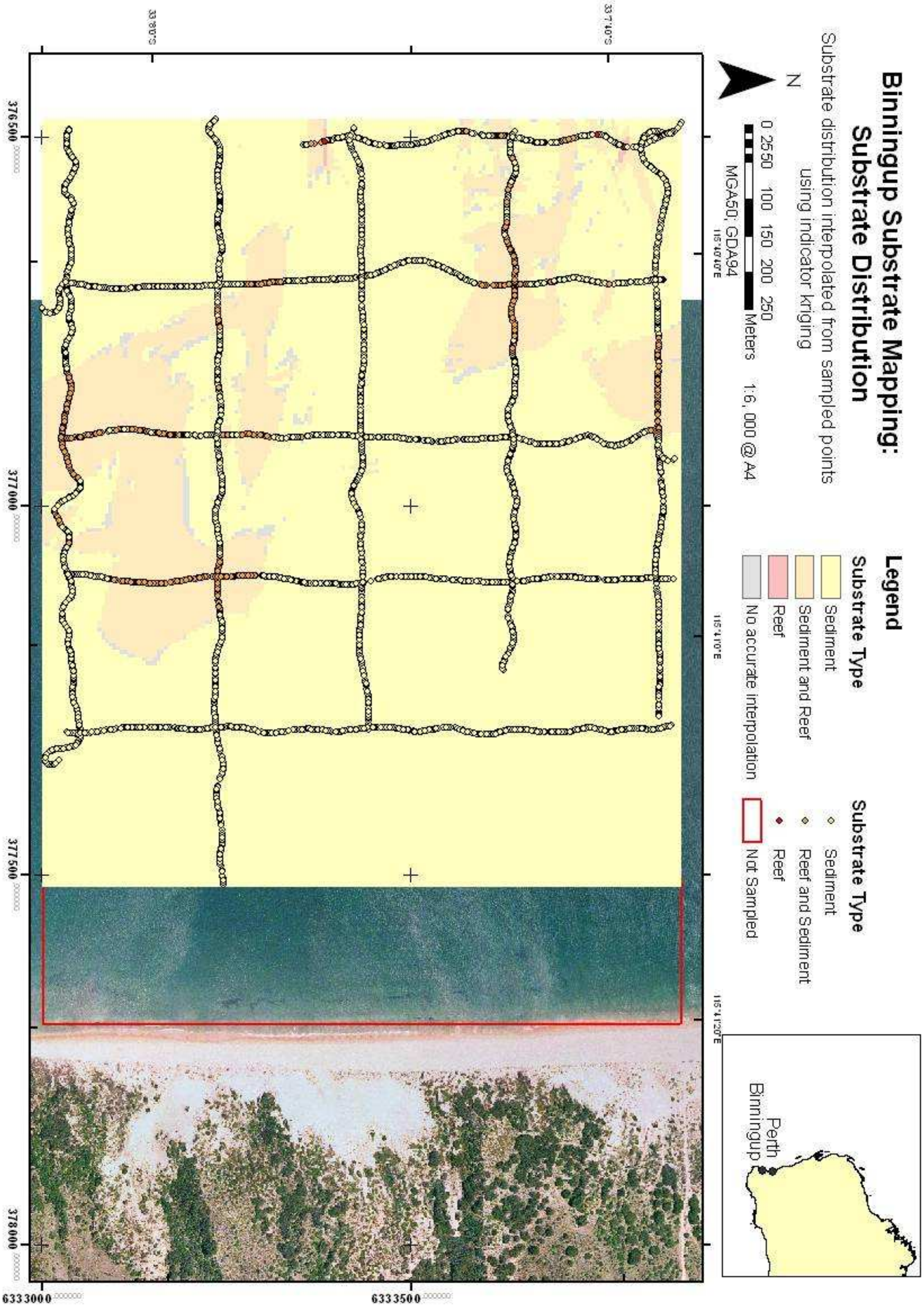
APPENDIX A - PLANNED AND ACTUAL SAMPLING



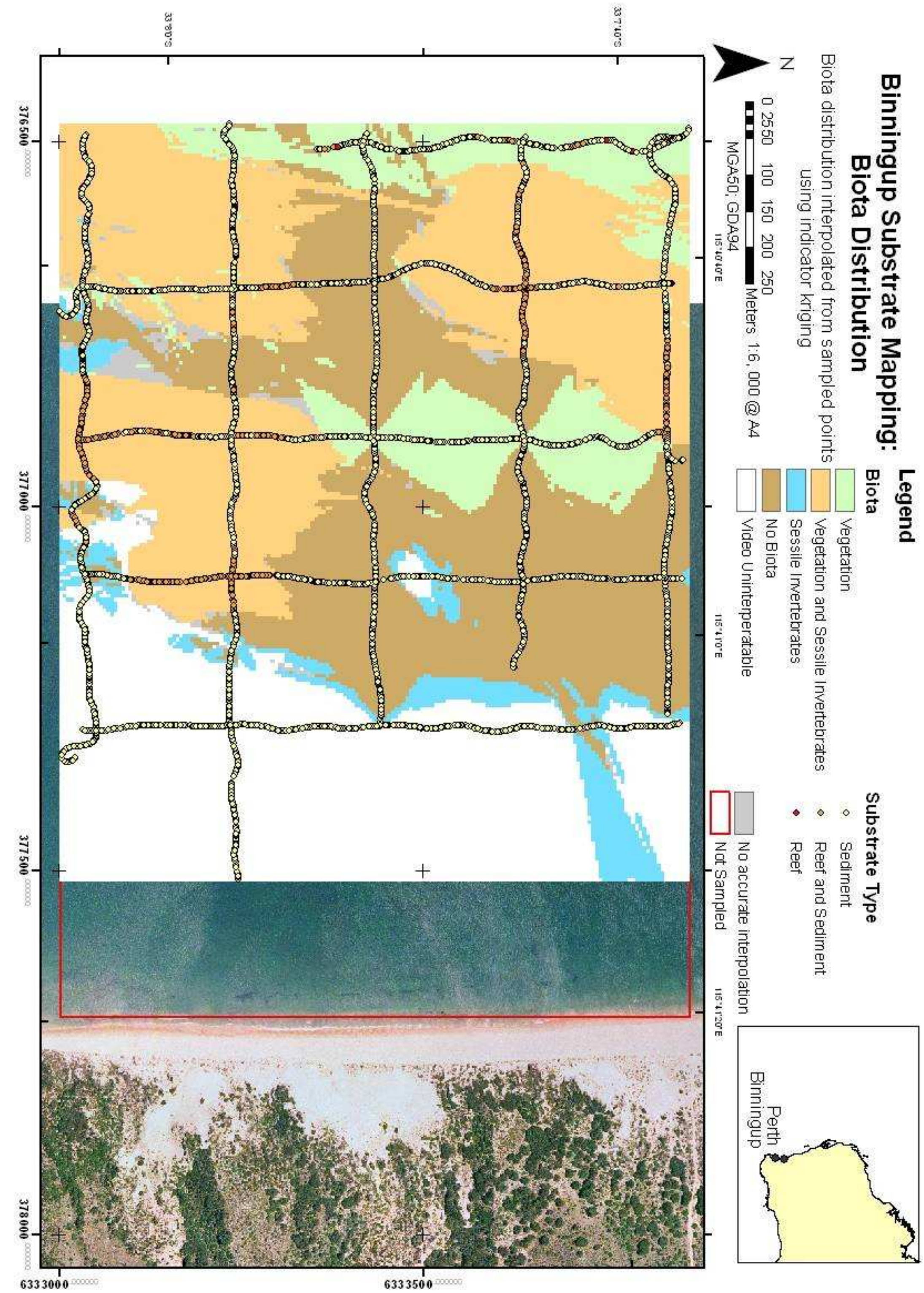
APPENDIX B – VIDEO INTERPRETATION UNDERTAKEN



APPENDIX C - SUBSTRATE DISTRIBUTION



APPENDIX D - BIOTA DISTRIBUTION



APPENDIX E - SEAGRASS DISTRIBUTION