Jurien Bay Benthic Habitat Mapping

444_07_001/1_Rev1

March 2018

Jurien Bay Benthic Habitat Mapping

Prepared for

Department of Transport

Prepared by

BMT

March 2018

Report No. 444_07_001/1_Rev1

Client: Department of Transport

Document history

Distribution

Revision	Author	Recipients	Organisation	No. copies & format	Date
A	M Capill	B Davis	BMT	1 x .docm	17/01/18
B	M Capill	L Synnot	BMT	1 x .docm	29/01/18
C	M Capill	M Bailey	BMT	1 x .docm	01/02/18
0	M Capill	L Clarke	BMT	1 x .pdf	02/02/18
1	M Capill	B Davis L Clarke	BMT	1 x docm	20/03/18

Review

Revision	Reviewer	Intent	Date
A	B Davis	Technical review	17/01/18
B	L Synnot	Client manager/editorial review	31/01/18
C	M Bailey	Director review	01/02/18
0	L Clarke	Project engineer	02/02/18

Quality Assurance

BMT Western Australia Pty Ltd (trading as BMT) has prepared this report in accordance with our Health Safety Environment Quality Management System, certified to OHSAS 18001, AS/NZS 4801, ISO 14001 and ISO 9001..

Status

This report is 'Draft' until approved for final release, as indicated below by inclusion of signatures from: (i) the author and (ii) a Director of BMT Western Australia Pty Ltd (trading as BMT) or their authorised delegate. A Draft report may be issued for review with intent to generate a 'Final' version, but must not be used for any other purpose.

Approved for final release:

Author
Date: 20/03/18

Director (or delegate)
Date: 20/03/18

Contents

List of Figures

List of Tables

List of Appendices

Acronyms

BPPH	Benthic primary producer habitat
DoT	Western Australian Department of Transport
ha	Hectares
km	Kilometres
m	Metres
m^2	Square metre
TCS	Towed camera system

1. Introduction

Jurien Bay Boat Harbour (hereafter, the Boat Harbour) is located north of the Jurien Bay town site, ~250 km north of Perth, Western Australia (Figure 1.1). The Boat Harbour services a range of government, recreational and commercial vessels and is managed by Department of Transport (DoT).

Wrack and marine sediments accumulate in the Boat Harbour on a frequent basis resulting in several negative impacts affecting the navigability, environment and aesthetic quality. To manage these impacts, routine maintenance dredging of the Boat Harbour is undertaken by DoT.

To inform future dredging requirements and marine environmental management of the Boat Harbour, BMT undertook benthic habitat mapping of Jurien Bay in November 2017. The specific objectives of the mapping project were to:

i. collect digital baseline data on the spatial extent and characteristics of benthic habitats in the mapping area, and
ii. qualitatively characterise the extent of benthic primary producer habitat (BPPH) surrounding the Boat Harbour, and develop a mapping product of suitable quality to meet multiple purposes (including informing dredging operations and potential future environmental approvals applications, if necessary).

This report provides an overview of the scope of work, methods and mapping products from the Jurien Bay benthic habitat mapping project.

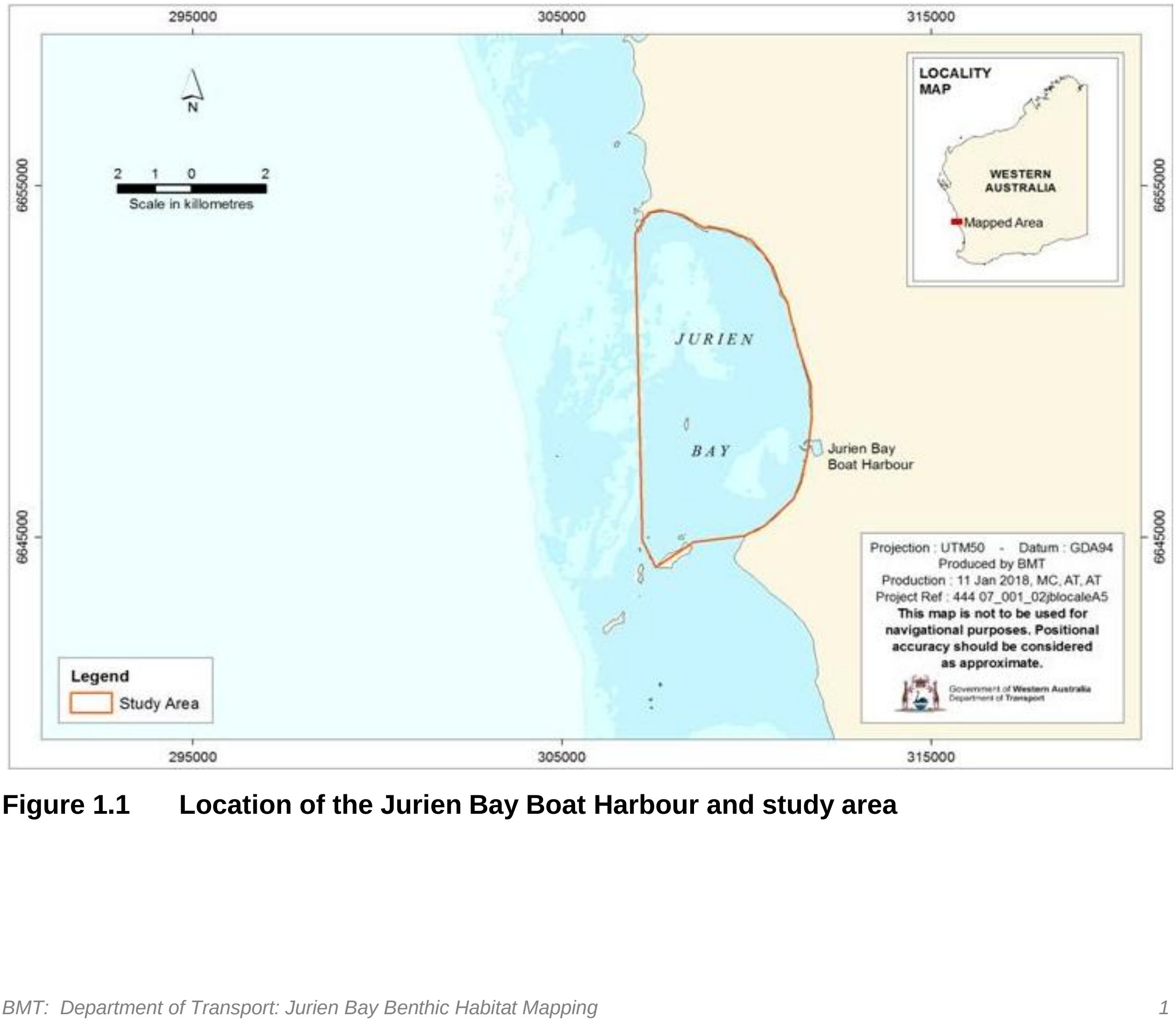


Figure 1.1 Location of the Jurien Bay Boat Harbour and study area

2. Description of the Marine Environment

2.1 General setting

The study area is located inside the Jurien Bay Marine Park (hereafter, the Marine Park) within the Central West Coast marine bioregion. The marine environment experiences a Mediterranean climate, low tidal range (maximum of ~0.7 m; Chua 2002), and predominantly wind driven currents (Holloway 2006). The marine flora and fauna of this region is comprised of a mixture of temperate and tropical species. Temperate species are transported north by the Capes Current from cool southern temperate waters, and tropical species are transported south by the Leeuwin Current from tropical northern waters (CALM 2005).

The near shore seabed topography of the region is complex, containing a series of shallow elongate limestone reefs that run parallel to shore. The numerous emergent rocks and islands associated with these reefs provide the coast with protection from swell waves, and result in the development of deep (>10 m depth) and shallow (<10 m depth) lagoonal environments. The shallow lagoons are interspersed with sandbars that run approximately perpendicular to shore (CALM 2005).

2.2 Marine flora and fauna

Marine Park waters are characterised by several BPPH types including (CALM 2005):

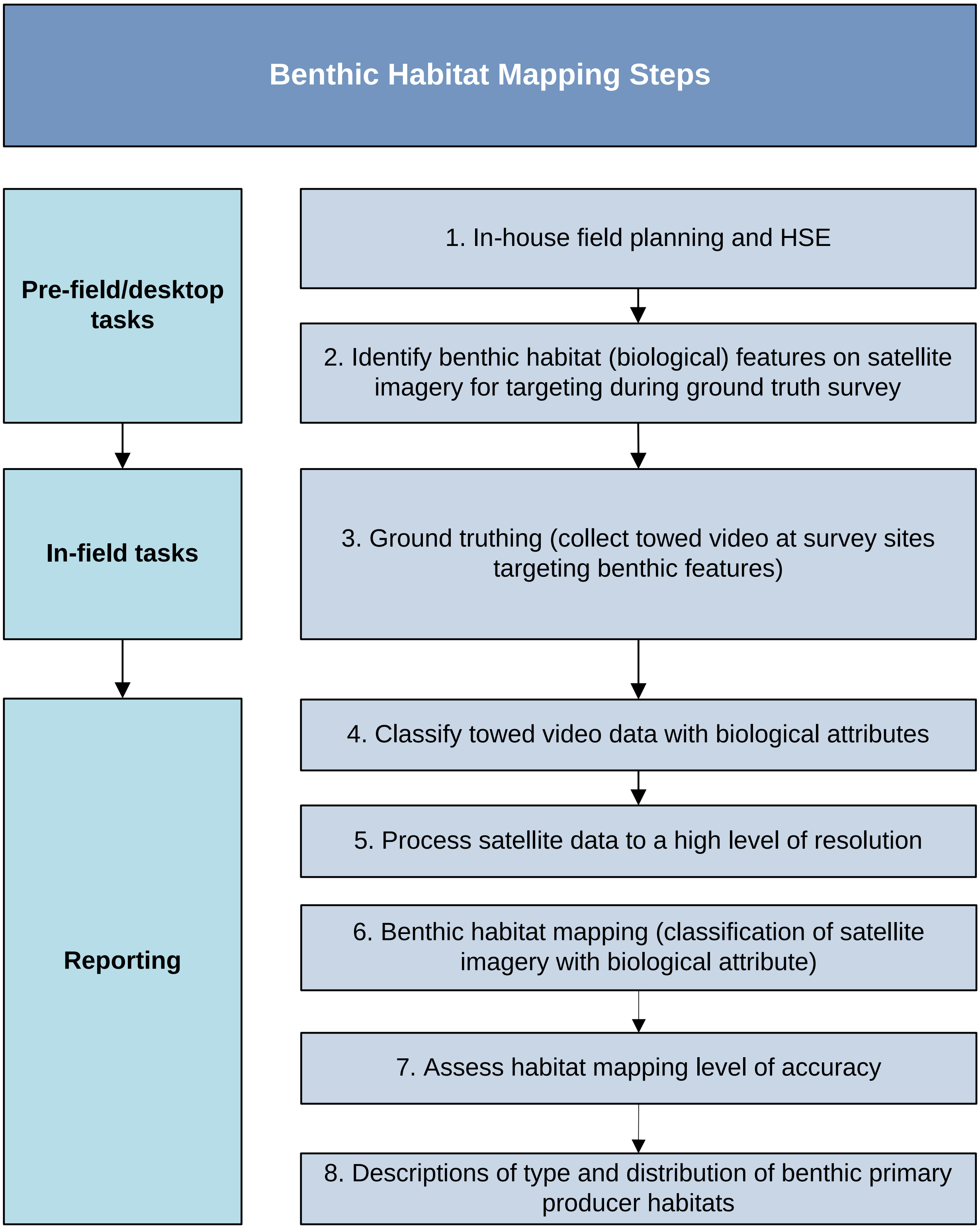
- seagrass meadows
- bare or sparsely vegetated mobile sand
- shoreline and offshore intertidal reef platforms
- subtidal limestone reefs
- reef pavement

These BPPH support diverse seagrass assemblages, with nine species of seagrass recorded in the Marine Park, and mixed macroalgal assemblages (CALM 2005). Although small coral communities are relatively common in the Jurien Bay region, there are no coral reefs (CALM 2005).

These local BPPHs in turn provide habitat and food for diverse fin-fish assemblages, with up to 127 species recorded in the Jurien Bay region (Atlas of Living Australia 2018). Examples include Western Australian dhufish (*Glaucosoma hebraicum*), pink snapper (*Chrysophrys auratus*) and baldchin groper (*Choerodon rubescens*). The commercially fished western rock lobster (*Panulirus cygnus*) is also common to the region and has the highest economic value of any single species commercial fishery in Australia. In addition, the Marine Park supports several species of marine mammals, including 14 species of cetaceans (five of which are listed as rare or likely to become extinct), and a large sea lion population (CALM 2005).

3. Benthic Habitat Mapping Methods

The steps involved to prepare the benthic habitat map are presented in Figure 3.1. In summary, satellite imagery was used to identify benthic habitat features to be ground truthed by towed video. Video footage was classified with biological attributes and combined with satellite imagery to create classified BPPH maps of an area offshore of the Boat Harbour.



Note:
1. HSE = Health, Safety and Environment

Figure 3.1 Steps undertaken to complete Jurien Bay benthic habitat mapping

3.1 Remote data collection

Satellite imagery collected over the study area in the last two years was assessed to determine the most suitable image for mapping. Multispectral satellite imagery from 24 August 2017 was used to identify benthic habitat assemblages for mapping the study area (Figure 3.2). Panchromatic (grey-scale) and multispectral (8 spectral bands) satellite imagery was acquired from the DigitalGlobe WorldView-2 sensor with a resolution of 2 m. The image selected had the clearest water and highest visibility of benthic features in the area of primary interest. Some turbidity was evident over the northern part of the image, but the visibility over these areas was considered sufficient to allow for spectral separation of habitat categories. Prior to commencing the habitat mapping, the satellite imagery was assessed for possible artefacts or sun-glint, but due to the high image quality, no corrections were required.

3.2 Ground truth survey

Ground truth data were collected using towed video camera surveys on 9 and 11 November 2017 and on 1 March 2018. The ground truth data were used to augment the spatial data from the satellite image analysis, and to enable definition of benthic habitat assemblages within the study area. The survey design, collection techniques and methods used to capture and classify video data are described below.

3.2.1 Survey design

In total, 60 transects were surveyed with towed video (Figure 3.2). Transect lengths varied from ~100 m to ~1.6 km, with a total survey transect distance of ~27.5 km. Transect positions were stratified to target areas of particular benthic features (sediments, reefs, seagrass, macroalgae habitats) prior to field mobilisation. Most video frames covered a ~1–2 m wide band of substrate, resulting in ~4.1 hectares (ha) (or 0.11% of the mapping area) of benthic habitat surveyed. Within this survey area, the video data analysis produced ~47 690 units of classified habitat data (with each unit corresponding to ~1.0 m^2 of mapping area).

3.2.2 Collection of towed video data

Towed video data were collected using a towed camera system (TCS). The TCS was configured for the project with two digital cameras (one standard definition and one high definition) mounted in a water proof sled/housing. The primary camera was mounted to a sled on a 45° angle, pointing forward. The system was connected to the vessel via an umbilical that could be let out to 50 m.

High definition footage from the camera was recorded onto the device's internal storage (128 GB) or external SD cards (up to 128 GB), while standard definition footage was used by the field team to navigate the sled. Footage was backed up at least daily throughout the survey.

During the towed video surveys, a track log was created in real-time within positioning software. The track log contained local date, local time, easting, northing, latitude and longitude, updated every 1 second. A single track log was generated for all towed video transects at the end of the survey.

3.2.3 Classification of video footage

Video footage was analysed and classified according to the benthic habitat categories outlined in Table 3.1. Analysis and classification of video footage was undertaken using TransectMeasure (SeaGIS 2013). The number of points from video tow that were classified for each benthic habitat category is provided in Table 3.2; each point represents ~1 m^2 of benthic habitat. Following classification, the time vs. classification log was merged with the position vs. time log to provide a single file with a classification for every position where valid video footage was obtained; this process was automated.

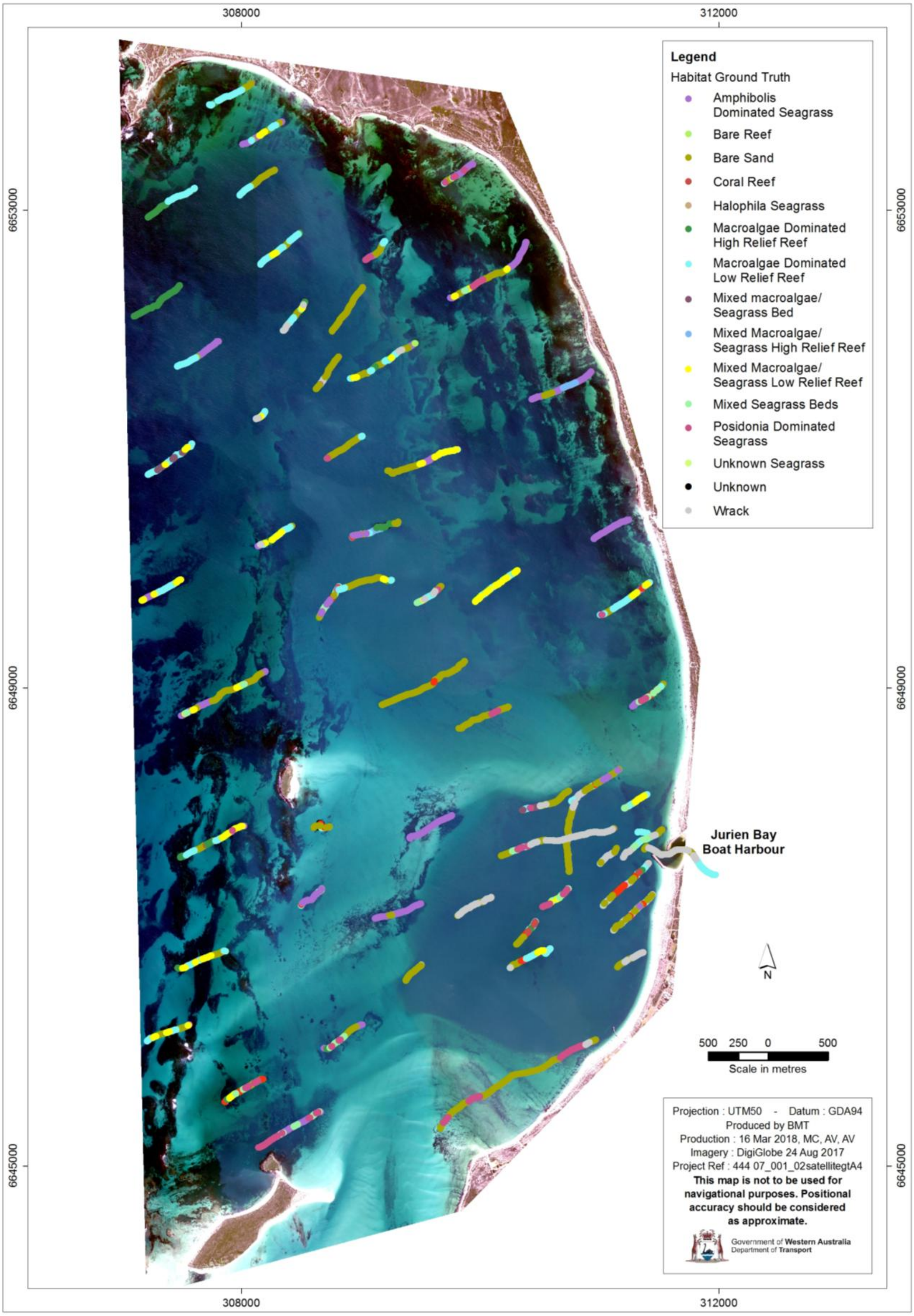
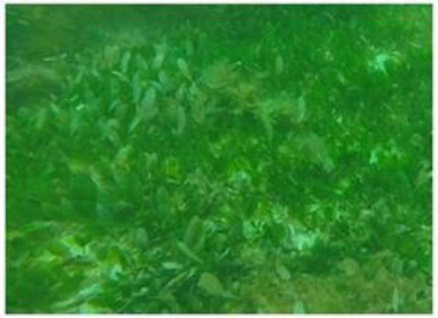
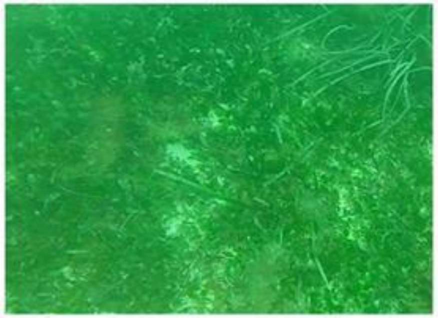
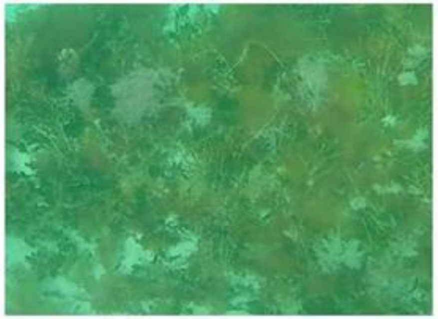
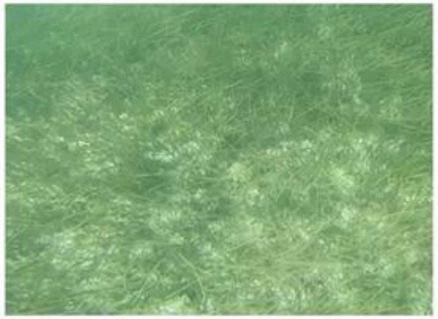


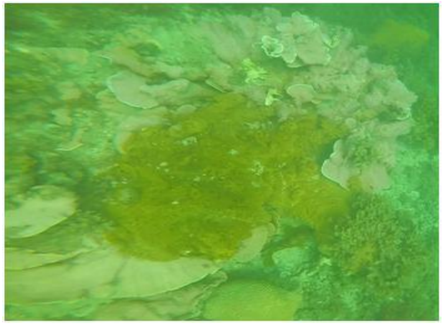
Figure 3.2 Jurien Bay benthic habitat mapping transect locations and habitat type

Table 3.1 Jurien Bay benthic habitat mapping categories and example images from video classification

Benthic habitat categories	Example images
Seagrass bed dominated by *Halophila* spp.	 
Seagrass bed dominated by *Amphibolis* spp.	  
Seagrass bed dominated by *Posidonia* spp.	 

Mixed seagrass bed	 
Macroalgae dominated low relief reef	  
Macroalgae dominated high relief reef	 

Mixed macroalgae/seagrass bed			
Mixed macroalgae/seagrass low relief reef			
Mixed macroalgae/seagrass high relief reef			

Coral	 
Bare reef	 
Bare sand	 

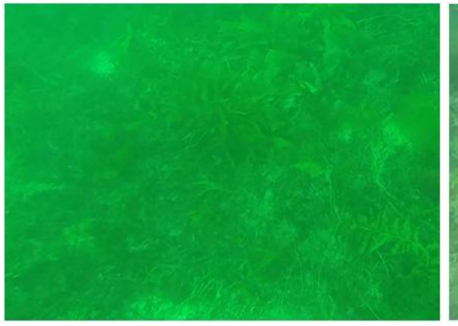
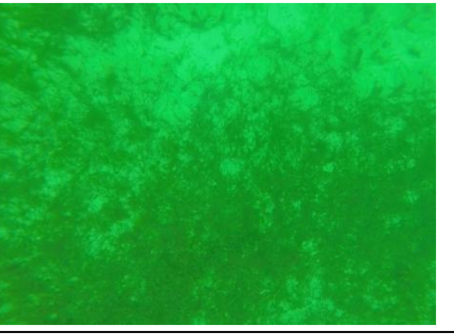
Wrack	  
Unknown seagrass	
Unknown	Feature does not fit into any of the above categories, and/or, cannot be determined.

Table 3.2 Benthic habitat categories points classified and proportion

Benthic habitat categories	Points classified	Proportion[1] (%)
Seagrass bed dominated by *Halophila* spp.	1094	2.3
Seagrass bed dominated by *Amphibolis* spp.	6108	12.8
Seagrass bed dominated by *Posidonia* spp.	1728	3.6
Mixed seagrass bed	1227	2.6
Macroalgae dominated low relief reef	8374	17.6
Macroalgae dominated high relief reef	1936	4.1
Mixed macroalgae/seagrass bed	332	0.7
Mixed macroalgae/seagrass low relief reef	3134	6.6
Mixed macroalgae/seagrass high relief reef	358	0.8
Coral	93	0.2
Bare reef	350	0.7
Bare sand	17154	36.0
Wrack	5645	11.8
Unknown seagrass	13	0.0
Unknown	144	0.3
Total	47690	100

Note:

1. Percentages do not add up to exactly 100 due to rounding.
2. Example images of classification categories are provided in Table 3.1.

3.3 Classification and mapping procedures

3.3.1 Classification procedures

Habitat mapping was performed using a supervised Maximum Likelihood classifier to classify the images using ERDAS IMAGINE 2015 (Hexagon Geospatial 2016). Training areas were based on ground truthing collected in the field using towed video (Section 3.2.3). A random split was applied to the ground truthing points to split them into classification (70%) and validation (30%) data. The 70% withheld classification ground truthing data were used to generate spectral signatures for the classification. Habitats could be reliably divided into vegetated cover of varying density, and non-vegetated areas, but could not be further classified into seagrass and reef categories as a result of high spectral similarity between seagrass and other vegetated areas (e.g. macroalgae, turfing algae). Therefore, the following categories were mapped:

- vegetated
- non-vegetated areas.

Vegetated areas included all regions with sparse to dense seagrass or macroalgal cover, while non-vegetated areas combined sand and bare rock pavement/reef. Seagrass and macroalgal categories were manually assigned at a later stage. Vegetated areas were defined as either dense (having no obvious gaps in the vegetation cover based on visual assessment of the imagery) or sparse vegetation (containing areas of bare sand or reef in between the vegetation cover). After the supervised classification had been performed, the classified images were visually assessed for consistency across the study area using ArcGIS 10.2. Bathymetric charts were also used to help delineate reef and non-reef areas based on visual assessment of the depth differences between features. The bathymetric information was then integrated with the habitat classification to allow for the separation of vegetated areas, according to reef or non-reef substrate.

3.3.2 Development of final habitat map

Ground truthing data (Figure 3.2) were used to manually define seagrass and macroalgal habitats over the vegetated reef and non-reef areas using ArcGIS 10.2, resulting in the categories described in (Table 3.1). Post-processing was then applied to improve the classification over areas of noise in the data, or misclassification resulting from spectral similarities between the categories, especially in more sparsely vegetated areas, and smooth the boundary between classified habitats. Areas affected by remaining turbidity were improved by applying additional image assessments and contrast stretches to maximise the visibility and confirm the extent of habitats. A minimum mapping unit of ~36 m^2 was considered suitable to remove small classified areas and merge with neighbouring polygons.

3.3.3 Assessment of accuracy

An accuracy assessment was performed on the habitat classification using the 30% withheld validation ground truthing data for the vegetated and non-vegetated categories. No accuracy assessment could be performed for the detailed habitat categories, as these were derived manually with no supervised classification approach and final categories deviated slightly from the final ground truth categories. However, a visual assessment showed good agreement between the detailed categories and the imagery and ground truthing.

The assessment of vegetated and non-vegetated categories achieved a very high overall accuracy of 93.40% and Kappa statistic of 0.87. The accuracies for the individual categories are reflected in Table 3.3. The Kappa value measures agreement between the classification of categorical data, and recognises the agreement that could occur by chance. Kappa values over 0.40 have been considered as representing moderate to strong agreement (Congalton 1991, 2001).

Table 3.3 Accuracy assessment of the benthic habitat classification

Habitat type		Reference Data			User's accuracy[1]
		Vegetated	Non-vegetated	Total	
Classified Data	Vegetated	58	5	63	**92.06%**
	Non-vegetated	2	41	43	**95.35%**
	Total	60	46	106	N/A
	Producer's accuracy[2]	**96.67%**	**89.13%**	N/A	N/A

Note:

1. User's accuracy, or reliability, indicates the probability that a pixel classified in the image actually represents that class on the ground (error of commission). It is calculated by dividing the total number of correct pixels in a class by the total number of pixels that were classified in that class (Congalton 1991).
2. Producer's accuracy indicates the probability of a reference pixel being correctly classified (error of omission). It is calculated by dividing the total number of correct pixels in a class by the total number of pixels of that class as derived from the reference data.

4. Distribution of Benthic Habitats

A total of 3667.2 ha of benthic habitat was mapped during the project (Table 4.1). Within this area, the dominant habitat types are (Table 4.1):

- bare sand (57.9%),
- sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.) (18.3%)
- sand inundated platform reef with macroalgae and perennial seagrass (*Amphibolis spp.*) (13.9%)
- reef dominated by macroalgae (6.1%)

Comparatively, a small proportion of mapped benthic habitat is inhabited by mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.) (2.6%) and even less by mono-specific perennial and ephemeral seagrass meadows (~1.0% for *Amphibolis* spp., *Posidonia* spp. and *Halophila* spp. combined). There is also little habitat within the mapping area occupied by filter feeders such as corals and sponges (0.3%). One area containing filter feeders was identified within a mixed assemblage of macroalgae and ephemeral seagrass (*Halophila* spp.) located south-west of the Boat Harbour approximately 750 m offshore (Figure 4.1).

The nearshore area north of the Boat Harbour is mostly comprised of a mixed assemblage of macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.). This occurred on sand inundated platform reef, extending ~500 m to 1 km offshore (Figure 4.1). South of the Boat Harbour, benthic habitat is less vegetated and is dominated by mobile sands with small scattered meadows of perennial seagrass (mixed assemblages of *Posidonia* spp. and *Amphibolis* spp. and mono-specific assemblages of *Posidonia* spp.) and ephemeral seagrass (*Halophila* spp.; Figure 4.1). This predominantly sandy area surrounding the Boat Harbour extends ~3 km offshore.

Further offshore, benthic habitat is dominated by a mixed assemblage of macroalgae and perennial seagrass (*Amphibolis* spp.) on sand inundated platform reef (Figure 4.1). Next to the dominant offshore benthic habitat, areas containing a mixed assemblage of macroalgae and mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.) also occur (Figure 4.1). In the north-west offshore region of the mapping area, there is an expansive area of reef dominated by macroalgae (Figure 4.1).

Inside the Boat Harbour Entrance Channel, benthic habitat is predominantly characterised by wrack overlying bare sand. Directly adjacent to the Boat Harbour Entrance Channel, wrack and sparse meadows of seagrass (*Posidonia* spp.) covered in sand and epiphytic growth by calcareous algae was observed. These seagrass meadows appeared partially dead and flattened on the seafloor, and therefore were classified as wrack for the purpose of the mapping project. It is noted that areas which comprised wrack have been classified as bare sand in Figure 4.1.

Table 4.1 Area and proportion occupied by benthic habitat categories

Benthic habitat type	Area (ha)	Proportion1 (%)
Ephemeral seagrass (Halophila spp.)	2.6	0.1
Perennial seagrass (Amphibolis spp.)	23.4	0.6
Perennial seagrass (Posidonia spp.)	12.2	0.3
Mixed perennial seagrass (Amphibolis spp. and Posidonia spp.)	94.5	2.6
Reef dominated by macroalgae	222.1	6.1
Sand inundated platform reef with macroalgae and perennial seagrass (Amphibolis spp.)	508.2	13.9
Sand inundated platform reef with macroalgae and mixed perennial seagrass (Posidonia spp. and Amphibolis spp.)	670.2	18.3
Platform reef with macroalgae, filter feeders (corals and sponges) and ephemeral seagrass (Halophila spp.)	11.5	0.3
Bare sand	2122.5	57.9
Total	3667.2	100

Note:

1. Percentages do not add up to exactly 100 due to rounding.

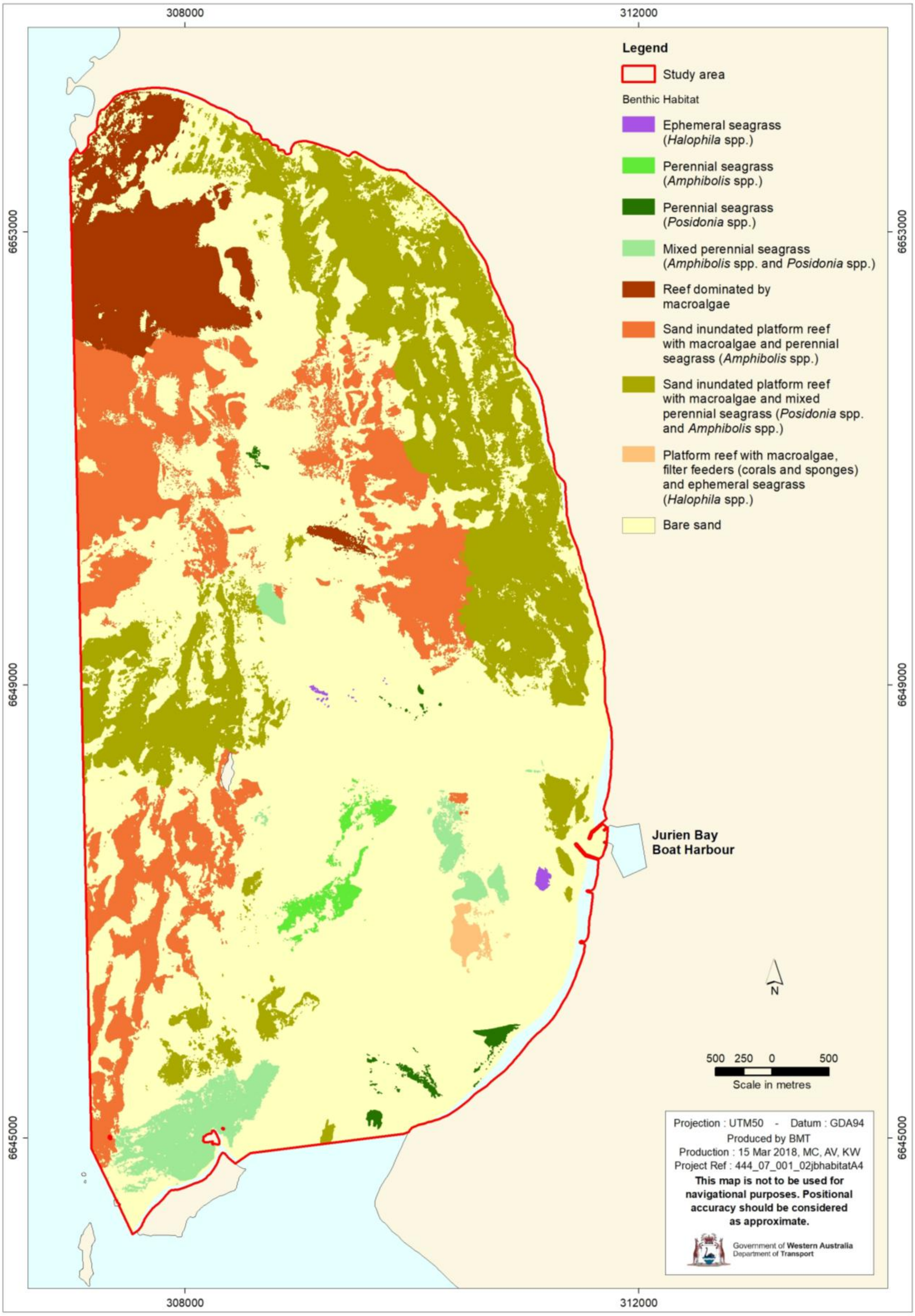


Figure 4.1 Classification of Jurien Bay benthic primary producer habitat extent and distribution

5. Conclusions

Benthic habitats of Jurien Bay were successfully mapped using satellite images and ground truthing data. The survey methods and approaches used to generate the benthic habitat map employed accepted scientific techniques that are repeatable.

Habitats primarily consisted of bare sand, sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.), sand inundated platform reef with macroalgae and perennial seagrass (*Amphibolis* spp.) and reef dominated by macroalgae. The mapped benthic habitats were representative of known regional and local habitats, and no new BPPH assemblages were observed.

This report and associated mapping products provide a high quality representation of the benthic habitats within the mapping area. All maps are suitable for environmental approvals processes with State and Federal regulatory authorities, and for facilitating future monitoring and management in the region.

6. References

Atlas of Living Australia (2018) Atlas of Living Australia website. Available at http://www.ala.org.au [Accessed 17 January 2018]

CALM (2005) Jurien Bay Management Plan 2005–2015. Department of Conservation and Land Management, Report No. 49, Perth, Western Australia

Chua J (2002) Oceanographic Modelling of Jurien Bay, Western Australia. University of Western Australia, Perth, Western Australia

Congalton RG (1991) A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment 37:35–46

Congalton RG (2001) Accuracy assessment and validation of remotely sensed and other spatial information. International Journal of Wildland Fire 10:321–8

Hexagon Geospatial (2016) ERDAS Imagine Classification Supervised Classification. Available at <https://hexagongeospatial.fluidtopics.net/reader/~P7L4c0T_d3papuwS98oGQ/r3McCpL65xdeQ0Mcu5SfzA > [Accessed on 11 October 2017]

Holloway K (2006) Characterizing the Hydrodynamics of Jurien Bay, Western Australia. University of Western Australia, Perth, Western Australia

SeaGIS (2013) Transect Measure – single camera biological analysis tool. SeaGIS Pty Ltd, Bacchus Marsh, Victoria, Australia. Available at http://www.seagis.com.au/transect.html [Accessed 15 May 2013]

Appendix A

Electronic data

The following data were supplied electronically to Department of Transport for the Jurien Bay mapping project:

- Towed video
- Transect locations and time stamp data
- TransectMeasure classifications – raw data
- Raw satellite imagery (2017)
- Ground truth video overlay
- Mapping products – final BPPH map

PO Box 2305 Churchlands
WA 6018 Australia
Tel: +61 8 6163 4900
www.bmt.org