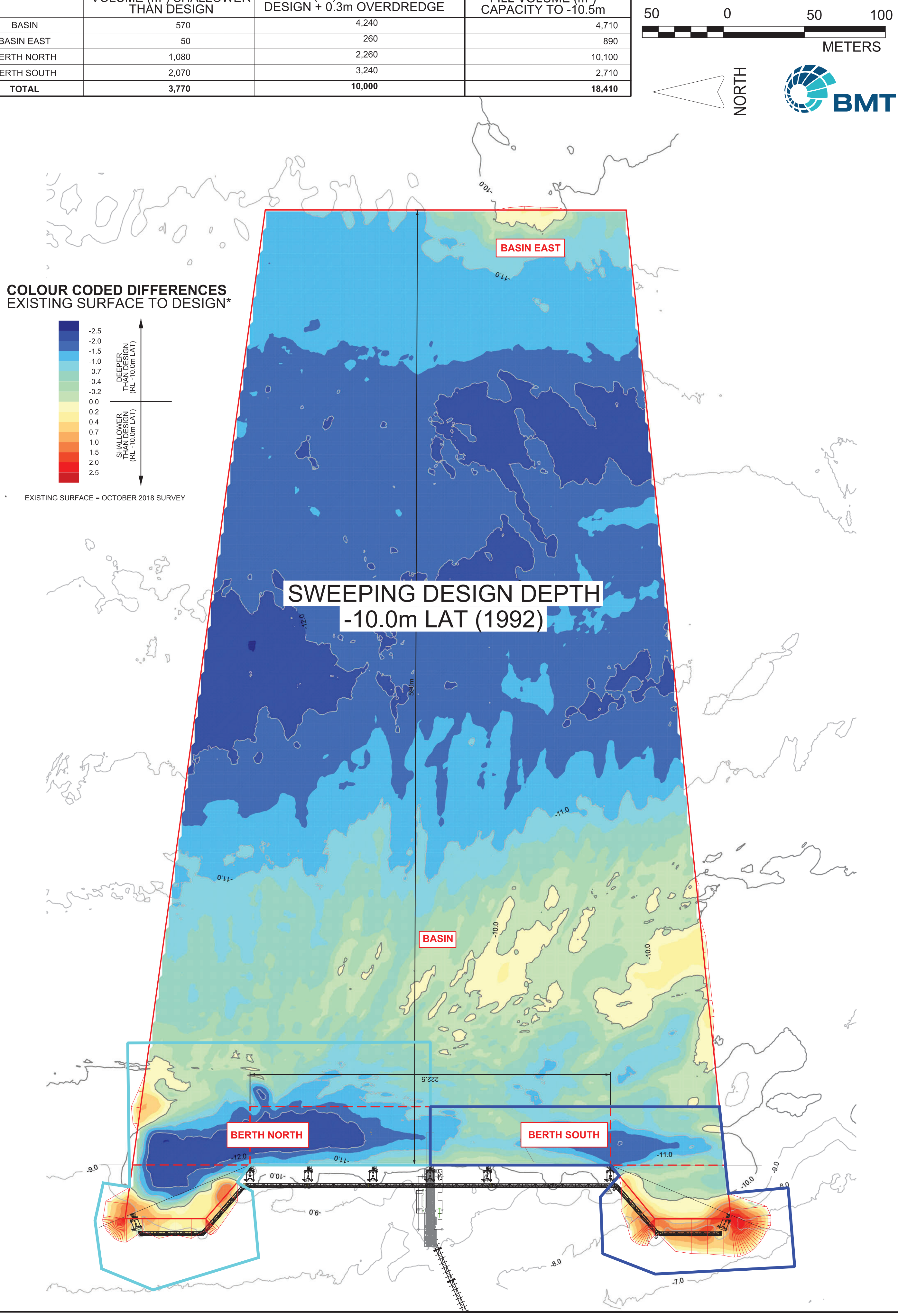
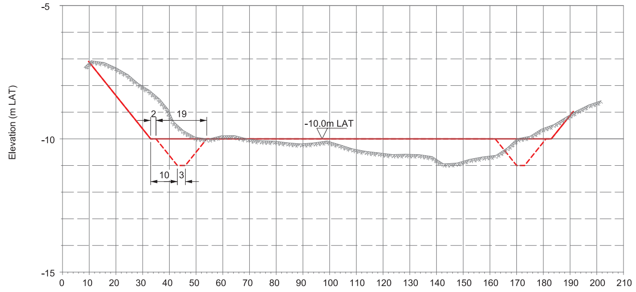
Appendix B Draft Design Drawings

VOLUMES - WITH BATTER

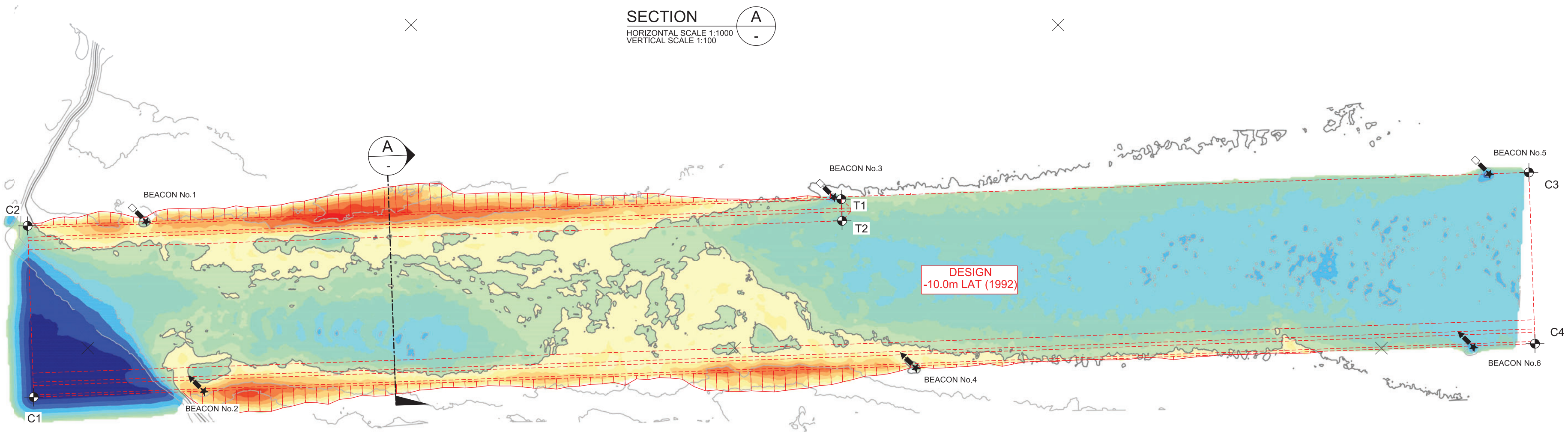
DREDGE AREA	VOLUME (m³) SHALLOWER THAN DESIGN	VOLUME (m³)SHALLOWER THAN DESIGN + 0.3m OVERDREDGE	FILL VOLUME (m³) CAPACITY TO -10.5m
BASIN	570	4,240	4,710
BASIN EAST	50	260	890
BERTH NORTH	1,080	2,260	10,100
BERTH SOUTH	2,070	3,240	2,710
TOTAL	**3,770**	**10,000**	**18,410**



158000-06-10A

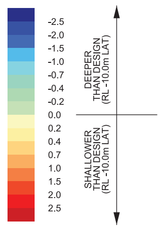


SECTION A
HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:100



LEGEND

- DREDGE DESIGN
- TRENCH DESIGN
- OCTOBER 2018 SURVEY
- SETOUT POINT



NOTE: COLOUR CODED DIFFERENCES IS TO DESIGN -10m (NO TRENCH)

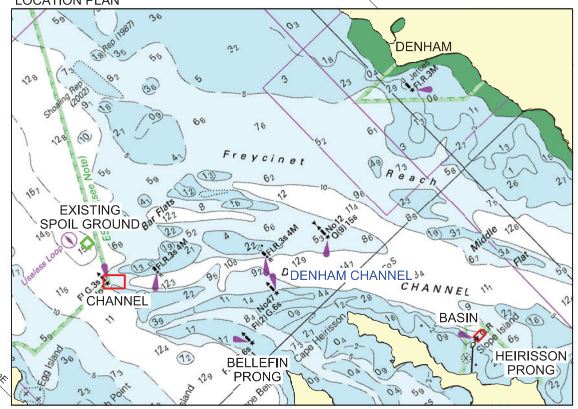
TIDAL PLANES	HEIGHT ABOVE DATUM(m)
HAT	1.58
MHHW	1.37
MLHW	1.12
MSL	0.85
AHD	0.77
MHLW	0.59
MLLW	0.34
LAT (2015)	0.01
LAT (1992) DATUM	0.00

SETOUT POINTS

POINT	EASTING	NORTHING
C1	725136.3	7134803.1
C2	725238.5	7134912.8
C3	726199.9	7134017.6
C4	726097.7	7133907.8
T1	725758.2	7134426.2
T2	725745.2	7134412.3

DREDGE AREA	VOLUME (m³) SHALLOWER THAN DESIGN	VOLUME (m³)SHALLOWER THAN DESIGN + OVERDREDGE
CHANNEL (WITH TRENCH)	38,010	68,200
BASIN	3,820	19,590
TOTAL	**41,830**	**87,790**

LOCATION PLAN



REV	DATE	AMENDMENT	DRN	APP
B	23/03/20	VOLUMES UPGRADED,TABLE AMENDED, TIDE PLANES ADDED	GKB	
A	11/04/19	INITIAL ISSUE	SM	

ORIG SIZE A1
ARCHIVE SBR_1588_00-01-01B.dgn, SB_2018-10-31_Ns_PO_mga94_LAT.dtm
SB_Channel_Design_2020-05-05.dtm, SB_DiffPlot_2018-10-31_to_Design_channel.dtm

NOTES
1. NAVAID POSITIONS PROVIDED BY SURRICH HYDROGRAPHICS SURVEYORS
2. DESIGN CHANNEL OVERDREDGE IS +0.3m VERTICAL AND 1.0m HORIZONTAL (NO HORIZONTAL FOR TRENCH)
3. ALL BATTERS 1:8
4. AUS CHART 331

SCALE 1 : 2000
50 0 100 200 METRES

DATUM
VERTICAL USELESS LOOP, LOWEST ASTRONOMICAL TIDE 1992
4.062m BELOW BENCHMARK, EDEL 5
0.77m BELOW AHD (2013)
HORIZONTAL MAP GRID OF AUSTRALIA BASED ON GDA 94, ZONE 49

GDA
BebbCart
BMT

ENGINEER	H.SUNARKO	11/04/2019
DRAWN	S.MOUCHEMORE	11/04/2019
DRAFTING CHECK	C.LIVINGSTONE	11/04/2019
ENGINEERING CHECK		
APPROVED PROJECT MGR		

CLIENT SHARK BAY SALT
PROJECT USELESS LOOP - MAINTENANCE DREDGING
TITLE COLOUR CODED DIFFERENCES 31 OCTOBER 2018 SURVEY TO DESIGN CHANNEL
DRAWING NUMBER SBR 1588 00 - 01 - 01
REV B

Appendix C Shark Bay Resources Dredging: Benthic Habitat Mapping Report

Shark Bay Resources Dredging: Benthic Habitat Mapping Report

R-1588_00-3

June 2020

Document Control Sheet

Project	Shark Bay Resources Dredging
Report Title	Shark Bay Resources Dredging: Benthic Habitat Mapping Report
Client	Shark Bay Resources
Report No.	R-1588_00-3
Date	June 2020

Distribution

Revision	Author	Recipients	Organisation	No.copies & format	Date
A	C Hart	A Bevilaqua	BMT	1 x docx	30/03/2020
B	C Hart	A Bevilaqua R De Roach	BMT	1 x docx 1 x docx	15/04/2020 17/04/2020
C	C Hart	A Bohnen	Shark Bay Salt	1 x pdf	20/04/2020
0	C Hart T Newnham	A Bohnen	Shark Bay Salt	1 x pdf	12/06/2020

Revisions

Revision	Reviewer	Intent	Date
A	A Bevilaqua	Technical and Editorial Review	08/04/2020
B	A Bevilaqua R De Roach	Final Client Manager Review Project Director Review	16/04/2020 19/04/2020
C	A Bohnen	Client Review	24/04/2020

Quality Assurance

WWW.JAS-ANZ.ORG/REGISTER

BMT Commercial Australia Pty Ltd has prepared this report in accordance with our Integrated Management System, certified to OHSAS18001, ISO14001 and ISO9001

Status

This report is 'Draft' until approved for final release by the Project Director (or their authorised delegate) as indicated below by signature. 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:

Head of Western Region (or delegate)
Date: 12 June 2020

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List of Terms and Abbreviation

BCH	Benthic communities and habitats
ha	Hectares
km	Kilometres
LAU	Local assessment unit
m	Metres
km^2	Square kilometres
SBR	Shark Bay Resources

1 Introduction

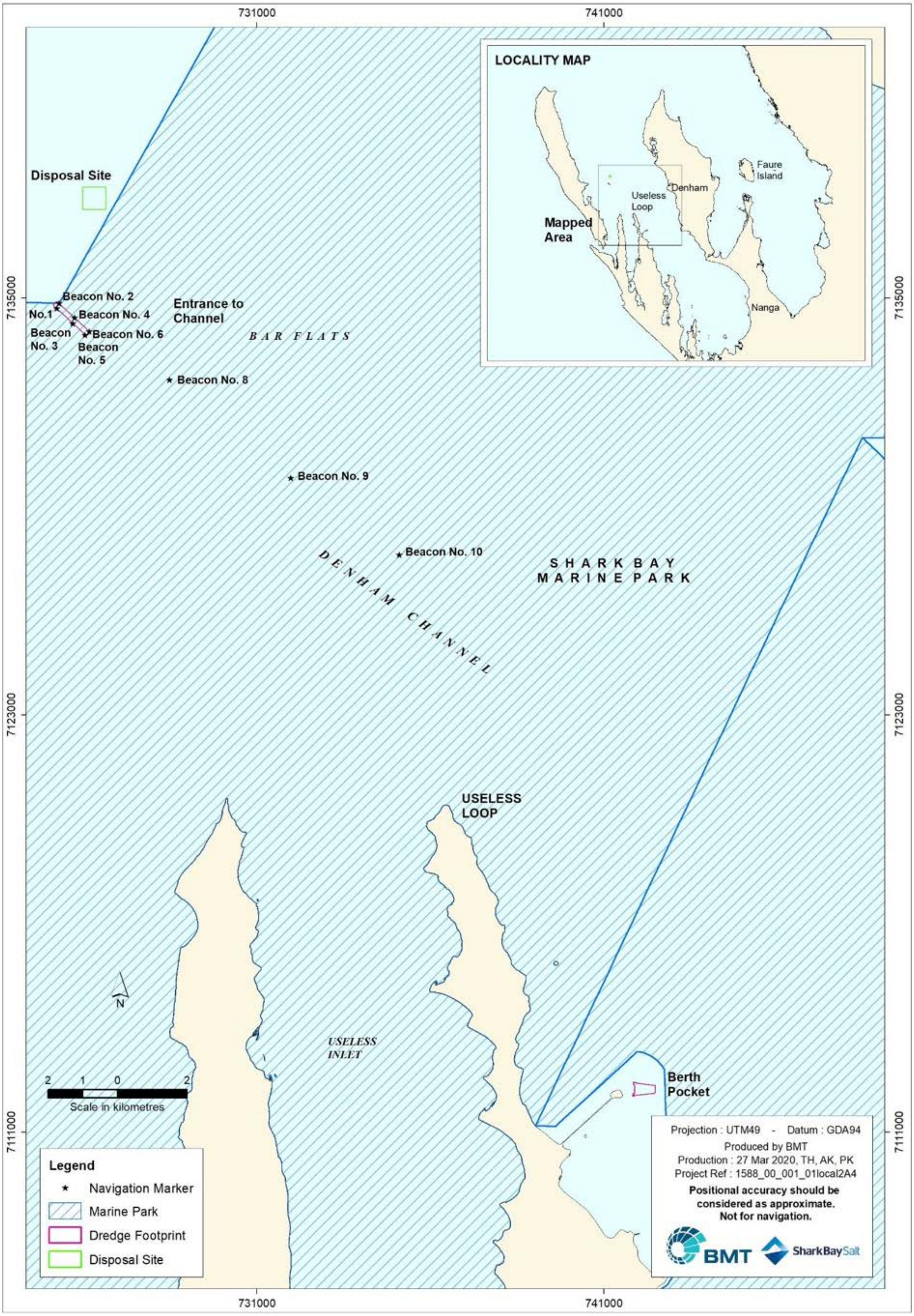
Shark Bay Resources Pty Ltd (SBR) operates a solar salt field at Useless Loop in Shark Bay, Western Australia. The salt field began operating in 1965 by enclosing natural inlets at the southern end of Useless Inlet and Useless Loop, occupying 130 km^2 of land (Figure 1.1). Salt is exported from a port facility consisting of a stockpile, jetty and loader (hereafter, the Port). The Port is accessed via Denham Channel (the entrance channel), extending through to the northern entrance of the Shark Bay Marine Park (hereafter, Marine Park). The salt field and Port are surrounded by, but excised from, the Shark Bay World Heritage Area and Marine Park (Figure 1.1).

Over time, areas of the Port berth pocket and entrance channel have become shallower due to siltation, reducing the allowable draft for incoming and outgoing salt cargo vessels. SBR wish to complete dredging works (hereafter, the Project) within the Port berth pocket and entrance channel to bring navigable depths back to design levels to ensure ongoing port accessibility. It is proposed to dispose the dredge material to an offshore placement area.

To inform the environmental impact assessment for the proposed Project, benthic communities and habitats (BCH) adjacent to the Port and entrance channel were investigated. The specific objectives of the mapping project were to:

- collect digital baseline data on the spatial extent and characteristics of benthic communities and habitats in the mapping area
- quantitatively characterise the extent of BCH near the dredge and disposal areas to develop a map product of suitable quality for environmental referral requirements.

This report provides an overview of the methods and map products from the SBR benthic habitat mapping surveys.



Note:
1. The map also includes proposed dredge and disposal areas current at the time of preparing this report

Figure 1.1 Shark Bay Resources entrance channel and Port facility

2 Marine Setting

Shark Bay is at the southern end of the Gascoyne Coast and is characterised by a series of gulfs, inlets and shallow basins. It is the northern limit of the transition between temperate and tropical environments and experiences hot, dry summers with average temperatures between 20 and 35°C (CALM 1996, McCluskey 2008). Winters are mild and annual rainfall is low with an average maximum of 400 mm (BoM 2020). Evaporation is high and the area is strongly influenced by southerly winds, creating effective conditions for the solar salt fields.

Oceanic water moves in and out of Shark Bay through various channels. Denham Channel is the main entrance to Useless Loop and the Port facility (Figure 1.1). Hydrodynamic movement and mixing varies across the region but is largely driven by tidal and wind mixing (Hetzel et al. 2013), with tides ranging between 0.61 m and 1.70 m (CALM 1996, Burling et al. 2003, McCluskey 2008). This brings productive phytoplankton communities into the bay and creates strong tidal mixing of nearshore ocean waters (Burkholder et al. 2013, Hetzel et al. 2013).

The unique environmental conditions coupled with topography and hydrological circulation patterns have a major influence on the extent and distribution of benthic habitat within Shark Bay. Shark Bay has one of the largest and most diverse seagrass assemblages in the world (~4000 km^2). Twelve seagrass species are known to occur in the region with particularly high densities present in shallower waters, generally less than ~5 m deep (Burkholder et al. 2013, Bessey 2013). The temperate perennial seagrasses *Amphibolis antarctica* and *Posidonia australis* are the most prevalent species in the region and are generally associated with shallower water depths (<5 m, Oceanica 2009, Burkholder et al. 2013, Strydom et al. 2020). Two other species of Posidonia also occur in the area, *P. coriacea* and *P. sinuosa*, although are more infrequent. Species such as *Halophila spinulosa, H. ovalis*, *Cymodocea* spp. and *Halodule uninervis* are relatively common but in lower densities confined to deeper waters (CALM 1996, Anderson 1994, 1998, McCluskey 2008, Burkholder et al. 2013).

3 Mapping Methods

An overview of the steps involved in preparing the benthic habitat map is presented in Figure 3.1, and described in detail in Sections 3.1 to 3.4.

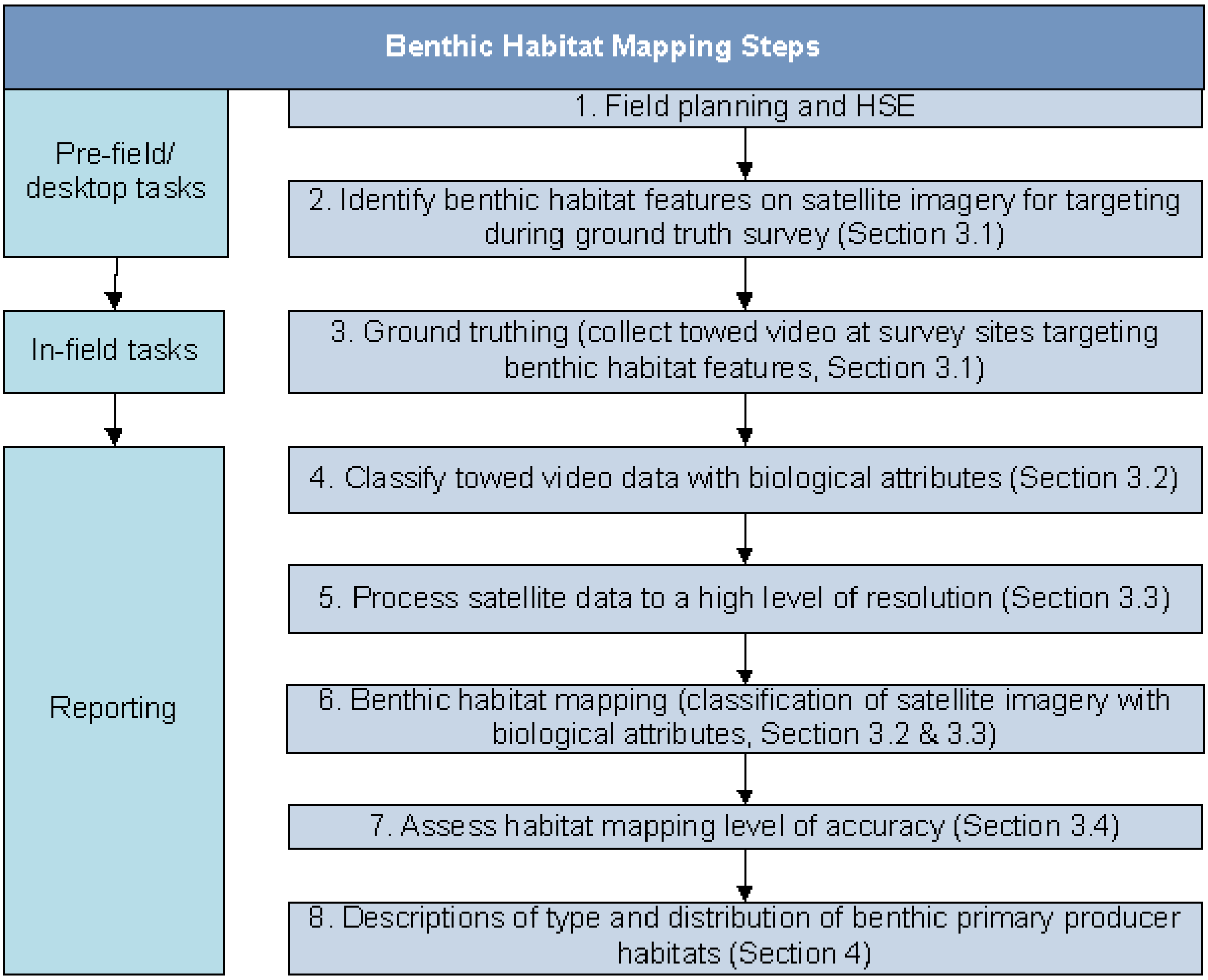


Figure 3.1 Steps undertaken to complete Shark Bay benthic habitat mapping

3.1 Survey design and data acquisition

BMT defined a preliminary local assessment unit (LAU) for the subtidal benthic habitat mapping scope to ensure alignment with the Environmental Protection Authority *Technical Guidance: Protection of Benthic Communities and Habitats* (EPA 2016). The LAU encompasses an area of ~75 km^2 that is split between the southern survey area that encompasses the Port (50 km^2) and the northern survey area that encompasses the entrance channel and proposed offshore disposal area (25 km^2)[1]. The initial shape and size of the survey area was defined by early Project concept design, including the investigation of a secondary nearshore disposal option, that was previously approved by the Department of Agriculture, Water and the Environment[2] in 2001. The previously approved nearshore disposal option is no longer being pursued by SBR, however the initial habitat survey work had already been completed and so the extent of the map still reflects this initial Project concept.

Prior to field surveys, BMT collated available marine spatial data (including infrastructure layers, ecological protection areas, bathymetry contours, satellite imagery and existing nearshore habitat mapping products at Shark Bay) and overlayed all layers in ArcGIS 10.2.1 and QGIS 2.14.3 for assessment of the Project survey area in Figure 3.2.

---

[1]The study area and subsequent BCH calculations (Section 1.1) exclude the Port infrastructure
[2]Previously, Department of the Environment and Energy.

Video ground truth data were collected in July 2019 and February 2020 to assist with habitat classification of satellite data. High definition video footage was collected along 55 pre-defined transects throughout the survey area to capture features of interest identified during pre-processing of satellite data (Figure 3.2). The camera was attached to a towing apparatus, which provided a live feed from the camera to the survey vessel. The height of the camera above the seafloor was moderated by a field crew member in real-time so that the field of view contained a ~2–3 m wide band of benthic habitat, resulting in a final total of ~1.2 km^2 of ground truth survey data. The start time of each video was recorded so that the classified transect data could later be matched with the GPS tracklog.

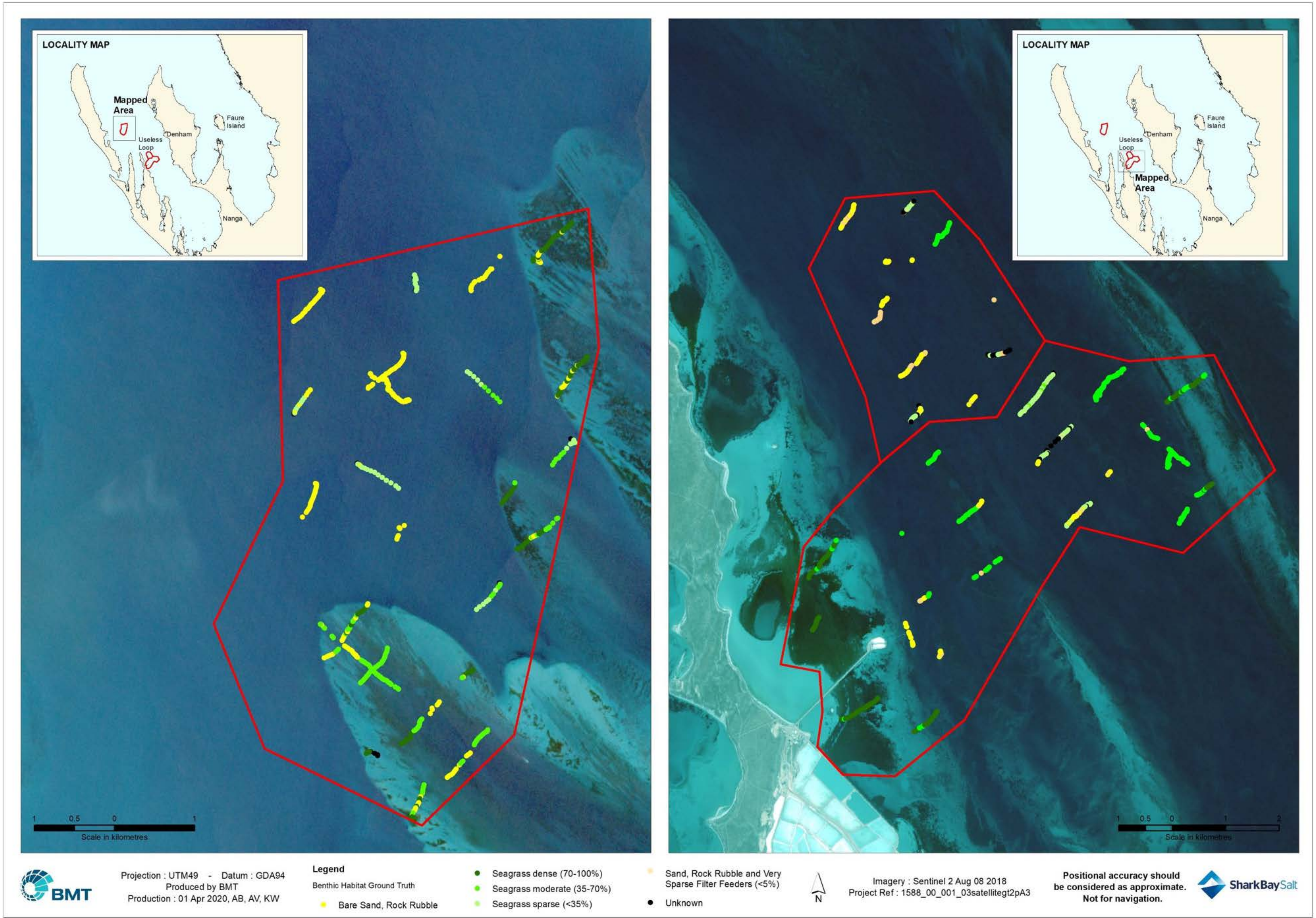


Figure 3.2 Towed video survey transects adjacent to the proposed entrance channel and offshore disposal site (left) and berth area (right)

3.2 Video analysis and classification categories

Video footage was analysed and classified by a marine scientist using the categories listed in Table 3.1 and TransectMeasure software (SeaGIS 2013). The software allows a single benthic habitat type to be assigned to each frame of video footage. Benthic habitat was classified by identifying the dominant substrate and presence or absence of biota in each frame of the video. A percent cover (hereafter, cover) category was also applied to each frame of the video during classification of habitat, ranging from very sparse to dense (Table 3.1). The cover classification is cumulative of all biota present within a frame, including mixed assemblages.

Across the transects, different species of seagrasses were present in varying densities dependent on the depth of the site. In general, *H. spinulosa* was the dominant seagrass in deeper waters (>5 m), with other ephemeral seagrasses like *H. ovalis* and *H. minor* also present but in very low cover, often observed growing beneath stands of *H. spinulosa*. These species were grouped into one taxonomic category, *Halophila spp*. (Table 3-2**)**. In shallower waters (<5 m), *P. australis* and *A. antarctica* were identified as the dominant species and were categorised as *Posidonia* spp. and *Amphibolis* sp., according to the dominant genus (Table 3.1). Seagrasses were mapped based on percent cover per frame (Section 3.3).

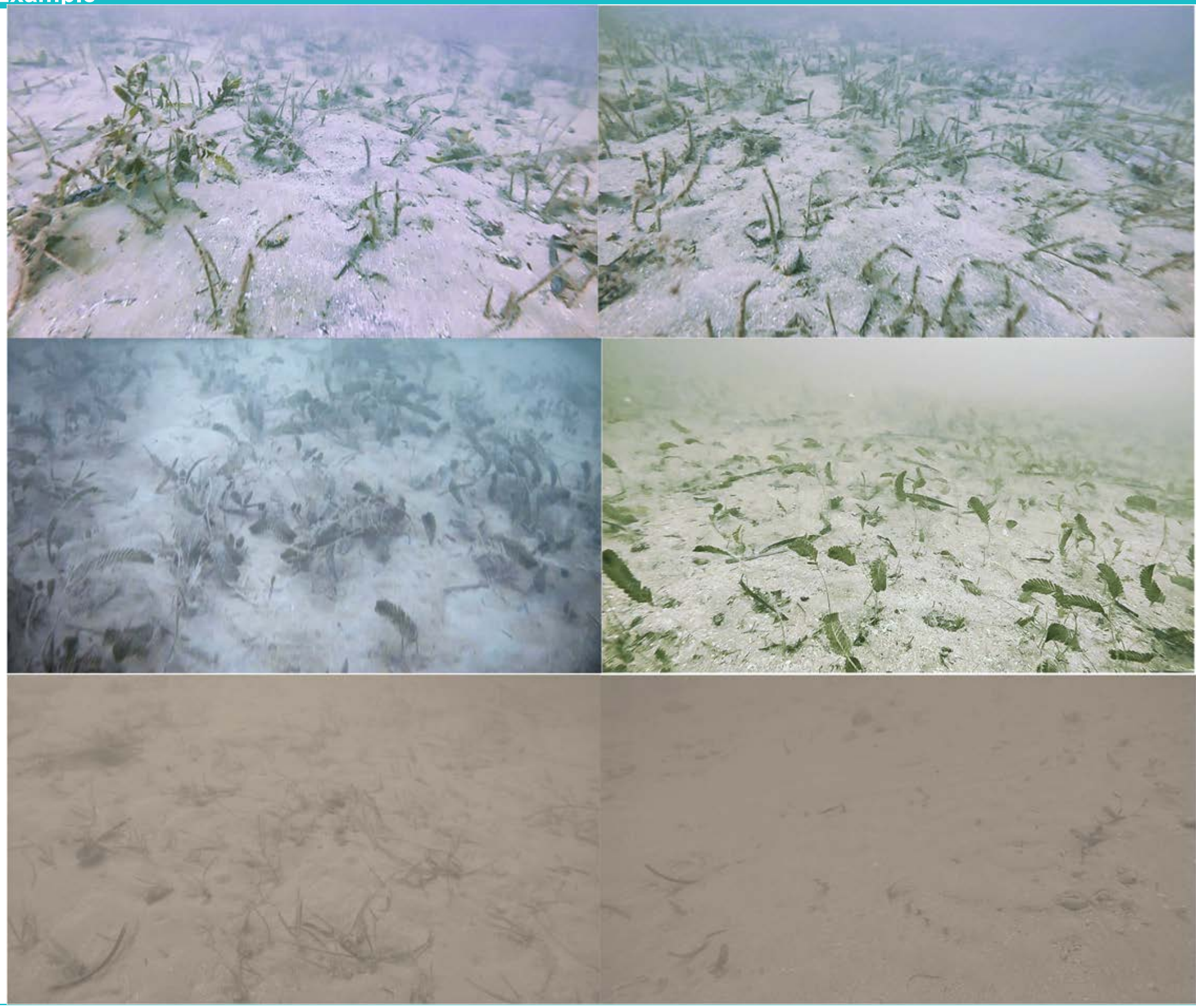
Filters feeders (i.e. sponges and hydroids) were also observed within the southern study area, however their cover was sparse throughout and did not exceed 5% at any location. Filter feeders were largely associated with bare sand and/or rock/rubble substrate and were not classified taxonomically because of the species variation and very low abundance (Table 3-2). Sponges included branching, fan, barrel and cup morphotypes. Some sections were classified as bare sand or sand and rock rubble in the absence of any other biota (seagrasses and filter feeders).

Table 3.1 Preliminary benthic habitat classification

<table>
<tr><th>Biota (major category)</th><th>Biota (minor species category)</th><th>Biota (minor category description)</th><th>Percent cover (per frame)</th></tr>
<tr><td rowspan="4">Seagrass</td><td>Halophila spp.</td><td>Commonly dominated by H. spinulosa but includes H. ovalis and H. spinulosa</td><td rowspan="7">Very sparse (<5%)
Sparse (5–35%)
Moderate (36–75%)
Dense (76–100%)</td></tr>
<tr><td>Posidonia spp.</td><td>Dominated by Posidonia australis. but including P. australis, P. coriacea and P. sinuosa</td></tr>
<tr><td>Amphibolis sp.</td><td>Dominated by A. antarctica</td></tr>
<tr><td>Other</td><td>Dominated by other ephemeral seagrass species, including Cymodocea sp. and Halodule uninervis</td></tr>
<tr><td>Filter feeders</td><td>Filter feeders</td><td>Typically, a sparse distribution of sponges, and hydroids growing on rocky substrate with sparse H. spinulosa also present</td></tr>
<tr><td>Sand</td><td>Bare sand</td><td>n/a</td></tr>
<tr><td>Rock substrate</td><td>Bare rock reef/rubble</td><td>n/a</td></tr>
</table>

Note:
1. n/a = not applicable

Table 3.2 Benthic habitat and percent cover classifications with example images from towed video

Category	Description	Example
Sparse seagrass	Seagrass coverage of 5–35% cover Mixed species, although significant *H. spinulosa*	

Category	Description	Example
Moderate seagrass	Seagrass coverage of 36–70% cover Dominated by *H. spinulosa*	 
Dense seagrass	Seagrass coverage of 71–100% cover Generally dominated by *P. australis* and *A. antarctica*	   

Category	Description	Example
Very sparse filter feeders	Filter feeders (hydroids, sponges soft corals) coverage of <5%, generally growing over sand and rock rubble, +/- sparse macroalgal assemblages	   
Bare sand	Area of bare sand	 

Category	Description	Example
Sand and rock rubble	Area of mixed substrate including sand, gravel and rubble	 

3.3 Classification and mapping procedures

The ground truthed transects were overlaid on 10 m Sentinel-2 satellite imagery (ESA 2019) to create a benthic habitat map of the study area encompassing the proposed maintenance dredging and disposal sites based on ground truthed transects collected in the field. A dominant habitat type was assigned to sections of the transects and then a 500 m high confidence buffer was applied around the transects. The 500 m buffer was informed by observations in the field and corroborated where possible by the Sentinel-2 satellite imagery.

The study area was mapped using a combination of methods as the depth of the study area reduced the visibility of benthic habitat features in the satellite imagery. A supervised classification approach with ERDAS IMAGINE 14.0 remote sensing software (Hexagon 2019) was applied to a suitable Sentinel-2 image (captured on 26 August 2018) over areas of approximately <12 m depth, which classified benthic habitat based on the spectral similarity to areas already surveyed by towed video. The results were reviewed against features visible in additional Sentinel-2 satellite imagery from multiple time periods between January 2018 and February 2020 to verify the accuracy of the classification.

Areas that could not be mapped with confidence using the supervised classification approach due to depth (approximately >12 m) or turbidity were mapped by extrapolating the ground truthed data in ArcMap v10.2.1 within the 500 m high confidence buffer. Areas outside the 500 m buffer were assigned a low confidence category.

Habitats could be reliably divided into vegetated cover (seagrass and filter feeder) of varying density, and non-vegetated areas, but could not be further classified into specific species habitat cover categories as a result of high spectral similarity between vegetated areas (e.g. *Halophila* and *Posidonia* spp.), particularly mixed seagrass assemblages. This was managed by further consolidating the level of detail within the classification categories to a subset of biota and cover classifications, which were mixed in some instances, to allow accurate mapping over the large study area (noting that ground truthing data is at a much finer scale (meters) than the satellite imagery (10 m pixel size)). Seagrass categories presented a level of fine-scale variation (changed within meters along transects) that were combined to ensure confidence in mapped habitat. Further, the two sparse categories (very sparse <5% and sparse 5–35% cover, Table 3.1) were combined to create an overall 'sparse' category.

3.4 Assessment of accuracy

No accuracy assessment could be performed for the habitat categories, as the mapping was a combination of supervised classification and manual approach and final categories that deviated slightly from the final ground truth categories due to the different scale of the ground truthing, satellite imagery and required map detail. Instead, the confidence buffers were applied as an indication of mapping accuracy. A visual assessment also showed good agreement between the detailed categories and the imagery and ground truthing.

4 Distribution of Benthic Habitats

A total of 75.09 km^2 of benthic habitat was mapped within the survey area (Table 4.1). Of this area, 60.84 km^2 was mapped with high confidence based on the supervised satellite classification and ground truthing transects. The remaining 14.25 km^2 was classified as low confidence, which was predominantly bare sand/rock rubble (9.17 km^2) and sparse (<35% seagrass) in deeper water (>5 m) (Table 4.1). Within the survey area the dominant habitat types (including low confidence data) were:

- sparse seagrass (38%)
- bare sand, rock rubble (34%)
- moderate seagrass (17%).

The total survey area was characterised by 65% or 48.42 km^2 seagrass cover; dense, moderate and sparse coverage (Table 4.1). The remaining area was largely unvegetated sand and rock rubble (34% or 25.57 km^2), with a much smaller area with sparse cover of filter feeders (1% or 1.09 km^2) (Table 4.1). Given the very sparse nature of filter feeders in the region, these areas could also be considered largely unvegetated.

In the southern survey area, in shallow waters around the Port (<5 m), there was dense coverage[3] of the perennial seagrasses *P. australis* and *A. antarctica*, similar to mapping completed by Oceanica (2009). In deeper waters (>5 m) offshore from the Port there were mixed assemblages of seagrasses, dominated by *H. spinulosa*, with sparse occurrences of *Posidonia* spp. (Figure 4.1). There were also intermittent patches of bare sand and rocky rubble that contained infrequent filter feeders such as gorgonians, tubular and cup sponges, and hydroids (Figure 4.1).

In deeper waters (>5 m) within the northern survey area, adjacent to, and north of the entrance channel, transects yielded mostly unvegetated sand and rocky substrate with patches of sparse seagrasses, including mixed assemblages dominated by *H. spinulosa*, interspersed with patches of bare sand, rock rubble (Figure 4.1). Shallower areas to the north east of the northern study area contained stands of *Posidonia* spp. at almost 100% coverage (Figure 4.1).

Table 4.1 Extent of benthic habitat categories in mapped area

Habitat	Area (km^2)	Proportion (%)
Seagrass dense (70–100%)	7.20	10
Seagrass moderate (35–70%)	12.42 (0.53)	17 (1)
Seagrass sparse (<35%)	28.80 (4.55)	38 (6)
Sand, rock rubble and very sparse filter feeders (<5%)	1.09	1
Bare sand, rock rubble	25.57 (9.17)	34 (12)
Total	**75.09**	**100**

Note:
1. values in parentheses indicate the proportion of the habitat classified in low confidence

[3] These areas of dense cover were not ground truthed due to proximity to the Port, and were conservatively mapped as seagrasses via manual review of satellite imagery. As such, classification of this area as dense seagrass could be an artefact of shading caused by berth infrastructure rather than seagrass cover.

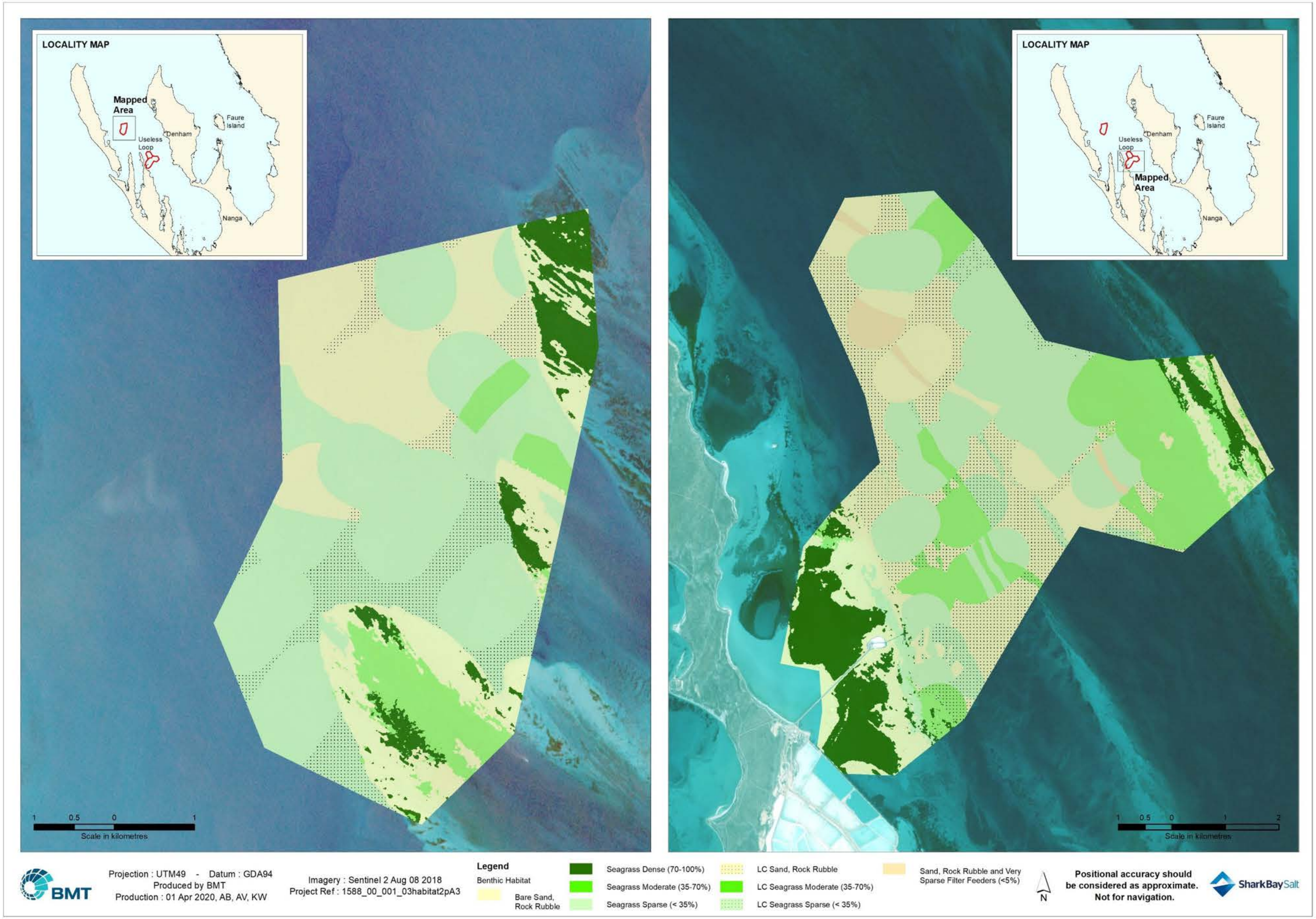


Figure 4.1 Classification of benthic habitat extent and distribution, Shark Bay

5 Conclusion

The extent and distribution of BCH adjacent to the Port and entrance channel were successfully mapped using satellite images and ground truthing data. Seagrass was the dominant benthic habitat within the survey area (totalling 48.42 km^2), consisting of mixed ephemeral and perennial seagrass meadows. As previous studies have identified, shallow waters (<5 m) were dominated by *P. australis* and *A. antarctica,* at relatively high percent cover. Deeper waters (>5 m) were dominated by sparse patches of *H. spinulosa.* Bare sand and rocky rubble was also a major benthic substrate observed within the study area (25.57 km^2), with a much smaller proportion (1.09 km^2) of bare sand and rocky rubble areas also containing sparse filter feeders (with such sparse cover they were largely determined as unvegetated areas). The mapped benthic habitats were representative of known regional and local habitats and no new BCH were observed.

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