SOUTH THOMSON BAY BARGE AND CARGO FACILITY

Assessment of Benthic Habitats

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Thomson Bay Habitat Survey
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1 INTRODUCTION

As anticipated in the *Rottnest Island Management Plan 2014-19* (RIA 2014), the Rottnest Island Authority (RIA) is proceeding with development of the former Army Jetty in south Thomson Bay into a barge ramp and cargo handling facility with contingency ferry berth (Figure 1). The barge landing area, breakwater and groyne components of this development will be constructed from limestone boulders, with seabed spoil from associated dredging operations used as infill.

Rottnest Island is an A-class reserve with significant ecological, cultural and social values (RIA 2014). The marine reserve is characterised by a unique blend of tropical and temperate species, and a diverse range of habitats and communities including coral reef and extensive seagrass meadows. Protection of this unique environment is one of five critical areas of focus for the RIA (RIA 2014), and as such it has undertaken a preliminary assessment of the environmental impacts associated with the proposed development. These are primarily associated with impacts of dredging and development footprints on benthic marine communities and habitats (BCH), in particular the seagrass meadows that dominate Thomson Bay and comprise ~30% of the total seagrass area around Rottnest Island (Harvey 2009).

Based on early-stage design concepts it was estimated that the proposed development would result in the irreversible loss of up to 1.5% of these seagrass meadows in Thomson Bay, which is approximately 0.5% of the total area of seagrass within the Rottnest Island Marine Reserve (RPS 2019). However, RPS (2019) also noted that discrepancies existed in benthic habitats shown in recent (2014 and 2018) aerial images and the benthic habitat maps developed by Harvey (2009). As such, RPS (2019) recommended that an updated habitat map based on ground-truthed aerial imagery be developed for Thomson Bay, to enable more accurate assessment of impacts to benthic habitat due to the proposed development.

Based on recommendations by RPS (2019) and in preparation for referral of the proposed development under Section 38 of the *Environmental Protection Act 1986*, the objectives of this report are to:

- define a Local Assessment Unit (LAU) for assessment of benthic impacts from the proposed development
- assess the veracity of habitat mapping by Harvey (2009) and its suitability for LAU-scale estimates
- develop detailed benthic habitat map of development area
- confirm estimates of BCH (seagrass) loss due to the proposed development.
- estimate cumulative BCH loss.

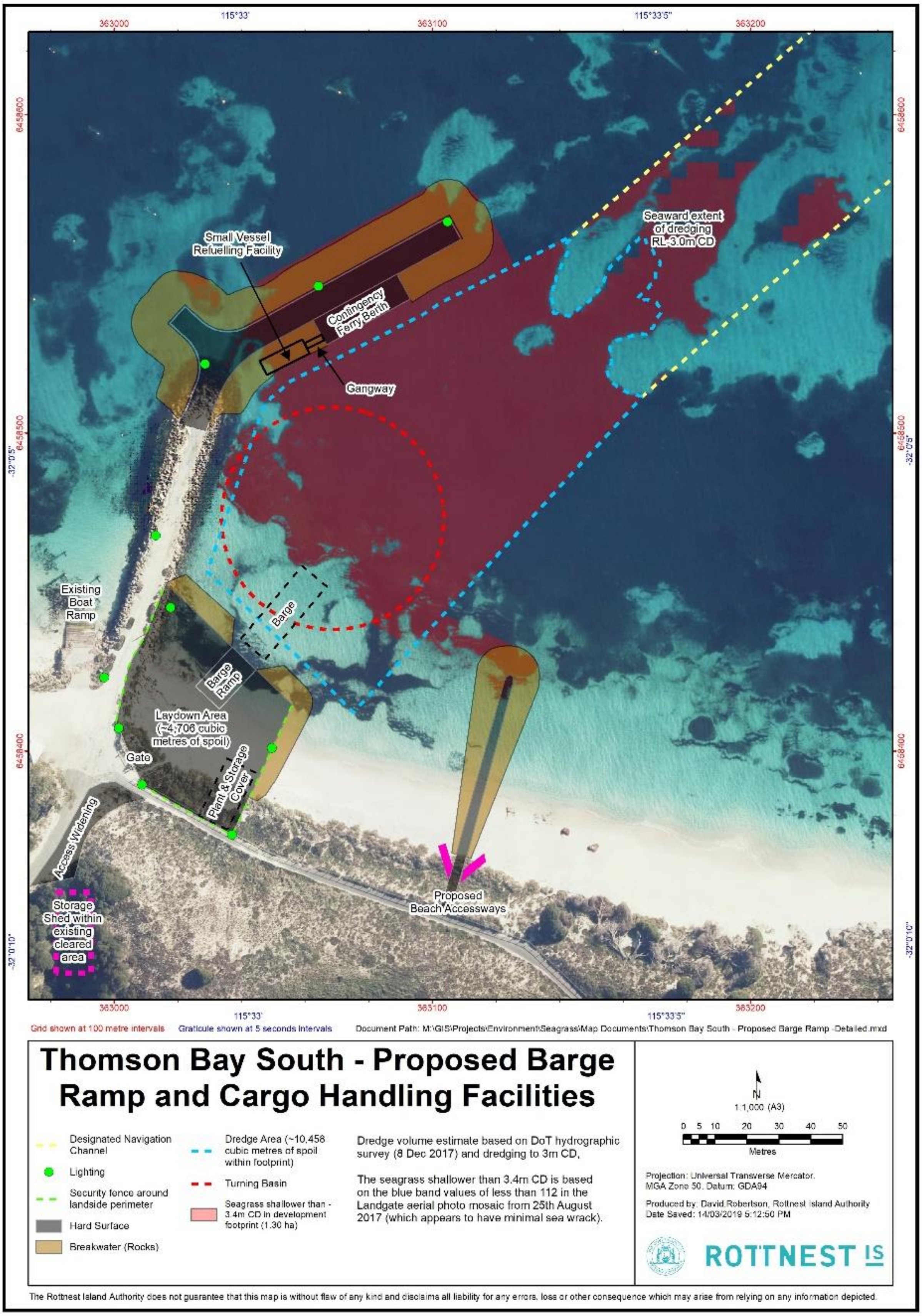


Figure 1. Proposed barge ramp and cargo handling facilities at the former Army Jetty in Thomson Bay, Rottnest Island

2 METHODS

2.1 Field Survey

Objectives of this report required assessment of habitat within an area of south Thomson Bay encompassing the proposed development. This area measured approximately 2.6 x 1.0 km and is referred to as the 'Field Survey Area' (FSA; Appendix A).

The FSA defined the extent of a benthic habitat survey used to ground-truth aerial images for development of the habitat map. The survey was completed between 0830 and 1400 hrs on the 27th March 2018. Weather was fine with light cloud cover and 10 - 15 KN southerly. Water visibility was good, with detailed benthic habitat classification (ie distinguish mixed biota) reliable to approximately five metres and general classification (ie identify dominant habitat) to approximately seven metres. Tides on the day were: low tide (0304 hrs/0.41 m) and high tide (1254 hrs/0.86 m).

The RIA ten metre rigid inflatable vessel *Ranger 1* was used during the survey. This was skippered by an RIA Ranger who navigated along pre-determined transects within the FSA that included the former army jetty and proposed navigation channel within Thomson Bay (Appendix A). These transects were orientated directly north-south and set ~200 m apart. Along each transect, the skipper stopped the vessel at pre-determined locations 100 metres apart. Additional 'off transect' locations to assess habitat of interest (as identified from the aerial image) were also surveyed.

At each location an RPS field scientist lowered a glass bottomed viewing tube into the water and made a point assessment of the habitat type vertically below the viewing location near the rear of the vessel. The assessment area was approximately two metres across. Data recorded was percent cover of seagrass (to genus), macroalgae, bare substrate (sand or limestone reef/platform) and wrack (unattached macroalgal thalli and dead seagrass leaves) (Appendix B). Data was recorded by a second RPS field scientist along with sampling location onto a digitised aerial image of the survey area.

2.2 Data processing

Sampling locations recorded during the field survey were downloaded into GIS and correlated with habitat classes. These classes were derived from percent cover of biota and bare substrate obtained during the field survey, as described in Section 2.2.1. A map of benthic communities and habitat was subsequently developed using methods described in Section 2.2.2.

2.2.1 Habitat Classification

The classification scheme used in the field component of this study was based on that developed for Seamap Australia (Butler et al. 2017). This is a dominance-based scheme, i.e. the classes are defined based on the dominant biota, or a mixture of one or more dominant species (Table 2.1). In this study the criteria for dominance is >50% cover. A mixed class is identified where the percentage cover of the two or more dominant classes are separated by ≤ 30% (relative to the percentage cover of the most dominant class). For example, a sampling location consisting of 25% macroalgae and 60% *Posidonia* spp, would be classed as *Posidonia*-dominated, whereas a location consisting of 40% macroalgae and 60% *Posidonia* spp, would be classed as mixed *Posidonia* / macroalgae habitat. The classification scheme was also designed to be compatible with the hierarchical scheme developed by Harvey (2009) for classifying marine benthic habitats of Rottnest Island, to enable extrapolation to broader spatial scales.

Table 2.1 Classification scheme used in analysis of benthic habitat

Habitat Class	Description
Sand	71 – 100% bare sand
Sand with seagrass	≤ 30% seagrass
Sand with wrack	>30% wrack (note: wrack present with other biota is not classified)
Posidonia dominated	>50% *Posidonia* spp.
Amphibolis dominated	>50% *Amphibolis* spp.
Macroalgae dominated	>50% brown macroalgae
Mixed seagrass	% cover of dominant seagrasses separated by ≤ 30%
Mixed algae/seagrass	% cover of dominant seagrass/algae separated by ≤ 30%
Limestone reef / pavement	Limestone reef or platform with minor (<30%) attached seagrass/macroalgae

2.2.2 Development of benthic habitat map

Habitat mapping was undertaken using Esri's ArcMap to create a digitized image in vector shapefile format. This image was based on Landgate's August 2017 and August 2018 Web Map Service aerial photographs, which were selected for their water clarity and well-defined seabed features. Comparison between the two photographs also enabled mobile areas of wrack to be identified and where relevant removed from areas of seagrass habitat. Further assessment of habitat was undertaken using fine-scale bathymetric data and the Global Mapper GIS application. Areas of habitat on the digitised image were then classified into habitat classes using data from the RPS field surveys, which was pooled where necessary to provide a more reliable description of habitat across the FSA.

3 RESULTS AND DISCUSSION

3.1 Defining a Local Assessment Unit (LAU)

The LAU is a geographical area that establishes the spatial context for the calculation and assessment of recoverable impacts and cumulative losses (EPA 2016a). Local assessment units are location specific and should take into account local physical, ecological, administrative and jurisdictional considerations.

The most appropriate LAU for the proposed development is the area mapped by Harvey (2009). This comprises 2,746 ha of described habitat in which historic habitat loss from anthropogenic impacts have been estimated (Oceanica 2013; as discussed further below). It also represents a complete island ecosystem and is consistent with EPA guidance for the size of an LAU in Western Australia (EPA 2016a).

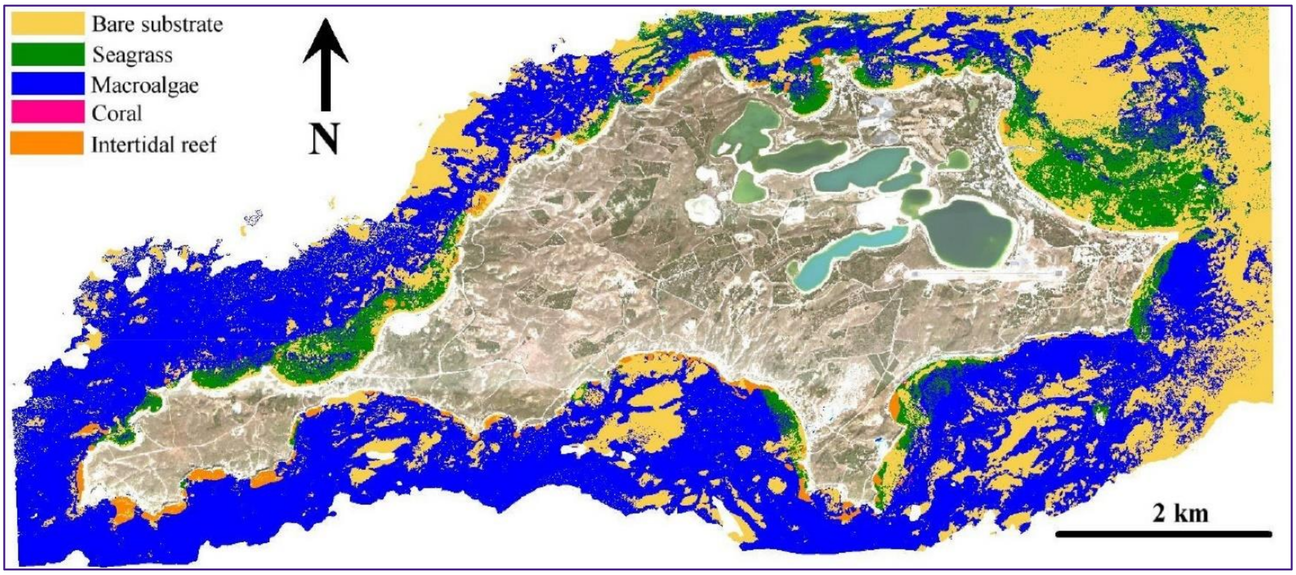


Figure 2. Habitat map of Rottnest Island by Harvey (2009)

3.2 Benthic habitat map within the FSA

A benthic habitat map is necessary for estimating historic habitat loss and predicting additional losses from planned developments (EPA 2016a). The benthic habitats of Rottnest Island were mapped by Harvey (2009) using a combination of *in situ* observation and aerial hyperspectral imagery. Benthic habitats were classified at four levels by Harvey (2009), where Level 2 identified seagrass, macroalgae, coral, intertidal reef, sand and unclassified (typically beach). Approximately 399 ha or 14.5% of the total mapped area (2746 ha) was classified as seagrass meadows, with 119 ha located within Thomson Bay.

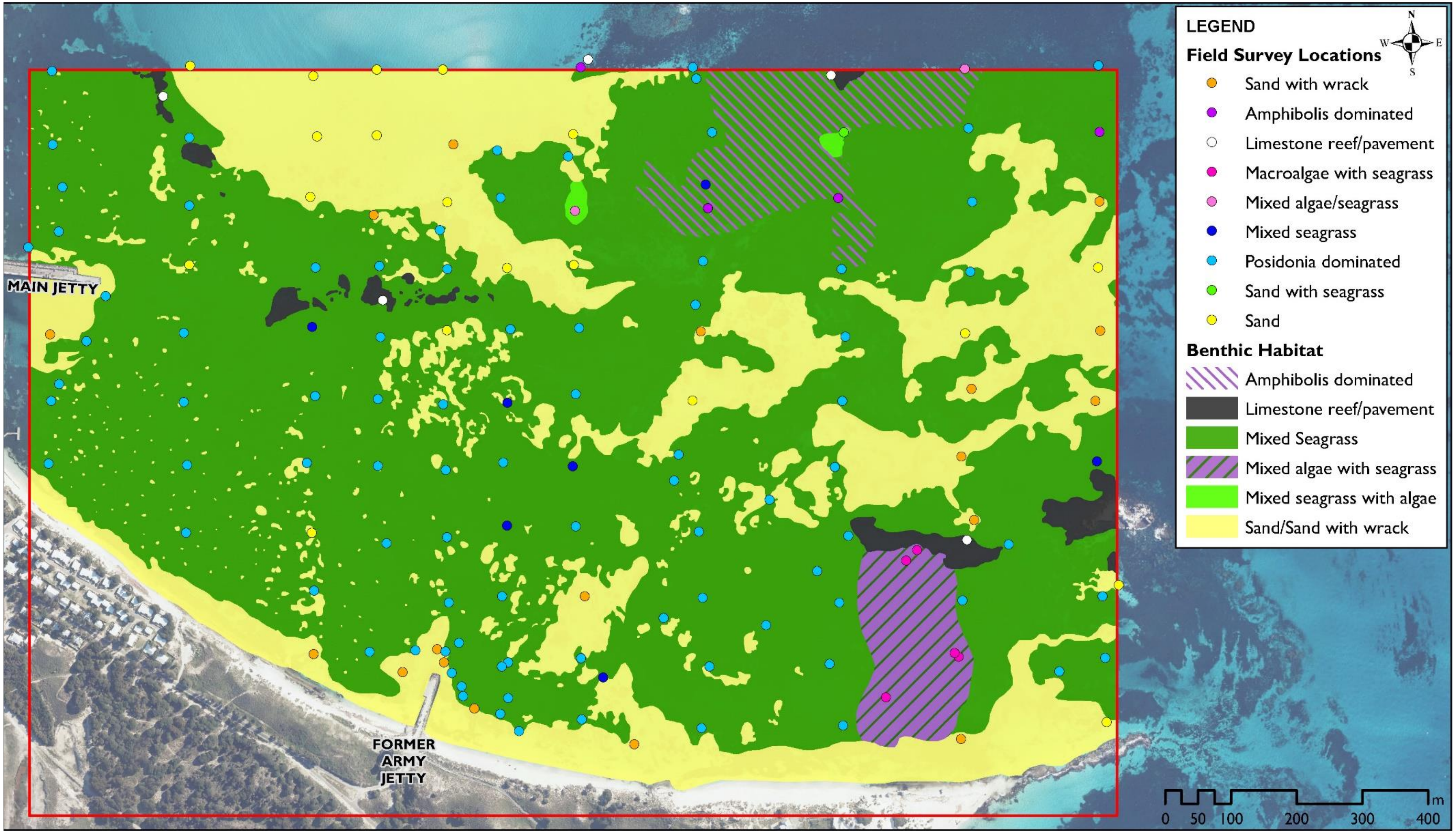
The benthic habitat map developed here for assessment of the south Thomson Bay development (Figure 3) shows the distribution of seagrass in the vicinity of the proposed development and more broadly across southern Thomson Bay. The relative cover of the different habitat types is shown in Table 3.1 and confirms the dominance of seagrass, in particular *Posidonia* spp. 'Bare' sand habitat also occupies a substantial part of the FSA, and the presence of wrack over sand in 14% of the sampling sites confirms observations by RPS (2019) that estimates of seagrass habitat may be affected by its presence. Areas of mobile wrack over sand that might otherwise have been classified as seagrass or other habitat were identified by comparison of the 2017 and 2018 aerial images. These areas can be seen as darker areas of sand in Figure 3 and are common across the FSA, particularly in nearshore waters.

The benthic habitat map shown in Figure 3 also indicates an area dominated by macroalgae in the southeast part of the FSA. This was identified by several of the survey locations however the boundary of this area was difficult to define from the aerial images, even with depth contours overlaid and with use of Global mapper to distinguish between colour values. Similarly, a broad area in the northern part of the FSA appears to comprise a mix of seagrass and algae that could not be clearly defined from the aerial images. This may also be grouped with seagrass habitat to define benthic primary producer habitat.

Table 3.1 Habitat type at each field survey site

Habitat type	# of sites	Percent of total
Amphibolis dominated	4	3%
Limestone reef/pavement	5	4%
Macroalgae dominated	4	3%
Mixed algae/seagrass	2	2%
Mixed seagrass	6	5%
Posidonia dominated	69	54%
Sand	18	14%
Sand with seagrass	2	2%
Sand with wrack	18	14%
Grand Total	**128**	**100%**

Figure 3. Benthic habitat map of the survey area within south Thomson Bay, Rottnest Island



3.3 Assess the veracity of existing habitat maps

The EPA (2016a) notes that technical reviews and assumptions forming the basis of predictions of cumulative loss of BCH within clearly defined LAUs should be clearly described in environmental impact assessments. The habitat maps developed by Harvey (2009) are an important resource for impact assessments within the Rottnest Island Marine Reserve. These maps were developed using hyperspectral imagery obtained in 2004 and based on spectral signatures of the dominant habitat components. At the broadest scale, areas of bio-substrate were separated from bare substrates in the image with an overall accuracy of 95%, whereas at the finest scale, bare substrates and dominant species or genera were separated with an accuracy of 70% (Harvey 2009).

One reason for the decrease in accuracy at the finer scale was the inherent spatial inaccuracy of the geo-location of both the image and the validation data collected in the field (Harvey 2009). Harvey (2009), in comparing the habitat maps he developed with an earlier map by Ong et al. (1998), also noted similarities at the broad scale but less so at the finer scale. Similarly, when comparing the benthic habitat map by Harvey (2009) to aerial images taken in August 2014/2018 and observations from the site visit, RPS (2019) identified mismatches in areas of seagrass and sand habitat, considered most likely to be due to fine-scale misclassification of habitats by Harvey (2009). In particular, RPS (2019) observed that misclassification of mobile wrack as seagrass by Harvey (2009) would result in an overestimate of the amount of seagrass loss within the planned development footprint.

The spatial scale of analysis is therefore a critical element in determining the accuracy of habitat maps, and therefore in assessing the impacts associated with the proposed development. Table 3.2 highlights broad similarities between the habitat map developed in this study for the FSA and the Level 2 habitat map developed by Harvey (2009) for the same area. However, it also indicates that the map by Harvey (2009) underestimates the amount of seagrass in south Thomson Bay and overestimates the amount of algae, particularly in the area identified during the current study as comprising a mix of algae and seagrass (see Section 3.2). The map by Harvey (2009) also indicates more areas of sand than the current study.

Based on the above, and considering the guidance by EPA (2016a) that the understanding of benthic communities and their habitats should be proportional to the scale of the proposed development, it is considered reasonable that the habitat map developed by Harvey (2009) is satisfactory for description of habitat within the LAU defined for the proposed development. It is also a conservative approach because the map by Harvey (2009) is shown to underestimate seagrass habitat within the FSA. For this reason, it is more appropriate to base assessment of seagrass habitat loss due to the proposed development on the habitat map developed during the current study (Section 3.2).

Table 3.2 Comparison of habitat area estimates between RPS and Harvey habitat maps

Harvey (2009) category	RPS category	Harvey hectares	RPS hectares	Difference
macroalgae/intertidal	limestone reef/pavement	16.04	7.09	8.95
	mixed algae with seagrass			
	mixed seagrass with algae			
seagrass	mixed seagrass	91.69	110.28	-18.59
	mixed seagrass (*Amphibolis* dominated)			
	mixed seagrass (*Posidonia* dominated)			
sand	sand/sand with wrack	55.12	46.09	9.03
unclassified	na	0.56		0.56

3.4 Estimates of BCH loss as a consequence of the proposed development

Detail of the proposed development is shown in Figure 1 and overlaid on the benthic habitat map in Figure 4. The calculations by RPS (2019) of BCH loss or permanent alteration were based on the following impacts:

- footprint of all new infrastructure, including the barge landing area, breakwater and beach groyne
- an additional 15 m 'halo' around new infrastructure (excluding dredged areas), consistent with observations around the former Army Jetty and Main Jetty
- area enclosed by the breakwater and beach groyne, incorporating the (dredged) barge turning circle
- outer envelope of potential dredged areas (including batter) within the barge approach corridor to allow for access of various vessel drafts
- 15 m buffer applied to dredged areas as a notional area for localised indirect sedimentation and erosional impacts.

dredging of navigation channel to -3.4 m LWMF or -4.16 m AHD within dredge area.

Based on these parameters the following estimates of seagrass loss as a consequence of the proposed development are made [NOTE: need to check with RIA if they can confirm these calculations due to GIS budget issues]:

- 1.43 ha direct seagrass loss (permanent):
  - Development direct loss: 0.23 ha
  - Dredging direct loss 1.07 ha
  - Dredging 15m halo direct loss 0.13 ha
- 0.47 ha indirect seagrass impact – effectively irreversible of where recovery is unlikely to occur for at least five years.

This total of 1.9 ha represents irreversible loss and does not consider short-term recoverable impacts from dredge-generated sediments. Estimates of recoverable impacts require predictive modelling of hydrodynamic and sediment transportation as well as consideration of sediment characteristics (EPA 2016b). These are not considered here.

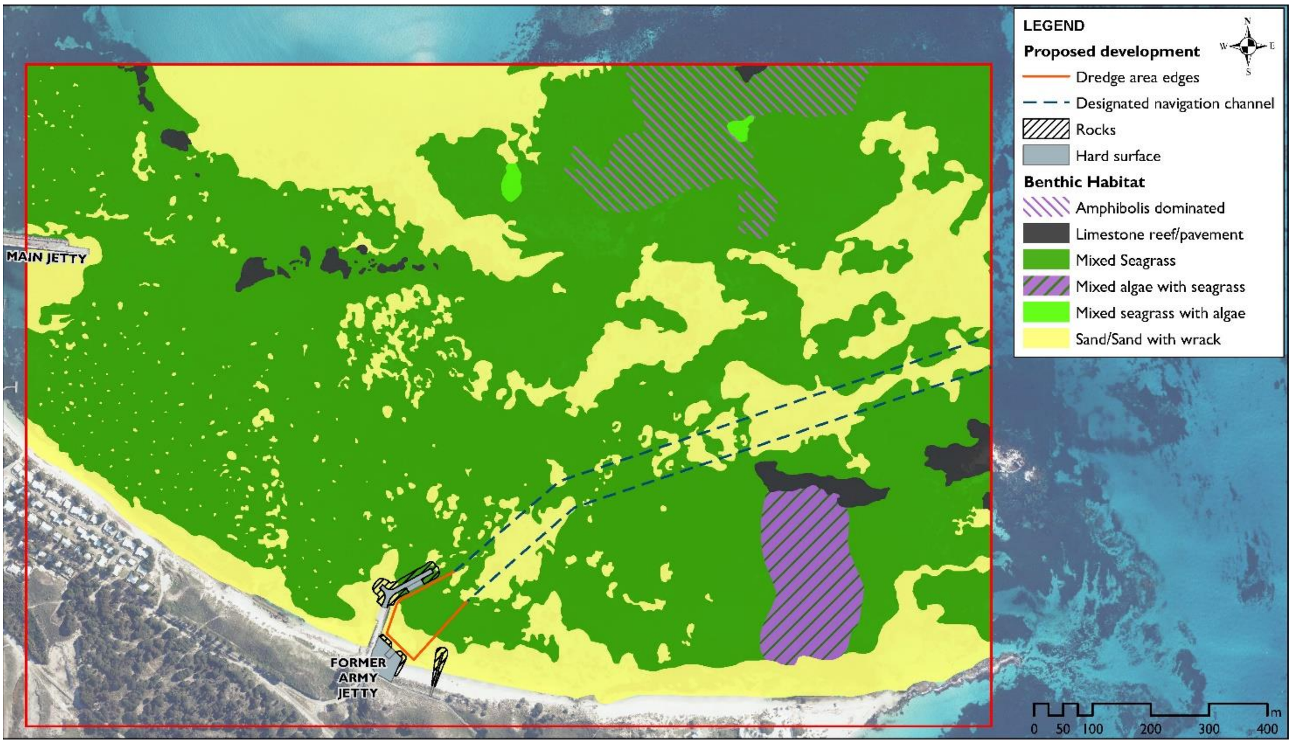


Figure 4. Footprint of proposed development in Thomson Bay overlaid on benthic habitat map

3.5 Estimates of cumulative BCH loss

Calculation of cumulative BCH loss within a defined LAU requires estimates of the extent of BCH (EPA 2016a):

- prior to all human-induced disturbance
- at the time of the proposed development
- remaining after the development is completed

Oceanic (2013) provided estimates for the first two points above through calculations of historic BCH loss within the defined LAU for Rottnest Island. These are reviewed below. Preliminary estimates for the third point above (BCH loss due to the proposed development) are described above in Section 3.4, with a combined calculation of cumulative BCH (seagrass) loss described below.

3.5.1 Historic BCH loss

Oceanica (2013) estimated historic anthropogenic BCH loss associated with vessel moorings (mooring scars) and jetties from a review of aerial imagery taken in March 2008. Their estimates are only for seagrass because there was insufficient data for other habitat types such as coral and macroalgae, and because seagrass meadows typically occur within sheltered, shallow bays where this marine infrastructure is located. This is acceptable for the current study because seagrass is the key impacted habitat. The estimates by Oceanica (2013) did not consider other potential sources of anthropogenic stressors such as eutrophication, propeller scour and sedimentation, and assumed that areas of bare sand around marine infrastructure and moorings were previously 100% seagrass. The latter may result in an over-estimate of seagrass loss as some areas may have historically been bare sand (RPS 2019). Further, there appears to have been some recovery of cleared seagrass due to the change to environmentally friendly mooring designs which has allowed some seagrass regrowth (Oceanica 2013). RPS (2019) found evidence of both degradation and regrowth of seagrass habitat to the east and west of Main Jetty in Thomson Bay, respectively, and noted that regrowth may be associated with a change in the species composition of seagrass. Ultimately, estimations of historic anthropogenic losses are inherently difficult due to a lack of reliable baseline data and lack of understanding of loss due to natural events such as storms and alongshore sediment transport (RPS 2019). A conservative approach is therefore taken in this report by not accounting for areas of regrowth.

In considering the above, the estimate of seagrass loss around Rottnest Island by Oceanica (2013) is acceptable for LAU-scale calculations. These estimates use the data by Harvey (2009) to estimate the 'current' extent of seagrass habitat as 398.70 ha which, when combined with the amount lost due to human-induced disturbance (7.95 ha) results in an estimated 406.65 ha of seagrass habitat within the LAU prior to impacts due to human activities. This represents a 1.95% loss of historic seagrass habitat within the LAU.

3.5.2 Increase in cumulative BCH loss due to proposed development

Based on calculations described in Section 3.4 the direct and indirect seagrass losses as a consequence of the proposed development represent a 0.35% increase in cumulative loss over the LAU. (from 1.95%) [NOTE: this figure needs confirming with data in section 3.4]

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Appendix A: Thomson Bay Benthic Survey

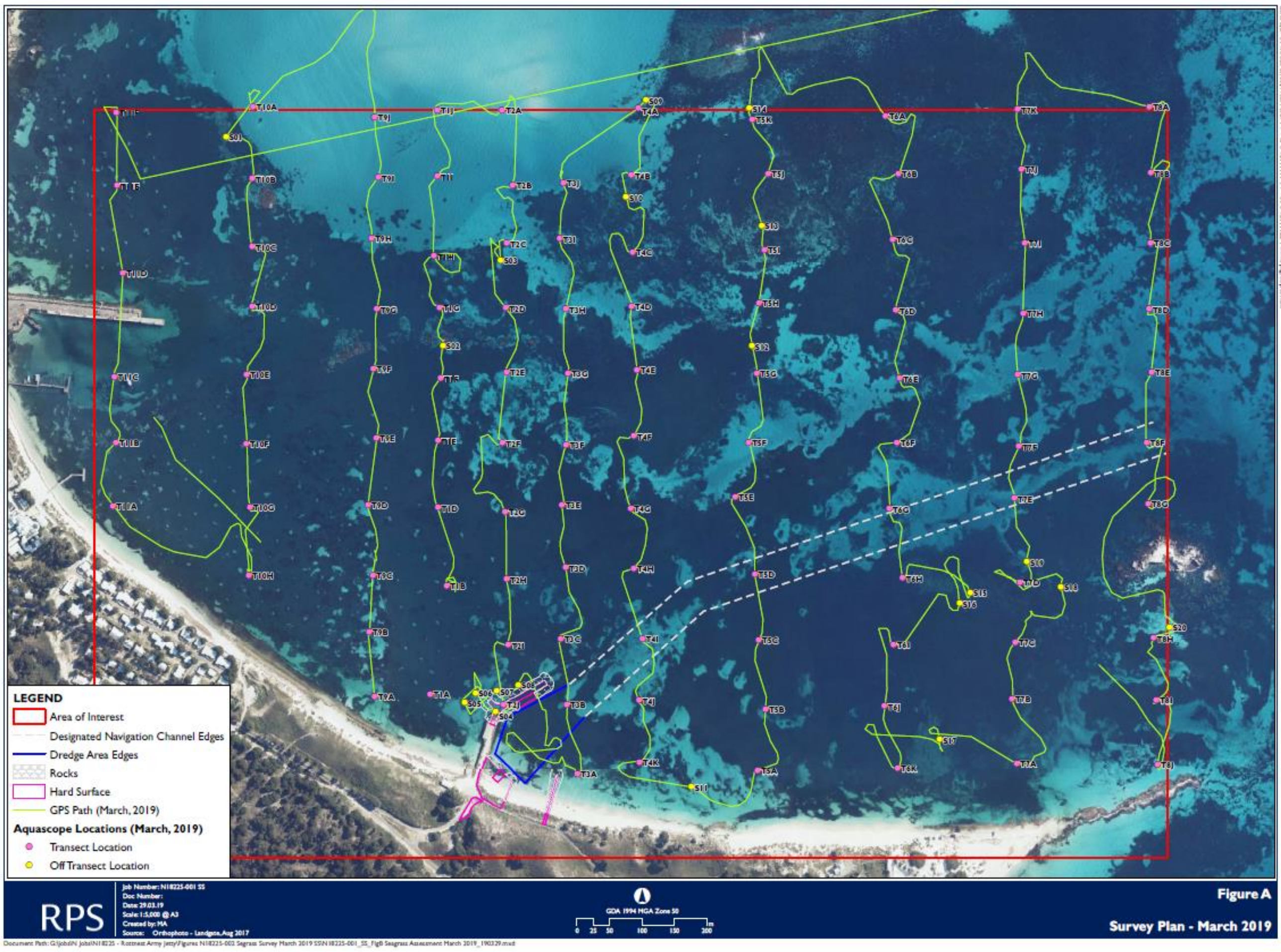

Figure A. The FSA within Thomson Bay (red rectangle), vessel track and sites ground-truthed during the survey. Also shown are the proposed channel and development footprint

Appendix B: Field Survey Data

New_ID	LAT_dd	LONG_Dd	Habitat classification
S01	-31.993218	115.545670	Limestone reef/pavement
S02	-31.996108	115.549166	Limestone reef/pavement
S03	-31.994951	115.550124	*Posidonia* dominated
S04	-32.001122	115.549945	*Posidonia* dominated
S05	-32.000994	115.549437	Sand with wrack
S06	-32.000863	115.549617	*Posidonia* dominated
S07	-32.000850	115.549968	Sand with wrack
S08	-32.000769	115.550319	*Posidonia* dominated
S09	-31.992794	115.552524	Limestone reef/pavement
S10	-31.994117	115.552181	*Posidonia* dominated
S11	-32.002192	115.553123	Sand with wrack
S12	-31.996176	115.554200	*Posidonia* dominated
S13	-31.994531	115.554390	Mixed seagrass
S14	-31.992920	115.554212	*Posidonia* dominated
S15	-31.999586	115.557713	Macroalgae dominated
S16	-31.999723	115.557537	Macroalgae dominated
S17	-32.001593	115.557182	Macroalgae dominated
S18	-31.999525	115.559192	*Posidonia* dominated
S19	-31.999180	115.558643	Sand with wrack
S20	-32.000096	115.560953	Sand
T1A	-32.000876	115.548878	*Posidonia* dominated
T1B	-31.999392	115.549173	*Posidonia* dominated
T1D	-31.998328	115.549048	*Posidonia* dominated
T1E	-31.997413	115.549063	*Posidonia* dominated
T1F	-31.996562	115.549119	*Posidonia* dominated
T1G	-31.995590	115.549120	*Posidonia* dominated
T1H	-31.994888	115.549037	Sand with wrack
T1I	-31.993794	115.549106	Sand
T1J	-31.992892	115.549120	Sand
T2A	-31.992904	115.550179	Sand
T2B	-31.993933	115.550337	Sand with wrack
T2C	-31.994724	115.550225	Sand
T2D	-31.995607	115.550193	*Posidonia* dominated
T2E	-31.996483	115.550193	Sand
T2F	-31.997453	115.550112	*Posidonia* dominated
T2G	-31.998399	115.550143	*Posidonia* dominated
T2H	-31.999320	115.550149	*Posidonia* dominated
T2I	-32.000216	115.550161	*Posidonia* dominated
T2J	-32.001033	115.550075	Sand with wrack
T2K			Sand with wrack
T3A	-32.001987	115.551264	*Posidonia* dominated

T3B	-32.001043	115.551105	*Posidonia* dominated
T3C	-32.000138	115.551022	*Posidonia* dominated
T3D	-31.999171	115.551116	Mixed seagrass
T3E	-31.998309	115.551073	*Posidonia* dominated
T3F	-31.997486	115.551149	Mixed seagrass
T3G	-31.996517	115.551198	*Posidonia* dominated
T3H	-31.995636	115.551172	Sand
T3I	-31.994674	115.551088	*Posidonia* dominated
T3J	-31.993912	115.551162	*Posidonia* dominated
T4A	-31.992902	115.552403	*Amphibolis* dominated
T4B	-31.993815	115.552269	Sand
T4C	-31.994868	115.552278	Mixed algae/seagrass
T4D	-31.995608	115.552250	Sand
T4E	-31.996477	115.552324	*Posidonia* dominated
T4F	-31.997382	115.552254	*Posidonia* dominated
T4G	-31.998373	115.552190	Mixed seagrass
T4H	-31.999194	115.552226	*Posidonia* dominated
T4I	-32.000154	115.552354	Sand with wrack
T4J	-32.001000	115.552282	*Posidonia* dominated
T4K	-32.001840	115.552281	*Posidonia* dominated
T5A	-32.001983	115.554207	*Posidonia* dominated
T5B	-32.001139	115.554347	*Posidonia* dominated
T5C	-32.000195	115.554253	*Posidonia* dominated
T5D	-31.999291	115.554204	*Posidonia* dominated
T5E	-31.998229	115.553897	*Posidonia* dominated
T5F	-31.997490	115.554130	Sand
T5G	-31.996543	115.554278	Sand with wrack
T5H	-31.995583	115.554328	*Posidonia* dominated
T5I	-31.994856	115.554423	*Amphibolis* dominated
T5J	-31.993818	115.554502	*Posidonia* dominated
T5K	-31.993077	115.554261	*Posidonia* dominated
T6A	-31.993053	115.556433	Limestone reef/pavement
T6B	-31.993838	115.556628	Sand with seagrass
T6C	-31.994742	115.556522	*Amphibolis* dominated
T6D	-31.995714	115.556559	*Posidonia* dominated
T6E	-31.996642	115.556606	*Posidonia* dominated
T6F	-31.997525	115.556546	*Posidonia* dominated
T6G	-31.998428	115.556409	*Posidonia* dominated
T6H	-31.999374	115.556611	*Posidonia* dominated
T6I	-32.000285	115.556450	*Posidonia* dominated
T6J	-32.001124	115.556284	*Posidonia* dominated
T6K	-32.001973	115.556486	*Posidonia* dominated
T7A	-32.001931	115.558433	Sand with wrack
T7B	-32.001049	115.558366	Macroalgae dominated
T7C	-32.000276	115.558437	*Posidonia* dominated

T7D	-31.999455	115.558520	Limestone reef/pavement
T7E	-31.998310	115.558450	Sand with wrack
T7F	-31.997597	115.558537	Sand with wrack
T7G	-31.996618	115.558534	Sand
T7H	-31.995774	115.558635	*Posidonia* dominated
T7I	-31.994817	115.558681	*PosidoniaPosidonia* dominated
T7J	-31.993806	115.558636	*PosidoniaPosidonia* dominated
T7K	-31.992990	115.558588	Mixed algae/seagrass
T8A	-31.992970	115.560739	*PosidoniaPosidonia* dominated
T8B	-31.993881	115.560746	*Amphibolis* dominated
T8C	-31.994836	115.560729	Sand with wrack
T8D	-31.995744	115.560692	Sand
T8E	-31.996606	115.560716	Sand with wrack
T8F	-31.997572	115.560620	Sand with wrack
T8G	-31.998400	115.560631	Mixed seagrass
T8H	-32.000246	115.560694	*PosidoniaPosidonia* dominated
T8I	-32.001094	115.560725	*PosidoniaPosidonia* dominated
T8J	-32.001971	115.560733	Sand with seagrass
T9A	-32.000894	115.547975	Sand with wrack
T9B	-32.000014	115.547896	*Posidonia* dominated
T9C	-31.999236	115.547972	Sand
T9D	-31.998274	115.547907	*Posidonia* dominated
T9E	-31.997362	115.548056	*Posidonia* dominated
T9F	-31.996414	115.548022	Mixed seagrass
T9G	-31.995598	115.548091	*Posidonia* dominated
T9H	-31.994630	115.548021	Sand
T9I	-31.993802	115.548143	Sand
T9J	-31.992972	115.548096	Sand
T10A	-31.992810	115.546115	Sand
T10B	-31.993792	115.546086	*Posidonia* dominated
T10C	-31.994727	115.546070	*Posidonia* dominated
T10D	-31.995540	115.546057	Sand
T10E	-31.996469	115.545955	*Posidonia* dominated
T10F	-31.997418	115.545937	*Posidonia* dominated
T10G	-31.998284	115.545981	*Posidonia* dominated
T10H	-31.999211	115.545947	*Posidonia* dominated
T11A	-31.998238	115.543745	*Posidonia* dominated
T11B	-31.997377	115.543805	*Posidonia* dominated
T11C	-31.996468	115.543797	Sand with wrack
T11D	-31.995058	115.543961	*Posidonia* dominated
T11E	-31.993865	115.543880	*Posidonia* dominated
T11F	-31.992855	115.543886	*Posidonia* dominated