Subtital Benthic Habitats and Biodiversity, Lower North Arm Western Port 2019

Technical Report A - Annexure D

AGL Gas Import Jetty Project

CEE Technical Report

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Western Port 2019

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Cover photo: Mixed benthic invertebrate community. Towed underwater video, Lower North Arm Western Port. 2019

"Subtidal Benthic Habitats and Biodiversity, Lower North Arm, Western Port 2019". CEE Pty Ltd report to AGL Australia Pty Ltd and AECOM Australia. Authors: Scott Chidgey, Peter Crockett, Amelie Mendrinna, Joana Costa and Merric Northey. CEE Pty Ltd, Melbourne, Australia 2019.

CEE Technical Report

Subtidal Benthic Habitats and Biodiversity, Lower North Arm

Western Port 2019

1 Project context

AGL Wholesale Gas Pty Ltd (AGL) and APA jointly propose to develop a Liquid Natural Gas (LNG) import terminal at Crib Point in the Lower North Arm of Western Port in Victoria, Australia. They propose to moor a floating storage and regasification unit (FSRU) at Crib Point Jetty Berth 2, install gas offloading facilities on the jetty and construct a transfer pipeline between Crib Pt and Pakenham. AGL proposes to engage a contractor to supply and operate the FSRU facility, while APA will develop and operate the gas transfer pipeline.

The Victorian Minister for Planning (the Minister) decided that based on the referral documentation an Environment Effects Statement under the *Environment Effects Act 1978* was required. The Victorian EES process is an accredited assessment process under the EPBC Act. The Minister issued scoping requirements (Ministerial Guidelines) for the EES in February 2018. The Ministerial Guidelines along with the EES referral documents (CEE, 2018a-d) and subsequent hydrodynamic modelling (Hydronumerics, 2019) were used to design technical marine ecosystem studies that fulfil the requirements for the Environment Effects Statement.

The EES referral process (CEE, 2018a-d) identified the pathways by which the proposal may impact upon the Western Port marine ecosystem, including benthic epibiota and infauna. The referral documents considered that the discharge of water that is cooler than ambient seawater and contains residual chlorine may impact the biota living on the seabed in the locality of Crib Point Jetty. Initial modelling of the cool water discharge and preliminary conservative environmental guidance values for temperature and chlorine indicated the potential effect of the discharge may extend across a localised area of the deeper seabed (>10 m water depth) in the locality of the FSRU at Crib Point. This was estimated to represent a localised area of Lower North Arm, less than 1 per cent of channel seabed habitat in Lower North Arm and 0.11 per cent of channel subtidal seabed habitat in Western Port.

The referral recommended documenting characteristics of the benthic habitat and ecosystem components (infauna and epibiota) along the potential dispersion pathways and at reference locations to inform the assessment of the nature of the benthic marine communities that may be affected by the discharge in relation to the distribution of habitats and communities over a wider area of Lower North Arm.

This technical report describes the EES investigations to describe and map the benthic habitats and associated biota in the main channel at Crib Point Jetty relevant to the project impact pathways. The information presented here is used in the EES Marine Environment Technical together with further development of hydrodynamic dispersion models and definition of guidance values for temperature and chlorine to assess the potential effects of the FSRU discharge on the benthic marine ecosystem of Lower North Arm, Western Port.

2 Background to seabed habitat and biota, North Arm

The physical features of the Western Port marine ecosystem have been described through studies on sediment composition (Marsden *et al* 1979, Coleman *et al* 1978), bathymetry (Aust. Hydrographic Office, DELWP) and hydrodynamics (Harris *et al* 1979, Hinwood and Jones 1979, EPA 2011).

Biological features of the intertidal segments of the Western Port marine ecosystem have been mapped (Blake and Ball 2001, Boon *et al* 2011, Bulthuis *et al* 1984, NSR 1974,) and there have been a variety of studies on the fauna associated with intertidal seagrass habitats (Edgar and Shaw 1995, Hindell *et al* 2000, Jenkins *et al* 1992, Jenkins 2015).

The major description of biological features and biodiversity of the benthic ecosystem of the Lower North Arm channel were described from aerial photography (NSR 1974, Marsden *et al* 1979), comprehensive infauna sampling using Smith MacIntyre dredge (Coleman *et al* 1978) and, most recently, using towed underwater video (Blake *et al* 2013). Other information is available from diver-based studies (CEE 2009, 2014, Marine Science and Ecology 1990, 2009, Smith *et al* 1975, Shepherd *et al* 2009).

The most recent synthesis of the distribution of benthic habitat and associated biological communities in Lower North Arm is shown in Figure 1.

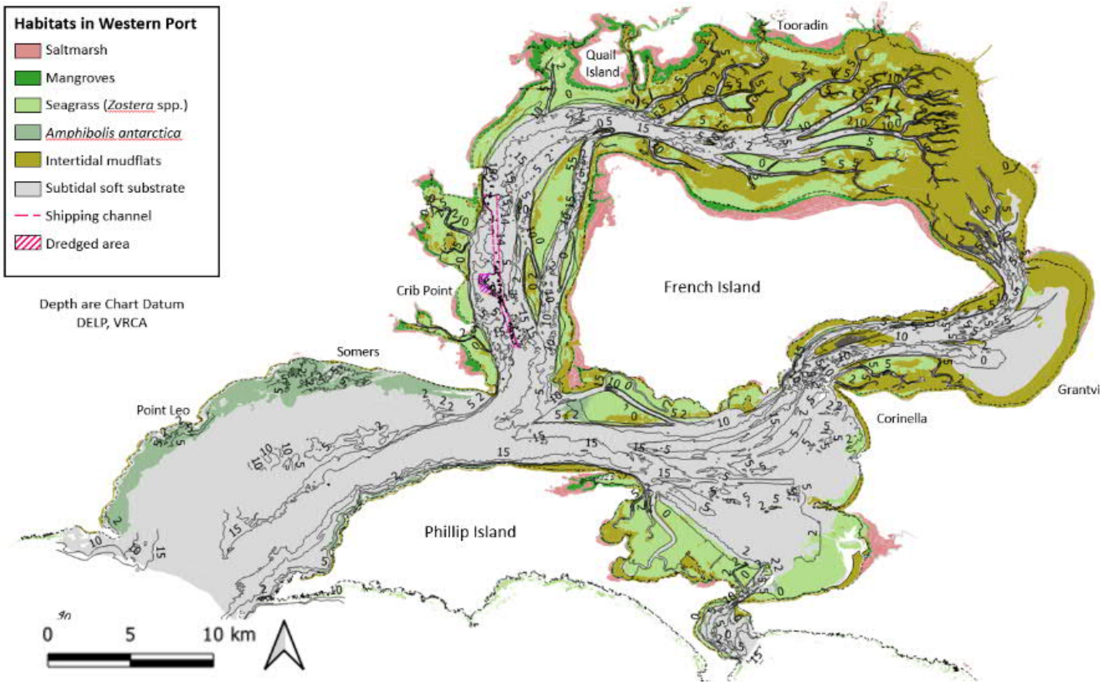


Figure 1. Benthic (seabed) Habitats in Western Port

Source: SeaMap Australia (Lucieer *et al* 2017) incorporating the work of French *et al* (2014), Boon *et al* (2011), Blake and Ball (2001), Blake *et al* (2013)

The habitats and associated communities in the main channels, including Lower North Arm, are generally described at a high level as relatively bare sandy and muddy sediments with sparse epibiota. The distribution of burrowing biota (infauna) are generally known from the 1970s collections (Coleman *et al* 1978)

2.1 Seabed habitat and community investigations

Project specific seabed habitat investigations were directed to the area that may be affected by the discharge of chlorinated heat exchange waters from the FSRU in the vicinity of Crib Point as informed by hydrodynamic modelling in the referral-stage of the project and early stages of the EES.

While the general description of the channel habitat was relatively bare and featureless sandy sediment as described above, the previous diver observations and more recent towed underwater video investigations and high resolution bathymetry indicate that, although the seabed is predominantly medium sand, the seabed comprises a mosaic of benthic features and associated biota. Hence, investigations focussed on documentation of the benthic habitat and associated visible biological communities, with additional information on biological characteristics below the surface (infauna) provided by grab sampling in areas of suitable sediment.

Methods were selected that recognised the known physical characteristics of the water column (strong tidal currents, high turbidity, low underwater light and poor clarity); known and likely physical and biological characteristics in the dredged shipping basin at Crib Point and more generally over the Lower North Arm Channel seabed.

3 Seabed habitat and epibiota

The habitat and associated biota on the seabed in Lower North Arm were surveyed using towed underwater video (TUV). The lightweight and compact nature of TUV make it an efficient, flexible and effective tool for rapidly characterise the seabed and associated biota over significant representative areas and depths of seabed from small to large vessels.

TUV provides real-time visual images of the seabed to operators on-board survey vessels as well as high definition video and high resolution still imagery along tow paths (transects). Video provides continuous context, while time-tagged high definition still images provide convenient accurate and re-analysable discrete samples. Time-tagged images are matched to GPS logs of position and depth for the image analysis and reference database.

3.1 Benthic habitat and epibiota - Methods

The rationale for selecting and planning sampling seabed habitat sampling sites around Lower North Arm was to:

1) Fill information gaps – focus on subtidal sites in the centre channel where biota have not been documented that are most relevant to potential Project impact pathways
2) Document the habitats and epibenthic biodiversity that occur within 500 m of Crib Point Jetty at a fine scale (less than 100 m)
3) Document the broad-scale distribution of habitats and epibenthic biodiversity in Lower North Arm by sampling at sites representative of the variations in depth, seabed type, and hydrodynamics in Lower North Arm channel between the Confluence Zone and Crawfish Rock
4) Prepare a GIS based system to enable examination of benthic habitats and species assemblage distributions to inform assessment of spatial extent potential impacts on seabed communities.

3.1.1 Locations and transects

Figure 2 shows the location of towed video transects used to characterise benthic habitats and biodiversity at four general regions in Lower North Arm based on the project area at Crib Point.

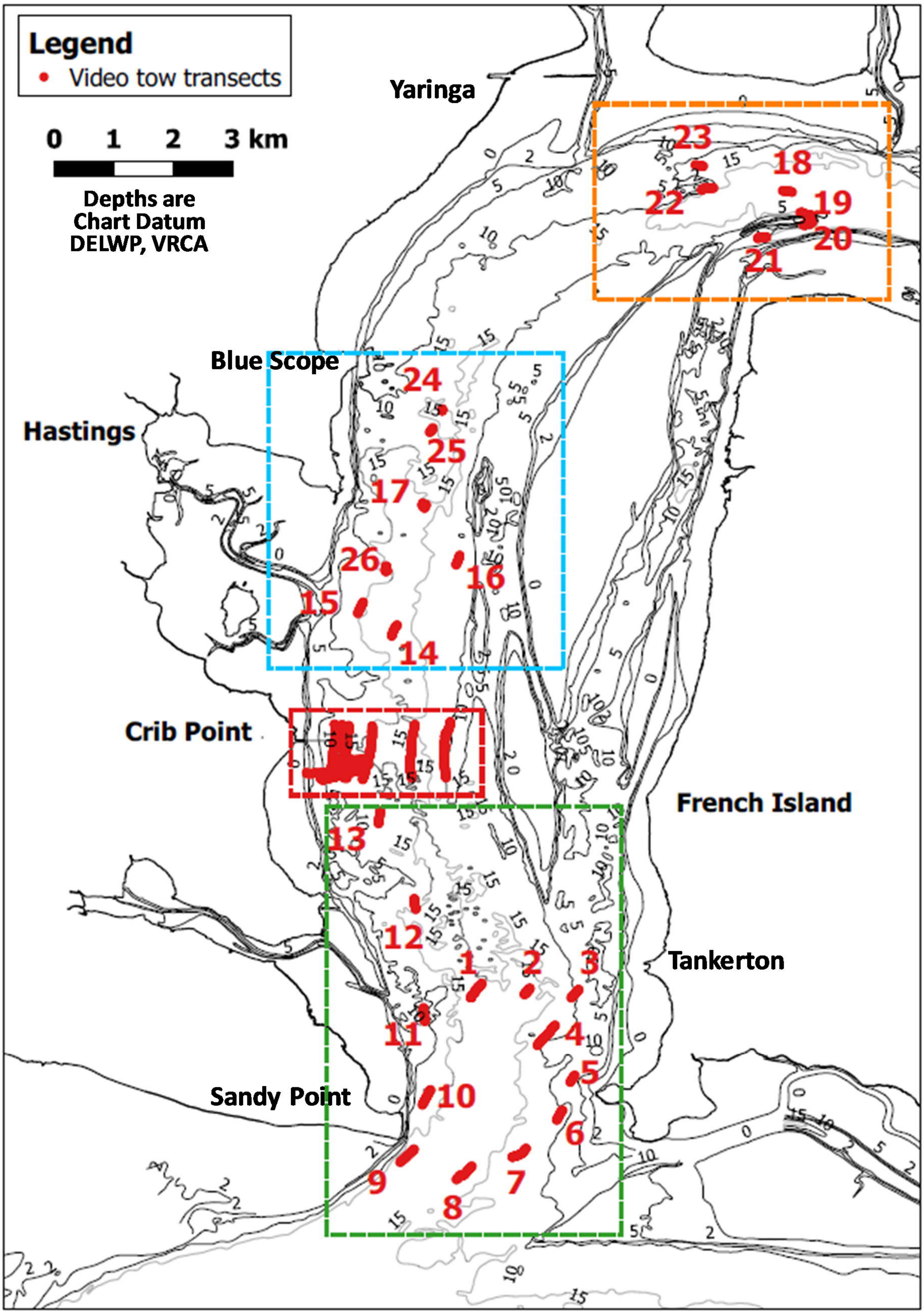


Figure 2. Towed video transects in Lower North Arm, Western Port

Start and end positions of 40 transects (or TUV tows) are listed in Table 1.
Further details of the video tows within the four regions is provided in the following sections including:

- Crib Point region, Figure **19** and Section 3.5.1;
- South (Sandy Point Tankerton) region, Figure 20 and Section 3.5.2;
- North (Hastings) region, Figure 21 and Section 3.5.3;
- North Yaringa/Eagle Rock region, Figure 22 and Section 3.5.4.

Table 1. Details of towed video transects in North Arm, Western Port

Transect Number	Date	Start Easting	Start Northing	End Easting	End Northing	Length (m)	Min depth (m)	Max depth (m)
Crib Pt Jetty								
1	18/12/2019	344557	5753402	345327	5753564	1000	3.3	16.8
2	18/12/2019	345320	5753665	344946	5753637	480	15.7	16.1
3	18/12/2019	344965	5754229	345014	5753357	890	14.7	18.2
4	18/12/2019	344863	5754238	344835	5753365	890	12.9	20.9
5	18/12/2019	345364	5754219	345262	5753344	890	13.9	17.4
6	18/12/2019	346398	5754309	346356	5753385	940	9.7	12.7
7	18/12/2019	345931	5754253	345907	5753354	910	14.7	18.3
8	18/12/2019	345054	5754216	345044	5753346	880	13.2	16.8
9	18/12/2019	344766	5753314	345165	5753447	530	9.3	14.4
10	20/11/2019	344418	5754798	344929	5754265	776	2	10
11	20/11/2019	344475	5754240	344827	5754017	501	2	10
12	20/11/2019	344461	5753832	344728	5753855	291	2	10
13	20/11/2019	344935	5753826	344905	5753829	33	15	10
14	20/11/2019	344958	5753627	344902	5753625	92	15	10
South of Crib Pt Jetty (Tankerton/Sandy Point)								
1	19/12/2019	346883	5749884	346751	5749660	300	17.8	20.9
2	19/12/2019	347522	5749818	347455	5749728	130	20.3	20.9
3	19/12/2019	348172	5749821	348072	5749677	200	8.8	12.4
4	19/12/2019	347876	5749214	347640	5748862	480	11.7	14.8
5	19/12/2019	348148	5748362	348087	5748238	150	6.3	8.5
6	19/12/2019	347989	5747768	347915	5747580	260	13.6	14.4
7	19/12/2019	347518	5747114	347331	5746958	430	14.9	15.8
8	19/12/2019	346791	5746779	346599	5746570	490	20.4	24.8
9	19/12/2019	346023	5747057	345850	5746852	460	20	21.7
10	19/12/2019	346236	5748059	346138	5747817	280	12.8	16.1
11	19/12/2019	346139	5749450	346163	5749230	220	10.3	12.7
12	19/12/2019	345980	5751304	346008	5751113	200	14.3	15.4
13	19/12/2019	345496	5752752	345478	5752543	210	13.5	14.9

(Continued over page)

Table 1. Metadata for towed video transects in North Arm, Western Port (cont).

Transect Number	Date	Start Easting	Start Northing	End Easting	End Northing	Length (m)	Min depth (m)	Max depth (m)
North of Crib Pt Jetty (Hastings)								
14	19/12/2019	345640	5755882	345593	5755726	170	16.5	17.6
15	19/12/2019	345193	5756261	345126	5756069	210	14.5	15.6
16	19/12/2019	346465	5757079	346407	5756914	190	10.7	11
17	19/12/2019	345960	5757958	345980	5757919	180	16	18.6
24	19/12/2019	346189	5759556	346192	5759526	30	13.5	17.1
25	19/12/2019	346072	5759228	346030	5759167	80	12.2	14.1
26	19/12/2019	345501	5756904	345522	5756830	140	12.8	16.6
Northern Lower North Arm (Yaringa/Crawfish Rock and Eagle Rock)								
18	19/12/2019	350752	5763313	350629	5763329	290	20.9	23.1
19	19/12/2019	351015	5762916	350868	5762968	240	4.9	24.9
20	19/12/2019	351028	5762802	350923	5762760	250	5.3	20.7
21	19/12/2019	350415	5762549	350313	5762509	210	13.2	15.4
22	19/12/2019	349704	5763362	349542	5763326	300	6.9	14.8
23	19/12/2019	349562	5763722	349451	5763746	210	12.8	13.6

3.1.2 Equipment and sampling method

Seabed images were collected using CEEs remotely operated towed video and photography equipment.

For short tows in low currents, the equipment comprised a ballasted 0.7 m tall tripod with a still camera mounted perpendicular to the seabed at the top of the frame (Figure 3). The still camera had a wide-angle lens with a field of view of approximately 1.4 m by 0.8 m. The still camera was set to capture an image every 2 seconds during the tow. An obliquely oriented HD CCTV camera, also fixed to the frame, provided a live feed to the operator’s screen.

For tows in moderate to strong currents, the equipment comprised a streamlined ‘tow-fish’ that allows for easy handling and quick manoeuvring. Both the still and live-feed CCTV cameras were mounted on the tow-fish to provide an oblique view of the seabed (Figure 4). The still camera was set to capture an image every 2 seconds in this configuration also.

Most tows were achieved by drifting with tidal currents, others were at very slow tow speeds so that the position of the towed imaging equipment was within 5-10 m of the vessel GPS position at all times (allowing for a variable catenary in the camera cable). Position data for each transect was recorded using GPS (accuracy ± 4 m) with a fix (trackpoint) recorded every 2 seconds. The start and end of each transect was recorded with a waypoint.

The light-weight (10 kg or less) imaging equipment was operated by hand using the live video as visual aid to control its position. The tripod was ‘hopped’ along the seabed and allowed to rest for around 5 seconds between each hop to capture a clear photo quadrat image of the seabed. The distance of each hop varied according to current strength, but was generally between 2 and 5 m. The tow-fish was maintained at between 10-20 cm above the seabed to record a clear image of the seabed and biota.

Video, images and GPS records were downloaded and prepared for analysis by:

- Editing GPS records to remove position data (trackpoints) that did not relate to transect positions
- Checking field records (notes of times, waypoints and observations) against GPS and video/image records
- Assigning video and image files to their respective transects
- Selecting still image files that were of sufficient quality for analysis:
    - Only non-overlapping images were used
    - Only clear images were selected for analysis from which seabed composition and biota could be categorised with a high level of certainty
- Image files were matched to GPS track records using their respective timestamps (both GPS records and images were recorded at 2 second intervals)
- Video files were matched to GPS waypoint records using their respective timestamps

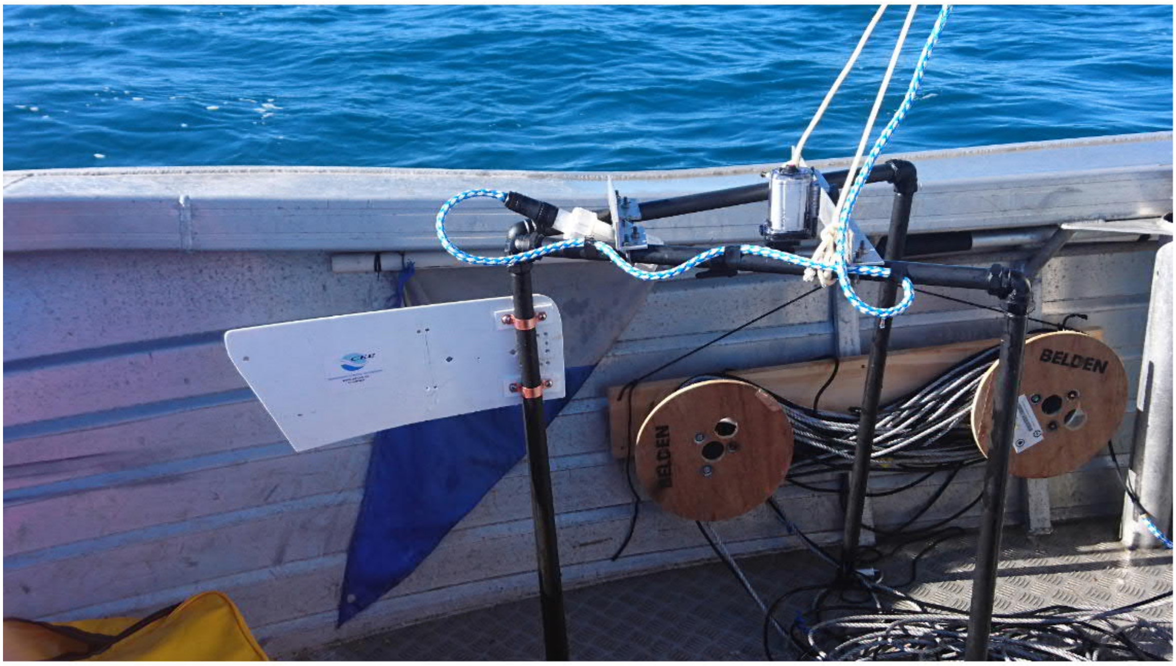


Figure 3. Tripod with cameras

Figure 4. ‘Tow fish’ with cameras

3.1.3 Data sources, analysis and presentation

Images were analysed for the habitat substrate present (sand, shell, gravel/cobble, reef) and presence of key biota (burrows, epibenthic invertebrates and macrophytes). These data were used to classify images according to a hierarchical habitat classification system appropriate to the seabed in the study area and project needs. Visible distinguishable species were also noted and recorded as present or absent. This approach is generally consistent with those developed by SeaMap Australia (Butler *et al* 2017) and can be re-configured for consistency with DELWP’s CoastKit database (based on CBiCS classification).

The image classification data (benthic habitats and species presence/absence) were used to determine the proportion of each transect occupied by each habitat/species, and the number of habitats/species present along each transect.

The position, habitat classification and species presence/absence data were compiled into Geographic Information System (GIS) compatible formats and used to produce the maps presented in this report. The maps show key spatial patterns in the distribution of habitats, species and biophysical combinations. The outputs were produced using the QGIS open-source GIS product.

3.2 Benthic habitat classification

Sediments were visually characterised by size fraction (silt, sand, shell, gravel, rubble) and mobility (ripples, waves) as shown in Figure 5. Sediment composition is a strong predictor for the types of benthic biota (Gray 1974) and degree of bioturbation by infauna. There is little hard substrate in Lower North Arm, though some areas have a high abundance of shell material and there are areas with rubble, particularly in the south of Lower North Arm. Small outcrops of hard clay/bedrock occur in places but the only substantial subtidal rocky reef habitat is at Crawfish Rock and Eagle Rock.

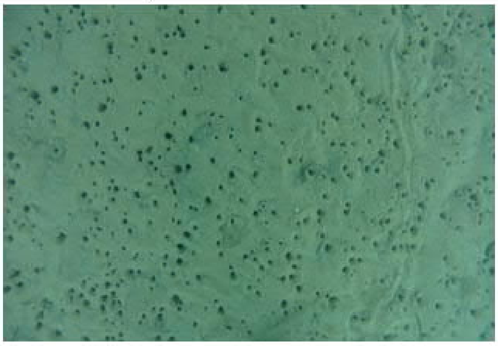
Sediment			
Fine sand	Fine sand, no waves	Silty sand w/o waves	Sand and silt, usually with shell and shell grit, no waves
			
Silty sand with waves	Sand and silt, usually with shell grit formed into waves	Medium sand w/o waves	Medium sand, usually with shell grit, no waves
			
Medium sand with waves	Medium sand, usually with shell grit, formed into waves	Sand over clay	Sand over hard clay
			

Figure 5. Surface characteristics of sediments in North Arm, Western Port

Shell material from dead bivalves (mostly) debris creates habitat for a range of biota that attach to unconsolidated hard substrate, such as brachiopods, sponges, bryozoans, ascidians and macroalgae. High densities of shell can also indicate areas of strong currents (winnowing) or high abundance of living bivalves. Categories of shell material on the seabed are shown in Figure 6.

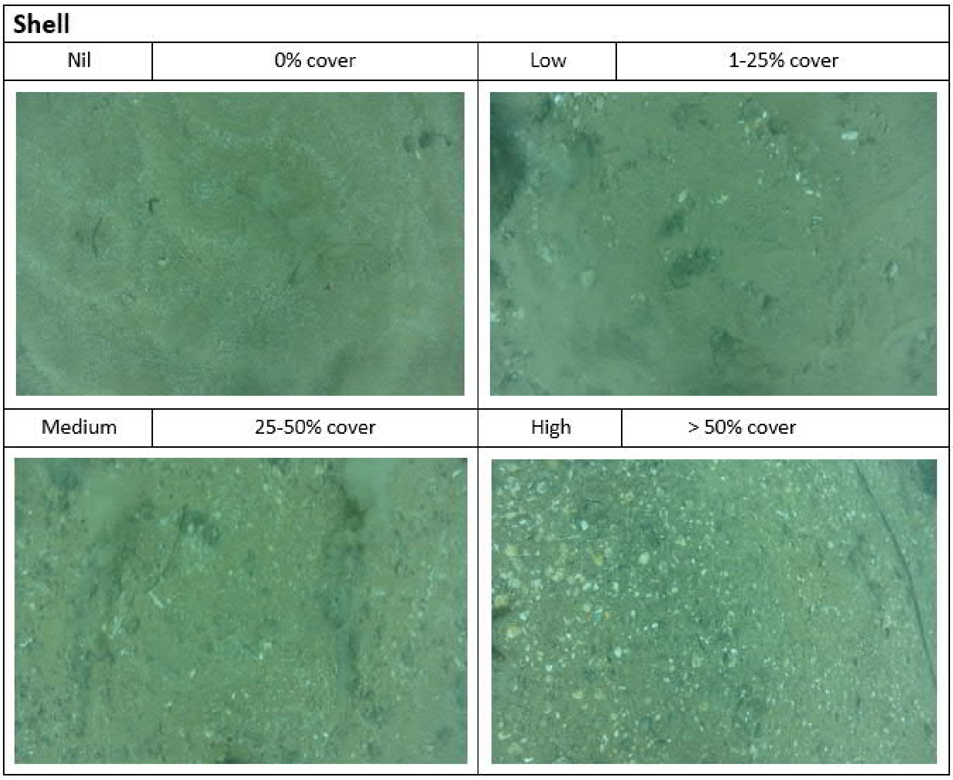


Figure 6. Shell content of surface sediments in North Arm, Western Port

The abundance of bioturbation as evidence of infauna in each image was ranked according to the density of visible burrows and mounds as shown in Figure 7.

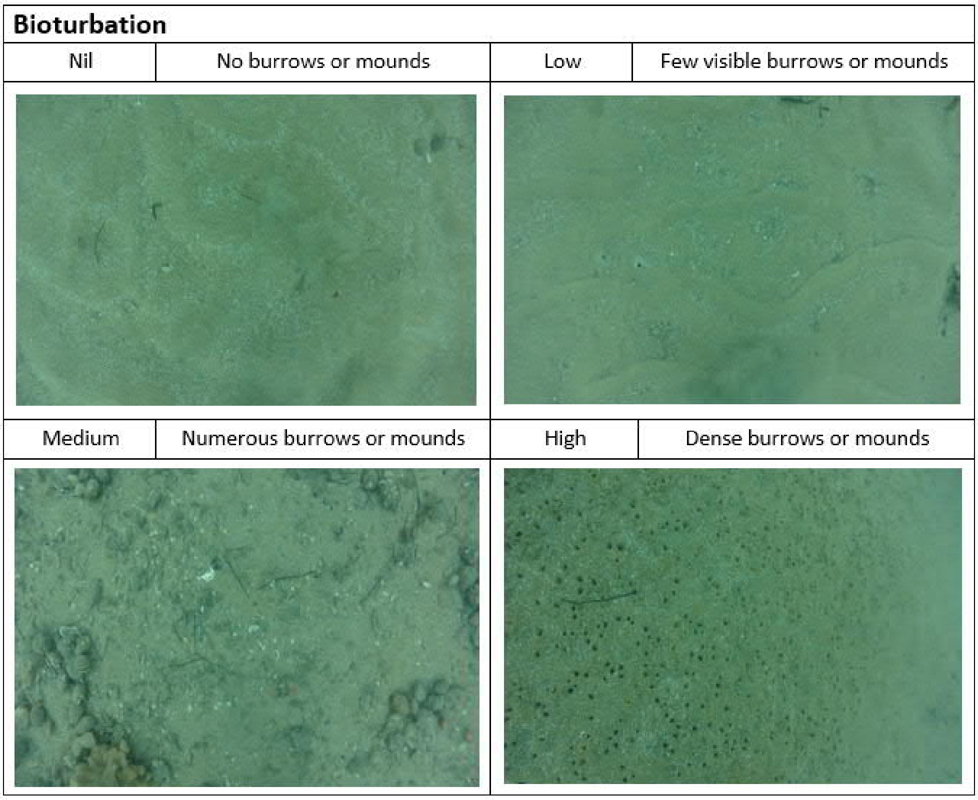


Figure 7. Sediment bioturbation in North Arm, Western Port

The types of macrophytes present was classified using four categories identified from the video and image records: Macroalgae (drifting and attached), *Zostera* and *Halophila* beds, and seagrass drift (Figure 8).

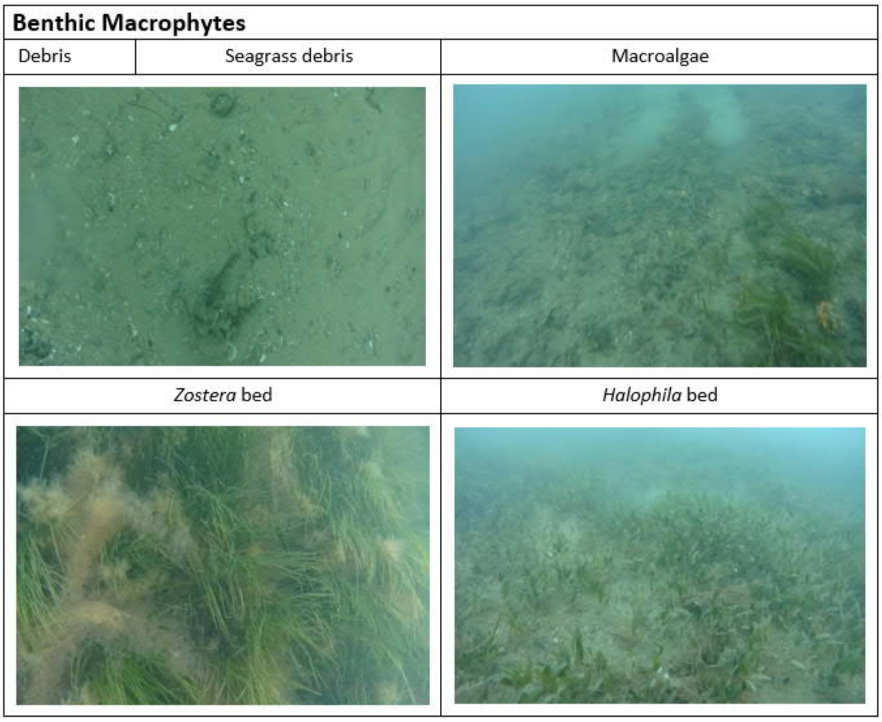


Figure 8. Types of benthic macrophyte cover in Western Port, North Arm

The cover of benthic invertebrate assemblages (sponges, bryozoan, urchin) was classified according to percent cover groups as shown in Figure 9.

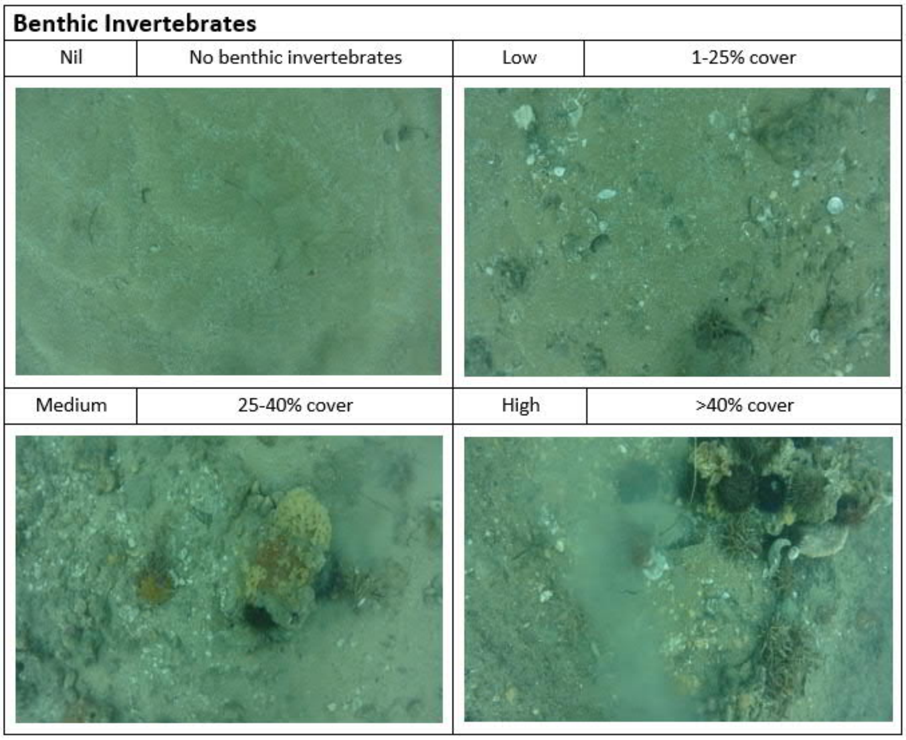


Figure 9. Benthic invertebrate abundance in Western Port, North Arm

The lamp-shell *Magellania flavescens* was abundant on the seabed in parts of Lower North Arm. The cover of this brachiopod was classified according to percent cover groups as shown in Figure 10.

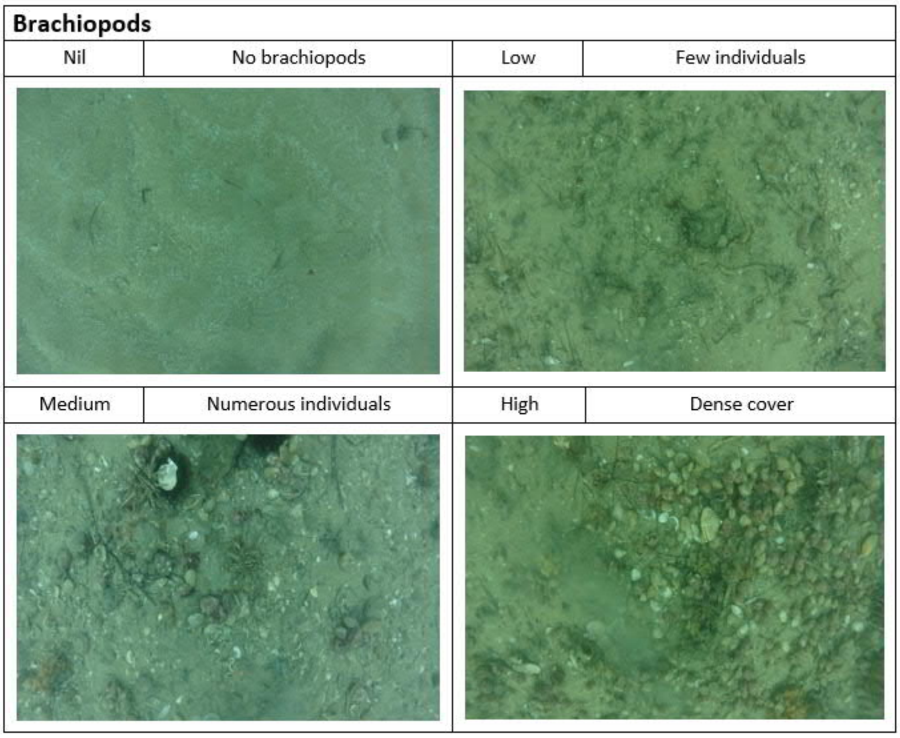


Figure 10. Levels of *Magellania* brachiopod cover in North Arm, Western Port

Examples of GIS outputs for individual seabed habitat descriptors at Crib Point are provided below.

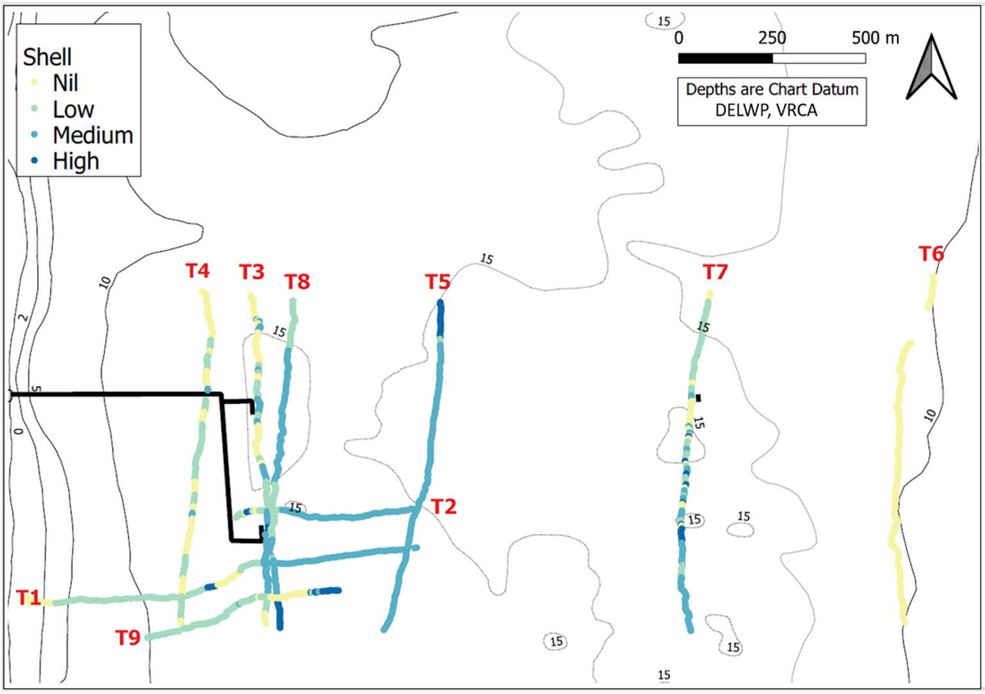


Figure 11. Shell debris around Crib Point Jetty

Levels of bioturbation varied among transects, however not as much within transects. The highest levels of bioturbation were found up to 300 m east of Crib Point Jetty as well as in the centre channel near the 10 m contour. Transects with very low bioturbation were located west of Crib Point Jetty and at transect T7 in the centre channel. Other transects close to the Jetty showed medium bioturbation mostly identified as small burrows and piles of dark grey silt on the sea bottom.

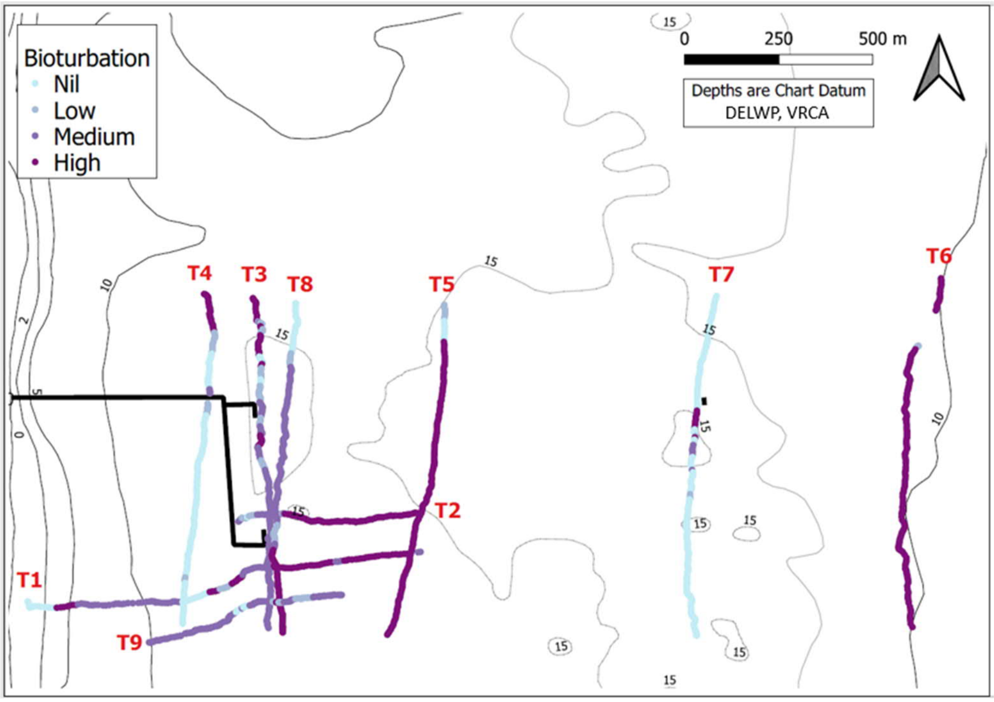


Figure 12. Bioturbation near Crib Point Jetty

Some areas of high bioturbation that varied in size from metres to tens of metres were characterised by larger burrows (5-10 mm) and clean sand devoid of sand waves and sedentary biota. Similar habitat was found in the near Tea Tree Point at French Island (Section 3.5.2, South of Crib Pt transect 3). High numbers of common ghost shrimps *Trypaea australiensis* were found in these areas during targeted sampling for threatened ghost shrimps (*Michelea microphylla* and *Pseudocalliax tooradin*). No threatened species were found.

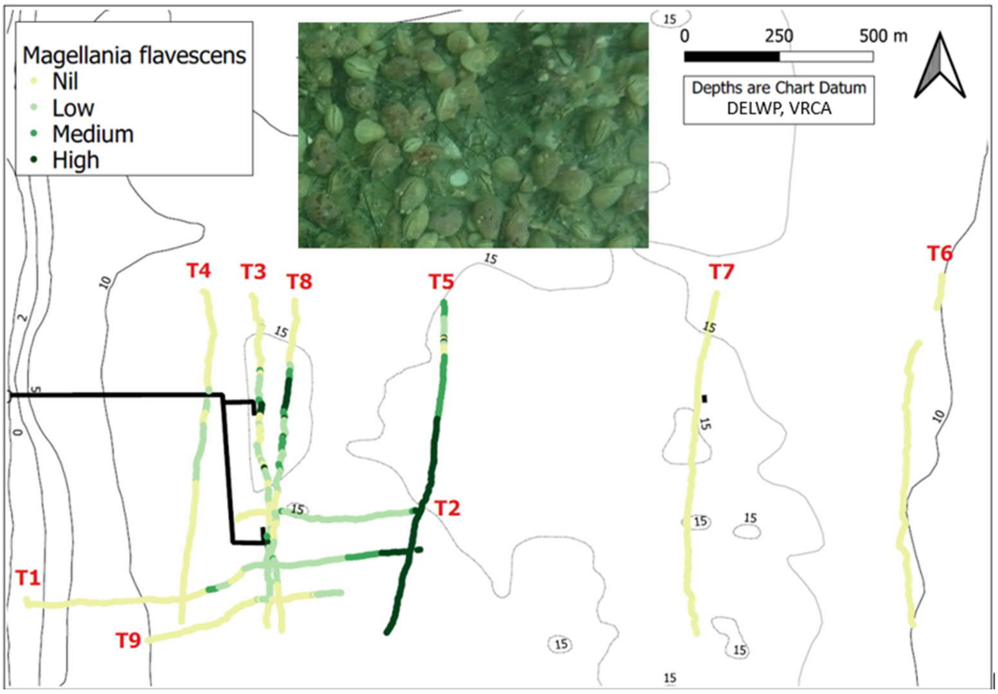


Figure 13. Distribution of lamp shell *Magellania flavescens* around Crib Point

The unusual brachiopod or Southern lamp-shell *Magellania flavescens* was one of the more common epibenthic species documented on the TUV tow transects and, in some areas, covered a substantial proportion of the seabed. Hence this species was assigned a habitat score (Figure 13) in addition to a species presence/absence score (Section 3.3, Table 3). *Magellania flavescens* was present at varying density on the seabed around Lower North Arm. This species is widespread from New South Wales, to southern Western Australia and the north coast of Tasmania. It is not listed as threatened in either State or Commonwealth regulations.

3.3 Epibiota taxa distribution and abundance

A presence/absence based approach was used to assess species or higher-level taxa distributions along the TUV transects in Lower North Arm. Taxa likely to be present in Lower North Arm was compiled based on review of the images and a literature review (Table 2).

Table 2. Taxa categories used in presence/absence analysis

Group	Taxon/Category	Group	Species/Taxon
Benthic Microalgae	Benthic microalgae	Spoon Worms (Echiura)	Echiuran (general)
Brown Algae	General	Crustaceans	Shrimp burrow
	Ecklonia radiata		Crustacean (general)
Red Algae	Drift	Bivalves, Gastropods Nudibranchs (Molluscs)	Mimachlamys asperrima
	Seagrass epiphyte		Pecten fumatus
	Frondose		Ostrea angasi
	Encrusting Coralline		Gastropod (general)
	Rhodolith		Ceratosoma amoenum
Green Algae	Caulerpa cactoides	Brachiopods	Magellania flavescens
	Caulerpa trifaria	Lace Corals (Bryozoa)	Phidoloporidae (cf. Triphyllozoon)
	Caulerpa scalpelliformis		Celleporaria spp.
	General		Bugula sp.
Seagrasses	Halophila australis		Orthoscuticella ventricosa
	Zostera nigricaulis	Sea Urchins, Seastars (Echinoderms)	Sea urchin (general)
Sponges (Porifera)	General		Heliocidaris erythrogramma
	Tethya sp.		Goniocidaris tubaria
	Holopsamma sp.		Tosia australis
Soft corals, hydroids, anemones (Cnidaria)	Sarcoptilus grandis		Seastar (general)
	Alcyonacea (soft coral)		Nectria sp.
	Ralpharia sp.		Meridiastra gunnii
	Hydroid (general)	Sea squirts (Ascidiacea)	Ascidian (Solitary)
	Pink anemone		Ascidian (Colonial)
	Anthonoe sp.		Stolonica australis
Worms (Polychaeta)	Eunice sp. (colony)		Pyura dalbyi
			Sycozoa sp.
	Tubeworm (general)		Pyura australis
	Fanworm (general)		Ritterela sp.

Clear still images matched to GPS records were selected at 5-20 m spacings along each transect depending on the speed of the tow (5-10 m for most transects). Presence or absence of the species listed in Table 2 was determined for each image. The data were used to identify patterns in species distributions, determine the species richness on different transects and the commonness of species (proportion of images where present) in Lower North Arm.

The presence/absence scores of benthic taxa recorded as the percentage of images on each transect (site) where key benthic species (or higher-level groups) were present are listed in Table 3. The table uses a colour scale, with darker green shading indicating a species was present in a higher proportion of images.

Table 3. Distribution abundance of key benthic taxa in Lower North Arm

Towed video Transect	Brown Algae	Red Algae	Green Algae	Seagrass	Sponges	Cnidaria	*S. grandis*	*Eunice sp.*	*M. asperimma*	*M. flavescens*	*Bryozoans*	*Celleporaria spp.*	*Echinoderms*	*G. tubaria*	*Ascidians*	*P. dalbyi*
Crib Point																
01	1	35	1	14	41	10	0	1	6	24	4	4	7	6	5	1
02	0	40	0	0	44	4	0	0	13	46	13	13	27	21	4	0
03	0	19	0	0	27	18	2	0	4	38	5	3	23	23	0	0
04	0	3	0	0	7	2	0	2	2	5	2	2	3	3	5	0
05	0	45	0	0	29	6	0	9	12	76	3	2	11	10	9	0
06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07	0	16	0	0	14	2	0	30	1	4	1	1	5	5	9	7
08	0	22	0	0	28	10	0	0	9	35	13	12	12	9	7	2
09	0	9	0	0	24	7	0	2	5	3	2	2	17	16	12	10
South of Crib Point																
01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02	0	50	0	0	50	31	0	63	0	13	31	13	38	13	38	31
03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04	0	94	0	0	59	6	0	9	3	31	59	31	22	13	50	38
05	9	100	0	0	55	9	0	0	0	0	0	0	18	18	9	0
06	0	44	0	0	89	0	0	17	0	0	11	11	50	0	94	94
07	0	67	0	0	57	0	0	81	0	0	67	48	14	0	67	62
08	0	6	0	0	88	0	0	100	0	0	38	31	25	13	44	44
09	0	13	0	0	94	0	0	50	0	0	19	19	6	0	81	81
10	0	30	4	0	96	4	0	57	0	0	26	26	70	17	30	30
11	0	100	0	0	96	0	0	43	4	4	26	26	39	4	13	4
12	0	82	0	0	41	0	0	53	0	35	0	0	0	0	41	35
13	0	53	0	0	42	0	0	32	5	32	5	5	21	16	11	5
North of Crib Point																
14	0	0	0	0	11	0	0	94	0	0	6	6	0	0	0	0
15	0	0	0	0	19	0	0	50	6	6	0	0	0	0	0	0
16	0	86	0	0	93	0	0	36	0	0	0	0	21	21	57	57
17	0	5	0	0	24	0	0	10	0	0	5	5	24	19	0	0
24	0	43	0	0	71	0	0	0	0	14	14	14	14	14	57	43
25	0	39	0	0	100	17	0	61	0	0	11	6	44	44	56	56
26	0	75	0	0	69	0	0	56	6	50	31	25	75	75	31	25
Crawfish and Eagle Rocks																
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	14	45	17	0	79	3	0	0	0	0	31	3	24	0	14	0
20	26	63	11	0	95	32	0	0	0	0	63	0	0	0	42	0
21	0	0	0	0	21	0	0	0	0	0	0	0	7	0	0	0
22	0	38	0	0	84	16	0	0	0	3	50	28	28	16	44	19
23	0	57	0	0	43	0	0	14	0	0	7	7	7	7	36	36
All	1	31	1	1	39	6	0	16	4	19	12	8	16	11	17	12

Figure 14 to Figure 17 (below) show examples of GIS outputs of the presence/absence of key taxa (tube worm, doughboy scallop, bryozoans and sea urchin) along towed video transects.

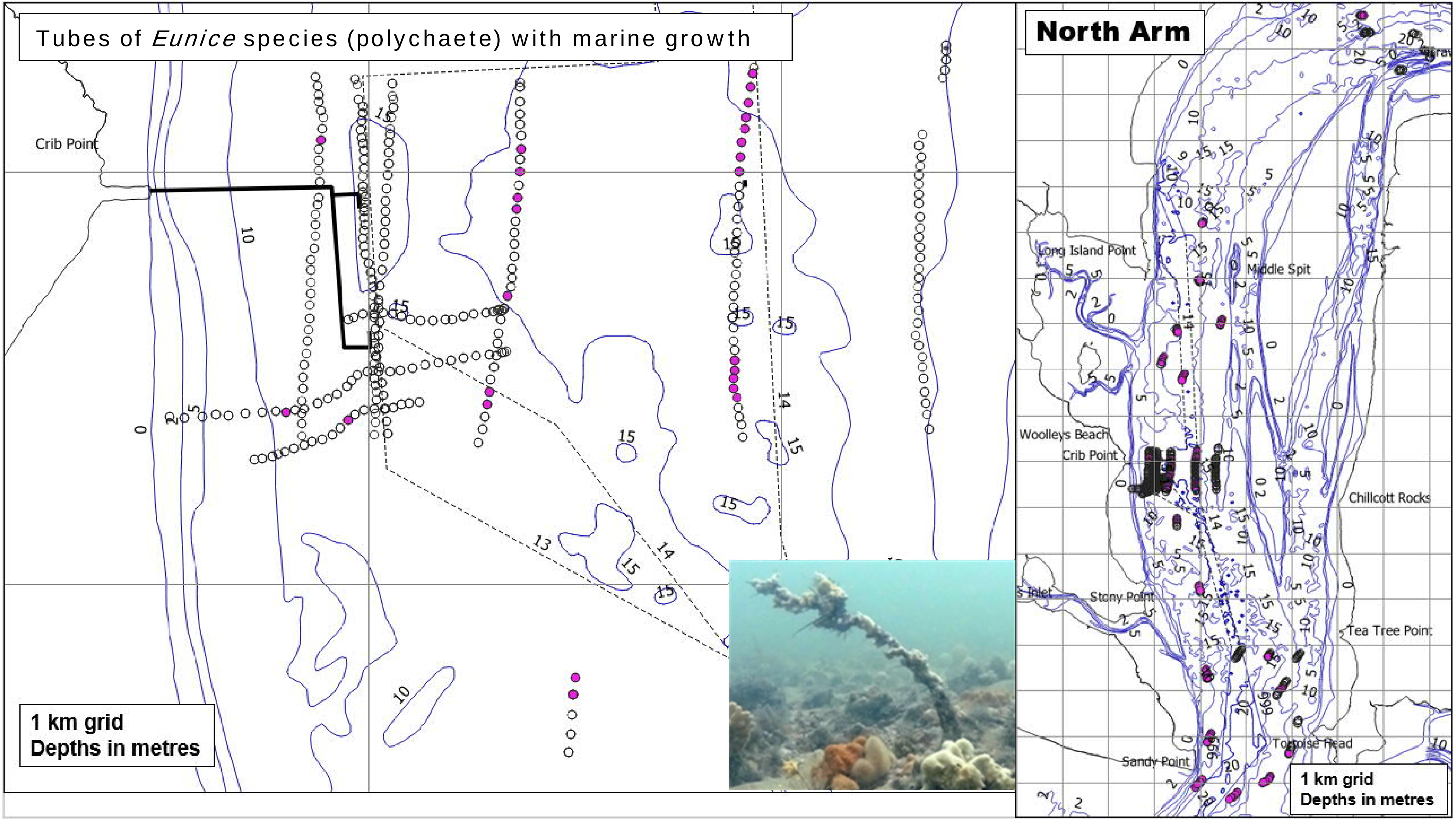


Figure 14. ***Eunice*** **sp. (polychaete) distribution near Crib Pt Jetty and in Lower North Arm**

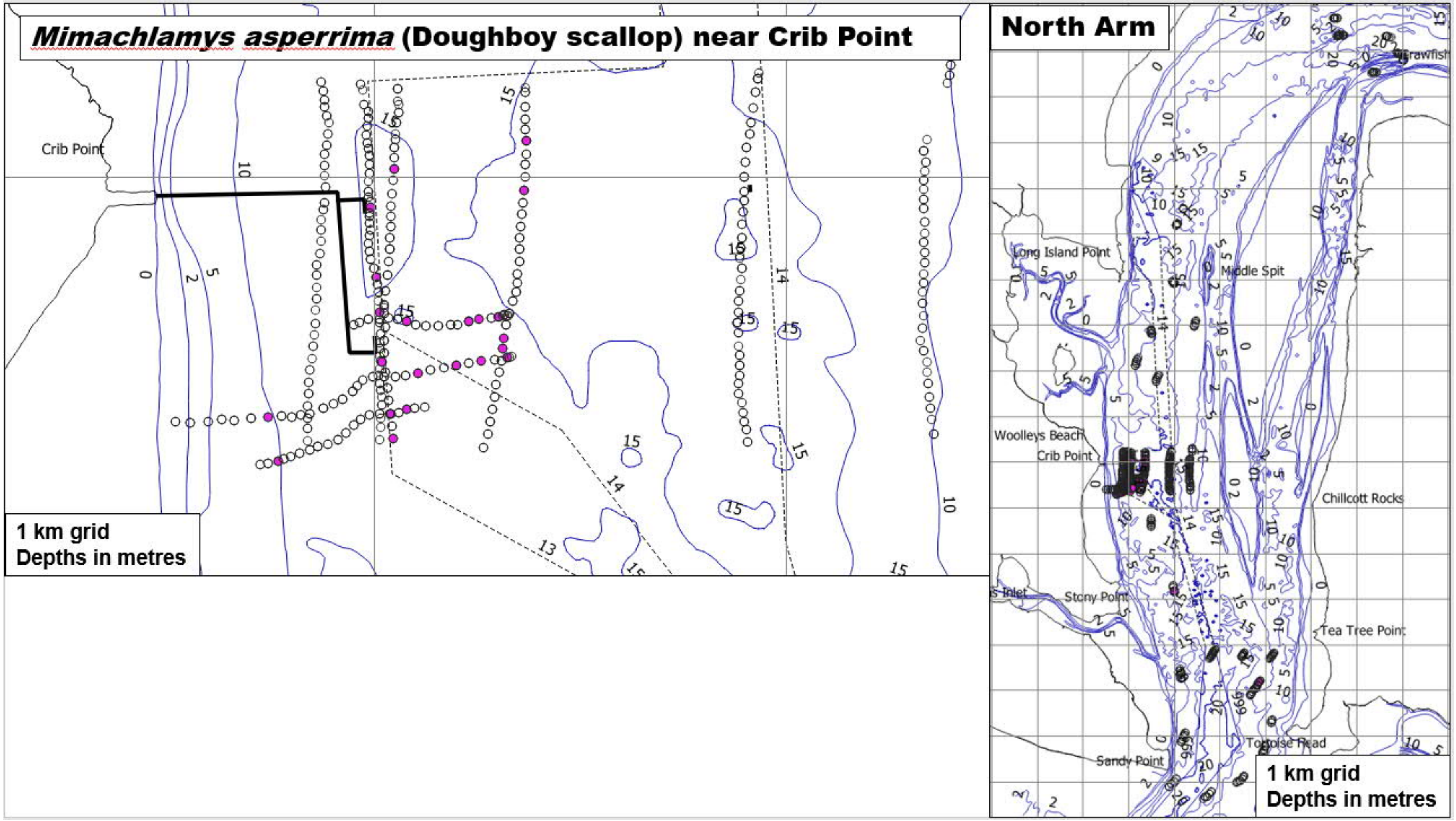


Figure 15. ***Michachlamys asperrima*** **(Doughboy scallop) distribution near Crib Pt Jetty and in Lower North Arm**

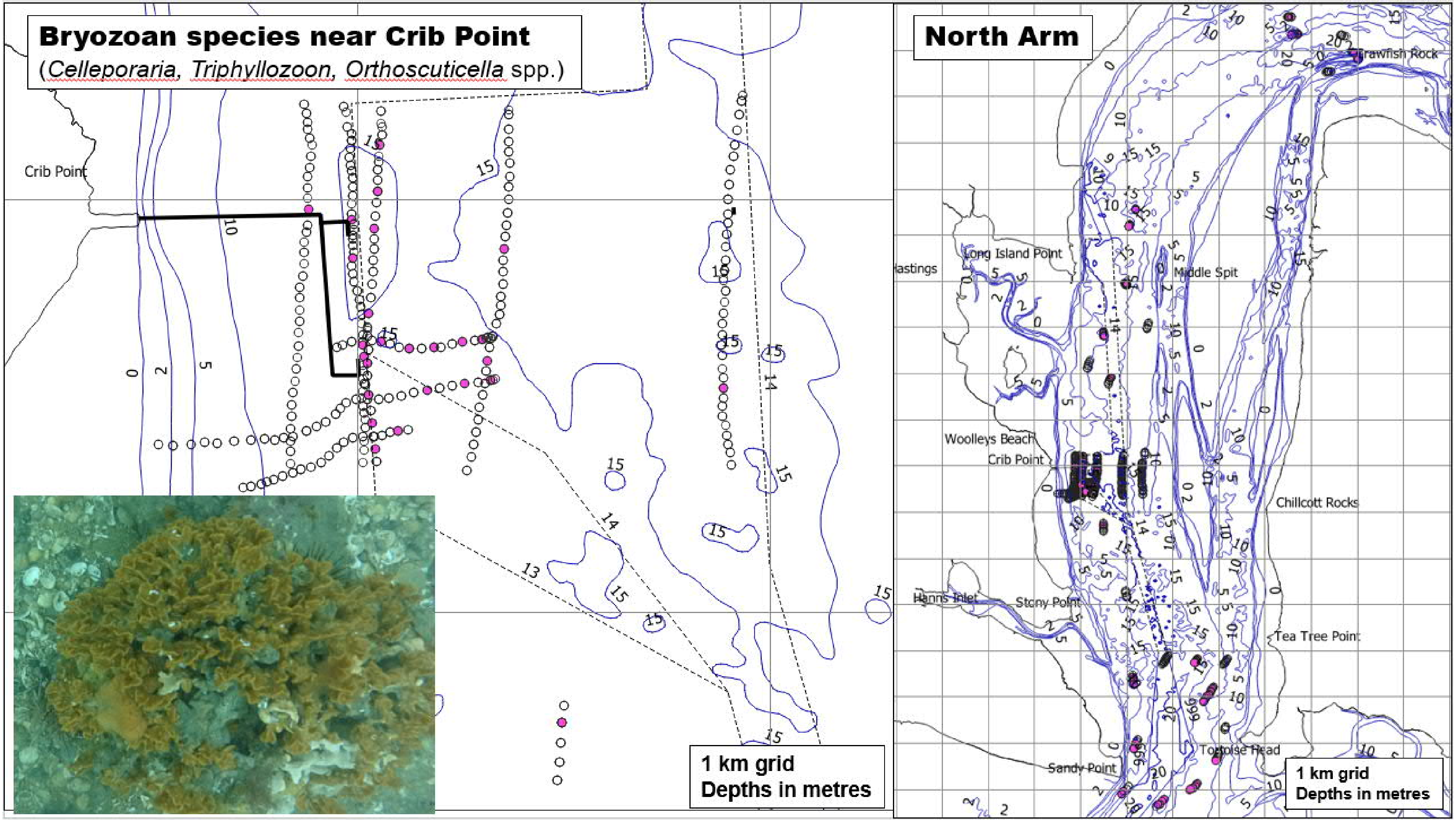


Figure 16. Bryozoan distribution near Crib Pt Jetty and in Lower North Arm

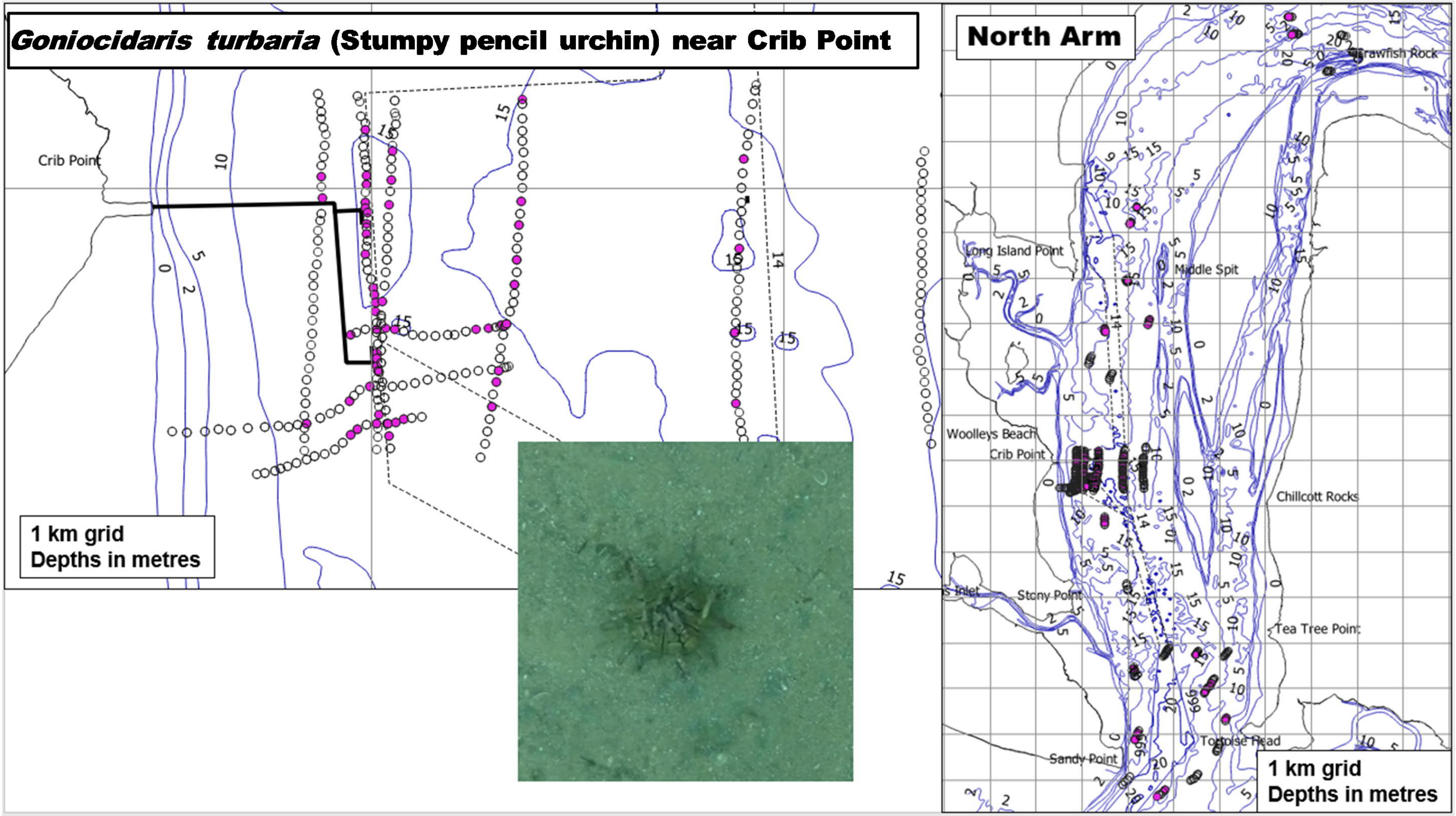


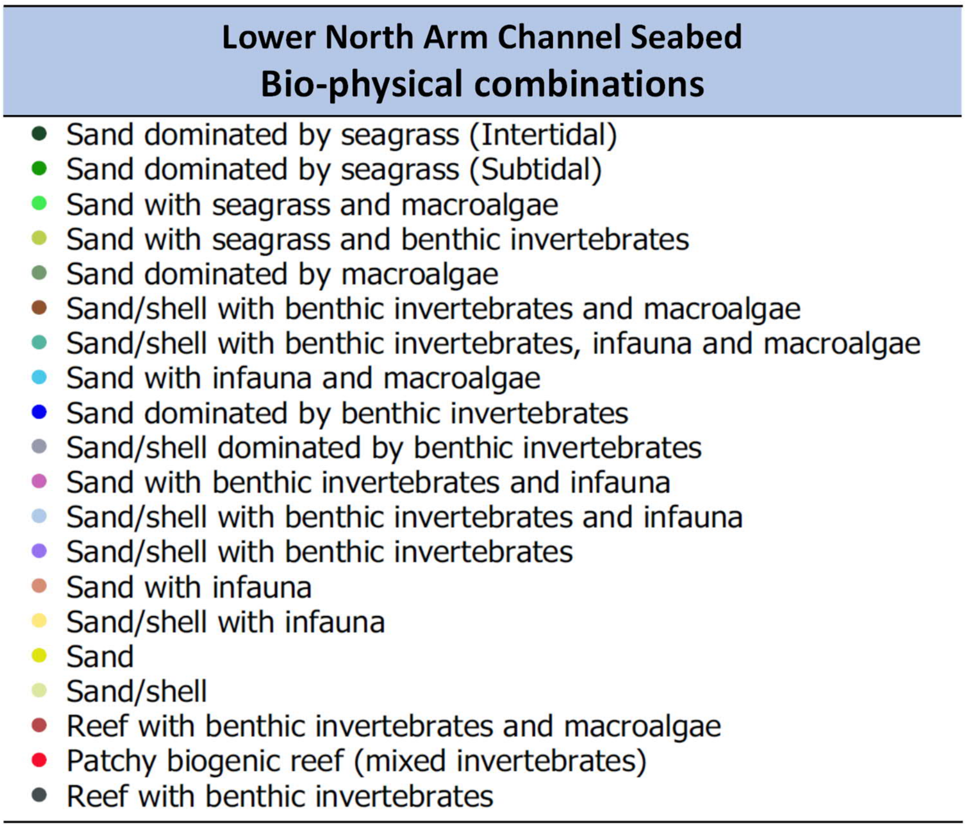
Figure 17. *Goniocidaris turbaria* (Stumpy Pencil urchin) distribution near Crib Pt Jetty

3.4 Bio-Physical habitat combinations in Lower North Arm

Following analysis of the images, a set of categories was compiled based on the geographic scale of the survey to inform the marine environmental assessment of potential Project impact pathways on habitat/taxa combinations. The categories are based on combinations of seabed and biological character and are generally consistent with other seabed habitat/biological classification systems.

These combination categories were assigned to each seabed image for GIS presentation to inform Project impact pathway assessment around Crib Point and nearby Lower North Arm channel seabed. The combinations are listed and colour-coded in Table 4.

Table 4. Lower North Arm seabed bio-physical combinations



Lower North Arm Channel Seabed Bio-physical combinations
● Sand dominated by seagrass (Intertidal)
● Sand dominated by seagrass (Subtidal)
● Sand with seagrass and macroalgae
● Sand with seagrass and benthic invertebrates
● Sand dominated by macroalgae
● Sand/shell with benthic invertebrates and macroalgae
● Sand/shell with benthic invertebrates, infauna and macroalgae
● Sand with infauna and macroalgae
● Sand dominated by benthic invertebrates
● Sand/shell dominated by benthic invertebrates
● Sand with benthic invertebrates and infauna
● Sand/shell with benthic invertebrates and infauna
● Sand/shell with benthic invertebrates
● Sand with infauna
● Sand/shell with infauna
● Sand
● Sand/shell
● Reef with benthic invertebrates and macroalgae
● Patchy biogenic reef (mixed invertebrates)
● Reef with benthic invertebrates

These combinations and colour codes were used to demonstrate the variation in the bio-physical nature of the seabed along the video tows plotted in Lower North Arm and its four study areas:

- Lower North Arm (Figure **18**);
- Crib Point region (Figure **19**);
- South (Sandy Point Tankerton) region (Figure 20);
- North (Hastings) region (Figure 21) and;
- North Yaringa/Eagle Rock region (Figure 22).

Table 5, following the figures, provides a summary of the frequency of the biophysical combinations on each transect in each of the four study areas.

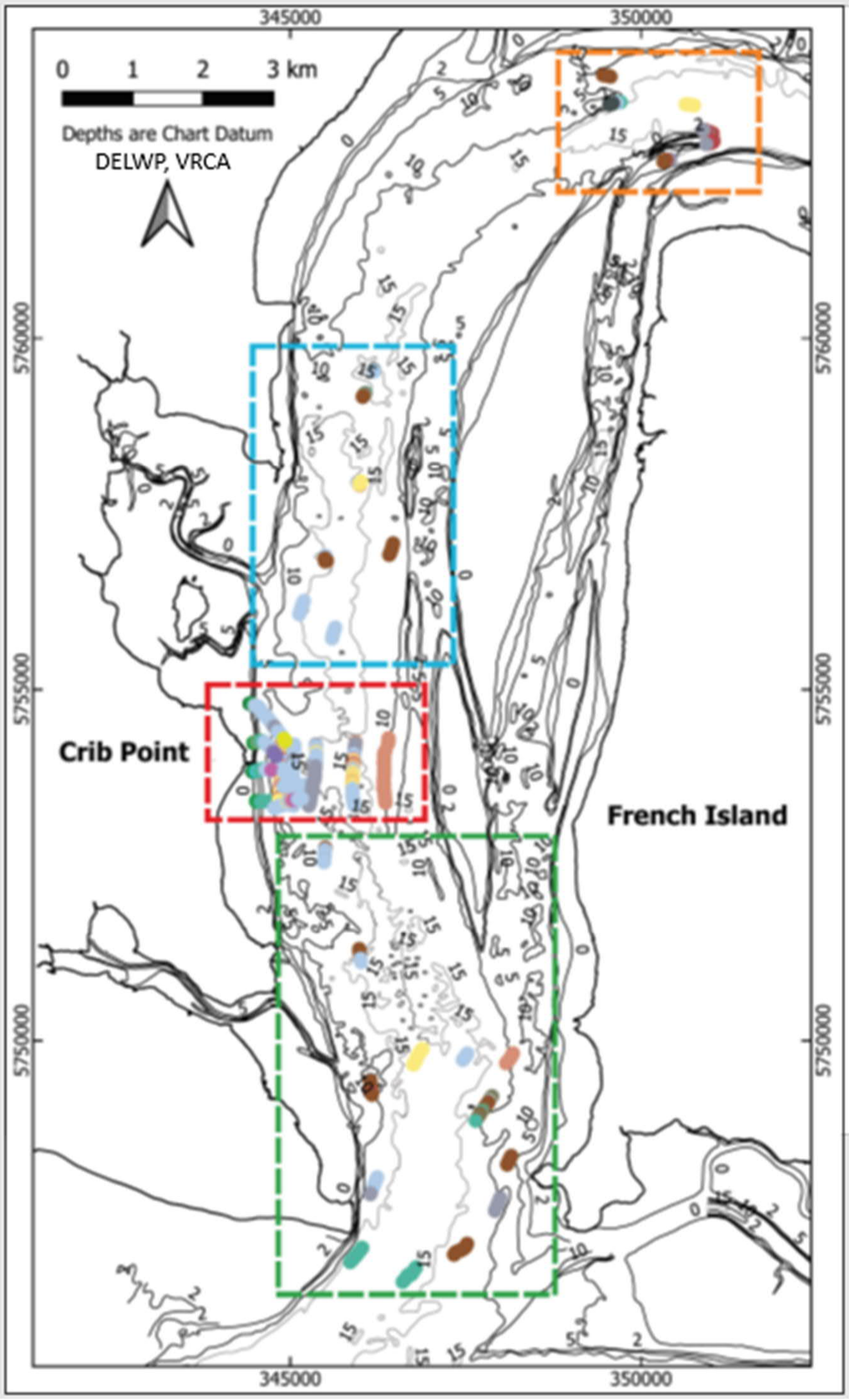


Figure 18. Bio-physical habitat combinations in Lower North Arm

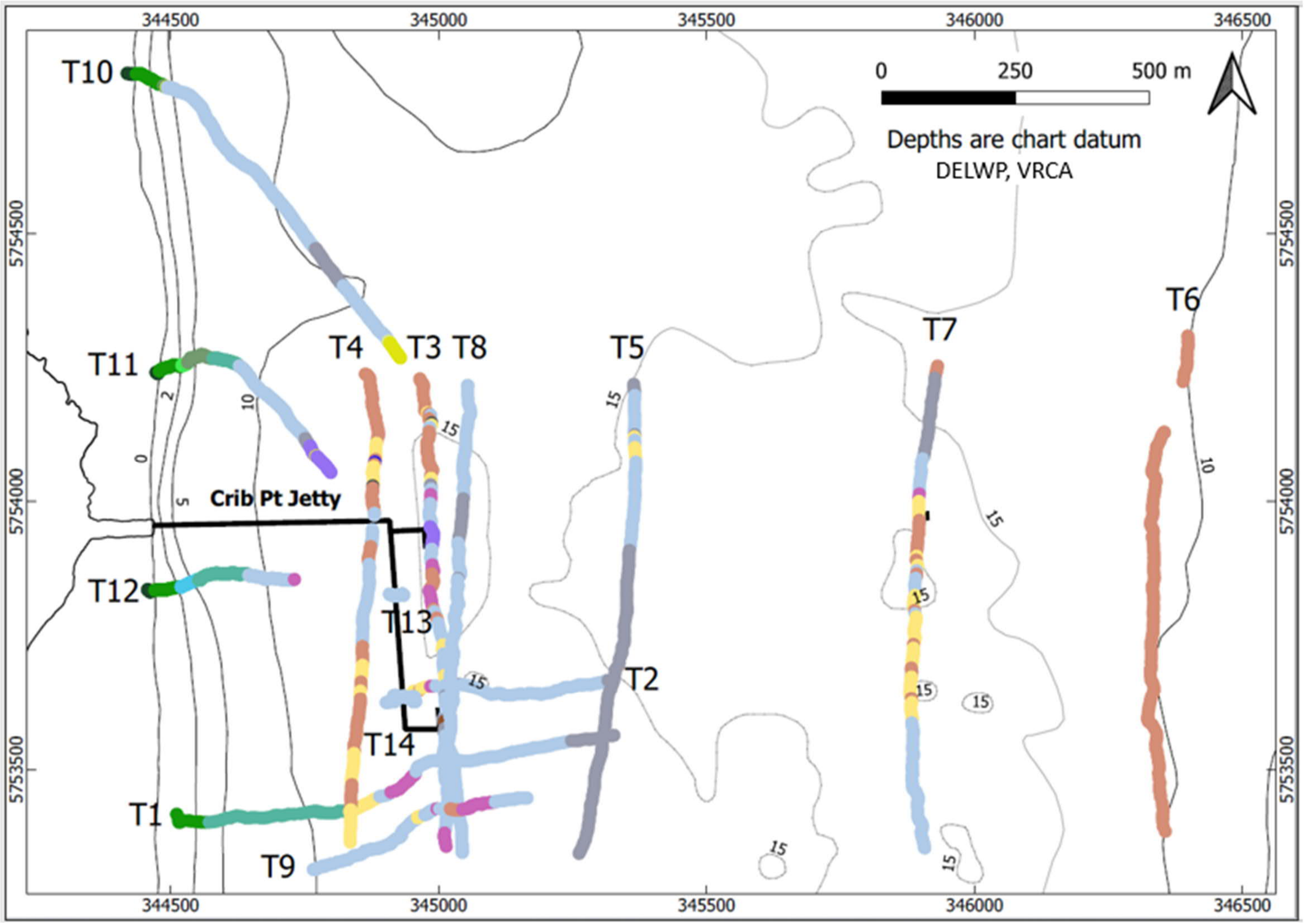


Figure 19. Bio-physical habitat combinations near Crib Point Jetty

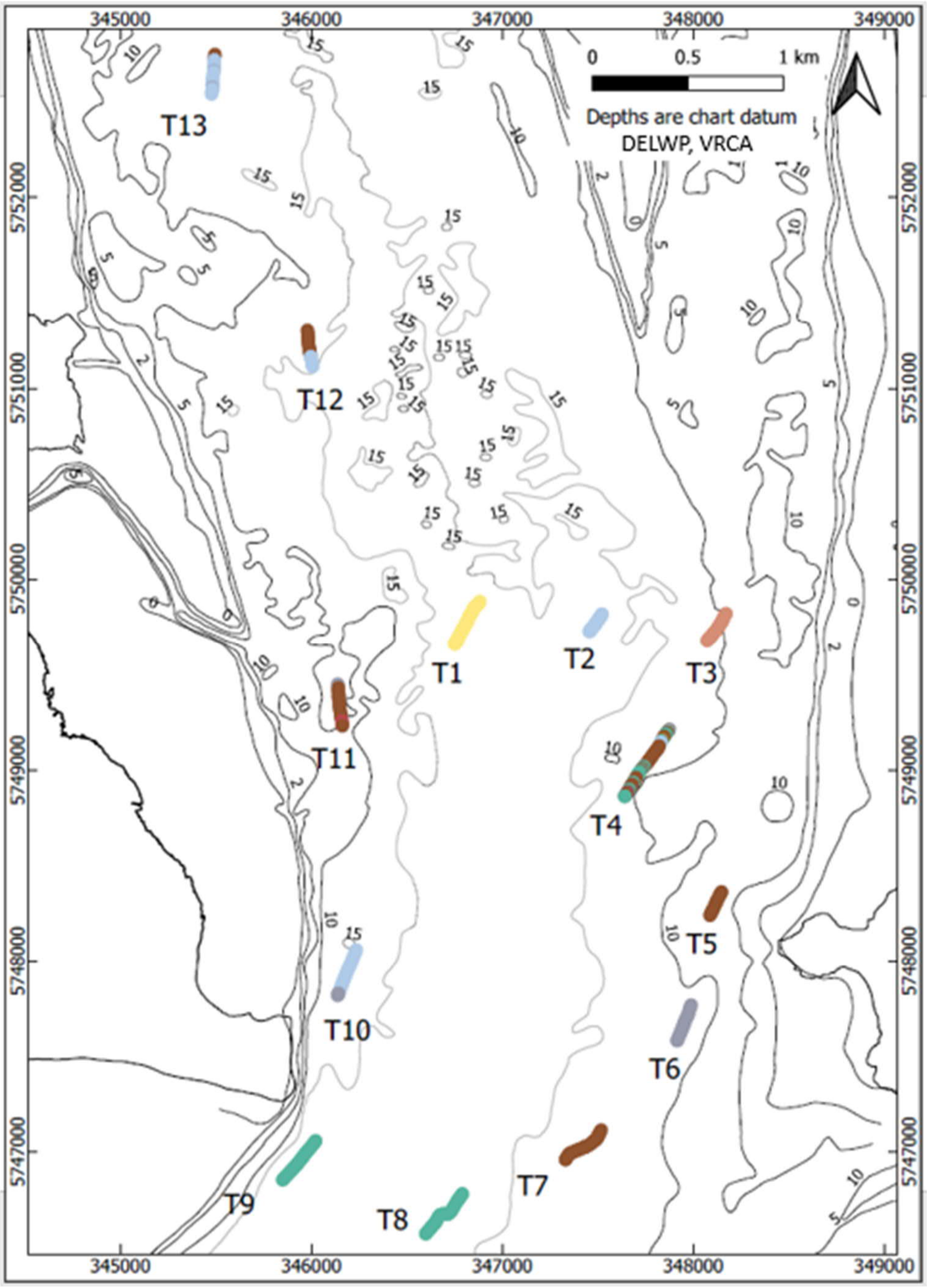


Figure 20. Bio-physical habitat combinations 'South of Crib Pt Jetty'

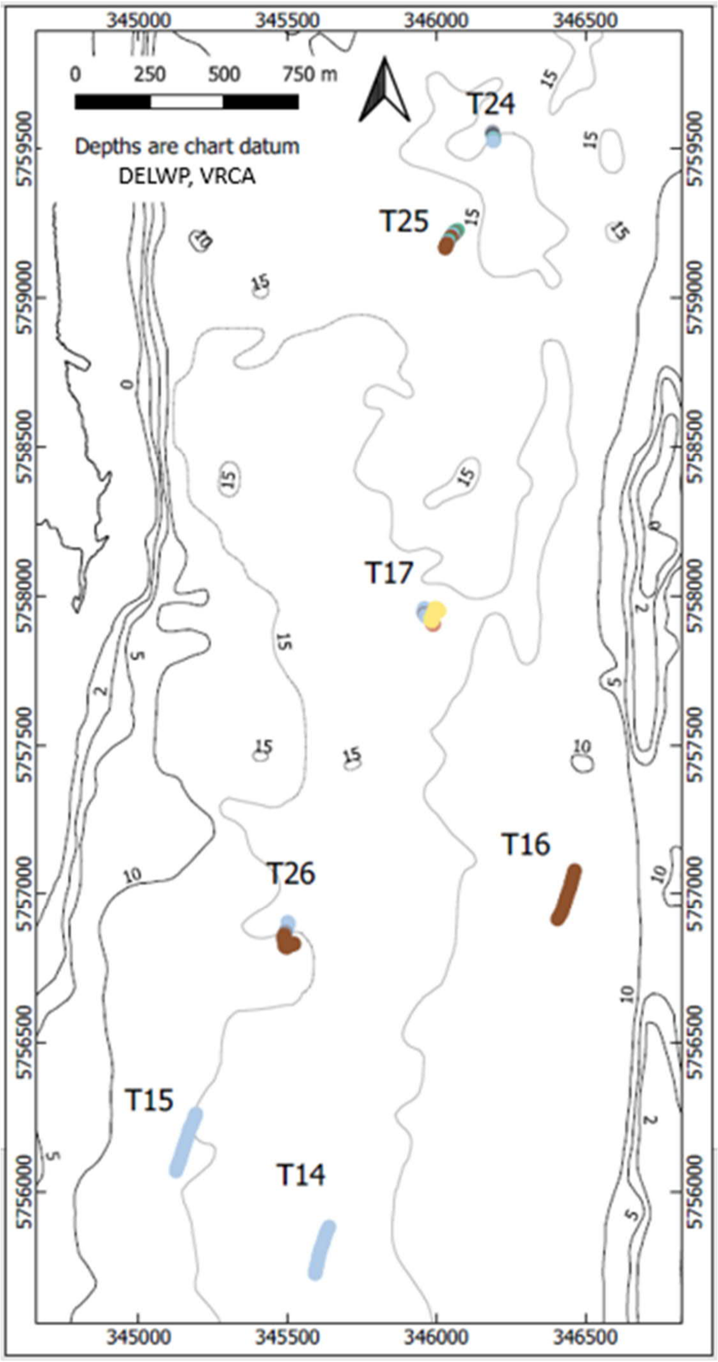


Figure 21. Bio-physical habitat combinations 'North of Crib Pt Jetty'

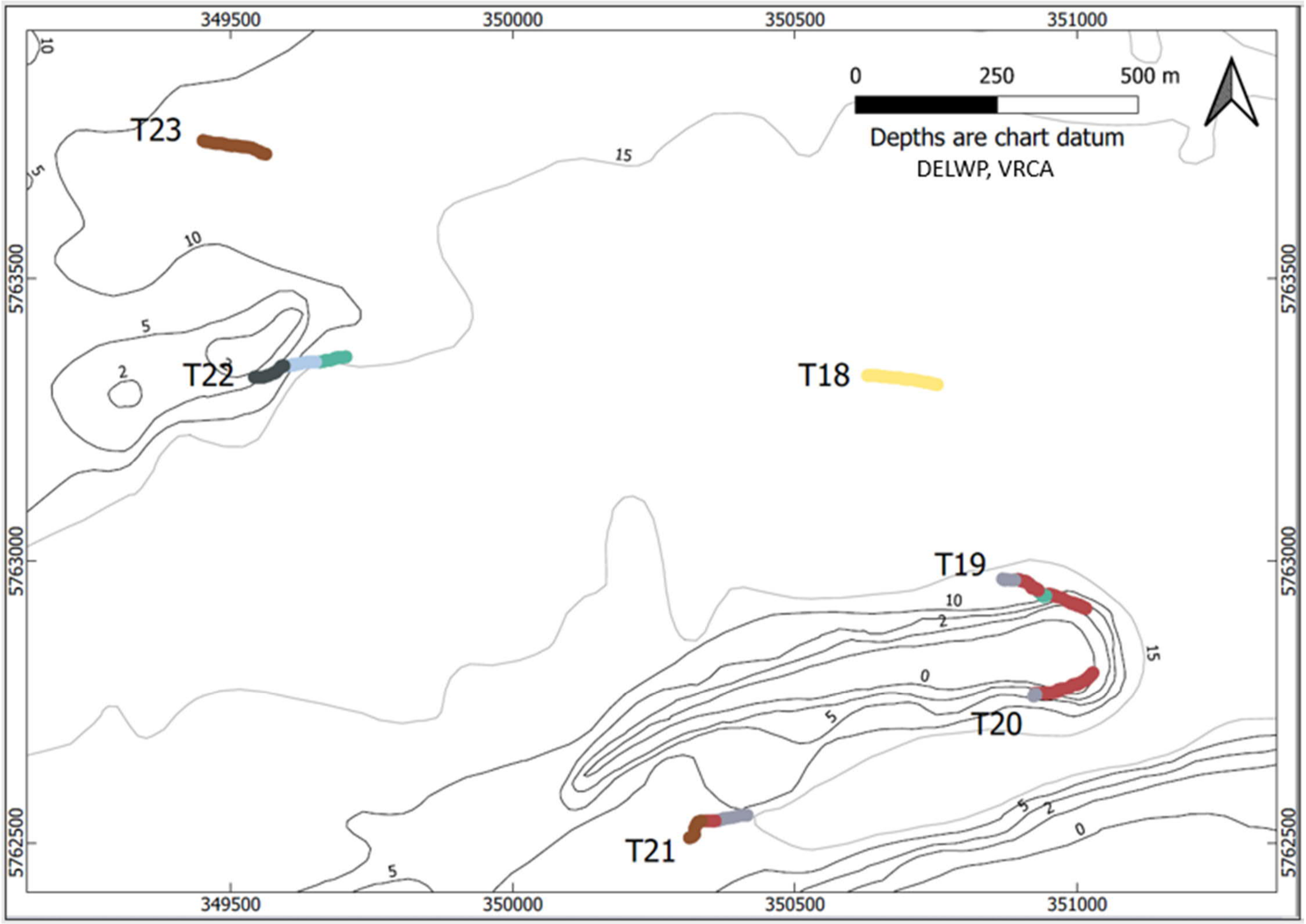


Figure 22. Bio-physical habitat combinations Crawfish Rock and Eagle Rock

Table 5. Distribution of seabed types on individual transects

Distribution of seabed types on individual transects																							
Transect	Date	Chart Depth Range (m)	Tow Length (m)	Sand dominated by seagrass (subtidal)	Sand dominated by seagrass	Sand with seagrass and macroalgae	Sand with seagrass and benthic invertebrates	Sand dominated by macroalgae	Sand/shell with benthic invertebrates and macroalgae	Sand/shell with benthic invertebrates, infauna and macroalgae	Sand with infauna and macroalgae	Sand dominated by benthic invertebrates	Sand/shell dominated by benthic invertebrates	Sand with benthic invertebrates and infauna	Sand/shell with benthic invertebrates and infauna	Sand/shell with benthic invertebrates	Sand with infauna	Sand/shell with infauna	Sand/shell	Sand	Reef with benthic invertebrates and macroalgae	Patchy biogenic reef (mixed invertebrates)	Reef with benthic invertebrates
Crib Pt Jetty																							
1	18/12/2018	1 - 15	878	0	6	0	0	0	0	30	0	0	13	10	35	0	0	6	0	0	0	0	0
2	18/12/2018	10 - 15	402	0	0	0	0	0	0	0	0	0	2	2	85	0	1	10	0	0	0	0	0
3	18/12/2018	1 5 - 20	945	0	0	0	0	0	1	0	0	0	2	13	50	5	20	8	0	0	0	0	1
4	18/12/2018	10 - 20	992	0	0	0	0	0	0	0	0	1	0	0	23	0	50	25	0	0	0	0	1
5	18/12/2018	10 - 20	924	0	0	0	0	0	0	0	0	0	72	0	25	0	0	3	0	0	0	0	0
6	18/12/2018	10 - 15	978	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0
7	18/12/2018	15 - 20	926	0	0	0	0	0	0	0	0	0	20	2	33	0	15	30	0	0	0	0	0
8	18/12/2018	10 - 20	910	0	0	0	0	0	0	0	0	0	10	0	90	0	0	0	0	0	0	0	0
9	18/12/2018	10 - 15	599	0	0	0	0	0	0	0	0	0	0	15	77	0	5	3	0	0	0	0	0
10	20/11/2019	2 -10	776	0	11	0	1	1	0	0	0	0	11	0	69	0	0	0	1	4	0	0	0
11	20/11/2019	2 - 10	501	4	14	7	0	21	0	13	0	0	2	0	26	11	0	0	0	1	0	0	0
12	20/11/2019	2 - 10	291	4	16	0	0	0	0	33	12	0	0	0	33	0	0	0	0	0	0	0	0
13	20/11/2019	15	33	0	0	0	0	0	0	0	0	0	0	1	91	0	0	0	0	0	0	0	0
14	20/11/2019	15	92	0	0	0	0	0	0	0	2	0	0	0	89	0	0	0	0	0	0	0	0

Distribution of seabed types on individual transects

Transect	Date	Chart Depth Range (m)	Tow Length (m)	Sand dominated by seagrass (subtidal)	Sand dominated by seagrass	Sand with seagrass and macroalgae	Sand with seagrass and benthic invertebrates	Sand dominated by macroalgae	Sand/shell with benthic invertebrates and macroalgae	Sand/shell with benthic invertebrates, infauna and macroalgae	Sand with infauna and macroalgae	Sand dominated by benthic invertebrates	Sand/shell dominated by benthic invertebrates	Sand with benthic invertebrates and infauna	Sand/shell with benthic invertebrates and infauna	Sand/shell with benthic invertebrates	Sand with infauna	Sand/shell with infauna	Sand/shell	Sand	Reef with benthic invertebrates and macroalgae	Patchy biogenic reef (mixed invertebrates)	Reef with benthic invertebrates
South of Crib Pt Jetty																							
1	19/12/2018	15 - 25	287	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0
2	19/12/2018	20 - 25	127	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0
3	19/12/2018	5 - 15	175	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0
4	19/12/2018	10 - 15	417	0	0	0	0	0	60	30	0	0	0	0	8	1	0	0	0	0	0	1	0
5	19/12/2018	5 - 10	134	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	19/12/2018	10 - 15	189	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
7	19/12/2018	15 - 20	248	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	19/12/2018	20 - 24	321	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9	19/12/2018	20 - 25	291	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0
10	19/12/2018	10 - 20	279	0	0	0	0	0	0	0	0	0	10	0	90	0	0	0	0	0	0	0	0
11	19/12/2018	10 - 15	235	0	0	0	0	0	80	0	0	0	8	0	0	0	0	0	0	0	12	0	0
12	19/12/2018	15	183	0	0	0	0	0	70	0	0	0	0	0	30	0	0	0	0	0	0	0	0
13	19/12/2018	10 - 15	219	0	0	0	0	0	15	0	0	0	10	0	75	0	0	0	0	0	0	0	0

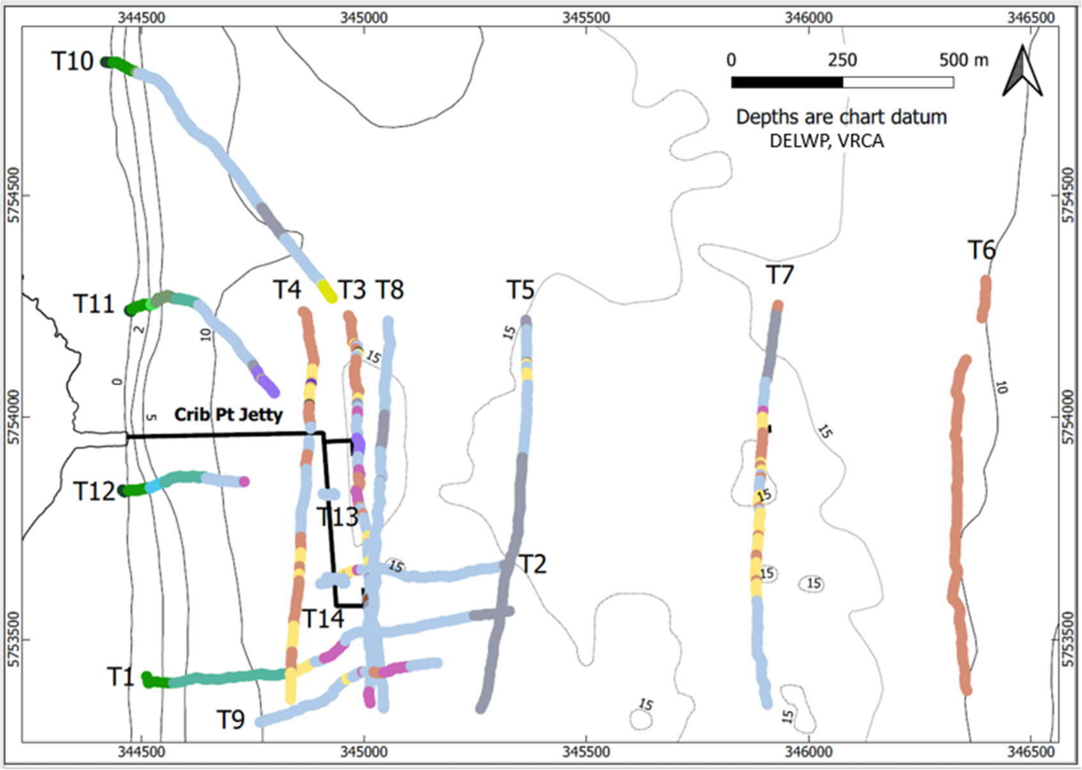
Distribution of seabed types on individual transects

Transect	Date	Chart Depth Range (m)	Tow Length (m)	Sand dominated by seagrass (subtidal)	Sand dominated by seagrass	Sand with seagrass and macroalgae	Sand with seagrass and benthic invertebrates	Sand dominated by macroalgae	Sand/shell with benthic invertebrates and macroalgae	Sand/shell with benthic invertebrates, infauna and macroalgae	Sand with infauna and macroalgae	Sand dominated by benthic invertebrates	Sand/shell dominated by benthic invertebrates	Sand with benthic invertebrates and infauna	Sand/shell with benthic invertebrates and infauna	Sand/shell with benthic invertebrates	Sand with infauna	Sand/shell with infauna	Sand/shell	Sand	Reef with benthic invertebrates and macroalgae	Patchy biogenic reef (mixed invertebrates)	Reef with benthic invertebrates
North of Crib Pt Jetty																							
14	19/12/2018	15 - 20	205	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0
15	19/12/2018	15 - 20	205	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0
16	19/12/2018	10 - 15	172	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	19/12/2018	15 - 20	173	0	0	0	0	0	0	0	0	0	5	2	20	0	10	63	0	0	0	0	0
24	19/12/2018	10 - 20	38	0	0	0	0	0	0	20	0	0	35	0	20	0	0	0	0	0	0	0	25
25	19/12/2018	10 - 15	97	0	0	0	0	0	60	33	0	0	0	0	7	0	0	0	0	0	0	0	0
26	19/12/2018	10 - 20	132	0	0	0	0	0	65	0	0	0	5	0	30	0	0	0	0	0	0	0	0
Eagle Rock and Crawfish Rock																							
18	19/12/2018	20 - 25	132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0
19	19/12/2018	5 - 25	193	0	0	0	0	0	0	15	0	0	17	0	0	0	0	0	0	0	68	0	0
20	19/12/2018	5 - 20	160	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	95	0	0
21	19/12/2018	10 - 15	137	0	0	0	0	0	33	0	0	0	50	0	0	0	0	0	0	0	17	0	0
22	19/12/2018	5 -15	171	0	0	0	0	0	0	33	0	0	0	0	33	0	0	0	0	0	0	0	33
23	19/12/2018	10 - 15	111	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0

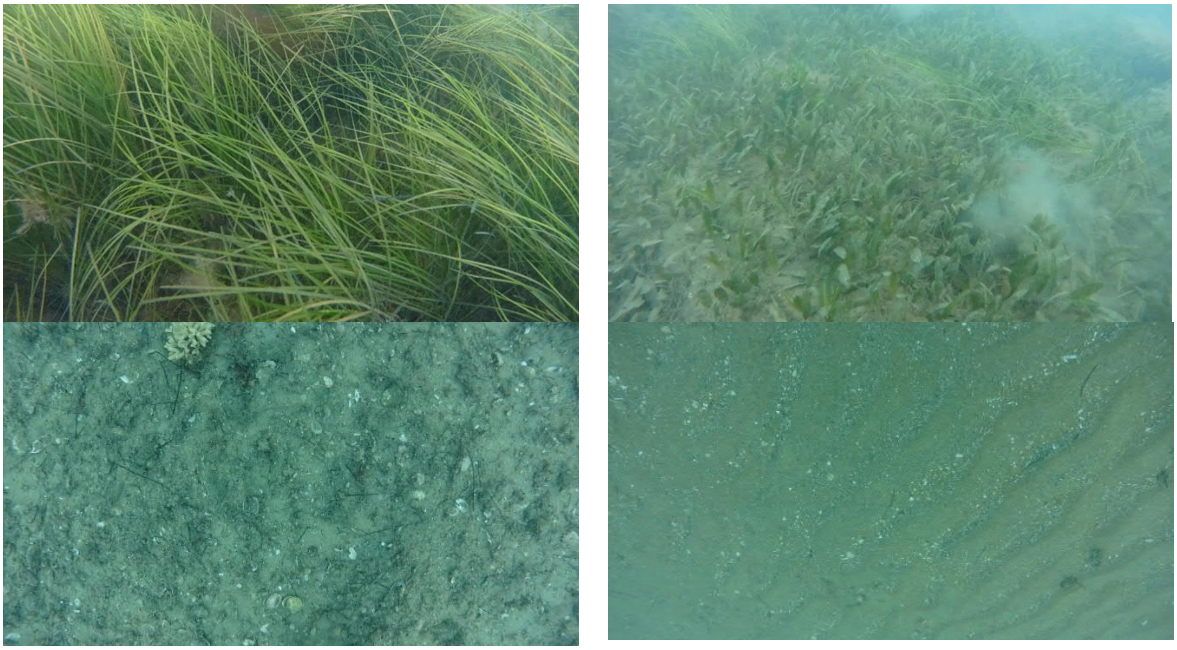
3.5 Seabed images along transects in four study areas

This section provides photographs of representative habitat and biological conditions along the TUV transects on the four study areas.

3.5.1 Crib Point TUV transect images



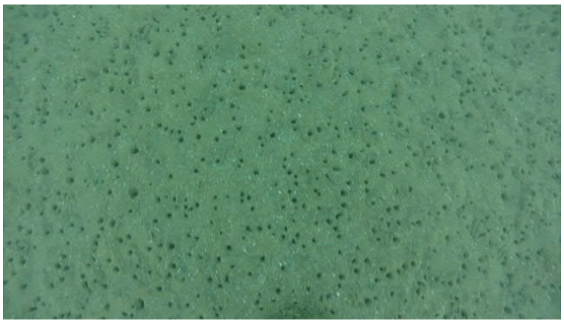
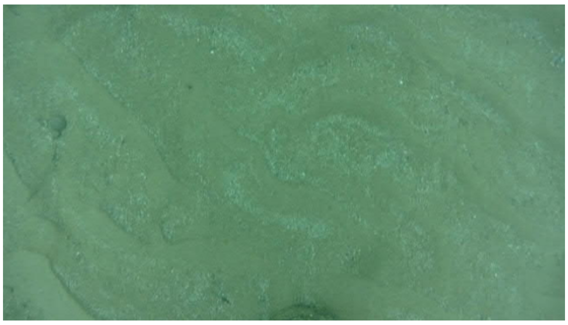
Crib Point Transect 1

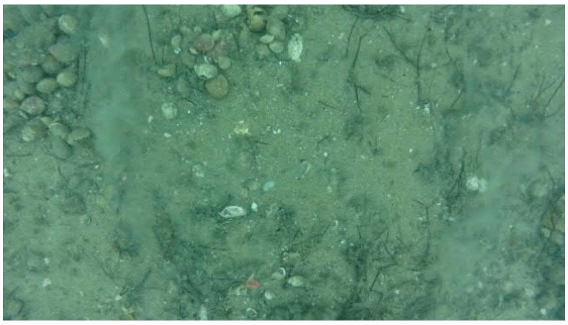


Crib Point Transect 2

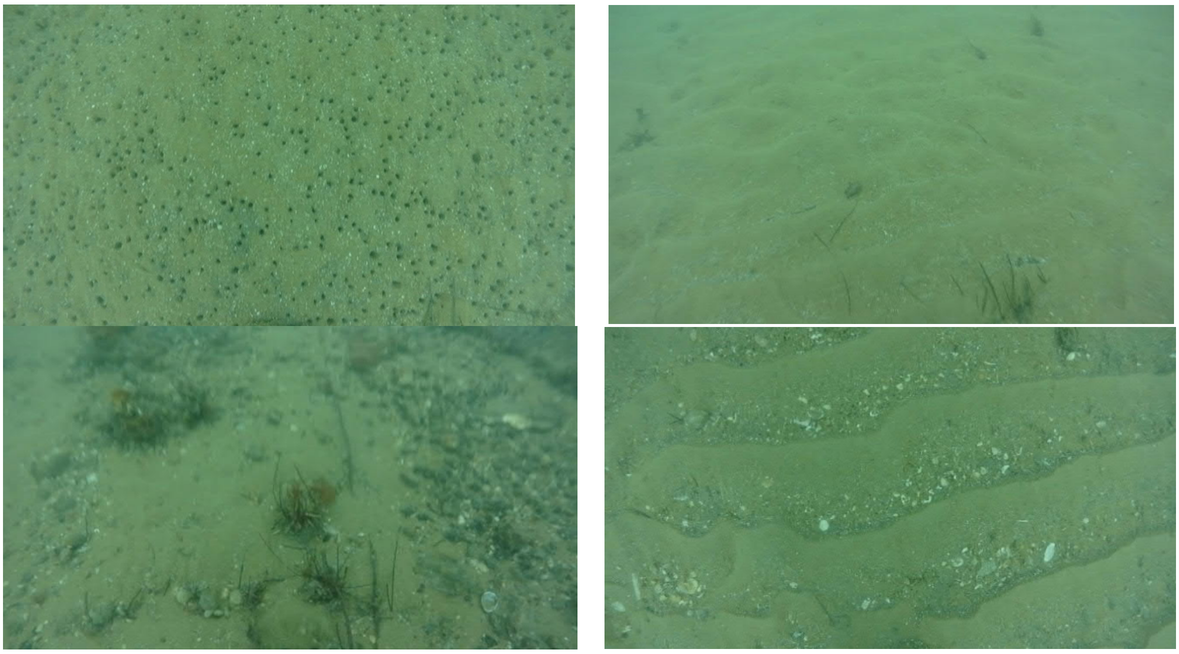



Crib Point Transect 3

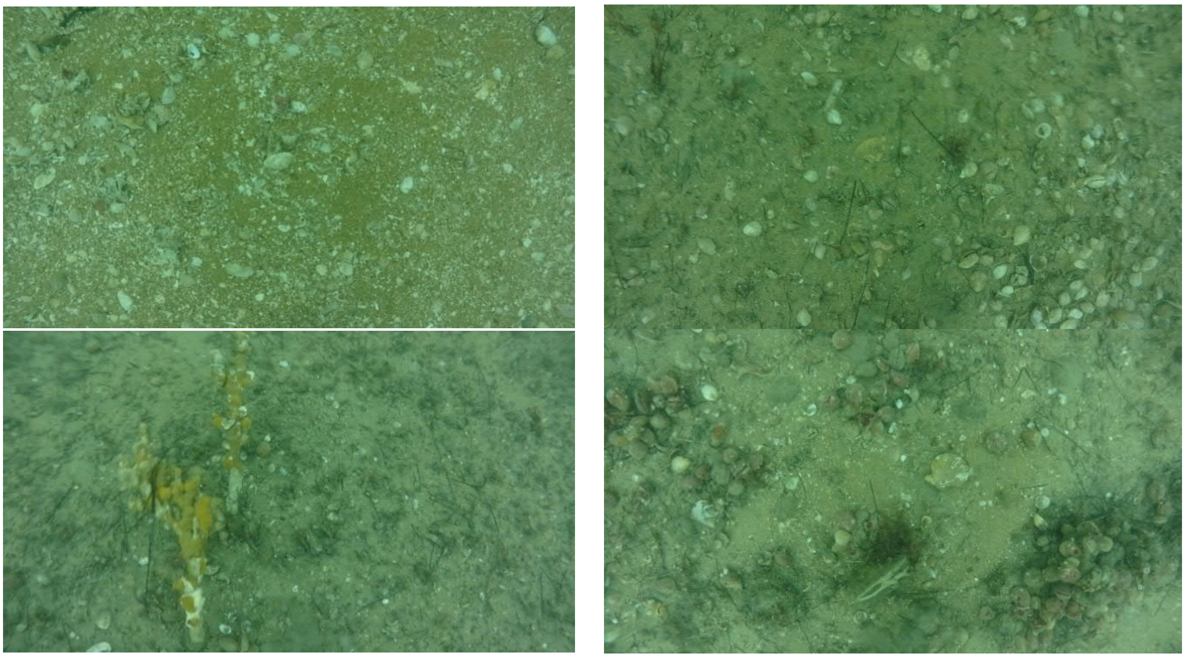





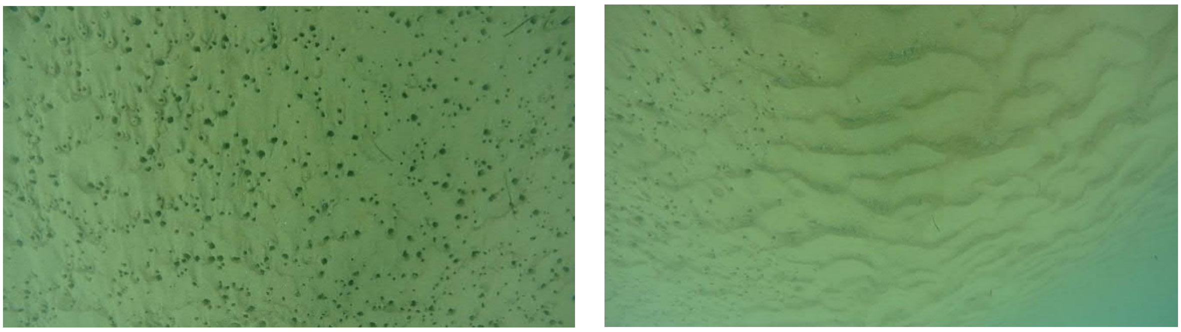
Crib Point Transect 4



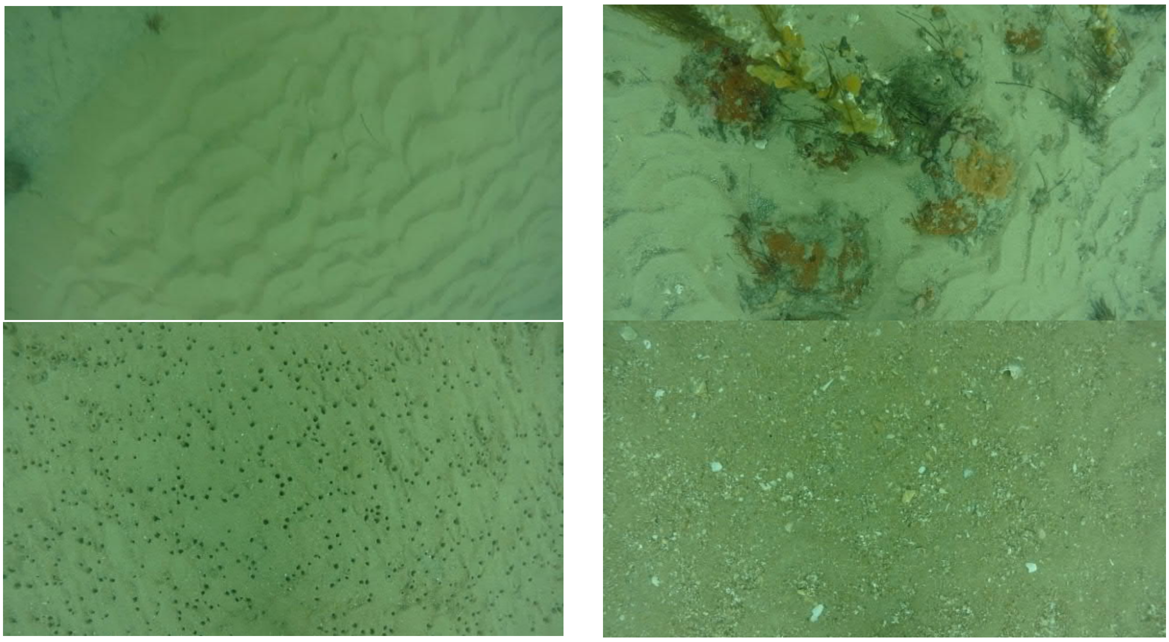
Crib Point Transect 5



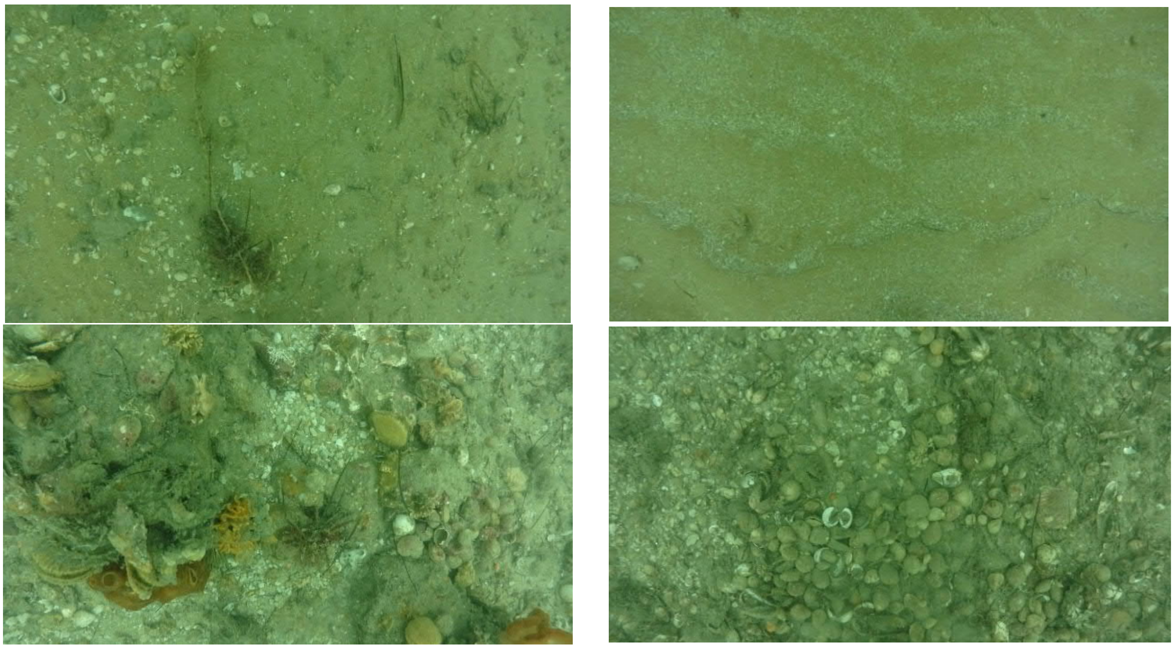
Crib Point Transect 6



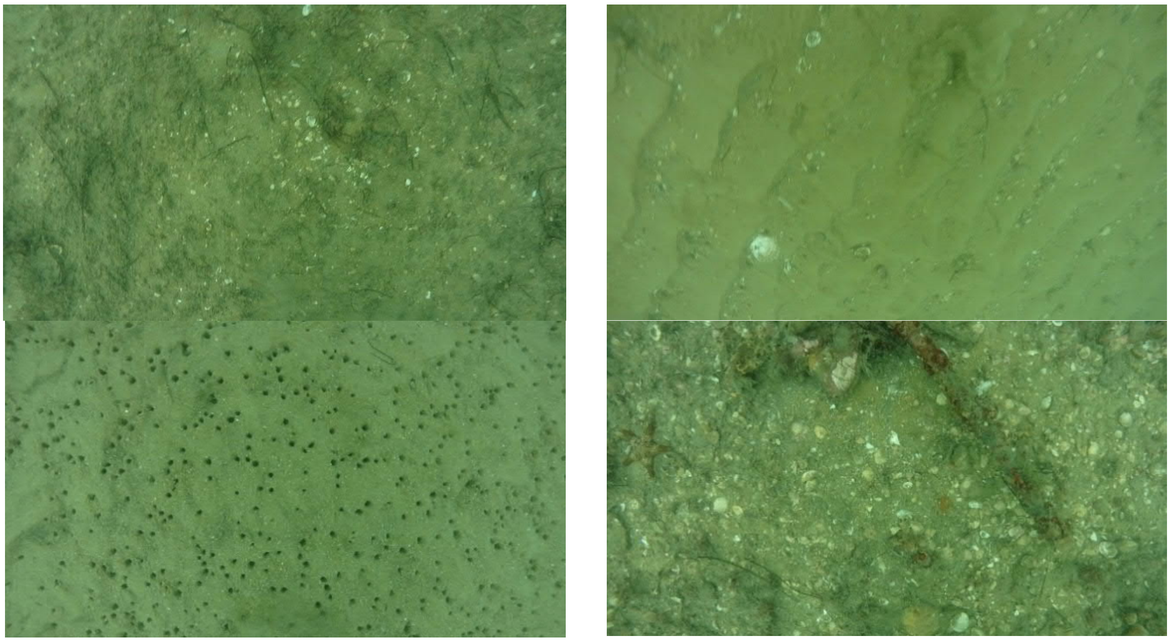
Crib Point Transect 7



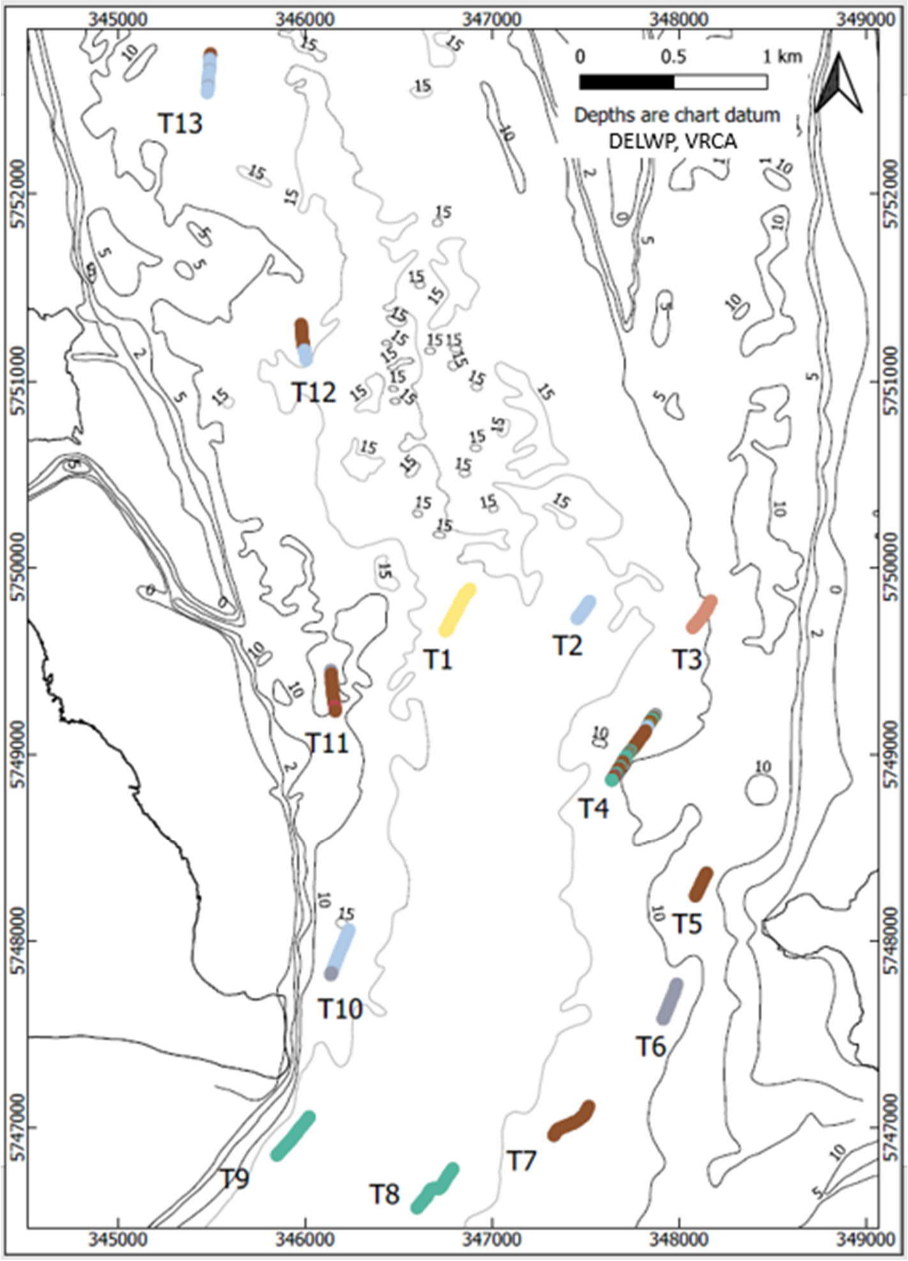
Crib Point Transect 8



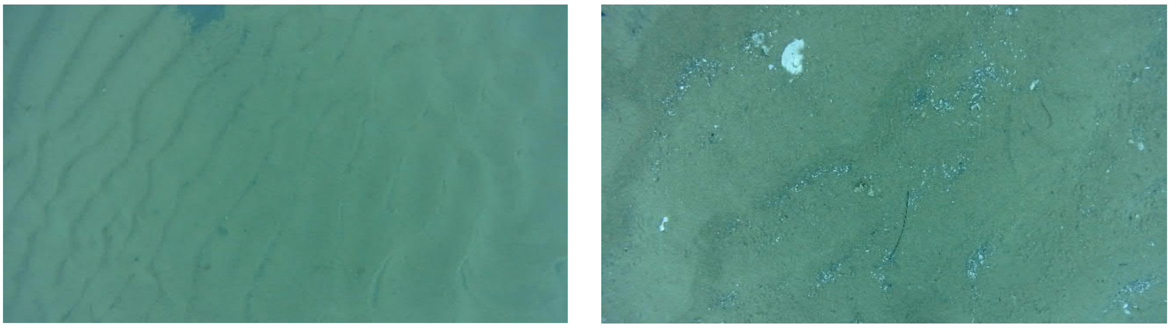
Crib Point Transect 9



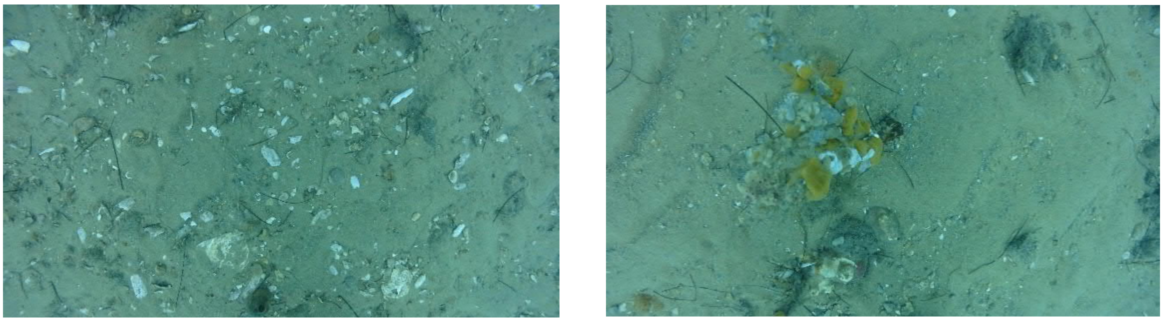
3.5.2 South of Crib Point TUV Transects



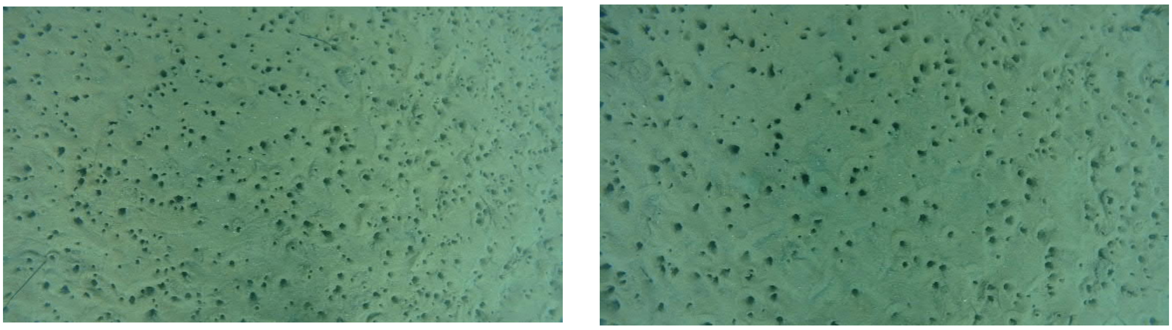
South of Crib Point Transect 1



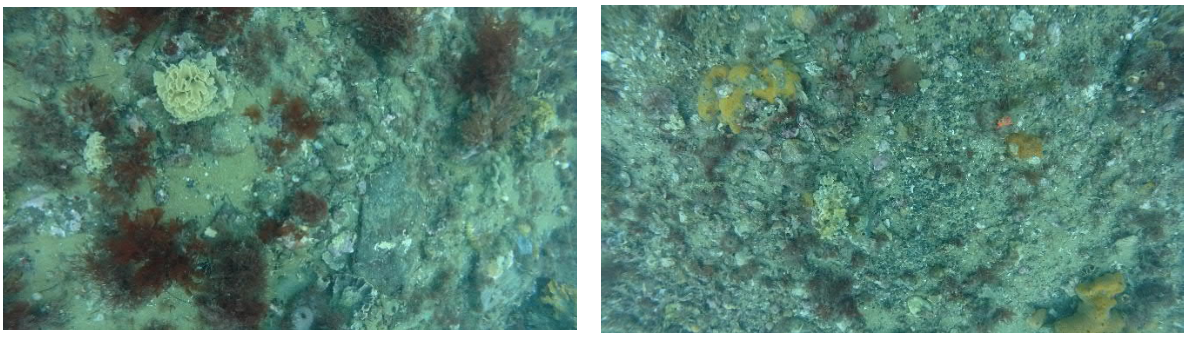
South of Crib Point Transect 2



South of Crib Point Transect 3

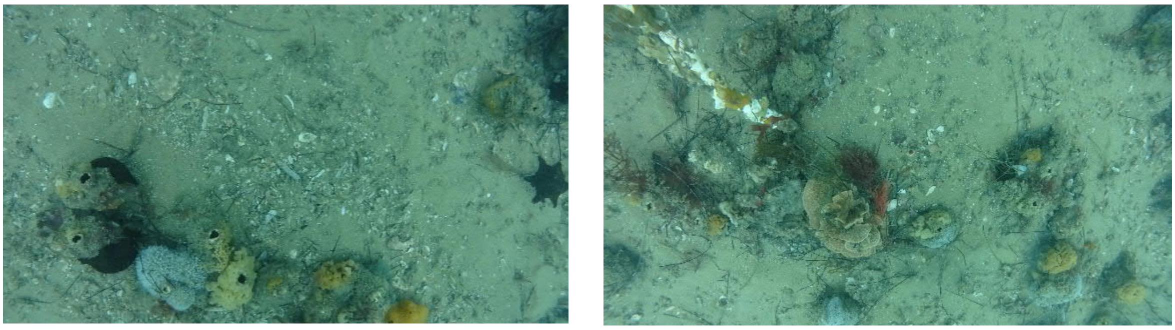


South of Crib Point Transect 4

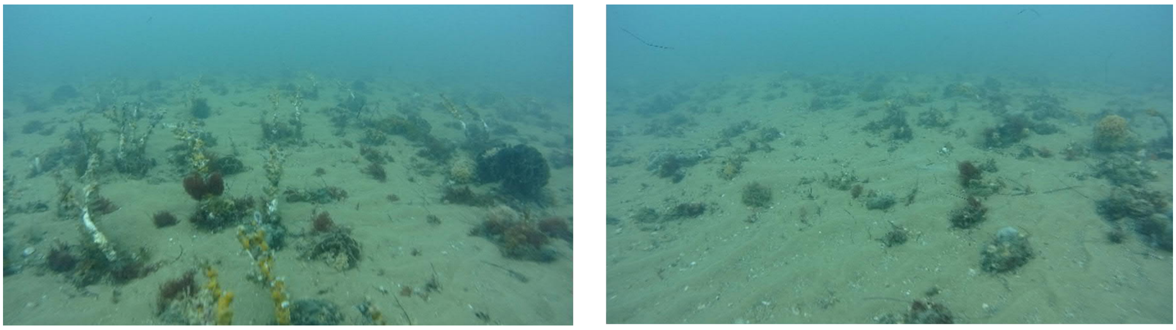


South of Crib Point Transect 5

South of Crib Point Transect 6



South of Crib Point Transect 7

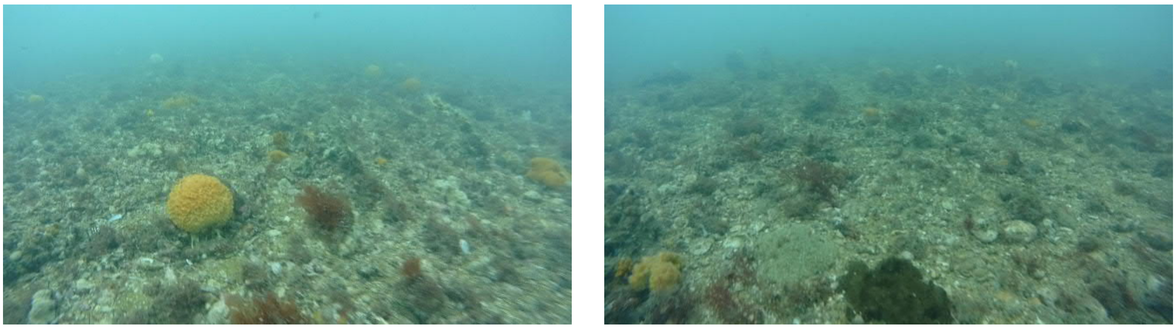


South of Crib Point Transect 8

South of Crib Point Transect 9

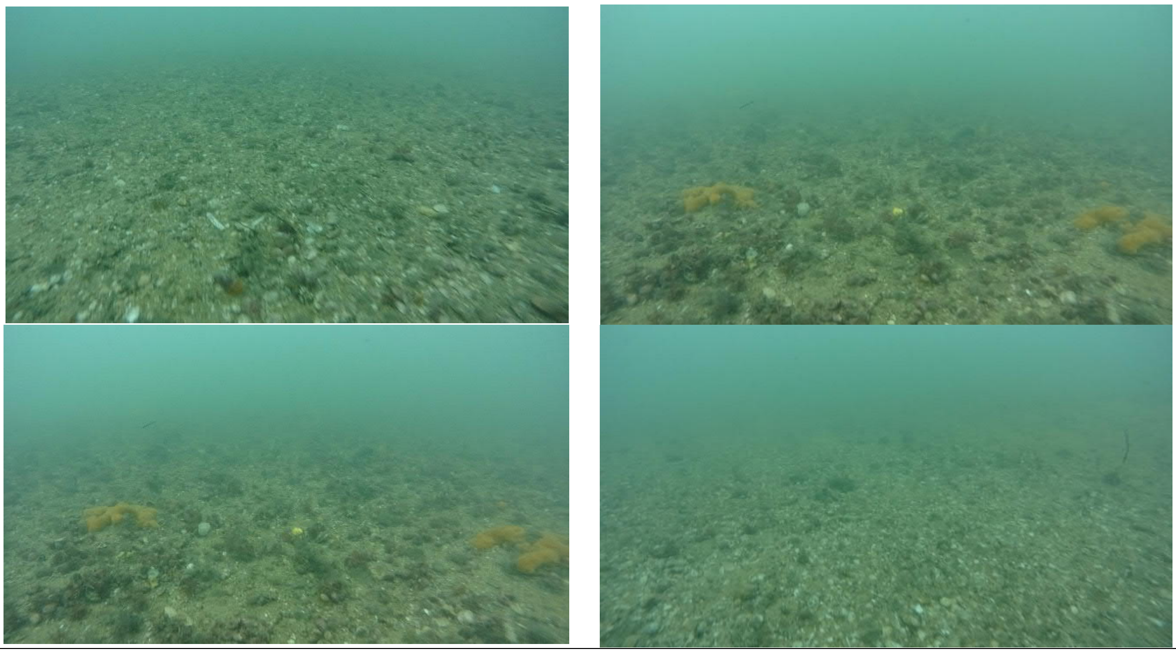
South of Crib Point Transect 10

South of Crib Point Transect 11

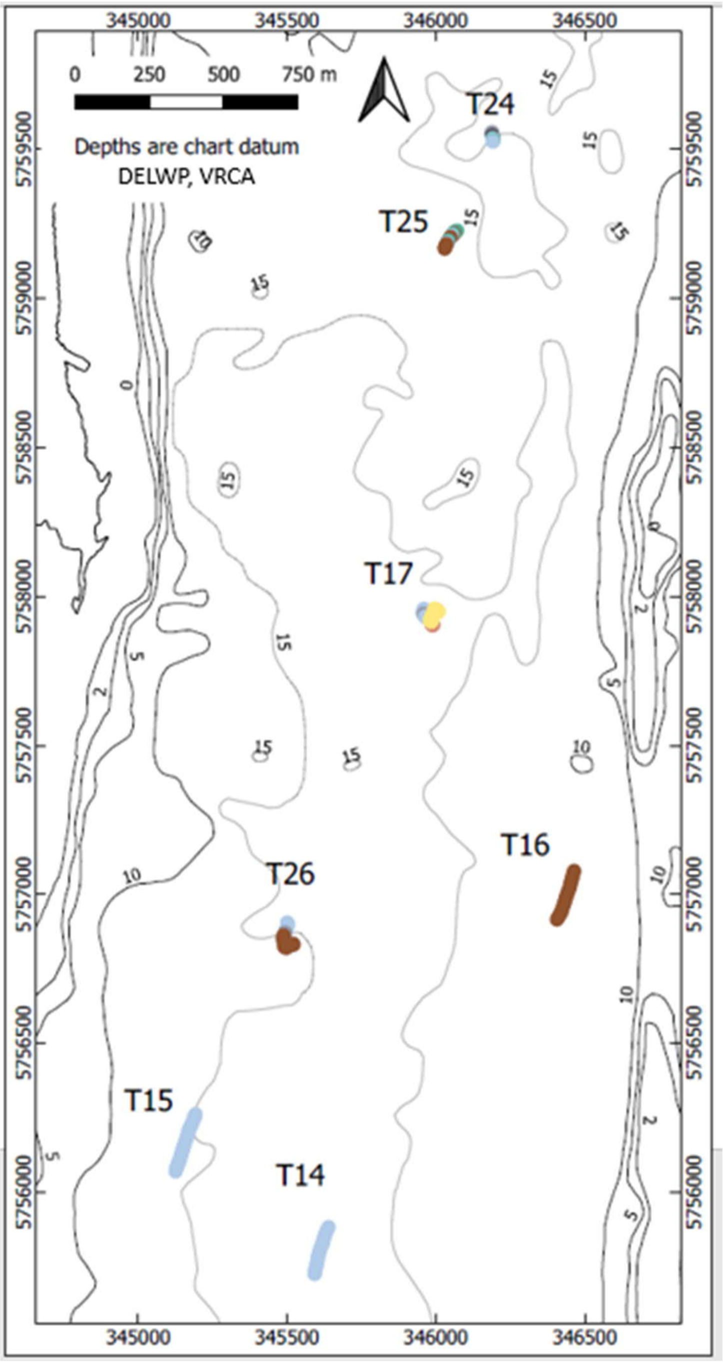


South of Crib Point Transect 12

South of Crib Point Transect 13



3.5.3 North of Crib Point TUV Transect images

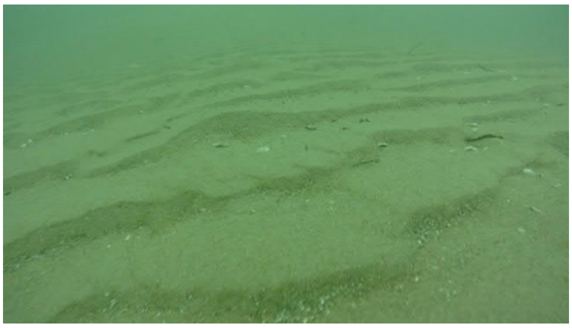


North of Crib Point Transect 14

North of Crib Point Transect 15

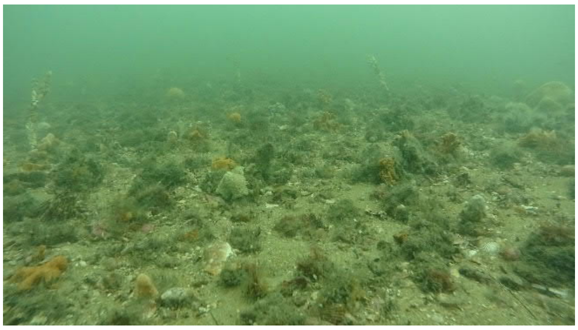
North of Crib Point Transect 16

North of Crib Point Transect 17



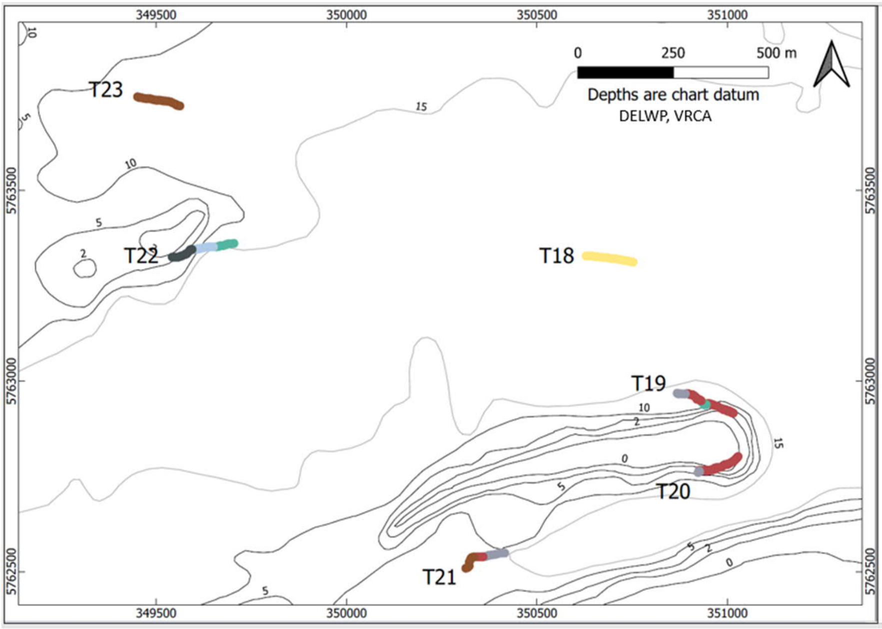
North of Crib Point Transect 24

North of Crib Point Transect 25

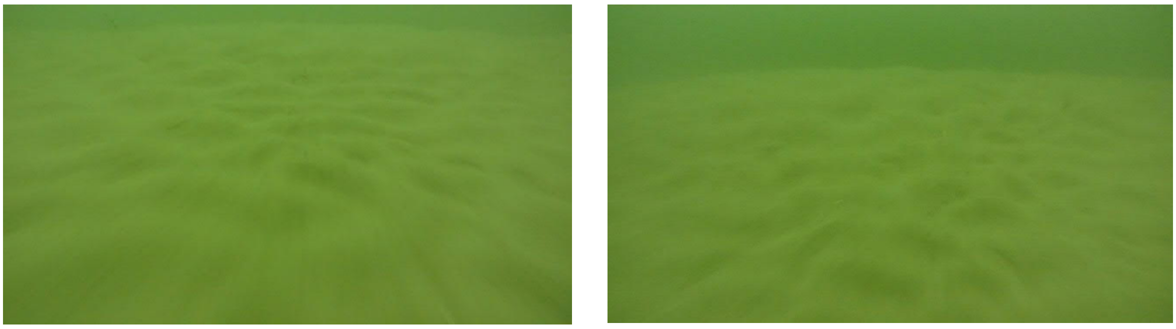


North of Crib Point Transect 26

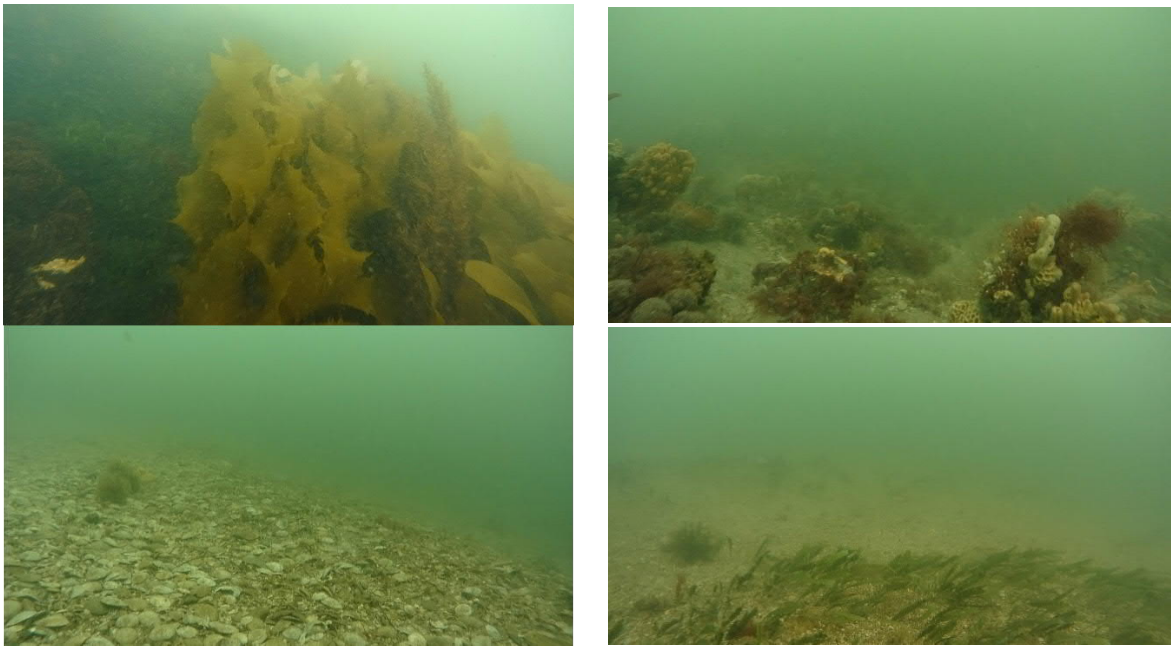
3.5.4 Crawfish Rock TUV Transect images



Crawfish Rock area Transect 18



Crawfish Rock area Transect 19



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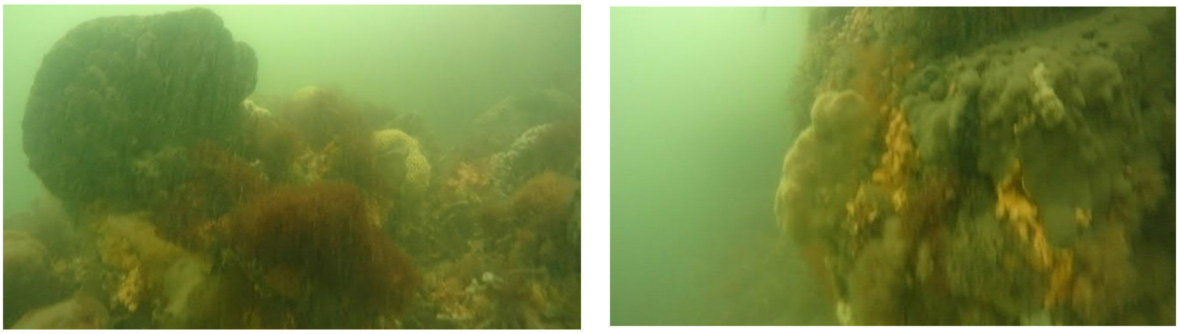
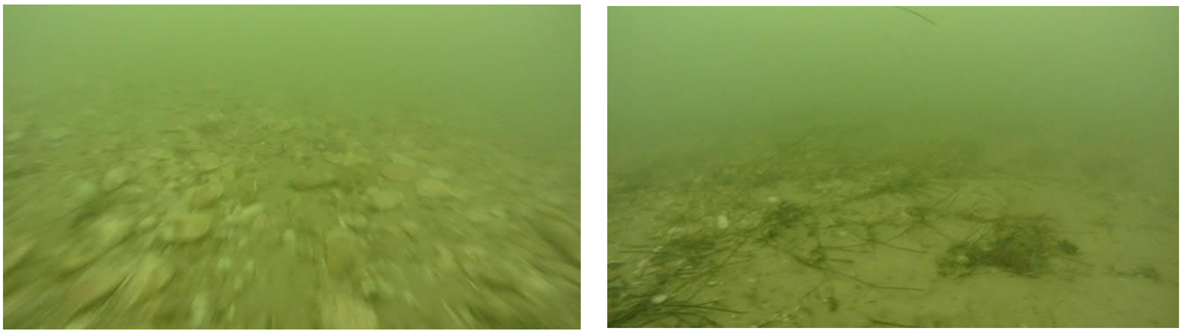
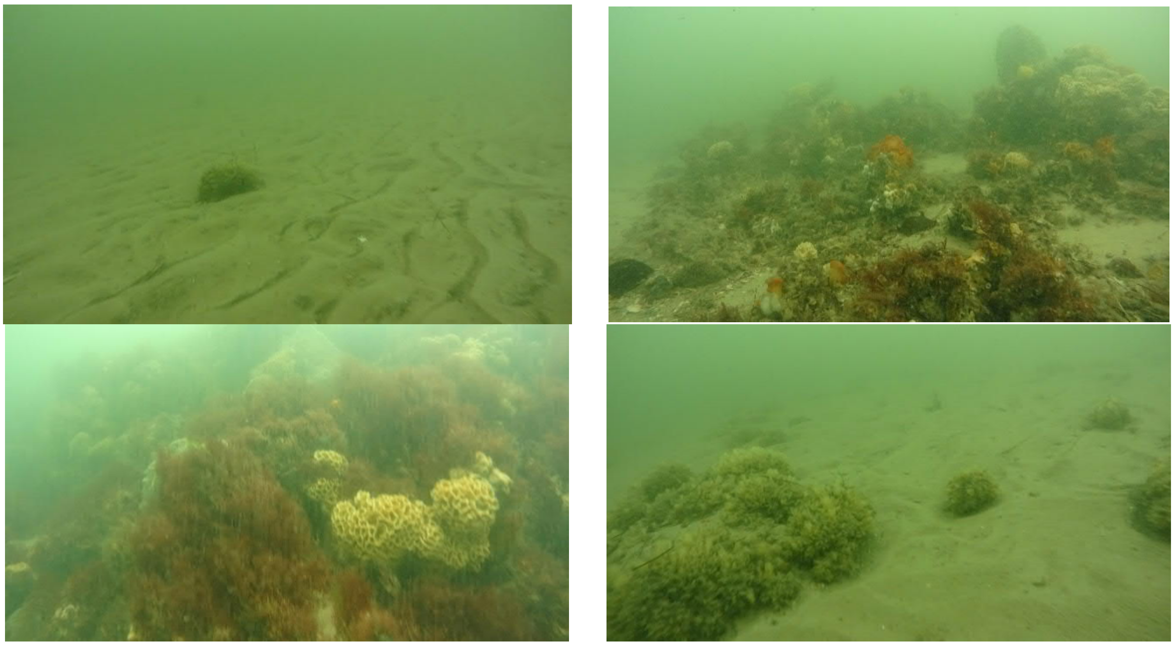


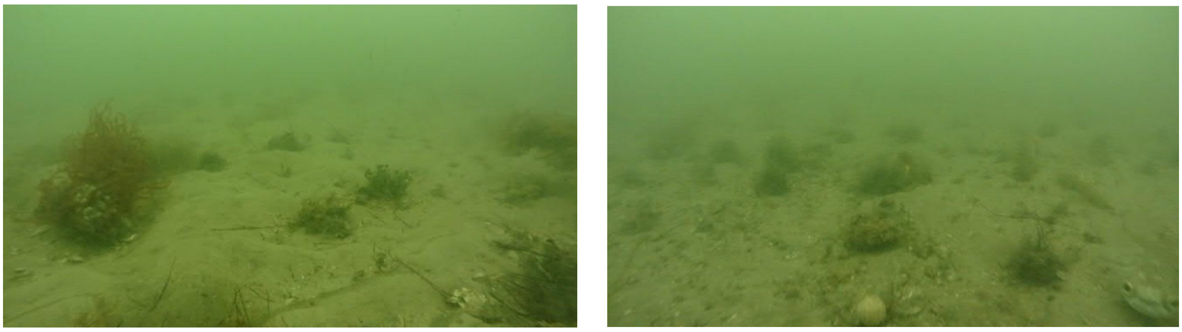
Crawfish Rock area Transect 21



Crawfish Rock area Transect 22



Crawfish Rock area Transect 23



4 Infauna

The physical composition of the seabed is a primary influence on the nature of infaunal communities (Gray 1974). Historically, infauna have been sampled in areas known to be ‘soft seabed’. The nature of the seabed in an infaunal sampling region would be described post-sampling, by grain size distribution of sediments from the grabs containing the infauna (for example, Coleman *et al* 1978).

Characterisation of the seabed by direct observation or high-definition acoustic survey (multi-beam) or both can provide substantial understanding of the nature of the seabed sediments if it is mapped prior to sampling. Hence, the towed video investigation described above was completed before final planning of the infauna sampling.

Section 3 of this report clearly shows substantial differences in seabed character around Crib Point and other regions of Lower North Arm that will affect the nature of the seabed infauna at relatively small scales that would not be understood from existing general description of the Lower Norm Arm channel seabed area as ‘soft seabed’. Hence outputs of the TUV seabed habitat and epibiota survey provide the primary source of benthic ecosystem information for the project effects assessment.

Infauna sampling was planned to provide additional information on the nature of the benthic communities associated with habitats identified from TUV tows and to inform selection of potential indicator species for baseline and impact assessment programs if the project proceeds.

4.1.1 Survey scope and area

The scope of the study of infauna was to:

- Document the characteristics of the infauna at representative soft seabed sites that may be suitable for Ponar grab sampling in the proposed locality of the FSRU at Crib Point Jetty
- Establish the broad-scale characteristics of the infauna in Lower North Arm by sampling at sites representative of the variations in depth, seabed type, and hydrodynamics between the Confluence Zone and Crawfish Rock
- Compare the characteristics of the infauna community to historical data, including sampling at sites used in the infauna study included in the Western Port Bay Environmental Study (Coleman *et al* 1978).

Sampling site groups are shown in Figure 23. Table 6 lists coordinates and depths of samples.

Berth 2 group: Nine samples located beneath and to the north, south and east of the proposed mooring position of the FSRU at Berth 2.
Berth 1 group: Two sites in berth pocket habitat at Berth 1 presently used for unloading fuel tankers to Crib Point storage facility.
West group: Four sites near the 10 m depth contour west of Crib Pt Jetty. Immediately inshore and at a depth where negligible exposure to the discharge is expected.
East group: Two sites near the 10 m depth contour on the eastern side of the main channel opposite Crib Point Jetty.
Reference: 11 sites up to 6 km north and south and 4 km east of Crib Point Jetty. Sites included deep channel habitat and subtidal (13-15 m depth) bank habitat. Five sites were in the same locations as sites sampled by Coleman *et al* (1978).

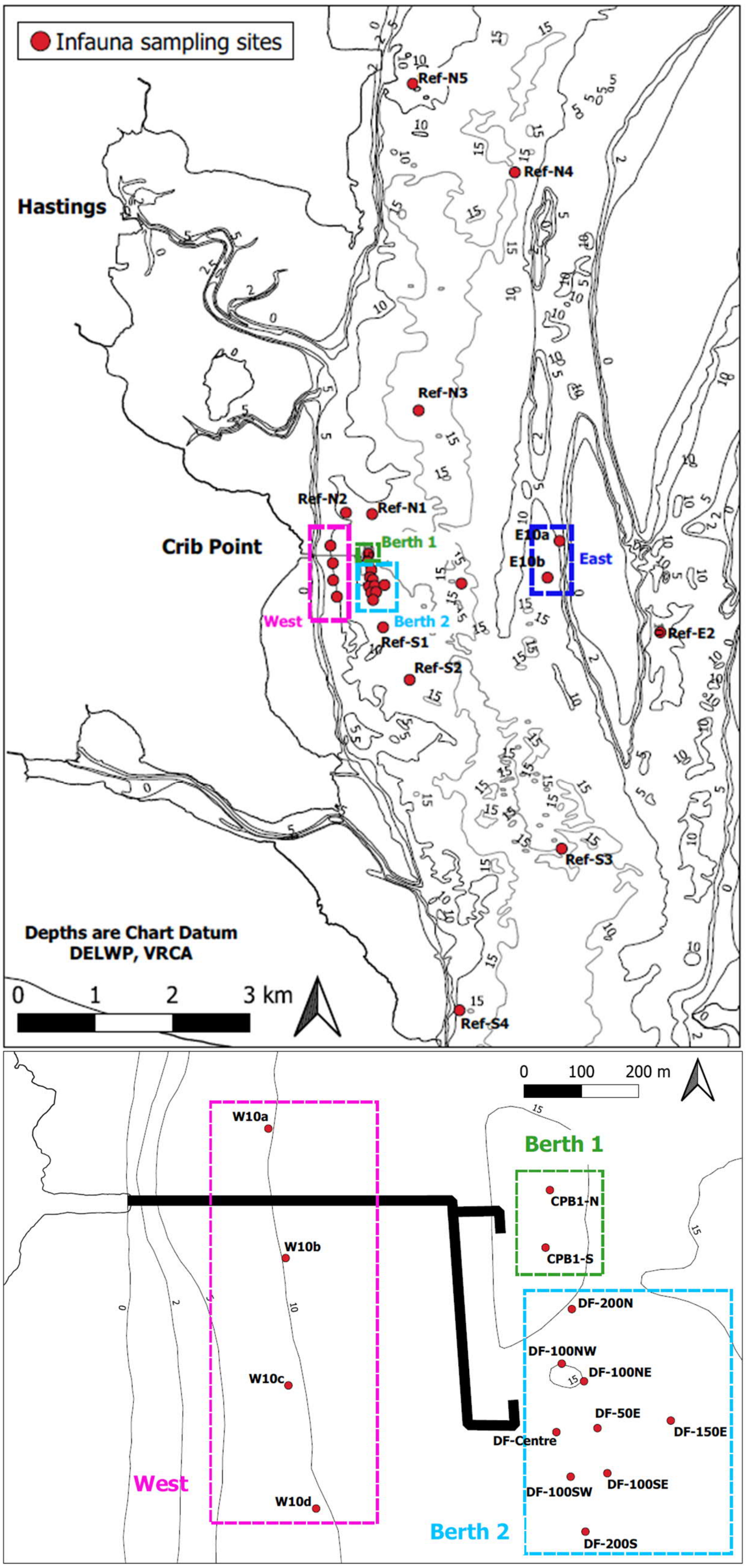


Figure 23. Infauna sampling sites in Western Port, North Arm

Table 6. Metadata of infauna sampling sites.

Date	Site name	Easting	Northing	Depth (m) Chart Datum	Notes
Berth 2					
19/09/2019	DF-200N	345076	5753779	14.3	
19/09/2019	DF-100NW	345064	5753684	14.3	
19/09/2019	DF-100NE	345095	5753654	14.3	
19/09/2019	DF-Centre	345059	5753565	14.3	approx. position of FRSU discharge
19/09/2019	DF-50E	345115	5753573	14.3	
19/09/2019	DF-150E	345215	5753588	14.3	
19/09/2019	DF-100SW	345080	5753488	12.8	
19/09/2019	DF-100SE	345130	5753495	12.8	
19/09/2019	DF-200S	345102	5753393	12.8	
Berth 1					
19/09/2019	CPB1-N	345042	5753985	15.8	
19/09/2019	CPB1-S	345038	5753885	15.8	
East					
19/09/2019	E10a	346987	5754191	10	
19/09/2019	E10b	346873	5753715	10	
West					
19/09/2019	W10d	344733	5753426	10	
19/09/2019	W10c	344691	5753639	10	
19/09/2019	W10b	344683	5753860	10	
19/09/2019	W10a	344655	5754085	10	
Reference (cross reference other studies)					
23/09/2019	Ref-N1	345278	5754807	12.3	AECOM contaminants sampling site
23/09/2019	Ref-N2	344804	5754515	12.3	AECOM contaminants sampling site
23/09/2019	Ref-N4	346632	5760748	13	approx. Coleman (1978) site 1724
23/09/2019	Ref-N5	345379	5760079	12	approx. Coleman (1978) site 1723
19/09/2019	Ref-E1	345998	5753622	14.3	approx. 1km East of Crib Pt Jetty
19/09/2019	Ref-E2	348036	5753030	11.1	approx. Coleman (1978) sites 1726-28
19/09/2019	Ref-S1	345211	5753040	10.7	AECOM contaminants sampling site
19/09/2019	Ref-S2	345494	5752367	12.1	AECOM contaminants sampling site
19/09/2019	Ref-S3	347084	5750208	13	Extension of Coleman channel sites
19/09/2019	Ref-S4	346084	5748101	11.1	approx. Coleman (1978) site 1729

4.2 Equipment and sampling method

Infauna were sampled using a Ponar grab operated from CEEs research vessel (Figure 24). The Ponar grab (total weight fitted with lead weights: ~20kg) collects sediments from a surface area of 0.07 m^2 and to a depth of 100 mm in homogenous sediments. Sediments in Western Port are heterogenous, containing quantities of shell and epibiota that can interfere with grab operation. Each grab sample retrieved from the seabed was inspected and the volume estimated (full, half, one-third). Multiple grabs were collected at sites where sample volumes were small and the volume of each recorded.

Sediment samples were sieved through 1 mm mesh to retain all material over 1 mm in size (including infauna). Samples were preserved in 5% v/v buffered formalin.

A drop camera was used to document the seabed conditions at each infauna sampling site (sediment type, epibiota). Data from the towed video survey was used where appropriate.

Figure 24. Ponar grab, davit and winch

4.2.1 Laboratory processing of infauna samples

Infauna samples were processed by specialist infauna laboratory Infauna Data. Infauna were identified to family taxonomic level and counted. The infauna specialists are experienced in identification of introduced and invasive infauna species and provide data on these if they are encountered.

4.2.2 Data compilation

Laboratory data were annotated with field records of sample position, depth and grab volumes. The number of infauna families at each site was calculated and abundances were standardised to the number of infauna per full grab.

4.3 Results

Table 7 summarises numbers and mean densities of the thirteen most abundant infauna families and higher taxonomic orders (>1% of total) at the five site groupings ‘West’, ‘Berth1’, ‘Berth 2’, ‘East’ and ‘Reference’ in the 2019 investigation. Infauna from 109 families were identified and counted.

4.3.1 Dominant infauna families

The number of infauna families at each site group ranged from 20 to 38, with generally more infauna found at the ‘Berth 2’ area (1335/grab) than at ‘Berth1’ (890/grab) ‘West’ (742/grab), and ‘Reference’ (219/grab) sites. The single sample from the ‘East’ site contained the most infauna (1832/grab). Most major groups were found at all sites, except Chaetopteridae and Eunicidae which were absent from the ‘East’ site.

The majority of infauna were crustaceans of the family Corophiidae, although their high total numbers were due to particularly high densities found at only one site E10a (‘East’). The second and third most abundant groups were Ampharetidae (terebellid polychaetes, 840/grab) and small shrimp-like crustaceans of the order Tanaidacea (657/grab). Among molluscs, Veneridae (“Venus clams”) were highest in numbers (137/grab). Polychaetes of the families Chaetopteridae, Lumbrineridae and Opheliidae, and the crustacean Ampheliscidae ranged between 107 and 189 individuals/grab.

Table 7. Infauna results summary

Zone	**Berth 2**	**Berth 1**	**West**	**East**	**Reference**	**Total**	**% of Total**
Number of samples	9	2	4	1	9	25	
Number of families	32	38	33	32	20	109	
Total infauna*	1335	890	742	1832	292	5091	100
Polychaeta (>1%)							
Ampharetidae*	430	267	83	3	57	840	16
Capitellidae*	20	4	21	9	8	61	1
Chaetopteridae*	19	66	2	0	21	107	2
Eunicidae*	8	6	24	0	2	40	1
Lumbrineridae*	74	53	35	12	16	189	4
Opheliidae*	40	44	15	33	36	168	3
Terebellidae*	15	5	25	15	3	63	1
Crustacea (>1%)							
Ampheliscidae*	32	24	55	61	2	174	3
Corophiidae*	124	41	126	1494	39	1824	36
Phoxocephalidae*	40	13	15	18	7	92	2
Tanaidacea*	280	222	101	39	15	657	13
Mollusca (>1%)							
Calyptraeidae*	19	9	32	6	2	69	2
Veneridae*	62	25	20	18	12	137	3
Other (96 families)*	172	111	188	124	72	667	15

* Average n/grab

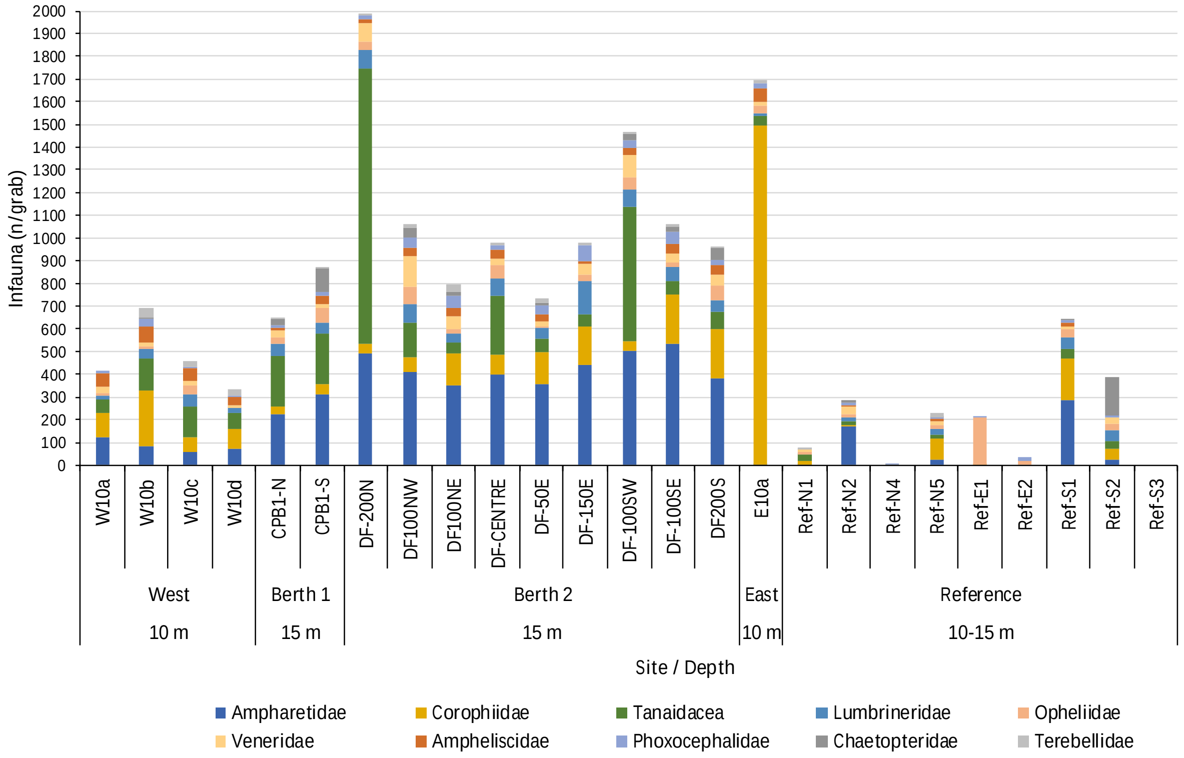


Figure 25. Ten most abundant infauna families in North Arm, Western Port

The distribution patterns of infauna families at individual sites is shown in Figure 25. Sites at ‘West’, ‘Berth1’ and ‘Berth 2’ generally showed similar distribution patterns with less infauna at the 10 m contour and more infauna at DF-200N (~2000/grab) and DF-100SW (~1500/grab) due to high numbers of Tanaidacea. The latter also occurred in relatively high numbers at ‘West’ and ‘Berth 1’ sites. Ampharetidae were the largest group at most sites at the ‘Berth 2’, whereas Corophiidae dominated the ‘West’ and contributed to the infauna community at ‘East’ by almost 90%. Ampharetidae, although found at most sites, were absent from the ‘East’ site.

4.3.2 Major classes

The abundance of the three main infauna classes and seabed categories found at 25 sites in North Arm, Western Port in the 2019 investigation are listed in Table 8.

Polychaetes (“bristle worms”) were the most abundant class (mean abundance per site: 392/grab), closely followed by crustaceans (385/grab). 64 molluscs per grab were present at each site on average. Only ~7 individuals per grab were associated with other classes or phyla including Echinodermata, Chordata, Cnidaria and Nemertea. All three main classes were found at all sites throughout North Arm, except Ref-S3 where no molluscs were present.

Most infauna were recorded at the ‘Berth 2’ area (876 – 2200/grab) while reference sites were least inhabited by infauna (32-764/grab). The infauna density generally correlated with the visually estimated level of bioturbation, except at E10a where high numbers of infauna (1833/grab) were documented but levels of bioturbation were rated as ‘Low’. This site showed a unique distribution of the main infauna classes with relatively low numbers of polychaetes (133/grab) and high numbers of crustaceans (1658/grab), mainly amphipods of the family Corophiidae.

Table 8. Main infauna classes and seabed categories

Site	Depth (m)	Infauna (n/grab)					Seabed categories				
		Polychaete	Crustacean	Mollusc	Other	Total	Sediment	Shell	Bioturbation	Macrophytes	Benthic invertebrates
West											
W10a	10	256	276	92	20	644	Silty sand w/o waves	N/A	N/A	N/A	N/A
W10b	10	370	625	115	30	1140	Silty sand w/o waves	N/A	N/A	N/A	N/A
W10c	10	300	348	36	4	688	Silty sand w/o waves	N/A	N/A	N/A	N/A
W10d	10	218	238	26	6	488	Silty sand w/o waves	Low	Medium	Macroalgae	Medium
Berth 1											
CPB1-N	16	362	341	48	10	761	Silty sand w/o waves	Medium	Medium	Debris	Low
CPB1-S	16	568	392	44	12	1016	Silty sand w/o waves	Medium	Medium	Low	Low
Berth 2											
DF-200N*	14	688	1356	148	8	2200	Silty sand w/o waves	Medium	High	Debris	Low
DF100NW*	14	770	327	206	18	1321					
DF100NE*	14	556	328	84	0	968					
DF-CENTRE*	14	652	508	60	8	1228					
DF-50E*	14	520	304	48	4	876					
DF-150E*	14	697	394	91	0	1182					
DF-100SW*	13	768	800	148	4	1720					
DF-100SE*	13	764	467	79	30	1340					
DF200S*	13	700	384	88	12	1184					
East											
E10a**	10	133	1658	43	0	1833	Medium sand w/o waves	Medium	Low	Debris	Medium

Site	Depth (m)	Infauna (n/grab)					Seabed categories				
		Polychaete	Crustacean	Mollusc	Other	Total	Sediment	Shell	Bioturbation	Macrophytes	Benthic invertebrates
Reference											
Ref-N1**	12	53	63	34	7	156	Medium sand w/o waves	Medium	Nil	Nil	Nil
Ref-N2**	12	258	44	54	12	368	Silty sand no waves	Medium	Medium	Debris	Medium
Ref-N4**	13	5	21	5	2	32	Medium sand with waves	Nil	Nil	Debris	Low
Ref-N5**	12	110	158	46	2	316	Medium sand w/o waves	Low	Low	Macroalgae	Low
Ref-E1**	14	258	36	3	0	297	Medium sand with waves	Nil	Low	Nil	Nil
Ref-E2**	11	30	44	26	2	102	Medium sand with waves	Nil	Low	Nil	Nil
Ref-S1**	11	424	297	30	12	764	Silty sand w/o waves	Low	Medium	Debris	High
Ref-S2**	12	332	120	36	8	496	Medium sand with waves	Medium	Low	Nil	Nil
Ref-S3**	13	6	85	0	0	91	N/A	N/A	N/A	N/A	N/A
Mean		392	385	64	8	848					

Seabed categories were inferred from habitat video tows post-survey

4.3.3 Infauna family richness and Shannon biodiversity

The number of infauna families in samples ranged between 24 and 44 families per site (Figure 26). Family richness was generally lower at reference sites with the lowest numbers at Ref-N4, E1 and S3.

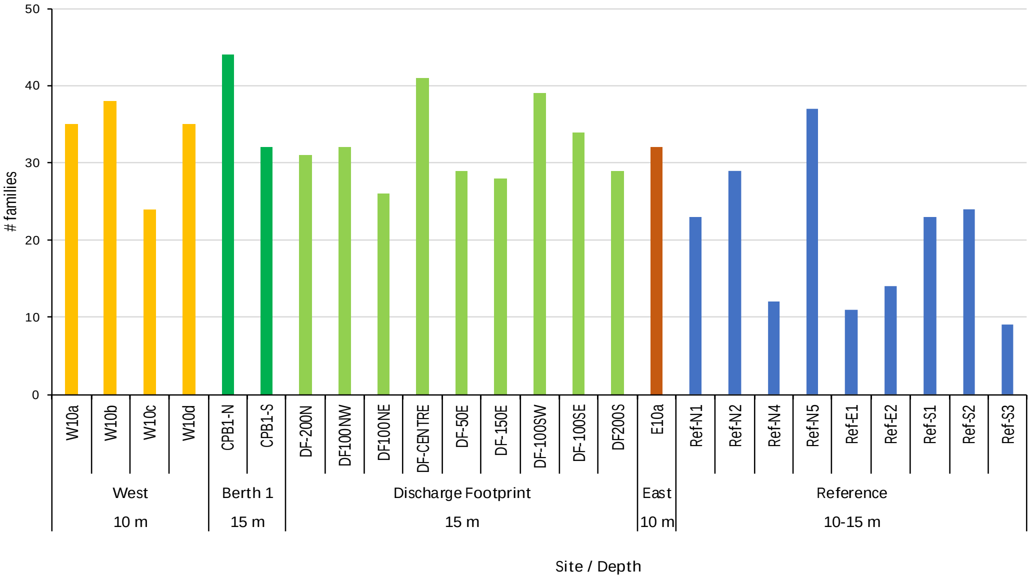


Figure 26. Number of infauna families in North Arm, Western Port

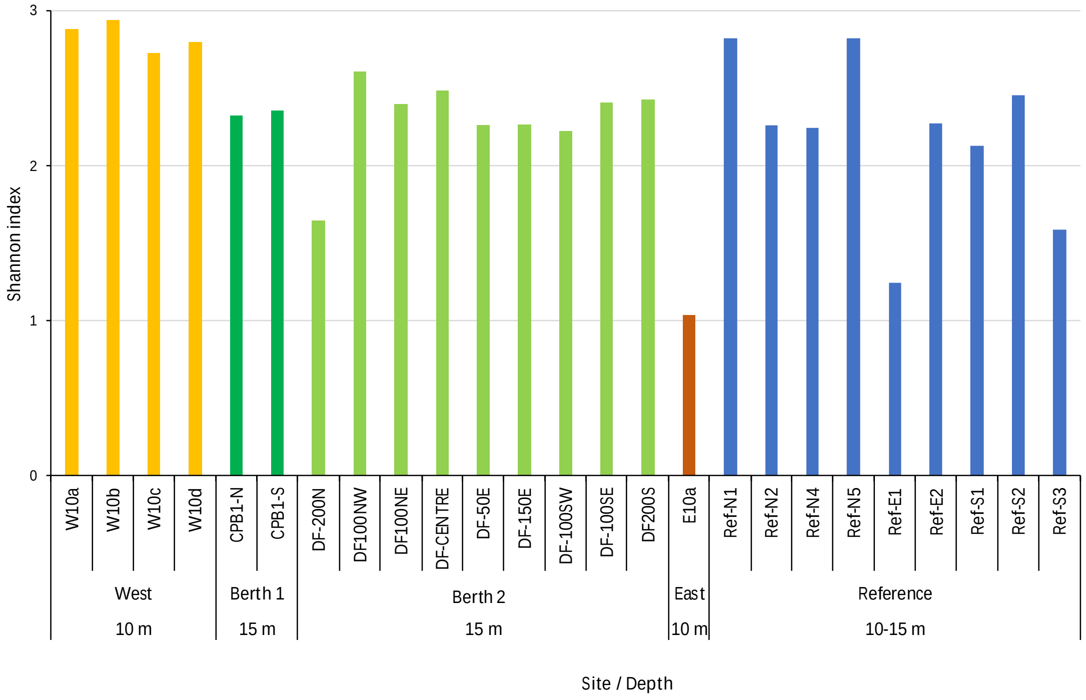


Figure 27. Shannon biodiversity of infauna families in North Arm, Western Port

Shannon biodiversity of infauna families (Figure 27) was relatively similar among all sites (~2.4), except at sites DF-200N, E10a, Ref-E1 and Ref-S3 were indices were lower (~1-1.7) (Figure 27). These sites were characterised by dominance of certain families as outlined in Section 4.3.1.

4.3.4 Multivariate analysis

The pattern of distribution of the infauna assemblages (species and abundance) is a multivariate array of species, species abundance and site. The complex array can be reduced to two or three 'dimensions' by statistical compilation of the data as a Bray-Curtis dissimilarity matrix and plotting the data using non-Metric Multidimensional Scaling (nMDS) (e.g., Clarke 1993, Clarke and Warwick 1994, Gray *et al* 1990). The outputs of MDS can show how sites group together (or apart) on the basis of the similarity (or dissimilarity) of the species and their abundances at each site in the data set.

The dataset comprised the most abundant 24 families, which represented 90 per cent of the infauna data. Data were square root transformed, log transformed and not transformed prior to Bray-Curtis + nMDS analyses. Two site groups were analysed a) all sites, and b) Crib Point Jetty sites only (Berth 1, Berth 2, West sites and near reference sites N1, N2, S1 and S2).

Initial analyses showed that the non-transformed data had the best two-dimensional (2D) statistical representation (Kruskal Stress < 0.1), although all transformations presented clear spatial differentiation with Kruskal Stress < 0.2 (Clarke and Warwick, 1994) for all options plotted. nMDS plots for the non-transformed data are presented below.

Figure 28 shows the 2D plot of the infauna data for all sites. The figure shows clear separation of the Crib Point Jetty sites (blue=Berth 1, green = Berth 2 and inshore jetty = magenta) from most of the reference sites, with reference sites S1, S2, N2 and N5 also within the Crib Point Jetty cluster (grey oval). This shows that the Crib Point cluster of sites are more similar.

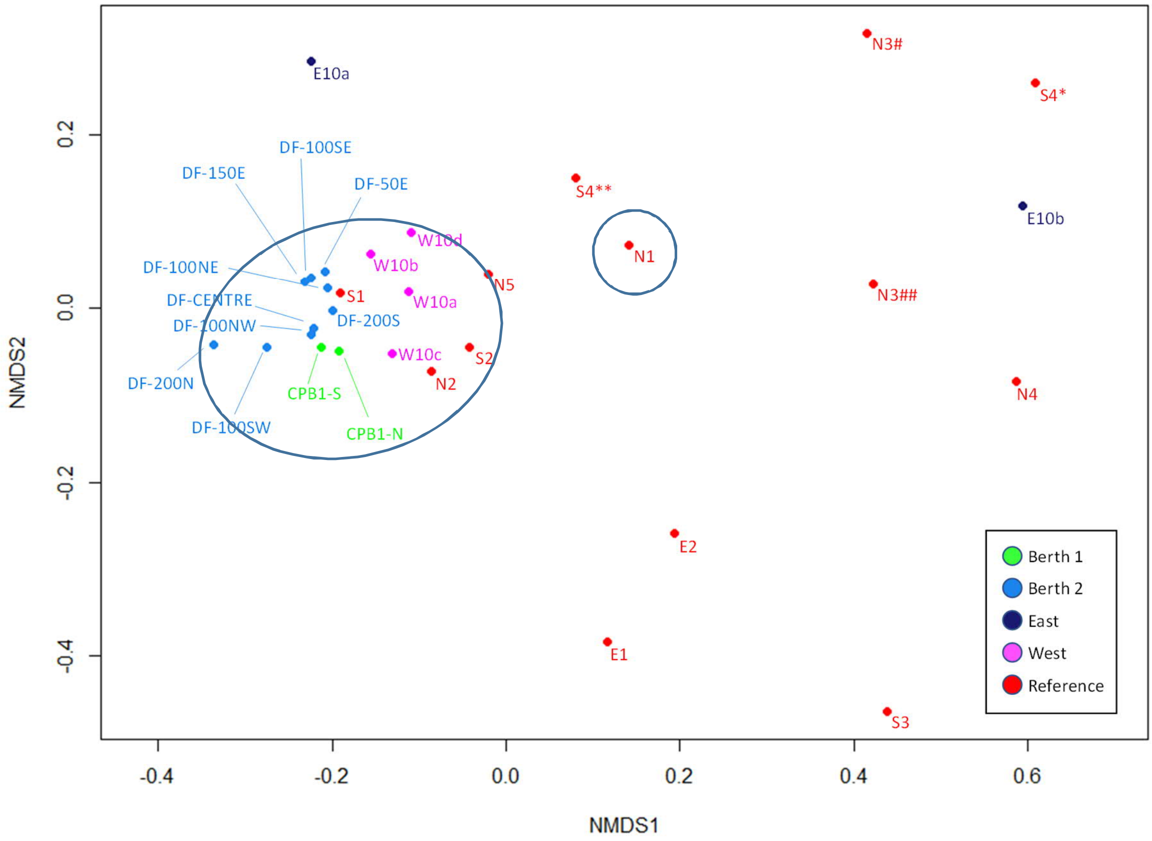


Figure 28. nMDS plot of infauna at all sites

(Kruskal stress = 0.093)

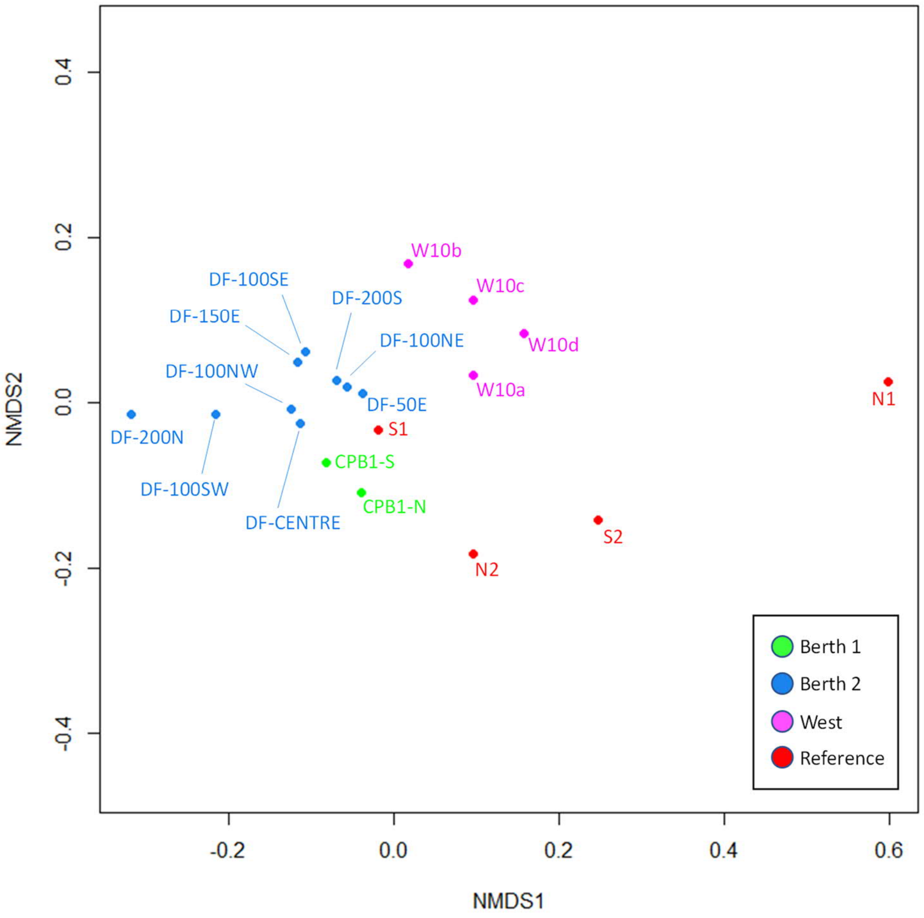


Figure 29. nMDS plot of infauna at Crib Point Jetty Sites

(Kruskal stress = 0.098)

Figure 29 show the NMDS plot for the Crib Point Jetty sites only. The sites are generally similar to the previous plot along the main axis (MDS1) with minor difference along the vertical axis (MDS2), which together with the low stress indicates a good statistical representation of the multivariate data in two dimensions.

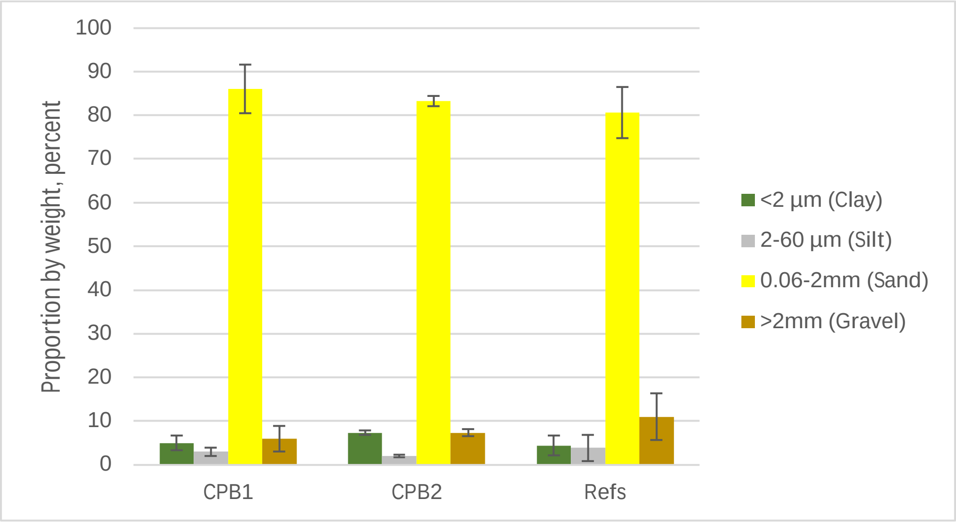


Figure 30. Grain size distribution at Crib Point Jetty sites, 2019

Figure 30 shows the grain size distribution for sediments at Berth 1, Berth 2 and four reference sites at Crib Point Jetty (data provided by AECOM from CEE 2019 survey). The figure shows that the sediments are primarily (medium to fine) sands, with slightly more, but variable, coarser material at the reference sites. Examination of the raw data showed that the amount of gravel was highest at site N1.

As expected, the nMDS plots show similar relationships between the infauna and the sites that are presented previously in Figure 25, Figure 26 and Figure 27. The relationships are evident in the proportions of taxa at each site shown in Figure 25. The differences in the infauna assemblages between the sites are likely due to the differences in the habitats which are visible by examination of seabed images as shown in Figure 5, Figure 6 and Figure 7, as well as particle size of the sediments (Figure 30).

5 Conclusion

The investigations described in this report were designed to provide information for input to the EES on the nature and distribution of habitats and associated biota on the seabed of Lower North Arm in and adjacent to the area that may be affected by discharge by seawater discharged from the heat exchange process and related operations on the FSRU.

The systematic collection and analysis of seabed images, compilation of spatially referenced ecological data (taxa abundance) and examples of GIS-based presentation of data demonstrates that the investigations and associated data formats provide a flexible tool for describing relevant detail of the habitats and biota in Lower North Arm of Western Port.

The outcomes of this investigation provide a substantial increase in knowledge and understanding of the deeper benthic habitats and associated biota in Lower Arm Western Port. The investigations document a more diverse mosaic of soft seabed habitats over the deeper channels than generally understood.

The combined information on seabed habitat, epibenthic biota and infauna community structure at Crib Point and reference areas presented here provide solid, evidence-based, ecological context for interpretation of impacts of the FRSU discharge in the assessment sections of the EES.

6 References

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