GHD Cocos Island Benthic Habitat Survey

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1. Introduction

1.1. Background

The Cocos (Keeling) Islands (CKI) are located within the Indian Ocean and are approximately 2750 kms northwest of Perth. The CKI are a group of classic coral atolls made up of 27 islands, of which only two (West Island and Home Island) are inhabited. The bathymetry of the atoll's lagoon is shallow (<3 m) in the south and deeper (10-12 m) in the north. The proposed Marine Offloading Facility (MOF) is located adjacent to the Rumah Baru wharf on West Island.

Analysis of historical data available from BoM (2020) indicates winds are predominantly south-easterly during the morning and afternoon for most of the year with daily averages of 5-8 m/s. Winds are typically stronger and from the east to south-east during April to October. Winds tend to be lighter and more easterly and northerly during November to March, which also corresponds with cyclone season.

1.2. Purpose and scope

Fulton Hogan Construction Pty Ltd proposes the construction of a Marine Offloading Facility (MOF) on the West Island of CKI (Figure 1). The MOF is needed to support upgrades to the airport of the CKI and will be located adjacent to the existing Rumah Baru Wharf. The MOF will be constructed across supra-tidal, inter-tidal and sub-tidal habitats, albeit over a very limited footprint, with minimal 'direct' impacts.

The primary purpose of this report is to glean a clear understanding of the health and condition of the benthic communities and habitat (BCH) present in the project area and surrounding areas, and how this development could potentially affect the condition of the surrounding environment. Predictive modelling of the construction related impacts/influences has allowed the project area to be divided up into the Zone of Impact (ZoIm), Zone of Indirect Impact (ZoII) and the Zone of Influence (ZoIn) indicating the varying levels of predicted exposure to elevated total suspended sediment (TSS) (Figure 2).

The secondary goal of this study is to validate the existing BCH map produced by EOMAP in 2016, to assess if using it at a larger spatial level is suitable to assess coverage of BCH in the lagoon area of CKI.

Subtidal habitats across the area were visually assessed using both logged and real-time footage of the BCH. A suitably qualified scientist undertook classification of the BCH footage using existing categories established by EOMAP (2016). Additional categories were added where possible to show a finer resolution in the BCH.

The field survey was carried out by a marine scientist primarily utilising an underwater drop camera, Remote Operated Vehicle (ROV) and a hand-held underwater camera.

The main assumption of this style of data collection is that BCH colonies recorded along the transect are typical of the range of species, colony size, health and habitat conditions found in the area, as this data will be used to interpolate habitat and substrate type between transects and drop camera locations.

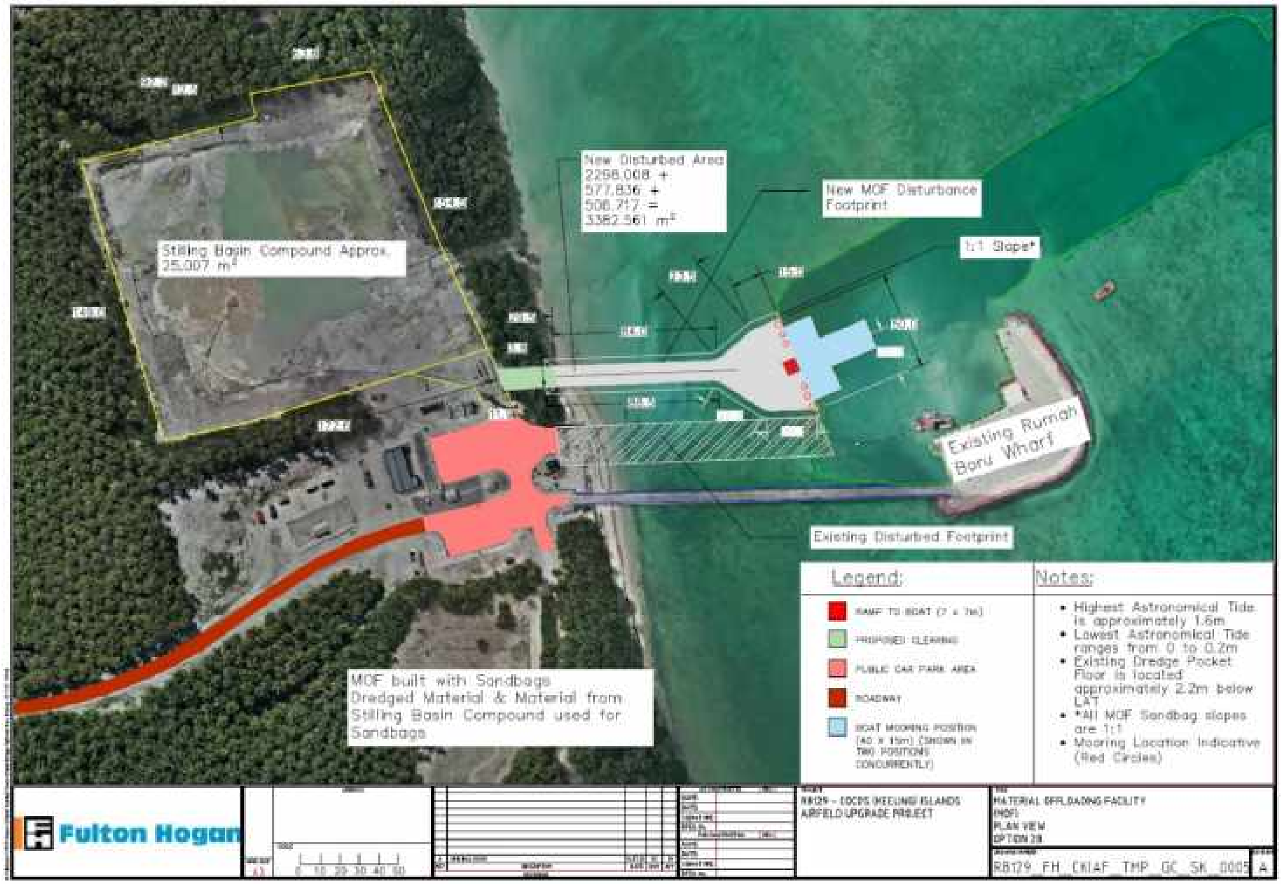

Figure 1: MOF design and footprint

Figure 2: Predicted Areas of Impact and Influence

1.3. Timing

The field survey for the collection of data was undertaken between 26th and 28th of October 2020.

2. Methodology

2.1. Video transects

The video graphic sampling regime employed a series of various length transects across the Local Assessment Unit (LAU), with specific spacing density according to the desired resolution of the individual zones of impact and influence areas. The sampling regime was primarily aimed at obtaining qualitative data to assist in the production of a detailed BCH map of the survey areas. The survey was implemented by using a mixture of live towed video and ROV.

The survey vessel deployed its anchor at the start of the transect and the GPS coordinates were recorded. As the ROV was deployed over the side of the vessel, a pre-determined heading or bearing was followed via the onscreen ROV display, and a video record taken along the length of the transect. The seafloor video record comprises an approximate 1.0 m x 1.5 m field of view. On completion of the transect, the ROV surfaced to indicate its final location and was piloted back to the vessel. Using the known distance of the ROV's cable (100m), a GPS coordinate was marked at the transect end point using the distance and bearing. This procedure was undertaken twice at each GPS mark, with the two transects run at 180 degrees from each other (i.e. one at 90° and one at 270°), thus giving 200m of coverage per transect.

The ROV transect data was supplemented with drop camera footage using randomly distributed points or when an object or habitat of interest was identified in situ. Once on location, a GPS coordinate was taken as the drop camera was lowered into the water. The vessel drifted with the current (<2 knots/hour) while live video footage was recorded. At the end of the transect (distance of transects varied), another GPS point was taken.

All video and drop camera footage was backed up on an external hard drive, and uploaded to the server (where possible) after the day's survey work was completed.

2.2. Line intercept still imagery

A line-intercept survey was undertaken to determine the abundance and health of the subtidal BCH at two (2) locations inside the MOF footprint area and one (1) reference site. Four 20m, haphazardly positioned, line-intercept transects were marked at each site over the substratum.

The transects were temporarily marked with weighted survey tapes with metric measurement markings along the substratum. The length of each transect was photographed by the in-water scientist, ensuring the markings on the survey tape were visible on the photographs for the communities to be measured during analysis. It was then estimated that the field of view for each photo is likely 1m x 1.5m each side of the weighted tape. GPS coordinates were recorded at the start and end of each line.

All still imagery was backed up on an external hard drive and uploaded to the server (where possible) after the day's survey work was completed.

2.3. Sampling Locations

Sampling was undertaken at a broad range of locations (Figure 3 & Table 1) which aligned with previous GHD observations, modelling results and existing aerial mapping data. The large spatial spread was designed in an attempt to capture the largest range of BCH in the field time available.

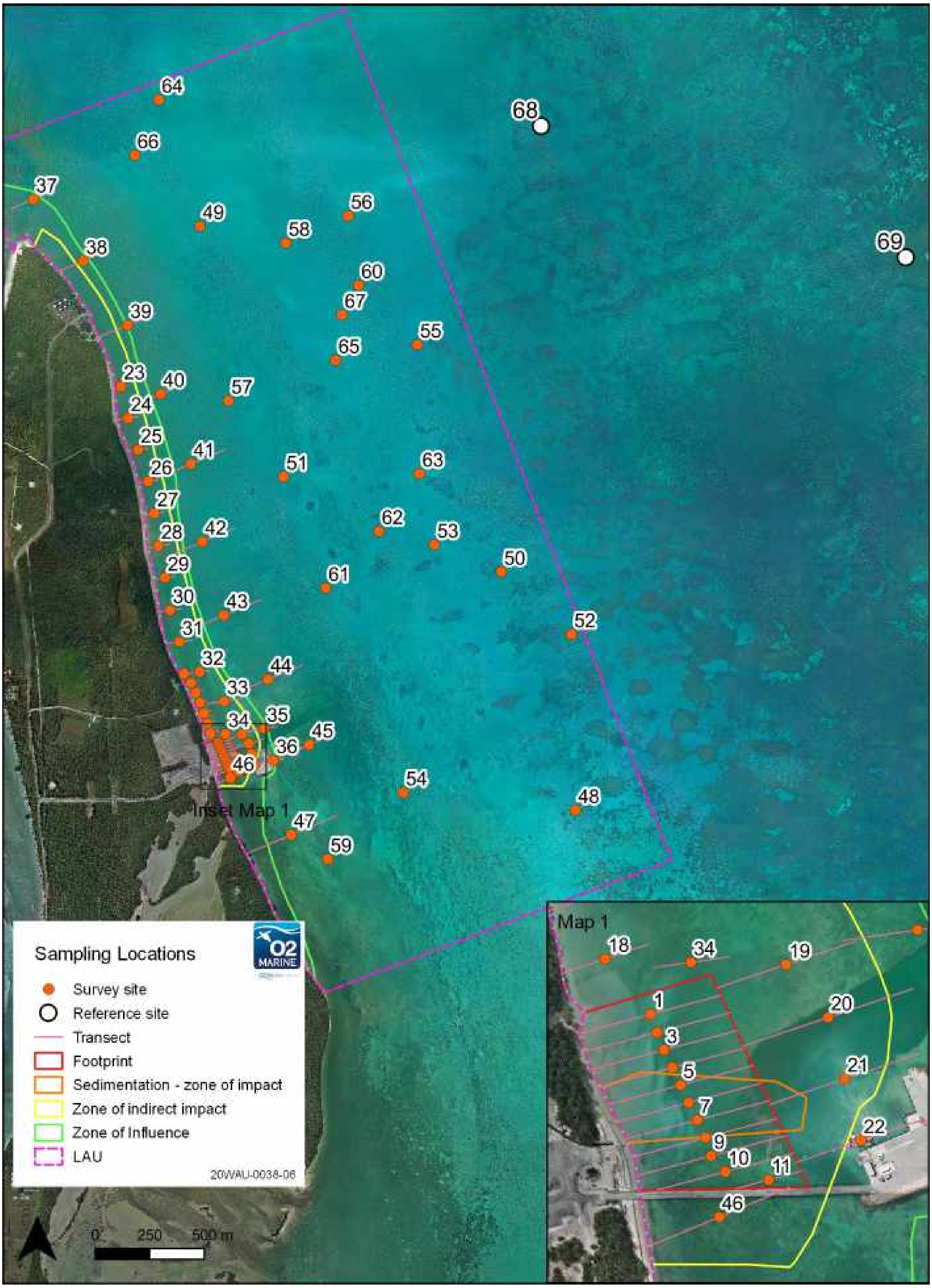

Figure 3: Sampling locations

Table 1: Sampling coordinates

Site Name	Site Type	X_WGS84_UTM47S	Y_WGS84_UTM47S
LAU C1	Local Assessment Unit	262595	8658027
LAU C2	Local Assessment Unit	264296	8658679
LAU C3	Local Assessment Unit	265794	8654772
LAU C4	Local Assessment Unit	264198	8654161
Footprint C1	Direct Impact	263665	8655311
Footprint C2	Direct Impact	263765	8655341
Footprint C3	Direct Impact	263842	8655174
Footprint C4	Direct Impact	263709	8655171
O2M 1	MOF Footprint	263718	8655310
O2M 2	MOF Footprint	263723	8655296
O2M 3	MOF Footprint	263728	8655282
O2M 4	MOF Footprint	263735	8655268
O2M 5	MOF Footprint	263741	8655254
O2M 6	MOF Footprint	263748	8655240
O2M 7	MOF Footprint	263754	8655227
O2M 8	MOF Footprint	263761	8655213
O2M 9	MOF Footprint	263765	8655199
O2M 10	MOF Footprint	263776	8655186
O2M 11	MOF Footprint	263811	8655180
O2M 12	Zone of Impact	263559	8655629
O2M 13	Zone of Impact	263592	8655587
O2M 14	Zone of Impact	263613	8655541
O2M 15	Zone of Impact	263633	8655496
O2M 16	Zone of Impact	263651	8655449
O2M 17	Zone of Impact	263668	8655402
O2M 18	Zone of Impact	263682	8655354
O2M 19	Zone of Impact	263824	8655349
O2M 20	Zone of Impact	263857	8655307
O2M 21	Zone of Impact	263870	8655259
O2M 22	Zone of Impact	263883	8655211
O2M 23	Zone of Influence	263270	8656949
O2M 24	Zone of Influence	263303	8656802
O2M 25	Zone of Influence	263349	8656657
O2M 26	Zone of Influence	263395	8656512
O2M 27	Zone of Influence	263424	8656365
O2M 28	Zone of Influence	263442	8656216

Site Name	Site Type	X_WGS84_UTM47S	Y_WGS84_UTM47S
O2M 29	Zone of Influence	263472	8656069
O2M 30	Zone of Influence	263496	8655921
O2M 31	Zone of Influence	263538	8655775
O2M 32	Zone of Influence	263631	8655637
O2M 33	Zone of Influence	263744	8655502
O2M 34	Zone of Influence	263749	8655351
O2M 35	Zone of Influence	263928	8655376
O2M 36	Zone of Influence	263970	8655231
O2M 37	Zone of Indirect Impact	264051	8654888
O2M 38	Zone of Indirect Impact	264134	8655302
O2M 39	Zone of Indirect Impact	263772	8655150
O2M 40	Zone of Indirect Impact	263644	8656236
O2M 41	Zone of Indirect Impact	263590	8656593
O2M 42	Zone of Indirect Impact	263944	8655603
O2M 43	Zone of Indirect Impact	263742	8655897
O2M 44	Zone of Indirect Impact	263097	8657524
O2M 45	Zone of Indirect Impact	262868	8657808
O2M 46	Zone of Indirect Impact	263452	8656914
O2M 47	Zone of Indirect Impact	263301	8657230
O2M 48	LAU	265355	8655002
O2M 49	LAU	263633	8657685
O2M 50	LAU	265015	8656097
O2M 51	LAU	264017	8656534
O2M 52	LAU	265337	8655810
O2M 53	LAU	264708	8656221
O2M 54	LAU	264565	8655083
O2M 55	LAU	264630	8657140
O2M 56	LAU	264313	8657732
O2M 57	LAU	263764	8656883
O2M 58	LAU	264027	8657608
O2M 59	LAU	264219	8654777
O2M 60	LAU	264360	8657413
O2M 61	LAU	264209	8656022
O2M 62	LAU	264454	8656284
O2M 63	LAU	264640	8656548
O2M 64	LAU	263445	8658266
O2M 65	LAU	264255	8657069
O2M 66	LAU	263334	8658011

Site Name	Site Type	X_WGS84_UTM47S	Y_WGS84_UTM47S
O2M 67	LAU	264284	8657278
O2M 68	REF	266870	8657541
O2M 69	REF	265198	8658145
GHD 1	Hard bottom covered with macroalgae	266992	8660922
GHD 2	Unconsolidated sediment	265845	8660513
GHD 19	Seagrass (<50% coverage)	270597	8652344
GHD 20	Seagrass (>50% coverage)	271832	8652968
GHD 21	Hard bottom covered with macroalgae	272312	8653402
GHD 22	Hard bottom covered with macroalgae	266506	8661165

2.4. Data Analysis

Qualitative analysis of video transects from the ROV was undertaken by a marine scientist. Video data was viewed at a reduced play speed and, over the course of the specified distance transects, coverage of BCH and identifiable genus/species under the following categories were recorded in density levels;

- Very sparse
- Sparse
- Medium
- High
- Very High

During analysis each transect was equally divided into four segments (irrespective of transect length) and the dominant species was classified qualitatively. As most transects were 100m in length, there are generally four distinct 25m segments of BCH classification. During larger transects, these segments increased in size proportionately to the length of the transect. As distance covered by the ROV during the transects is not available in the video feed, total known distance (i.e. 100m) divided by time taken, gives a reliable m/s speed and thus, the four distance segments can be divided up easily using elapsed time.

Line intercept footage was not classified or analysed for this report. The data was collected for possible future use if a more detailed analysis of BCH cover, health and diversity is required. Still imagery of photos will be stored on the O2M server in-case of further data analysis requirements.

Statistical analysis were not performed on this data set. All results described are based on a scientific visual assessment from a suitable qualified observer of the data.

3. Results

3.1. BCH coverage analysis

Total BCH substrate percentage coverage across all surveyed localities is presented in Figure 4. Mixed assemblages were the most common BCH substrate type across all locations, accounting for 37% of all cover. This was followed by hard bottom substrate with macroalgae cover (25%) and bare consolidated sediment (predominantly compacted sand) (23%) were the next most dominant BCH types. High and medium density coral substate was not commonly identified during the survey, however it should be noted that the category ‘mixed assemblages’ does include areas of medium and high coral cover, with the presence of other notable BCH. The BCH categories were intentionally designed with a lower resolution, to assist in paring this survey’s data with the previous EOMAP data.

MOF Footprint

The most common BCH category within the MOF footprint was mixed assemblage (46%). High density seagrass (22%) and sediment (20%) were the only other two substrates found with moderate rates of coverage. No pure coral communities were found within the MOF area.

Zone of Impact

The Zone of Impact was primarily composed of hard bottom with macroalgae (58%) at a high density of coverage. Sediment and mixed assemblages formed the majority of the remaining substrate cover (21% and 15% respectively).

Zone of Influence

The Zone of Influence had very high coverage (51%) of mixed assemblage across the transects, making up the majority of the overall composition of the BCH. Hard bottom with macroalgae (26%) and bare sediment (15%) were also identified in moderate quantities.

Zone of Indirect Impact

The Zone of Indirect Impact was very similar in BCH percentage cover composition as the Zone of Influence, primarily composed of mixed assemblage (43%), with macroalgae comprising 25% cover and bare sediment 15%. Noticeably, the Zone of Indirect impact also had small amounts of coral present (9% medium density and 1% high density).

Outside Areas of Impact

Consolidated sediment (50%) was the most dominant BCH category in all areas outside of the projects predicted influence. Mixed assemblage was next most dominant with 28% cover, while coral was also found in moderate density (11%) and high density (5%). Coverage of seagrass was a minimal 1% in these areas.

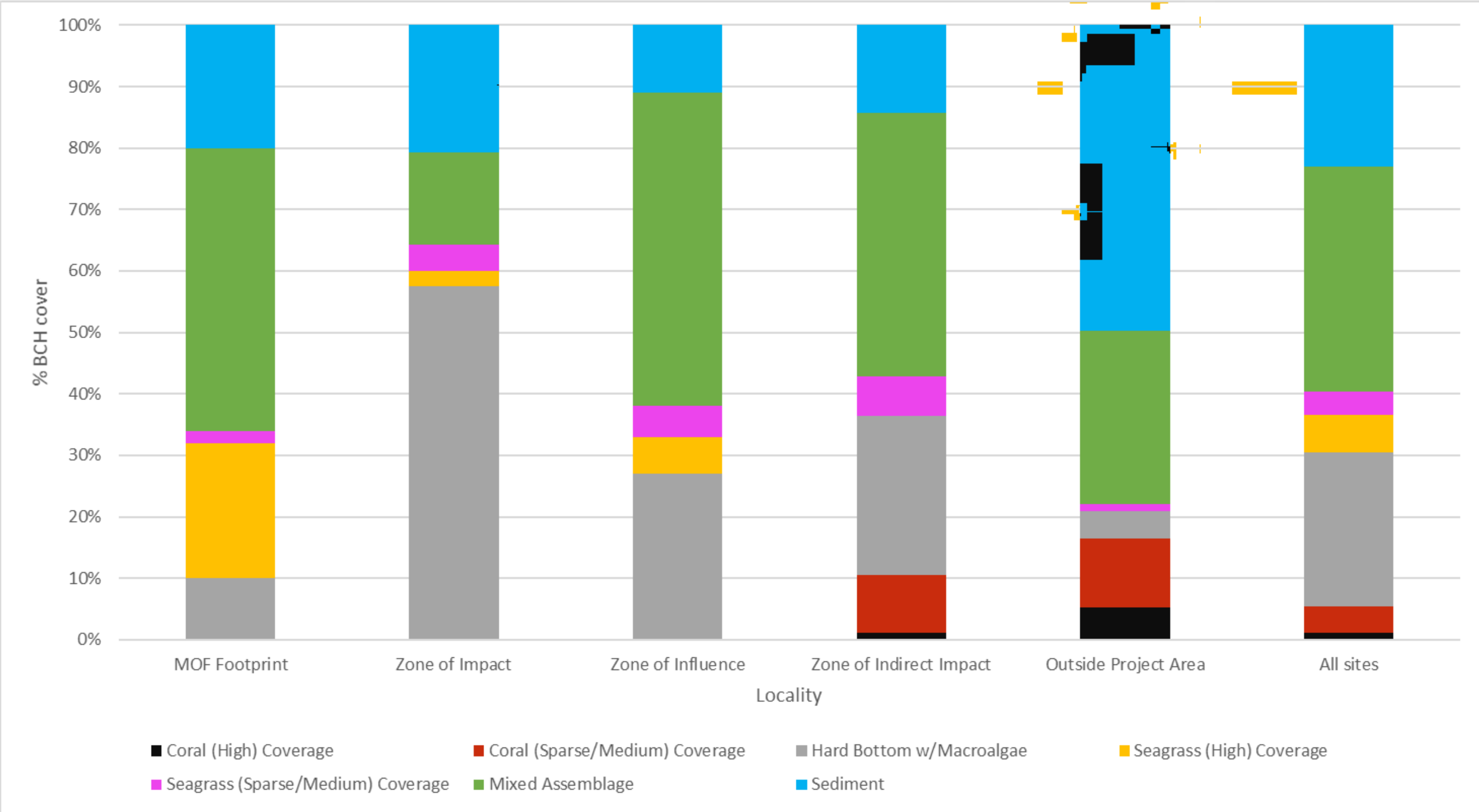

Figure 4: Total BCH coverage across all surveyed sites

3.2. BCH maps

The analysis of BCH cover from Section 3.1 was used to develop the BCH transect map shown in Figure 5. The data described is visually represented below at a higher classification resolution due to the inclusion of some additional subclass categories of BCH.

Interpolation of the line transect data to create the imagery shown in Figure 6, was based on the available information obtained from the in-situ data, satellite imagery, and assumptions based on certain BCH characteristics. Descriptions and analysis of the interpolated map is purely based on visual assessment.

Within the Zone of Impact, almost all the BCH is classed as macroalgae or seagrass, with a small amount of bare sediment present. The Zone of Indirect Impact has approximately one quarter of its spatial area covered by assemblages of macroalgae and seagrass, with areas of purely seagrass or macroalgae also a common occurrence. The shoreline is dominated with sediment and a small amount of seagrass and macroalgae. The Zone of Influence encompasses more areas to the south and west of the Zone of Indirect Impact and is primarily composed of macroalgae and seagrass, with smaller patches of sediment and one relatively large area of predominately coral at the north point of the island.

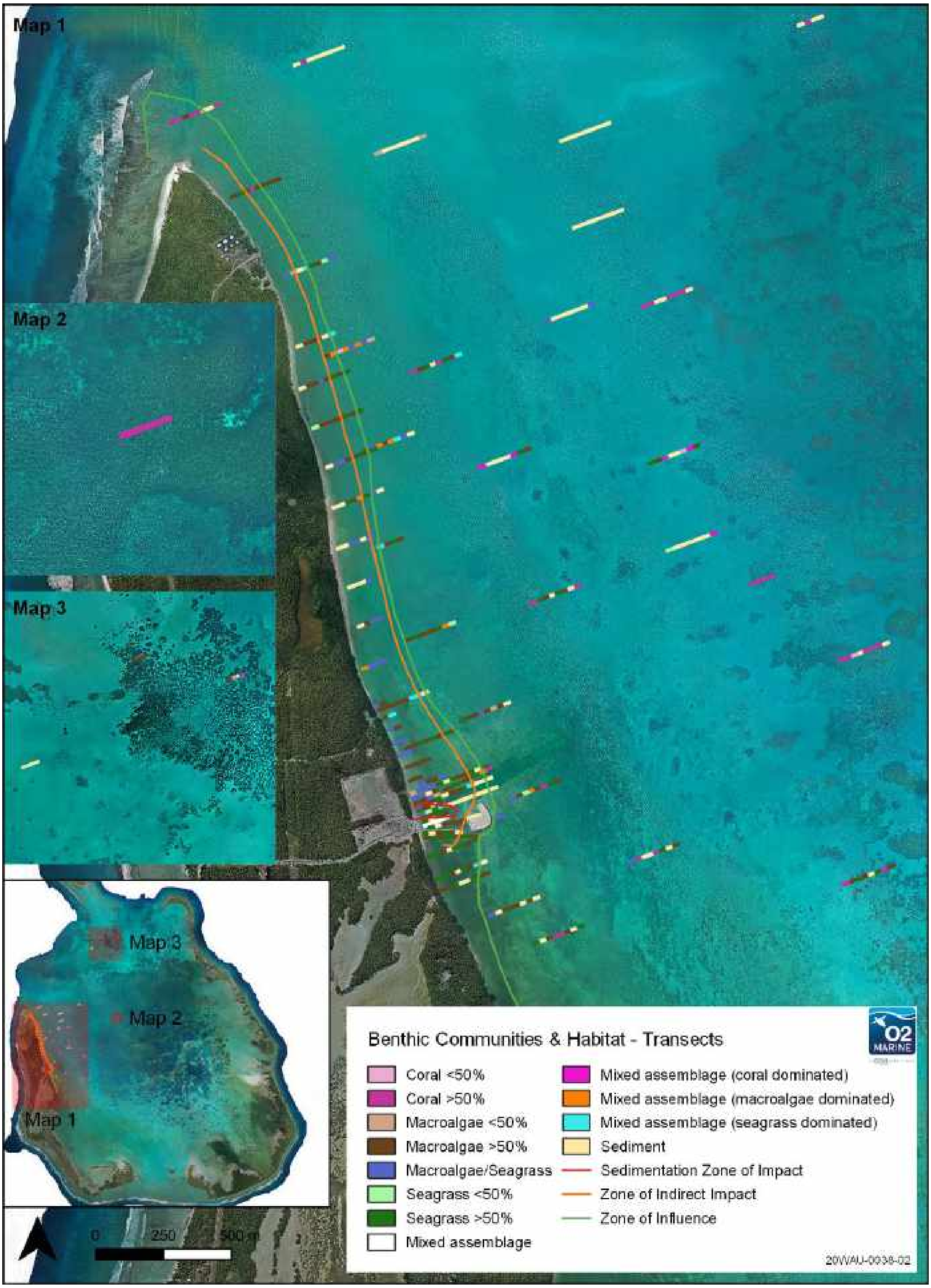

Figure 5: BCH Transect results

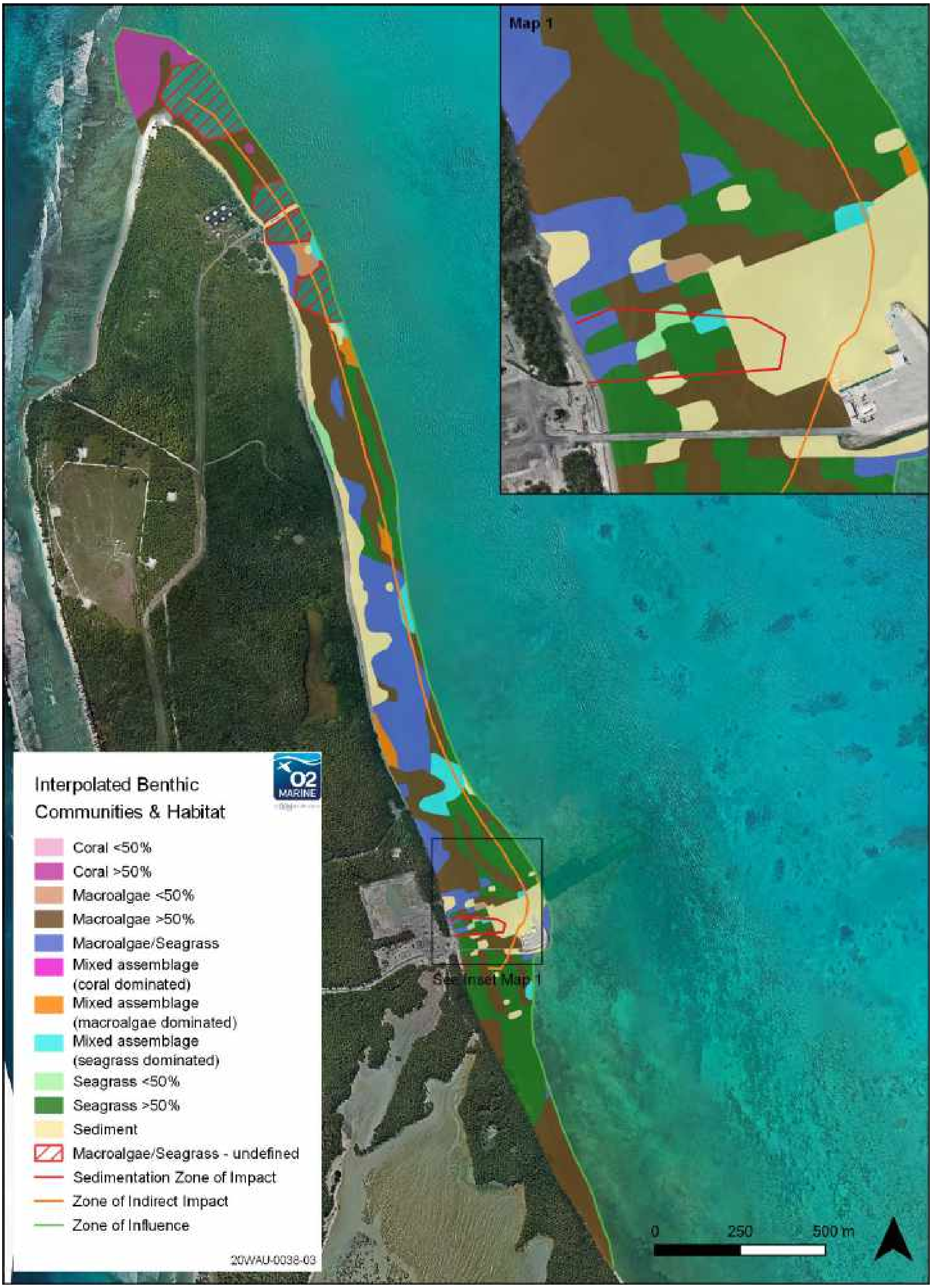

Figure 6: Interpolated BCH data

3.3. EOMAP comparison

A comparison of the October 2020 line transect GIS data set and the 2016 EOMAP data set has been undertaken by overlaying the in-situ data on top of the existing EOMAP BCH map (Figure 7). Generally, the coarse resolution of the EOMAP does not align particularly well with the 2020 in-situ data. This is most evident in the deeper areas away from shore. Nearshore BCH substrate and high-density coral does align slightly better, however it could be described as loosely fitting at best.

There are a few transects that do validate certain portions of the EOMAP such as within the Zone of Influence and Indirect Impact, the EOMAP displays a large area of seagrass (more than 50%), covering a portion of the survey area. Also, towards the north point of West Island, both maps confirm a high degree of coral density.

Most transects within the Zone of Indirect Impact include at least 25 metres of sediment closest to the shoreline, juxtaposed against a mostly sediment BCH within the EOMAP. The EOMAP identifies a much more extensive seagrass BCH cover across the lagoon, with the overlaying in-situ transects indicating more patchy distribution of seagrass with macroalgae and sediment also present.

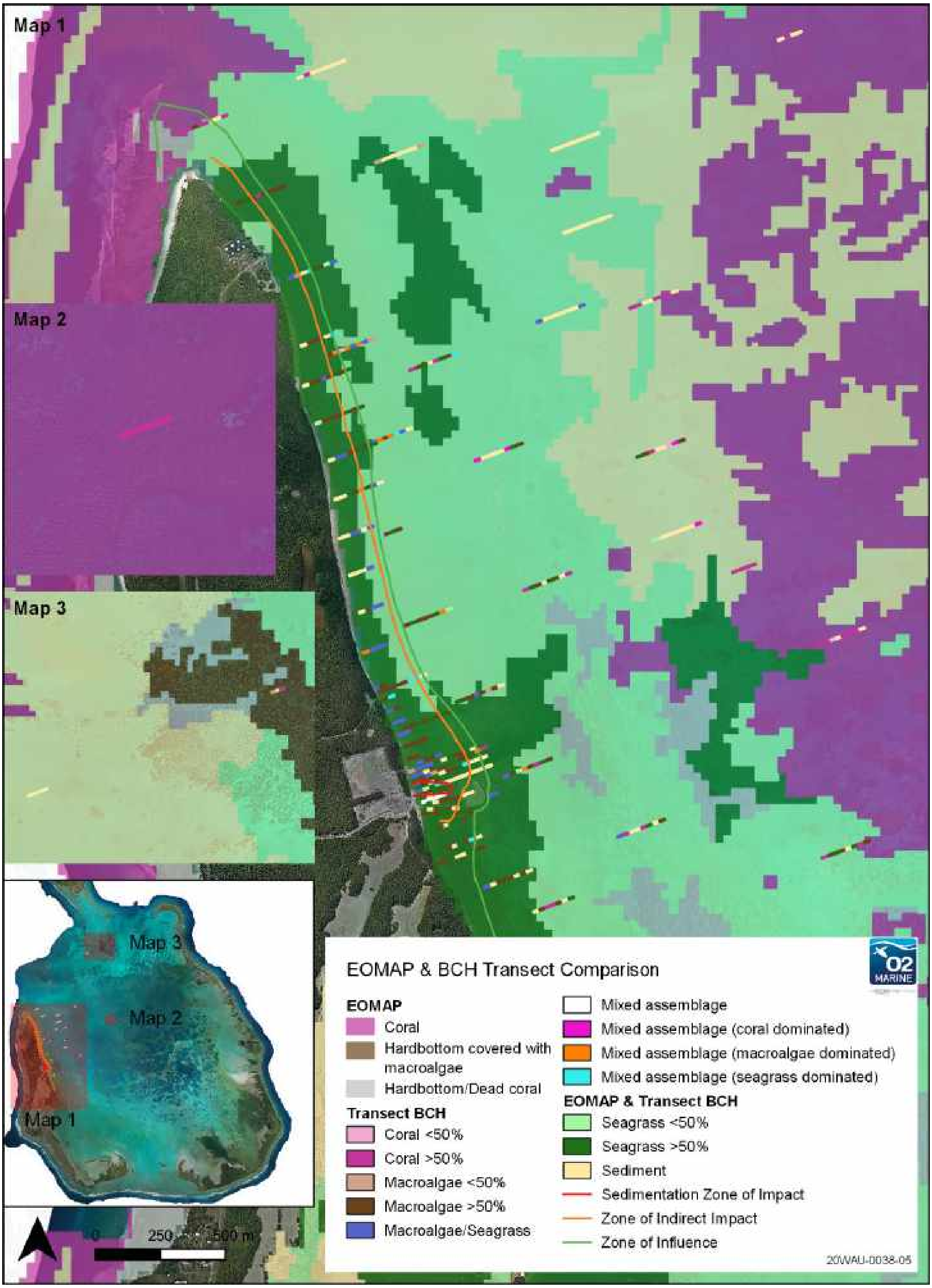

Figure 7: GHD EOMAP overlayed with O2M transect data

4. Discussion

The in-situ data collected and analysed lends itself to confirming the presence of some previously identified classifications of BCH substrate. The BCH seen along the project areas of impact and influence (both direct and indirect) and surrounding locations is indicative of inshore coral reefs found around CKI.

In general terms, the health of most types of BCH cover was deemed to be in a good condition, considering the regular marine traffic the areas is exposed to. High use areas are often prone to damage from vessels, anchors, propeller wash and associated sedimentation, as well as recreational swimming and diving. While there is data to suggest there is an impact from these detrimental activities, the health of the BCH substrate seen still remains high. The only locality where notable damage was seen was in the MOF area.

Acropora is a fast-growing species that are characterised by fine-structured, branching or tabular growth forms which tend to be more susceptible to bleaching and influences (WAMSI, 2017). This may explain the extent of *Acropora* debris, especially around the MOF footprint and Zone of Impact (Figure 8). Although it should be noted that *Acropora* reproduce through fragmentation, therefore the *Acropora* rubble should not be entirely discounted as an indicator of environmental stressors.

Porites was the second most dominant coral species observed within the entire study area (and was commonly observed in a singular massive form). *Porites* are less susceptible to environmental influence due to their massive and sub-massive growth formations in comparison to an *Acropora* branching or tabular formation (WAMSI, 2017). There were generally less damaged or stressed *Porities* in comparison to the *Acropora*. This may indicate that the more resilient coral species are generally not adversely affected by the current human influences in these areas.

Figure 8: Predominant *Acropora* rubble

Hard corals are especially susceptible to anthropogenic influences like propeller wash, and as filter feeders are also sensitive to the ensuing sedimentation that may create an inability to filter feed efficiently (Jones et al. 2020), therefore causing mortality. Construction impact modelling undertaken by GHD confirms that there is to be limited indirect impacts in terms of sedimentation loads on the BCH in relative proximity to the proposed MOF site (GHD, 2020).

Macroalgae, in comparison to coral and seagrass, are more resistant to harsh environmental conditions such as heavy sedimentation loads, increased current propulsion (i.e. from propeller wash) or changes in hydrology. Previous studies conducted by GHD detail the presence of *Caulerpa spp*. and its estimated density (GHD 2017). These previous studies align with the results obtained through this BCH study, as *Caulerpa spp*. is the most dominant of all macroalgae species at all sites (observed at every transect in the Zone of Indirect Impact). *Padina spp*. was also regularly identified throughout the same area. The more resilient nature of these macroalgae seen in these areas is likely a factor in their proportionally larger coverage in comparison to other BCH substrates (WAMSI, 2017).

There were four seagrass species identified throughout the survey, two different types of *Halophila* (*Ovalis* and *Decipiens*), *Halodule* and *Cymdocea*. These seagrass species were observed at regular intervals within all surveyed areas. A previous study undertaken by GHD details the average percentage cover of seagrass at 0% during the December 2014 and November 2017 benthic cover studies. This differs greatly from both the in-situ data collected during this survey and the EOMAP data from 2016. Seagrass meadows are known to be highly transient, with most species having the potential to reproduce and populate consolidated bare sediment substartes if conditions are suitable. The consolidated sediment within the lagoon therefore appears suitable for seagrass recruitment and development, assuming favourable environmental conditions (WAMSI, 2017a). Bare sediment identified in areas known to hold seagrass communities should be treated as potential seagrass substrate. Additional surveys undertaken during peak dry and monsoon seasons (this survey undertaken between the two seasons) would also allow for an improved understanding of the nature of the seagrass habitat.

During construction, it would be likely that less hardy species of coral, sponges and seagrass in the direct impact and indirect impact zone would be the most susceptible environmental receptors. However, most species found in these nearshore environments (where most of the elevated construction related suspended sediment is predicted) are fairly resilient to high level of suspended sediments which are naturally present. The high turbidity in this area was also noted during the field campaign (Figure 9).

Figure 9: Turbid water around the MOF

Visibility in inshore areas, particularly around the MOF, was a limitation. Due to the high turbididty within the area, species identification of seagrass and macroalgae was not attempted during data analysis. Density was still able to be accurately estimated at all locations. Figure 10 shows the limited visibility from the imagery recorded whilst surveying.

Figure 10: High turbidity levels within the MOF

Another limiting factor of the survey is that data towards the southern extent of the zones of influence and impact is limited due to a revision during the field campaign.

This survey's data is higher resolution and accuracy in terms of BCH classification categories than the EOMAP data. Through undertaking physical ground truthing, a more in depth understanding of health condition and broader spatial coverage and distribution of BCH has been established, than if the 2016 EOMAP data was solely relied upon. This is reinforced via habitat classification boundaries that the 2016 EOMAP did not accurately classify and thereby provide erroneous BCH distributions. For example, though location 68 in the EOMAP it is classified as coral, yet as pictured in Figure 11, the area is largely consolidated sediment. Furthermore, large nearshore areas of seagrass identified by EOMAP were shown to be present in much lower coverage percentages or not present at all (at least as a dominant substrate type).

Figure 11: Site 68 typical transect video data

This finer resolution of this survey's BCH classification allows an accurate estimation of the percentage of coverage by type within the MOF footprint, Zone of Impact (sedimentation), Zone of Influence and Zone of Indirect Impact. Using the interpolated data map (Figure 6) a key summary of BCH coverage percentage across the various areas is possible (Table 2).

Table 2: BCH percentage coverage across the various areas of potential impact

	Zone Footprint Area			
	MOF	Zone of Impact	Zone of Indirect Impact	Zone of Influence
Total Area (Ha)	1.9	0.09	33.35	27.72
Coral >50%				12.18%
Coral <50%				0.01%
Macroalgae >50%	29.30%		32.27%	31.14%
Macroalgae <50%	2.34%		0.89%	0.78%
Macroalgae/Seagrass	22.47%		26.87%	2.86%
Mixed Assemblages (coral dominated)				
Mixed Assemblages (macroalgae dominated)			1.72%	1.32%
Mixed Assemblages (seagrass dominated)	1.56%		3.55%	2.97%
Seagrass >50%	25.84%		10.35%	26.35%
Seagrass <50%	3.62%		1.26%	
Macroalgae/Seagrass - undefined			8.66%	17.22%
Sediment	14.87%	100.00%	14.43%	5.18%

In the 1.9 ha covered by the MOF footprint, macroalgae dominated substrate and bare sediment are up to 69% of cover, with the remaining 31% seagrass dominant substrate. The ZoIm is only comprised of bare sediment substrate with 100% cover. Its relatively small area is due to most of the ZoIm overlapping with the MOF footprint, and therefore accounted for in the MOF area rather than the ZoIn. The comparatively large 33.35 ha of the ZoII shows a similar composition, with 76% macroalgae dominated substrate and bare sediment. Seagrass dominated habitat covers 15% of the area, while 8% of the ZoII is predicted to be a combination of macroalgae and seagrass. The 27.7 ha of the ZoIn is the most diverse habitat in terms of BCH type coverage. Predominantly macroalgae and bare sediment substrate make up 41% of all BCH cover, seagrass dominated habitat is representative of 29%, while coral accounts for 12%. Undefined macroalgae and seagrass habitat makes up the remaining 17%.

The propose construction project, from an environmental perspective, should have low impact on key BCH habitat in the ZoII and ZoIn. The nearshore corridor that makes up the majority of the ZoII area is predominantly inhabited by macroalgae dominant substrate, which is much more resilient to increases in TSS than other types of BCH. TSS impacts to coral will be minimal as they only exists in small scattered mixed assemblage colonies within the ZOII. Of the coral that is found within the ZoII, *porites sp*. was the most common species, which has a high high natural resilience to increased sediment loads. It is unlikely that the majority of BCH outside of the MOF or ZoI will be permanently affected by the proposed construction.

5. Reference list

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