Supplemental Environmental Assessment Document

East Micronesian Cable (EMC) Project

Marine Benthic Ecological Assessment Shallow Waters Associated with the Lelu Harbor cable alignment - Kosrae

December 2019

Prepared by FSM CIU Safeguard Advisor - Marine Ecologist Specialist

Acronyms

BMH	Beach Man Hole
CIU	Central Implementing Agency
COT	Crown of Thorn Starfish
EMC	East Micronesian Cable
ESMP	Environmental and Social Management Plan
EMP	Environmental Management Plan
FD	Free Dive
FSM	Federated States of Micronesia
GPS	Global Positioning System
km	Kilometers
m	Meters
m^2	Meters squared
ME	Marine Ecologist
MPA	Marine Protected Area
SCUBA	Self Contained Underwater Breathing Apparatus
SD	SCUBA Dive
SA	Safeguard Advisor
TOR	Terms of Reference
WB	World Bank
WWII	World War Two
UXO	Unexploded Ordnances

List of Figures

List of Tables

2, 3, 4, 5 and 6) undertaken during the marine benthic substrate assessment within Lelu Harbor.

Table 3: Location (GPS), linear length (m), total area (m^2) and summary description of the six intertidal reef flat transect sites (TR 1, 2, 3, 4, 5 and 6) undertaken during the marine benthic assessment within Lelu Harbor.

Table of Contents

1.0 EXECUTIVE SUMMARY

The Government of Federated States of Micronesia (FSM) has received assistance from the World Bank through a grant "East Micronesian Cable" (EMC) project to provide a submarine telecommunication fibre optic cable to the state of Kosrae. The Kosrae cable will be a branch line connected to the EMC and enter the natural harbor of Lelu located on the eastern side of Kosrae Island.

This report provides a detailed assessment of the shallow water marine benthic ecosystem and resources associated with the agreed submarine cable deployment alignment for the island of Kosrae. The supplementary information detailed in this report is to be read in conjunction with the East Micronesian Cable (EMC) projects existing Environmental and Social Management Plan (ESMP) and as such information detailed in the ESMP is not repeated herein. Information detailed by this assessment has been incorporated as required into the projects original Environmental Management Plan (EMP) to further strengthen the environmental management of the submarine cable deployment.

A marine baseline survey assessment was undertaken on the marine benthic abiotic and biotic habitats (intertidal and subtidal) and marine resources (vertebrate and invertebrate) within and adjacent to the proposed submarine cable alignment entering Lelu channel and terminating at Sanskrit school on the southern side of Lelu harbor. The assessments undertaken were divided into three separate marine areas, which include:

a. The marine benthic assessment of the intertidal and subtidal benthic ecosystems associated with the reef systems adjacent to the proposed submarine cable alignment corridor which includes four free dives sites;
b. The marine benthic assessment of the sea substrate (floor) within the channel and harbor along the proposed submarine cable alignment corridor which includes the six SCUBA dives site; and
c. The marine benthic assessment of the intertidal reef flat ecosystems located on the northern and southern reefs adjacent to the Lelu harbor channel, which includes the six transect sites. This section also includes a brief description of the submarine cable proposed landing site.

The marine assessment was undertaken in November 2019 using a combination of SCUBA diving, free diving (snorkeling) and reef walking (transects) qualitative and quantitative benthic habitat and resource assessment scientific visual survey methods.

Six SCUBA dives were undertaken (maximum water depth 45 m) within Lelu harbor and channel which were located in close proximity of the proposed cable alignment. An area of 5 m^2 of the sea floor was assessed for each dive. Four (4) distinct intertidal and subtidal free diving marine reef areas were assessed in full. Free diving sites were undertaken on the southern and northern fringing reef systems associated with the Lelu channel and on the southern side of the patch reef located within the center of the harbor in close proximity to the channel covering a total combined assessed area of 3.74 hectares (ha). Six (6) benthic transects were undertaken from the shoreline to the outer reef edge, four and two transects undertaken on the southern and northern intertidal reef systems respectively within Lelu harbor. Total linear length of 1.4 km and a total area assessed of 0.56 hectare for all transect combined. All transects were undertaken during low water with the majority of the

reef system exposed during the assessment. In addition, the shallow water marine environment associated with proposed terrestrial land site was visually assessed.

The northern and southern coastal waters adjacent to the Lelu channel and outer harbor possess an extensive and dynamic intertidal and subtidal coral reef ecosystem. This includes an expansive shallow water intertidal reef flat that is exposed during low spring tides and contain extensive healthy sea grass beds, a distinctive outer reef crest and edge possessing spur and groove systems in the southern and northern outer reef margins and upper and lower reef slopes that posses a steep vertical decline through to the seabed. Within the Lelu channel the reef slope on the southern side is almost vertical with a distinctive reef wall. Significant and diverse hard coral percent coverage, morphological form and species abundance are found predominately on the reef edge through to the lower reef slope of all sites assessed. Higher hard coral species diversity, abundance and variety of morphological forms were recorded within the Lelu channel than within the harbor reef systems. These parameters decrease rapidly once the harbor is entered.

The benthic substrate associated with the proposed cable alignment within Lelu channel and southern side of the harbor is relatively homogenous and almost exclusively dominated by soft substrate sediment composed of coral sand and terrigenous fine silt. Levels of silt on the sea floor increase further into the Lelu harbor. The substrate is devoid of sessile invertebrates, however supports in areas a healthy population of mobile burrowing marine worms. The key marine assessment findings include:

The Marine Substrate (sea floor):

- The seabed substrate associated with the proposed submarine cable alignment path is relatively homogenous throughout the area assessed, has a range of water depth between 14 and 45 m and is characterized by a bottom layer of coarse sand derived from terrigenous and coral reef origins with a fine silt top layer.
- The presence of coral fragments, rocks and bounders associated with the sea floor within the proposed cable alignment direct area of influence are rare and most likely buried due to sedimentation deposition.
- The depth of the silt layer decreases towards Lelu harbor channel and is replaced predominately by sand towards the center of the channel and beyond, however fluctuations in the depth of the sediment sand silt layer and resulting water turbidity is directly related to tidal and weather conditions prevailing at any given time.
- The relatively high level of suspended silt and sand based substrate located at all assessment sites has a significant detrimental effect on the ability of sessile benthic marine resources to settle (recruit) and survive in these area.
- No sessile (non motile) benthic invertebrate species were recorded at any of the deepwater substrate dive assessment sites located within the proposed submarine cable alignment pathway.
- Mobile benthic invertebrates and vertebrates (including finfish) recorded very low population and species numbers throughout the areas assessed. Marine worm (Polycheate) burrows were located at all dive assessment sites. These invertebrate resources are highly mobile and adaptive to environmental disturbances. As such these invertebrates would be expected to relocate if the benthic substrate and sediment profile is impacted.
- Anthropogenic garbage, machinery parts and infrastructure equipment were located on the sea floor in all assessment sites.

- There is a possibility of Unexploded Ordnances (UXO) associated with the sea floor within the cable alignment pathway. The likelihood of their presences in unknown. Investigations should be undertaken.

The Reef Systems:

- There are no coral reef systems nor hard coral communities located within the projects direct Area of Influence.
- Coral reef systems are located within the projects potential indirect area of influence. These reef systems are healthy and maintain diverse invertebrate benthic resource assemblages and are located on either side of the Lelu channel, along the margins of the outer sections of Lelu harbor and patch reefs within the harbor and as such are adjacent to the proposed cable alignment.
- These coral reef systems include a distinct zonation; shallow water intertidal reef flat that is exposed during low spring tides (varying in width 75 m – 280 m either side of the channel), subtidal reef flat (varying in width 10 - 30 m), distinctive reef edge and crest (3-10 m width), and upper and lower reef slope (5-10 m width) which for the most part have a vertical drop of between 30 - 80% (the southern side of Lelu harbor is almost vertical wall) that terminates directly onto a sand silt dominated seabed with depths ranging between 8 m in close proximity to the BMH through depths in excess of 45 m within the Lelu channel.
- Coral fragments, rocks and boulders are located in close proximity to the reef systems. They are all but absent within the channel and harbor associated with the proposed cable alignments area of influence.
- All reef sites assessed possessed a well developed intertidal and shallow water subtidal coral reef ecosystem.
- Hard coral percentage live coverage, morphological form, species diversity and abundance in general were similar throughout the sites assessed reflected the natural environmental forces affecting the different reef locations. A general decrease in these coral parameters was recorded from the entrance to the Lelu channel through to the inner harbor.
- The channels southern reef system recorded higher hard coral percent coverage, species diversity and a larger range of morphological forms than the northern channel reef site. Both channel sites recorded considerably higher live reef parameter levels that those recorded within the harbor patch reef and southern harbor reef margins in close proximity to the cable landing site (BMH).
- The cable marine landing site is devoid of a hard coral reef system rather is dominated by a sand silt benthic substrate that does not support benthic sessile invertebrate or vertebrate populations.
- Hard coral percent live coverage for the northern and southern channel reef systems for the intertidal reef, reef crest and edge and reef slope varied between 0-2 % and 0–2%, 0-10 % and 0–25%, and 5-80 % and 10–50%, respectively. The patch reef assessed recorded 0-10%, 0-15%, 5-25% coverage for the above parameters.
- Hard coral sub massive and massive (e.g. Porities sp., Favites sp., Monitipora sp., Lobophyllia sp., Goniopora sp.) and to a lessor degree digitate (e.g. Acropora sp., Pocillopora sp., Porities sp.), small branching (e.g. Acropora sp., Pocillopora sp, Millepora sp), encrusting (e.g. Acropora sp., Echinophora sp., Turbinaria sp.) and solitary (e.g. Fungia sp. and Heliofungia sp.) morphological forms dominated the subtidal reef flat, reef edge, crest and upper and lower reef slope at all assessment sites.
- The large sub massive and massive hard coral “bommie or coral head” morphological forms (predominately Porities sp.) were abundant at all sites accessed with a number of large colonies in excess of 4 m circumference located along the southern channel reef slope.

- Both remnant and newly recruited hard coral colonies of varying sizes were located at all sites, albeit at a lower level within the patch reef, providing direct evidence of natural hard coral recruitment is active in these areas.
- There was an absence of soft corals at all sites assessed.
- The intertidal reef systems either side of the channel extending into the harbor possessed extensive and healthy sea grass beds dominated by two species (Enhalus acrorides and Thalassia hemprichii). No sea grass was recorded within the area of influence of the proposed submarine cable alignment.
- Marine macro algae density, coverage and diversity recorded low densities at all sites with the largest percent coverage recorded within the subtidal reef flat on top of the patch reef within the harbor. The dominant macro algae recorded at all sites was several species of calcium carbonate green algae (Halimeda sp.), whilst the patch reef possessed healthy densities of the green algae (Caulerpa racemosa) commonly known as sea grapes.
- The inner shoreline sections of Lelu harbor support an extensive and diverse mangrove forest, however these trees are well outside of the projects direct or indirect area of influence and no impacts are expected from the projects activities.
- Finfish population numbers and species diversity was low at all sites assessed. Species that were present were juveniles and include reef dwelling plankitvores (small fish), herbivores (e.g. Acanthuridae, Scaridae) and there was a noticeable lack of predator reef fish.
- Very low numbers of reef associated invertebrates (apart from corals) were recorded at all assessed sites. Those that were recorded have no or little subsistence or commercial value (e.g. non commercial sea cucumbers).
- Reasonable levels of rubbish (e.g. plastic and glass bottles), machinery and old equipment were located on the substrate throughout the marine areas assessed. These should be removed.
- Several adult individual Crown of Thorns starfish (COTS) and their distinctive hard coral feeding scars were located during the assessment. The southern reef system recorded the highest numbers (5), however as these species are cryptic and generally nocturnal it is likely that the population on these reefs is higher than recorded during the assessment.
- There was no hard coral bleaching, however there was small scale evidence of disease associated with the hard coral communities at both the northern channel reef and patch reef assessment sites.
- 5 marine green turtles (Chelonia mydas) were recorded swimming within the channel and outer harbor during the assessment. These individuals were sub adults and were most likely foraging on the reefs. These animals are highly mobile and as such they would not be negatively impacted during the deployment of the cable. There has been no recorded turtle nesting on the shoreline beach of Lelu harbor for well over 4 decades.
- There were no threatened, endangered or endemic hard coral species located during the assessment, nor any State, national or international endangered or protected species (apart from the turtle discussed above).
- There are no marine or coastal designated marine protected areas or areas of significant biodiversity within or in close proximity to the proposed submarine cable alignment. The patch reef assessed has been discussed by the state government as a potential site for fisheries management area but has yet to be formally designed. It is expected that the deployment of the submarine cable will have no direct or indirect impact on the benthic resources associated with this patch reef system.
- The proposed cable alignment will not impact any State or National sites of cultural, customary or heritage significance. The historical plane and vessel wrecks are located well outside the proposed cable alignment.

- The benthic substrate associated with the proposed cable alignment is dominated almost exclusively of sand and silt benthic substrate and as such the benthic habitat within the project direct area of influence can be considered to have very low habitat and ecological value to the marine ecological systems of Lelu harbor and surrounding marine ecosystem.

Potential Impacts: The impacts derived from the marine scope of works are expected to be very minor, localized to the immediate footprint of the works, and easily managed through standard engineering good practice mitigation measures. There are no threats to the area's marine and coastal biodiversity associated with the project. As such the potential impacts of the works on the marine environment are considered to be minor, temporary, mitigatable and overall insignificant.

Mitigation Measures: Recommended mitigation measures during the construction phase of the project should include; (i) Deploy silt curtain/s around the termination location (shoreline adjacent to the BMH) of the submarine cable during all construction and redevelopment activities to directly manage and reduce the dispersion of benthic substrate (silt) disturbed during construction, and (ii) Ensure due diligence when operating machinery during all work activities to prevent and manage petrochemical spillage and contamination of the waters associated with the project.

The overall potential impact of the works on the marine biological environment is expected to be minor, localized and overall insignificant provided standard mitigation measures associated with good engineering practice as identified above are implemented. Furthermore due to the nature of potential minor impacts of the scope of works it is recommended that no specific marine monitoring program is required other than close supervision of the works to ensure that the above recommended mitigation measures are implemented and effective throughout the marine construction works.

2.0 INTRODUCTION

2.1 Background

This report provides a detailed assessment of the shallow water marine benthic ecosystems and resources associated with the agreed submarine cable deployment alignment for the island of Kosrae. The supplementary information detailed in this report is to be read in conjunction with the East Micronesian Cable (EMC) projects existing Environmental and Social Management Plan (ESMP) and as such information detailed in the ESMP is not repeated herein. Information detailed by the assessment has been incorporated as required into the projects original Environmental Management Plan (EMP) to further strengthen the environmental management of the deployment of the cable.

The submarine cable will originate from a southern branch line from the Pohnpei to Kiribati cable line located to the northeast of Kosrae. The agreed submarine cable alignment for the island of Kosrae is to enter the natural deep water reef passage and channel through the islands outer barrier reef entering Lelu harbor and then follow the channel veering south and enter the shallow subtidal and intertidal waters on the southern side of the harbor. The cable will terminate on the southern shoreline at the Sanskirt school ($5^0$19'13.27N and $163^0$01'33.04E), which is located on reclaimed state government land (Figure 1).

Figure 1: Location of the Submarine Cable entering Lelu Harbor and terminating at Sanskrit School.

2.2 Marine Baseline Assessment

A marine biological and non-biological baseline assessment was undertaken on the marine biomes associated with the intertidal and subtidal reef habitats and benthic substrate within Lelu harbor and channel associated with the proposed cable alignment. The in water visual field assessment and benthic profile data provides supplementary biological baseline data for the projects ESMP and has been utilized to update the projects EMP and safeguard requirements for the construction phase of the project.

The marine assessment was undertaken in November 2019 using a combination of SCUBA diving (SD), free diving (FD - snorkeling) and reef walking (transects) qualitative and quantitative benthic habitat and resource assessment scientific visual survey methods.

Six (6) SCUBA dives, four (4) free dive areas and six (6) intertidal reef transect site assessments were undertaken and as such are described in separate results and discussions sections below.

The area assessed included the inshore marine environments located within an extended area of influence of the submarine cable predicted alignment all of which are associated with the natural Lelu channel and harbor. This included the outer barrier reef, outer and inner channel, subtidal and tidal lagoonal reef areas and the cables terminal location on the shoreline adjacent to Sanskrit School.

2.3 Methods

The marine resource and ecological assessment utilized standard and acceptable international marine biological methods (English et al., 1997) and was performed by CIU Safeguard Advisor (marine ecologist) with assistance from staff from the commercial dive company “Micronesia Eco-Divers” based in Kosrae (Figure 2).

Figure 2: Micronesia Eco-Divers staff involved in the marine assessment of the Kosrae Island cable alignment, Lelu Harbor.

Free diving (snorkeling) and SCUBA diving scientific visual survey methods were employed to assess and provide a general description of the shallow and deep water reef systems and benthic habitats/sea floor respectively, associated with the Lelu harbor. The marine assessment’s in-water field activities were completed between Tuesday the 12 and Thursday the 14th of November 2019.

The marine assessment included a qualitative and quantitative habitat and resource assessment of the existing coastal intertidal and subtidal marine environments associated with the Lelu harbor. Data collected included water depth, percent live coral cover, reef condition, dominant benthic forms, dominant hard coral genus and morphological forms, marine algae (turf, macro), sediment types and physical description including water movements/currents. Digital photos were taken of key biological features (biotic and abiotic) and a Global Positioning System (GPS) coordinates recorded for each dive location and reef system assessed.

In total, six SCUBA dives (SD 1-6, refer Figure 3) were undertaken during the assessment. All dives were undertaken within the Lelu harbor and channel and located within the proposed cable alignment throughout the harbor. Dive depths ranged from 14 m (SD 6) through 45 m (SD 5). The benthic SCUBA assessment included documentation (written and photographic) of the substrate and living resources within a 5 m^2 area in close proximity to the dives substrate entry point. There were no dives undertaken in the offshore area of the reef channel due to depths greater than safe diving limits.

Four (4) distinct intertidal and subtidal free diving marine reef areas (Free Dive 1 - 4) covering a total assessment area of 3.74 hectares (37,400 m^2) were assessed in full (refer Figure 3). Free diving sites were undertaken on the southern (FD 1 and 2), northern (FD site 3) reef systems associated with the Lelu channel and on the southern side of the patch reef located within the center of the harbor in close proximity to the channel.

The free diving assessments varied in water depth between 1-10 m. The shallow water assessments included documentation (written and photographic) of the reef benthic habitats for the subtidal reef flat, reef crest, reef edge and upper and lower reef slopes at all locations. The shallow water reef assessments were undertaken during low water on incoming tides to maximize water clarity. Total area surveyed in hectares for the four individual free dive site locations include: FD 1 (1.96), FD 2 (0.42), FD 3 (0.65) and FD 4 (0.71).

In addition, six (6) benthic transects were undertaken from the shoreline to the outer reef edge, four (1 - 4) and two (5 and 6) transects undertaken on the southern and northern intertidal reef systems respectively within the Lelu harbor (refer Figure 4). Linear length in meters and total area assessed (4 m width) were recorded for each transect. Table 1 provides the length and total area assessed for each transect. All transects were undertaken during low water with the majority of the reef system exposed during the assessment.

Table 1: Length (m) and area (m^2) of each transect undertaken during the marine assessment.

	TR1	TR2	TR3	TR4	TR5	TR6
Length m	500	280	320	70	70	160
Area m^2	2,000	1,120	1,280	280	280	640

Figure 3: The location of the marine assessment survey sites including the 6 Dive Sites (SD) and the 4 specific Free Dive intertidal and subtidal reef systems (red) in relation to the Lelu channel and proposed cable alignment (not to scale).

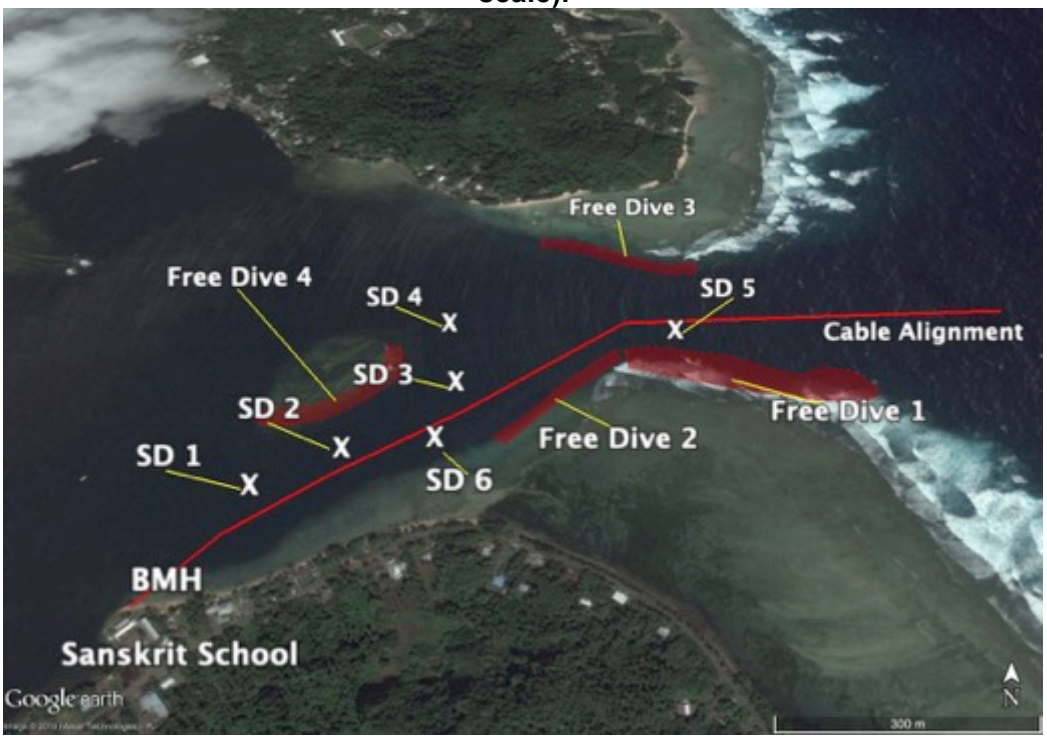
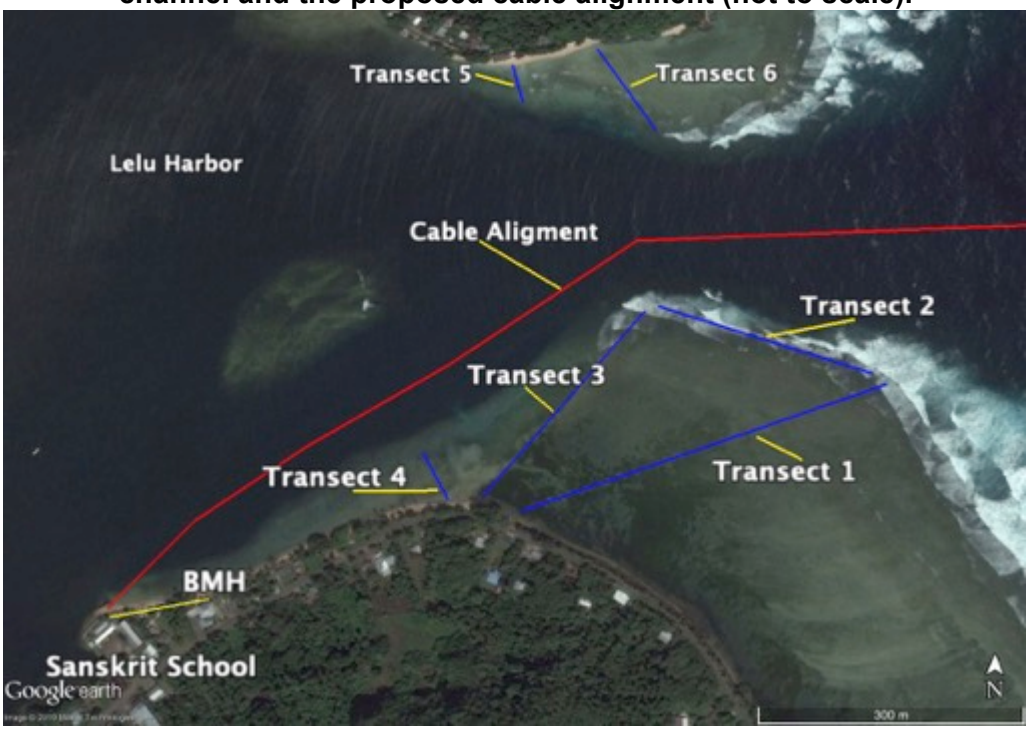


Figure 4: The location of the 6 intertidal reef transects in relation to the Lelu channel and the proposed cable alignment (not to scale).



The marine ecological and biological resource assessments are described for the Lelu harbor reef systems and benthic substrate habitat below.

3.0 MARINE SITE DESCRIPTION (GENERAL) OF THE LELU HARBOR

Lelu Harbor is located on the eastern side of the island of Kosrae directly adjacent and south of the small island of Lelu. The natural harbor is accessed through a deep water (averages depth greater than 50 m) natural reef pass that enters a small distinct reef channel (approximately 600 m in length and 200 m wide), bordered north and south by an intertidal fringing barrier reef system (average width of 230 m) that possess a vertical outer reef slope wall and opens into a tidal bay that covers an area of approximately 180 hectares (1.8 km^2).

Lelu harbor is boarded to the north by the small volcanic island of Lelu (includes the historic Lelu ruins), west by an extensive healthy mangrove system (predominately *Rhizophora sp.)* that includes a number of small freshwater streams and a distinct southern foreshore that includes isolated pockets of mangroves. A large stream system is located in the northern eastern corner of the harbor that up to recent times discharged and received oceanic water from an opening onto the reef north of the harbor. Several large patch reefs are located within the harbor that supports healthy hard coral communities on the top and reef slopes. Live coral coverage decreases considerable further away from the channel due to high levels of siltation and periodic freshwater inputs.

Lelu Island and the harbor's northern and southern foreshore areas have undergone extensive reclamation and alteration over the past century resulting in significant alteration to the natural environment, although the mangrove forests to the west remain relatively intact. The construction of a causeway between the island of Lelu and the mainland shoreline on the northern side of the island in the 1960's has greatly reduced the natural water circulation patterns within the harbor and as a result sediment deposition within the harbor especially either side of the causeway has been significantly altered. This has had a significant negative effect on the natural marine and coastal ecosystem within the harbor (Figure 5).

Figure 5: Natural ecological systems associated with Lelu Harbor.

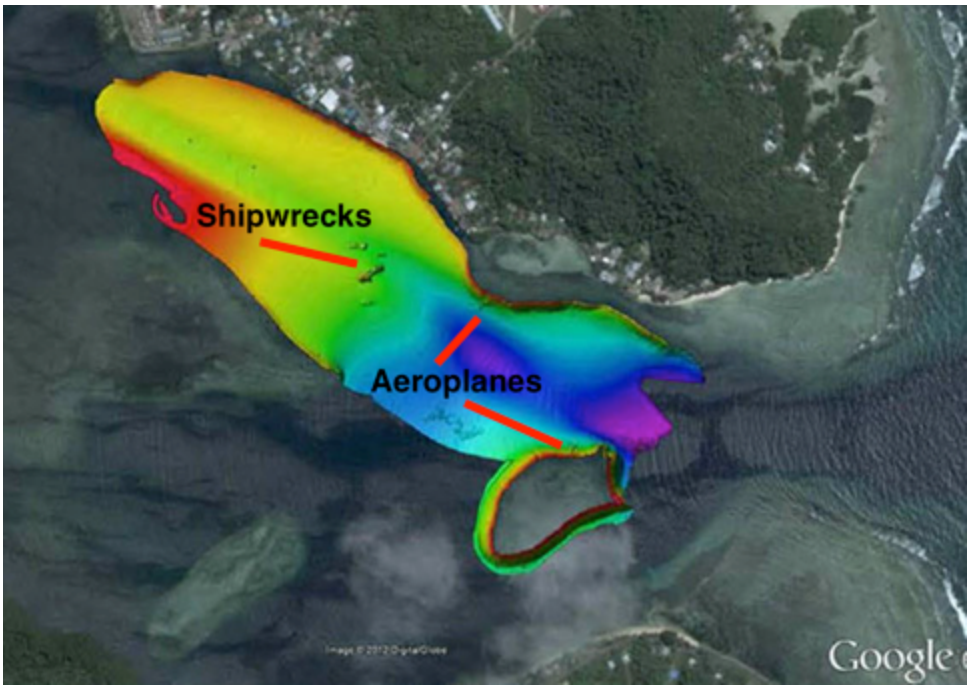
Lelu harbor has extensive coral reef systems throughout the outer portion of the bay, which slowly decreases further into the harbor and is replaced with sand and mud/silt associated with the mangrove areas. The harbors benthic substrate is predominately composed of sand-mud in all areas outside of the reef systems. The harbor is tidally influenced with an average daily tidal height fluctuation of 1 m.

Lelu harbor has no marine protected areas although the small subtidal patch reef in the center of the harbor has been discussed as a potential marine managed – fisheries protected area (refer Figure 5), however is yet to be finalized and gazetted.

A small concrete dock is located on the southern side of Lelu, which is used as a secondary dock for the state and services domestic vessel periodically (inter island vessels). Several permanent small boat moorings are located within the western portion of the harbor for visiting yachts however these are well outside the proposed area of influence of the submarine cable alignment.

The harbor includes three known shipwrecks, one of which was sunk in the mid 1830's (a whaler) and a second bombed and sunk during WWII, two aircraft and a range of anthropogenic debris. The shipwrecks and planes (Figure 6) are positioned on the northern side of the harbor and as such are outside of the proposed submarine cable alignment.

Figure 6: Bathymetric plate showing the location of the shipwrecks and planes within Lelu harbor.



During WWII Lelu Island and harbor shoreline was targeted by the US air force and reportedly received up to 40 tons of aerial bombs that resulted in extensive physical damage to the island itself with the harbor waterfront buildings, wharf and docks all demolished. 15 tons of bombs were dropped during a period of 8 days (17th- 24th) in February 1944. During this period it is reported that the Japanese cargo ship "Ebon Maru" was targeted within the harbor and sunk. This vessel remains were it was sunk within the harbor (refer Figure 6), northwest and well outside of the proposed submarine cable alignment.

Due to the WWII activities there is the potential that Unexploded Ordnances (UXO) resulting from WWII aerial bombing of Lelu Island and surrounding harbor waters may be present buried within the seabed. Due diligence needs to be undertaken when laying the cable to prevent inadvertent contact with UXO. Consideration of an UXO assessment of the final submarine cable alignment should be considered.

4.0 MARINE BASELINE ASSESSMENT – RESULTS

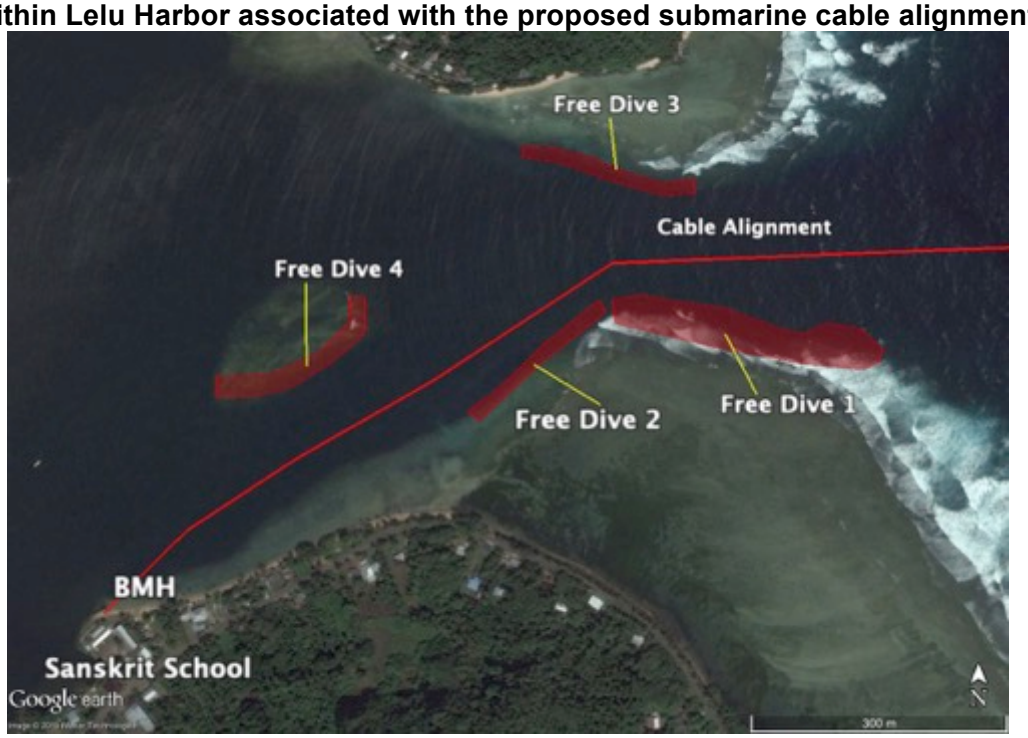
This section details the baseline survey results for the marine benthic habitat and resource (intertidal and subtidal) assessment undertaken within and adjacent to the proposed submarine cable alignment within Lelu harbor. The assessment results and discussions are divided into three separate sections, which include:

- Section 4.1, the marine benthic assessment of the intertidal and subtidal benthic ecosystems associated with the reef systems adjacent to the proposed submarine cable alignment corridor which includes four free dives sites;
- Section 4.2, the marine benthic assessment of the sea substrate (floor) within the channel and harbor along the proposed submarine cable alignment corridor which includes the six SCUBA dives site; and
- Section 4.3 the marine benthic assessment of the intertidal reef flat ecosystems located on the northern and southern reefs adjacent to the Lelu harbor channel, which includes the six transect sites. This section also includes a brief description of the submarine cable proposed landing site.

4.1 Lelu Harbor Intertidal and Subtidal Reef Marine Assessment

The information detailed below describes the biological (biotic) and non-biological (abiotic) marine resource baseline assessment survey undertaken on the reef systems to the south (Free Dive 1 and 2), north (Free Dive 3) of the Lelu channel and the small patch reef located west of the channel within the outer harbor (Free Dive 4) (Figure 7). These assessment sites fall outside of the projects direct Area of Influence, however are located within the proposed indirect Area of Influence and may be impacted, albeit at a low level by the project activities. As such there are no or limited expected significant environmental impacts on these reef systems and their resources associated with the proposed deployment of the submarine cable project.

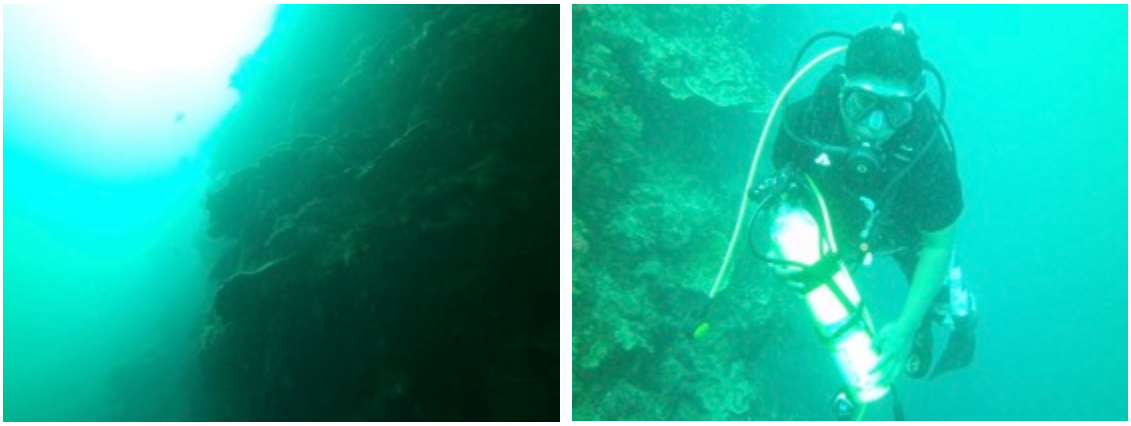
Figure 7: Location of the four Free Dive benthic marine assessment sites within Lelu Harbor associated with the proposed submarine cable alignment.



The northern and southern coastal waters adjacent to the Lelu channel and outer harbor possess an extensive and dynamic intertidal and subtidal coral reef ecosystem. This includes an expansive shallow water intertidal reef flat that is exposed during low spring tides, a distinctive outer reef crest and edge possessing spur and groove systems in the southern and northern outer reef margins and upper and lower reef slopes that posses a steep vertical decline through to the seabed. Within the Lelu channel the reef slope on the southern side is almost vertical with a distinctive reef wall (Figure 8). Hard and soft coral populations are found predominately on the reef edge through to the lower reef slope of all sites assessed. Higher hard coral species diversity, abundance and variety of morphological forms were recorded within the Lelu channel than within the harbor reef systems. These parameters decrease rapidly once the harbor is entered.

Five sub adult marine green sea turtles (*Chelonia mydas*) were located within the Lelu harbor (2) and the channel (3) whilst the assessment team was moving within the area during the marine assessment. It is suggested that these individual were actively foraging for food along the reef slope. Anecdotal information through literature search and personal communications indicated that no species of sea turtle has nested on the shoreline of the Lelu channel or harbor in recent times. It is reported that turtles have nested at these sites however form the information glean the last known case of a turtle nesting was in the late 1970 – early 1980's.

Figure 8: Southern reef slope wall located within the Lelu channel Free Dive Site 1.



Four distinct intertidal and subtidal free diving (snorkeling) marine reef areas (Free Dive 1, 2, 3 and 4) were assessed in full. The free diving assessments varied in water depth between 1-10 m and covered a total area surveyed of 3.74 hectares. The total areas surveyed in hectares for the four individual free dives site locations include: FD 1 (1.96), FD 2 (0.42), FD 3 (0.65) and FD 4 (0.71). These are described separately below.

4.1.1 Free Dive Sites 1 and 2

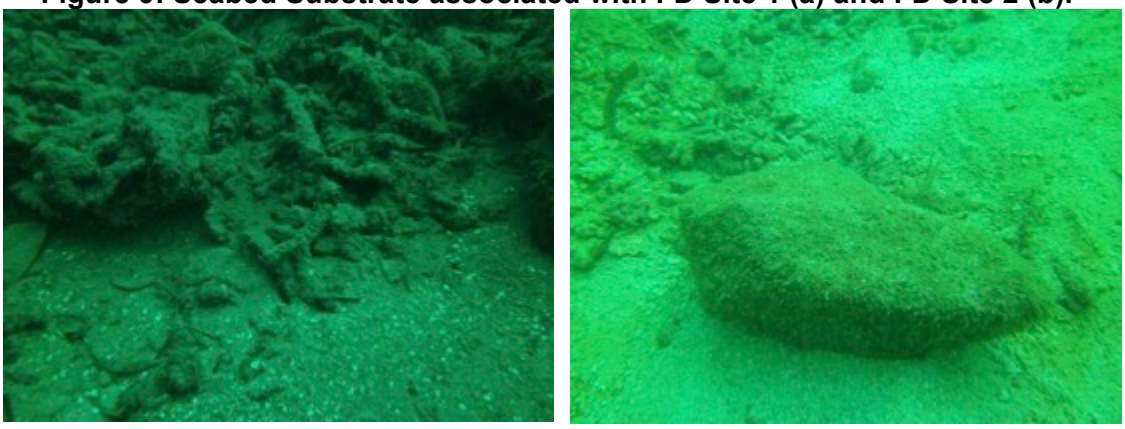
Free Dive Site Coordinates:
Site 1: (East: $5^0$19'25.97"N $163^0$02'05.94"E) (West: $5^0$19'27.57"N $163^0$01'54.04"E).
Site 2: (East: $5^0$19'27.32"N $163^0$01'53.50"E) (West: $5^0$19'22.01"N $163^0$01'47.66"E).

The southern side of the Lelu channel was divided into two assessment sites (FD Site 1 and FD Site 2) (refer Figure 7). FD Site 1 includes the subtidal reef area associated with the entire southern side of the Lelu channel, whist FD Site 2 is a

western extension of this site and includes the subtidal reef system located on the southeastern side of the inner harbor towards the submarine cable landing site.

The southern reef assessment sites include a distinctive intertidal and subtidal fringing coral reef system characterised by a benthic substrate profile that is relatively homogenous throughout the surveyed area. The sites include an expansive intertidal reef flat (refer section 4.3 for full assessment description) that is exposed during low spring tides, a small relative flat subtidal reef flat (10-20 m in width), a distinctive reef crest and reef edge (4-8 m in width), a short upper reef slope (4-8 m width) that has a steep descent (40-60 degree) which is more pronounced within FD Site 1 and a lower reef slope that continues steeply (almost a vertical wall in the outer sections of FD site 1 – towards the open ocean – refer Figure 8) that terminates directly onto a sand/slit/coral rubble dominated benthic substrate sea floor. Coral rubble and small coral fragments are located throughout the reef slope and directly below the living coral on the lower reef slope of both sites assessed, however due to high level of sedimentation associated with these sites it is envisaged that larger coral fragments deposited onto the sea floor during inclement weather conditions are covered (Figure 9). The subtidal reef system is more comprehensive and considerably deeper at FD Site 1 (40 m) than FD Site 2 (15 m). These reef zones support healthy hard coral communities, however hard coral diversity and percent coverage increases from west to east with highest hard coral results obtained towards the ocean side of the reef channel. Soft coral populations are noticeably scarce.

Figure 9: Seabed Substrate associated with FD Site 1 (a) and FD Site 2 (b).



FD Site 1 recorded considerably higher hard coral live coverage, coral diversity and morphological form diversity than FD Site 2. Resulting in remnant and newly recruited hard coral colonies and associated marine resources in this area.

The reef flat and deeper areas of the subtidal reef flat were all but devoid of hard coral colonies (only isolated small hard coral colonies were located), whilst the reef edge, crest and the upper and lower reef slopes recorded live hard coral coverage, diversity, abundance and diverse morphological growth forms throughout the reef areas assessed. In general, these parameters remained consistent throughout the areas assessed with the lowest parameters recorded in the western margins (FD Site 2) of the assessment sites within the harbor.

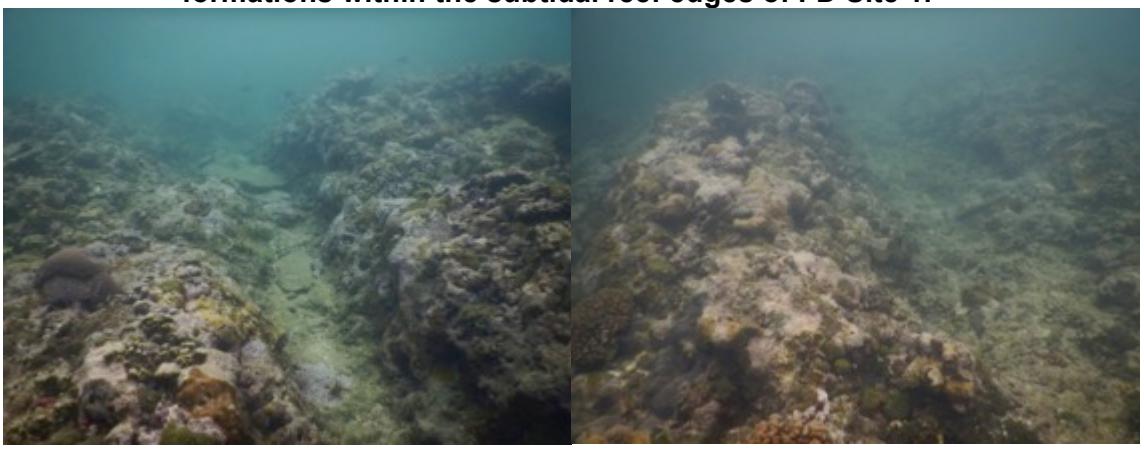
Hard coral percentage live coverage for all reef areas was considerably higher at FD Site 1 than FD Site 2 with the highest percent coverage and diversity of coral species recorded along the southern channel reef slope. Throughout both assessment sites a wide range of hard coral colony size was recorded and there were noticeable signs of different cohorts and species of small hard corals clearly indicating that natural

coral recruitment is occurring. A significant number of large massive coral heads (bommies) were recorded several in excess of 4-5 m circumference (Figure 10).

Figure 10: Examples of large massive hard corals located within FD site 1 and FD Site 2.

Live coral percent coverage associated with the inshore subtidal reef areas (reef crest and edge) for both sites ranged between 0 - 10 % for FD Site 1 and 0 – 2 % for FD Site B. Hard coral percentage coverage was recorded highest in areas that possessed the spur and grove reef formations towards the eastern side of FD Site 1 (Figure 11). In addition these areas recorded extensive areas of encrusting coralline algae coverage.

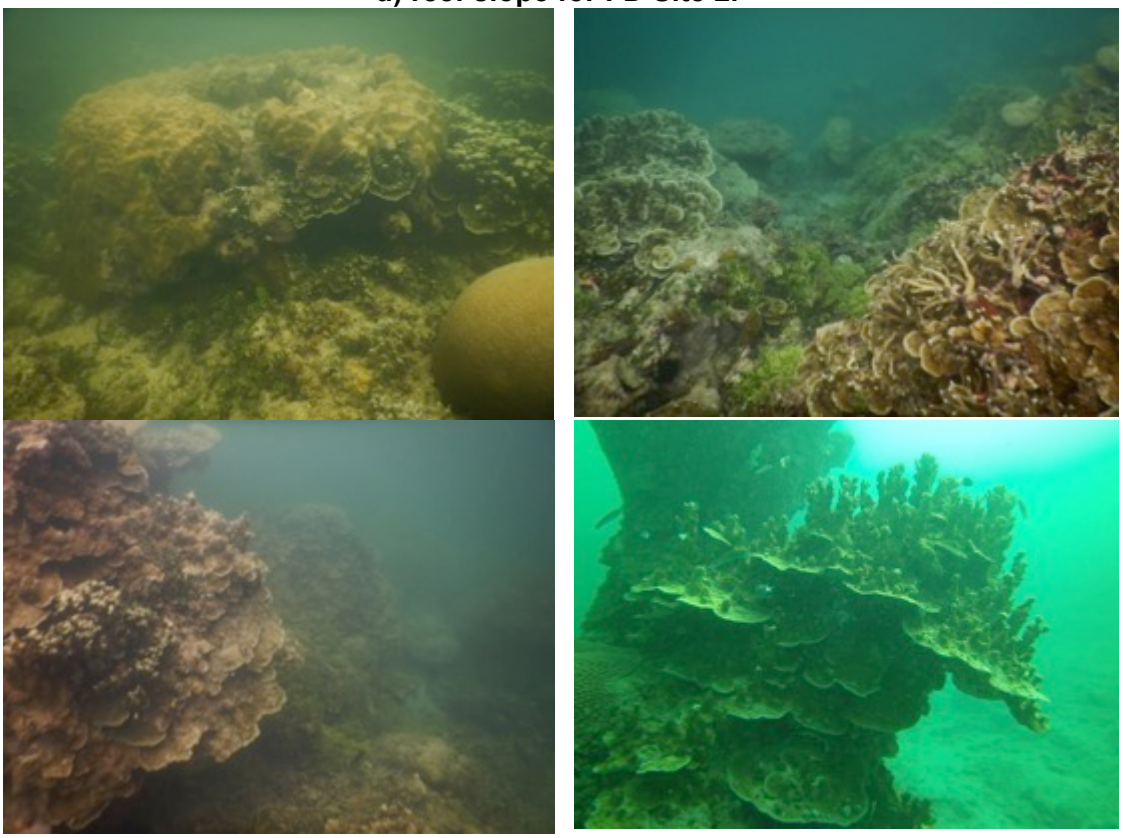
Figure 11: Hard coral colony examples located within the spur and groove formations within the subtidal reef edges of FD Site 1.



Hard coral live percentage coverage for the reef slope was considerably higher at FD Site 1 than FD Site 2. Live hard coral percent coverage associated with the upper reef slope (3-8 m water depth) ranged between 10 – 80 % for FD site 1 and 5 – 50% for FD Site 2, whilst hard coral percentage coverage for the lower reef slope (8- 20 m) ranged between 15-50% for FD Site 1 (Figure 12) and 5 – 35% for Free dive site 2 (refer Figure 13).

Figure 12: Hard coral live coverage for the subtidal upper (a & b) and lower (c & d) reef slope for FD Site 1.

Figure 13: Hard coral live coverage for the subtidal upper (a & b) and lower (c & d) reef slope for FD Site 2.



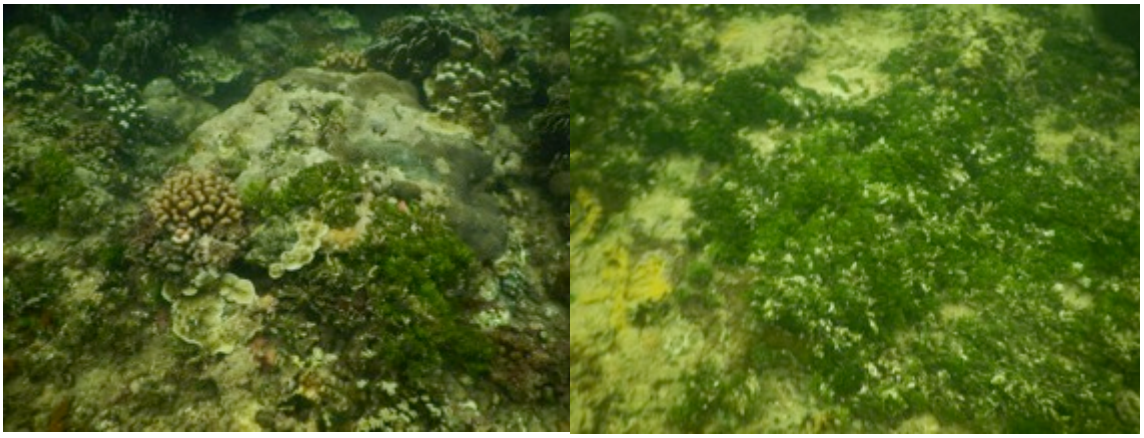
Hard coral morphological forms (size, structure) throughout both sites assessed were relatively homogenous and reflect the ecosystem parameters within the area. Hard coral species diversity and morphology remained similar in each of the reef zones throughout each of the assessment sites. Hard coral sub massive and massive (e.g. *Porities sp.*, *Favites sp.*, *Monitipora sp., Lobophyllia sp., Goniopora sp.)*, digitate (e.g. *Acropora sp., Pocillopora sp., Porities sp.*), small branching (e.g. *Acropora sp*., *Pocillopora sp, Millepora sp*), and to a lesser degree encrusting (e.g. Acropora sp., *Echinophora sp., Turbinaria sp.)* and solitary (e.g. *Fungia sp*. and *Heliofungia sp*.) morphological forms dominated the reef systems at both assessment sites. The large sub massive and massive hard coral "bommie or coral head" morphological forms (predominately *Porities sp*.) and to a lesser degree colonies of the branching fire coral *Heliopora coerulea sp*., (blue coral) (see Figure 12 b) increased abundance within the upper and lower reef slope at both sites (Figure 14).

Figure 14: Hard coral diversity located at FD Site 1 (a & b) and FD Site 2 (c & d).

Soft coral colonies (e.g. *Lobophytum sp*., *Sarcophyton sp., Sinularia sp.)* and anemones and their associated clown fish were rare at both FD sites 1 and 2.

Marine macro algae were located at both assessment sites predominately within the shallow marine waters associated with the reef crest, edge and upper reef slope. Macro algal population densities and species assemblages were similar at each site with a number of brown algae (*Sargassum* sp., *Padina sp*.), calcium carbonate green (*Halimeda sp.),* filamentous green, encrusting coralline algae and blue green algae were recorded at both sites (Figure 15). No sea grass or mangroves were associated with these sites.

Figure 15: Examples of marine macro algae located within the shallow reef areas associated with FD Site 1 and FD Site 2.



Finfish population numbers and species diversity was low with only a few individuals and species identified during the assessment. The absence of fish during the survey may be attributed to the time of the assessment and tidal height, however it may be a direct result of fishing pressure. Finfish species that were identified during the assessment were dominated by reef dwelling plankitvores (small fish) and herbivores (e.g. Acanthuridae, Scaridae) and there was a noticeable lack of predator reef fish. It is noted during the assessment that net fishing by local fishers (women) was undertaken.

Similarly, very low numbers of other invertebrates were recorded. Several mobile echinoderms were recorded including the sea urchin (*Diademia sp.*), several species of sea cucumber (*Actinopyga mauritiana* – surf red fish and *Bohadschia argus* – Tiger fish) (Figure 16 a & b), the coral predator crown of thorn starfish - COTS (*Acanthaster planci*) (Figure 16 c) and feather stars (Crinoids). Evidence of feeding scars both from the crown of thorn starfish and the small gastropod *Drupella sp*. were located at both sites assessed, albeit at low levels.

Very low numbers of mollusks (bivalves, gastropods, cephalopods) were recorded throughout the assessment site with only one small giant clams (*Tridacna maxima*) recorded for both sites. However, a number of juvenile and adult top shell herbivorous gastropod (*Trochus niloticus*) were recorded within the shallow reef edge and upper slope of FD site 1 (Figure 16 d).

The absence of predator finfish, the small size of individual finfish present and absence of subsistence and commercially valuable invertebrates indicates a high level of resource harvesting and/or an environment not conducive to support these resources. It is perceived that the former suggestion is currently operating within these reef areas.

Figure 16: Echinoderms (a, b & c) and Mollusks (d) located during the marine assessments of FD Site 1 and 2.

The marine benthic environment associated with the southern reef channel system entering the Lelu harbor contains anthropogenic rubbish and machinery (Figure 17) presumed to originate primarily from activities within and around Lelu harbor. FD Site 2 contained considerably more debris than FD site 1. A physical cleanup of this material in and around the channel and harbor is advisable to prevent further degradation of the marine environment.

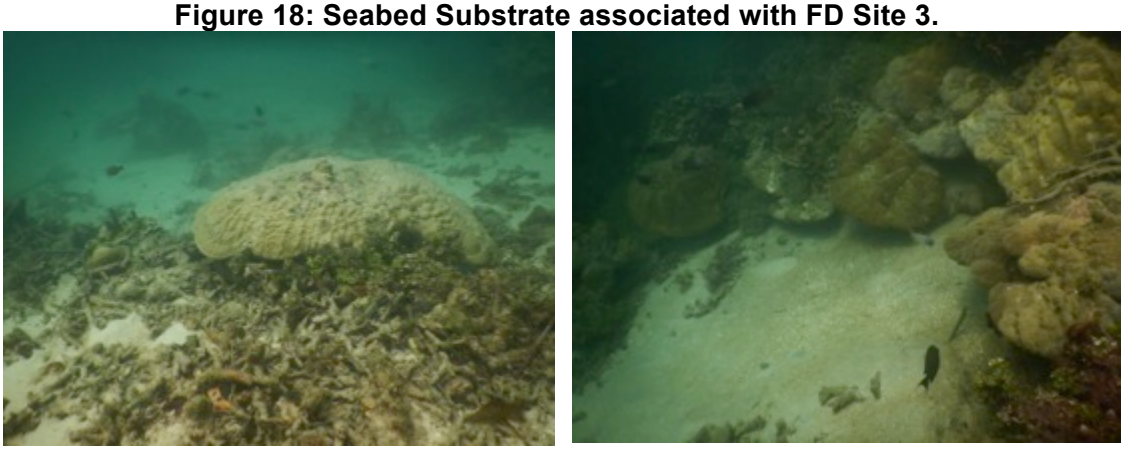
Figure 17: Anthropogenic material and garbage located during the marine assessment at FD Site 2.

4.1.2 Free Dive Site 3

Free Dive Site Coordinates:
(East: $5^0$19'33.75"N $163^0$01'58.34"E) (West: $5^0$19'35.81"N $163^0$01'49.88"E).

The northern side of the Lelu channel was assessed in its entirety (FD Site 3) (refer Figure 7) and includes the subtidal reef area associated with the entire northern side of the Lelu channel. This assessment included a distinctive intertidal and subtidal fringing coral reef system characterised by a benthic substrate profile that is relatively homogenous throughout the surveyed area. The site possess an expansive intertidal reef flat (refer section 4.3 for full assessment description) that is exposed during low spring tides, a small relative flat subtidal reef flat (5-8 m in width), a distinctive however small reef crest and reef edge (4-6 m in width), a short upper reef slope (4-6 m width) that descends (30-50 degree) into the lower reef slope that continues relatively steeply (40-70 degree) and terminates directly onto a sand/slit/coral rubble dominated benthic substrate sea floor. Coral rubble and small coral fragments are located throughout the reef system and directly below the living coral on the lower reef slope, however due to high levels of sedimentation associated with these sites it is envisaged that larger coral fragments deposited onto the sea floor during inclement weather conditions are covered (Figure 18). The subtidal reef system varies in depth west to east and ranges between 6 m towards the western side of the channel through to 10 m within the channel.

Figure 18: Seabed Substrate associated with FD Site 3.



The reef flat proper and deeper areas of the subtidal reef flat were all but devoid of hard and soft coral colonies (only isolated small hard coral (massive) colonies - were located within the subtidal reef flat areas), whilst the reef edge and the upper and lower reef slopes recorded significant live hard coral coverage, diversity, species abundance and diverse morphological growth forms throughout the reef area assessed. These reef zones support healthy hard coral communities with hard coral species diversity and percent coverage increasing from west to east with highest hard coral percent coverage results obtained towards the ocean side of the reef channel. The existing reef systems include remnant and newly recruited hard coral colonies and associated marine resources throughout this area. Soft coral populations are noticeably scarce.

Highest hard coral percent live coverage and species diversity for all reef areas assessed at this site were recorded within the upper and lower reef slope along the northern channel. Throughout the assessment a wide range of hard coral colony size, morphological form were recorded with noticeable signs of different age cohorts and species of small hard corals clearly indicating that natural coral recruitment is

occurring. A significant number of large massive coral heads (bommies) predominately *Porities sp*., were recorded, several in excess of 3 m circumference (Figure 19).

Figure 19: Examples of large massive hard corals located within FD site 3.

Live hard coral percent coverage associated with the inshore subtidal reef areas (reef crest and edge) for FD Site 3 ranged between 0 - 25%. Hard coral percentage coverage within these reef zones was similar throughout the assessment site and included hard coral massive, digitate and encrusting morphological forms (Figure 20).

Figure 20: Hard coral colony examples located within the within the subtidal reef crest and edges of FD Site 3.

Hard coral live percentage coverage associated with the upper reef slope (3-4 m water depth) reef areas ranged between 10–50 %, whilst hard coral percentage coverage for the lower reef slope (4-10 m) ranged between 10-45% for FD Site 3 (Figure 21).

Figure 21: Hard coral live coverage for the subtidal upper (a & b) and lower (c & d) reef slope for FD Site 3.

Hard coral morphological forms (size, structure) throughout FD Sites 3 were relatively homogenous and reflect the ecosystem parameters within the area. Hard coral species diversity and morphology remained similar in each of the reef zones. Hard coral digitate (e.g. *Acropora sp., Pocillopora sp., Porities sp.*), branching (e.g. *Acropora sp*., *Pocillopora sp, Millepora sp*), sub massive and massive (e.g. *Porities sp.*, *Favites sp.*, *Monitipora sp., Lobophyllia sp., Goniopora sp.)*, to a lesser degree encrusting (e.g. Acropora sp., *Echinophora sp.,*), foliase (*Turbinaria sp.)* and solitary (e.g. *Fungia sp*. and *Heliofungia sp*.) morphological forms dominated the reef systems throughout the assessment site (Figure 22). The large sub massive and massive hard coral "bommie or coral head" morphological forms (predominately *Porities sp*. and *Goniopora sp*.,) and to a lesser degree colonies of the branching fire coral *Heliopora coerulea sp*., (blue coral) increased abundance within the reefs upper reef slope.

Figure 22: Hard coral diversity located at FD Site 3.

Soft coral colonies (e.g. *Lobophytum sp*., *Sarcophyton sp., Sinularia sp.)* and anemones and their associated clown fish were rare at FD sites 3.

Marine macro algae were located throughout the assessment site predominately within the shallow marine waters associated with the outer sections of the subtidal reef flat, reef crest, reef edge and upper reef slope. Macro algal population densities and species assemblages included a number of brown algae (*Sargassum* sp., *Padina sp*.), substantial colonies of calcium carbonate green colonies (*Halimeda sp.),* filamentous green and blue green algae (Figure 23), whilst encrusting coralline algae were recorded only in the eastern end of the FD site. Higher population densities of coralline algae were recorded towards the wave action reefs to the north east of the assessment site. No sea grass or mangroves were located within this assessment site.

Figure 23: Examples of marine macro algae located within the shallow reef areas associated with FD Site 3.

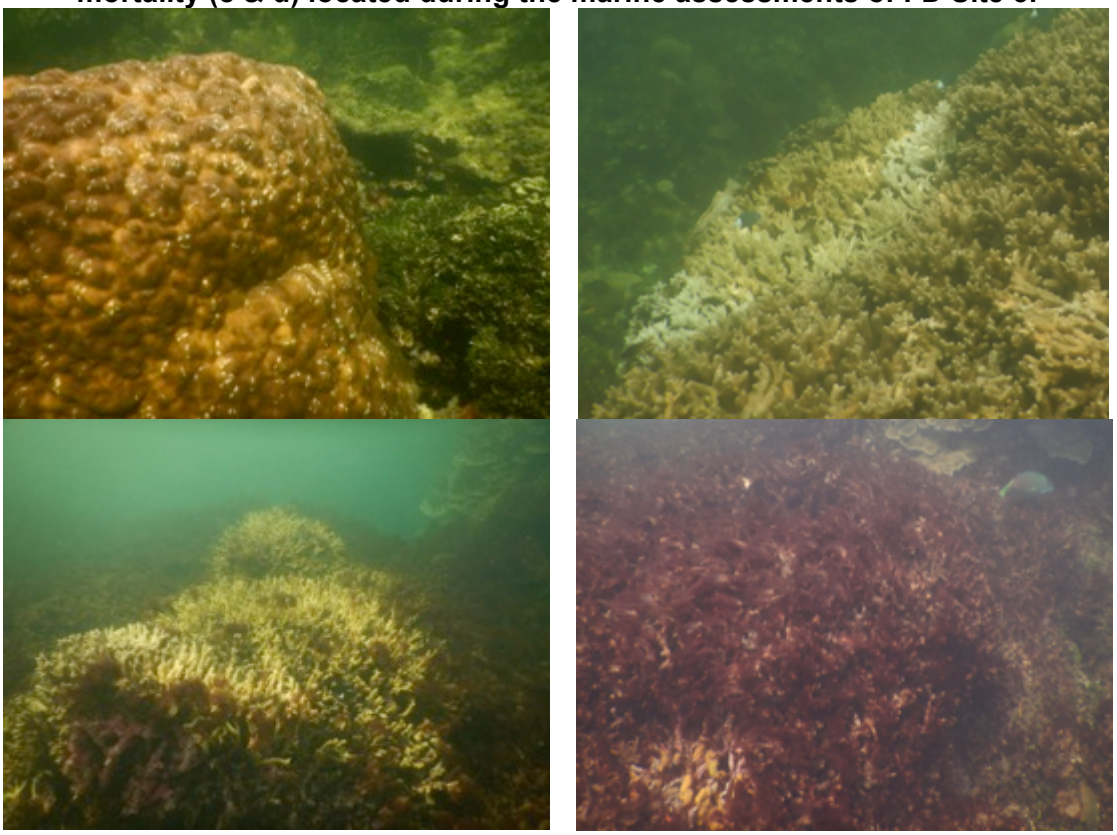
Finfish population numbers and species diversity was low with only a few individuals and species identified during the assessment. The absence of fish during the survey may be attributed to the time of the assessment and tidal height, however it may be a direct result of fishing pressure. Finfish species that were identified during the assessment were dominated by reef dwelling plankitvores (small fish) and herbivores (e.g. Acanthuridae, Scaridae) and there was a noticeable lack of predator reef fish. Feeding scars resulting from parrotfish (Scaridae) were noticeable on a number of massive boulder corals located within the assessment site indicating populations of these fish are present within the assessment area (Figure 24 a).

Very low numbers of marine invertebrates were recorded during the assessment. One individual sea cucumber was located (*Holothuria atra*) within the reef edge zone, evidence of feeding scars on branching hard corals of the coral predator Crown of Thorn Starfish - COTS (*Acanthaster planci*) (Figure 23 b) and one small octopi (*Octopus sp*.) and shell remnants of a benthic tropical bivalve (*Anadara sp*.).

The absence of predator finfish, the small size of individual finfish present and absence of subsistence and commercially valuable invertebrates indicates a high level of resource harvesting and/or an environment not conducive to support these resources. It is perceived that the former suggestion is currently operating within these reef areas.

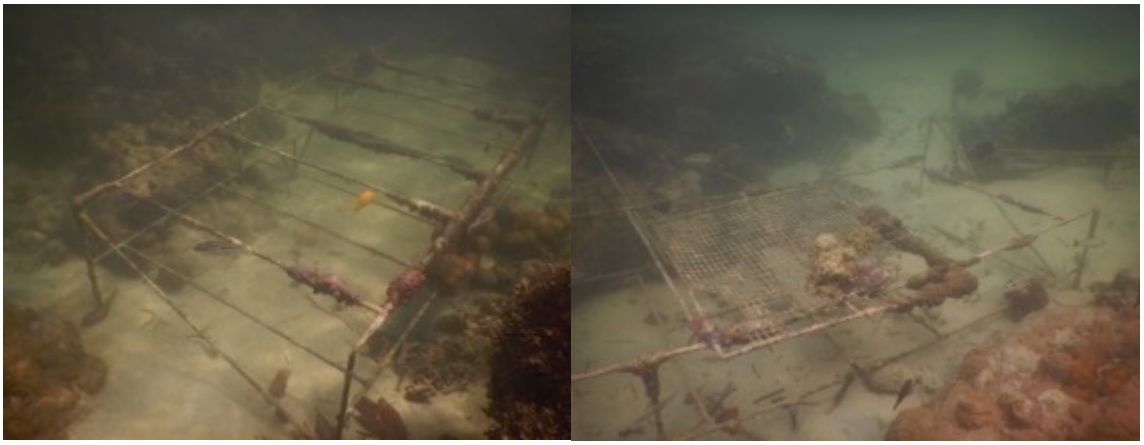
Evidence was located throughout FD Site 3 of hard coral mortality (recent and past events) predominantly associated with branching and digitate forms (Figure 23 c and d). There was no direct evidence of the cause of this mortality recorded.

Figure 24: Parrotfish (a) and COT starfish (b) feeding scars and hard coral mortality (c & d) located during the marine assessments of FD Site 3.



The marine benthic environment associated with the northern reef channel system entering the Lelu harbor contains anthropogenic rubbish (Figure 25 a & b) and decommissioned (abandoned) steel (re-bar) aquaculture structure's located within the upper reef slope (Figure 23 c & d) presumed to originate primarily from activities within and around Lelu harbor and past hard coral and clam growout nursery phases, respectively. A physical cleanup of the abandoned aquaculture structure should be undertaken taking care to remove and reposition the coral growing on thee structures.

Figure 25: Anthropogenic material, rubbish (a & b) and decommissioned aquaculture structures (c & d) located during the marine assessment FD Site 3.



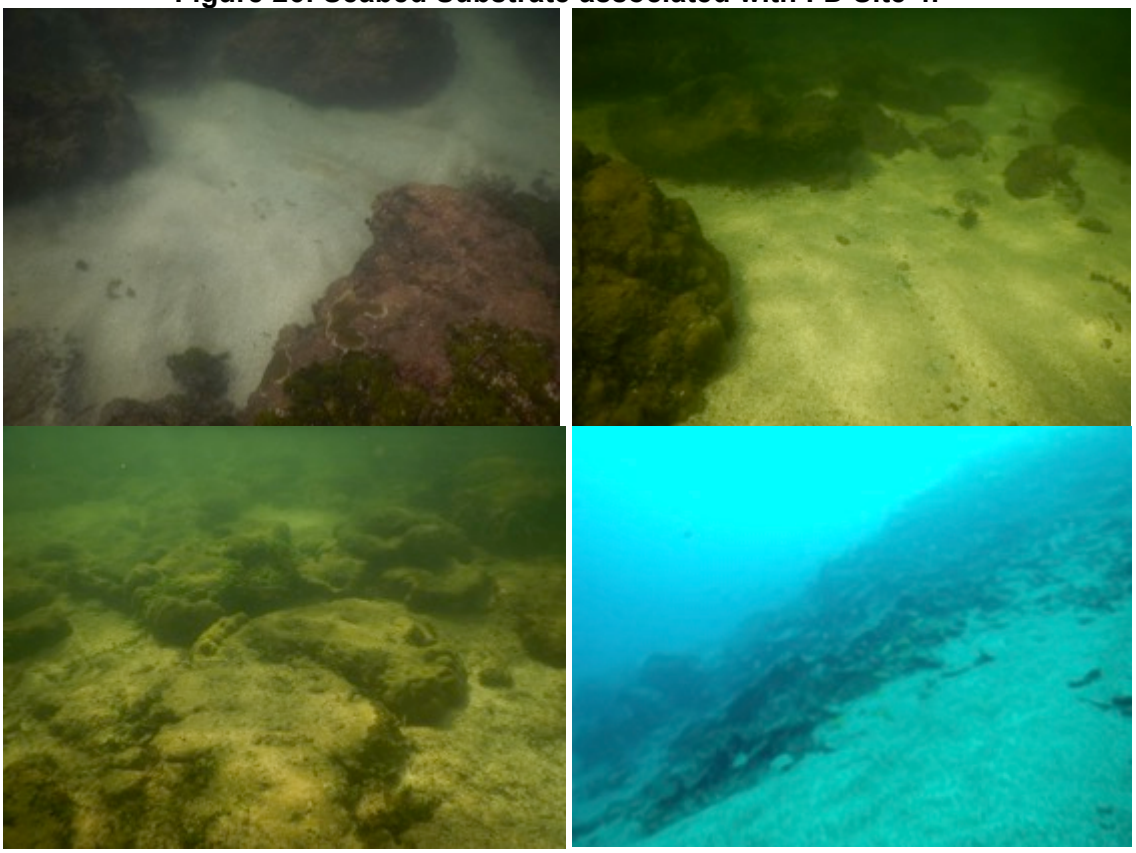
4.1.3 Free Dive Site 4

Free Dive Site Coordinates:
(East: $5^0$19'28.79"N $163^0$01'42.48"E) (West: $5^0$19'23.02"N $163^0$01'36.70"E).

The subtidal patch reef located directly west of the Lelu channel within the middle of the Lelu harbor (FD Site 4) (refer Figure 7) was assessed along its northeastern corner (open to the channel) and along the southern side of reef system. The assessment included a distinctive intertidal and subtidal patch coral reef system characterised by a benthic substrate profile that is relatively homogenous throughout the surveyed area. The site possess an intertidal and subtidal reef flat that is exposed partially during low spring tides located across the entire top of the patch reef, a distinctive however very small reef crest and reef edge (2-5 m in width) which in sections is difficult to identify, a short upper reef slope (5-8 m width) that descends (20-40 degree) into the lower reef slope (5-10 m width) that continues relatively steeply (40-70 degree) and terminates directly onto a sand/slit/coral rubble dominated benthic substrate sea floor. Coral sand, rubble and small to medium size coral fragments are located throughout all reef areas assessed and completely dominates all benthic habitats directly below the living coral on the lower reef slope (Figure 26). Higher levels of mud/silt (sediment derived from terrigenous origins) within the benthic substrate were located throughout the site when compared the FD Site 1 and 2, which reflects the water circulation patterns within Lelu harbor and their direct affect on this reef system. The subtidal reef system varies in depth west to east and ranges between 6 m towards the south western side of the patch reef channel through to 10-12 m on the north western end towards the channel.

This patch reef system has been assessed and identified by the Kosrae State government as a potential marine and fisheries managed area. Anecdotal information acquired during stakeholder discussions indicated that the reef system has yet to be official declared however, it is generally understood by the general fishing community of its pending status. The specific management regime to be declared was not located.

Figure 26: Seabed Substrate associated with FD Site 4.



The reef flat proper and deeper areas of the subtidal reef flat (on the top of the patch reef) had a very low number of hard colonies throughout the assessed areas (isolated colonies of sub massive and massive colonies), whilst the reef edge and the upper and lower reef slopes recorded a low level of live hard coral coverage, diversity, species abundance and diverse morphological growth forms throughout the reef area assessed. This assessment site recorded less hard coral species diversity, morphological form and percent coverage than FD Site 1, 2 and 3 within the Lelu channel. Nevertheless, these reef zones support healthy hard coral communities with hard coral species diversity and percent coverage increasing from west to east with highest hard coral percent coverage results obtained towards the ocean side of the patch reef. The shallow reef areas associated with the assessment site recorded health and a high percent coverage of a number of species of marine macroalgae. The existing reef systems include remnant and low levels of newly recruited hard coral colonies and associated marine resources throughout this area. Soft coral populations are noticeably scarce.

Highest hard coral percent live coverage and species diversity for all reef areas assessed were recorded within the upper and lower reef slope towards the south eastern margins of the patch reef – closest to the Lelu channel. Throughout the assessment a range of hard coral colony size and morphological forms were recorded with identifiable signs of different age cohorts and species of small hard corals indicating that natural coral recruitment is occurring.

Live hard coral percent coverage associated with the intertidal and subtidal reef flat (the top of the patch reef) for FD Site 4 ranged between 0 - 10%. Hard coral percentage coverage within these reef zones was similar throughout the assessment site and included almost exclusively sub massive hard coral massive morphological forms, predominately *Porities sp*. (Figure 27).

Figure 27: Hard coral colony examples located within the intertidal and subtidal reef flat of FD Site 4.

Live hard coral percent coverage associated with the subtidal reef areas (reef crest and edge) for FD Site 4 ranged between 0 - 15%. Hard coral percentage coverage within these reef zones was similar throughout the assessment site (Figure 28).

Figure 28: Hard coral colony examples located within the subtidal reef crest and edges of FD Site 4.

Hard coral live percentage coverage associated with the upper reef slope (3-4 m water depth) and lower reef slope were similar and ranged between 5 – 25 % for FD Site 4. Hard coral sub massive and massive morphological forms dominated the assessment areas, however small colonies of hard coral branching, digitate and encrusting forms were recorded (Figure 29).

Figure 29: Hard coral colony examples located within the subtidal reef slope systems for FD Site 4.

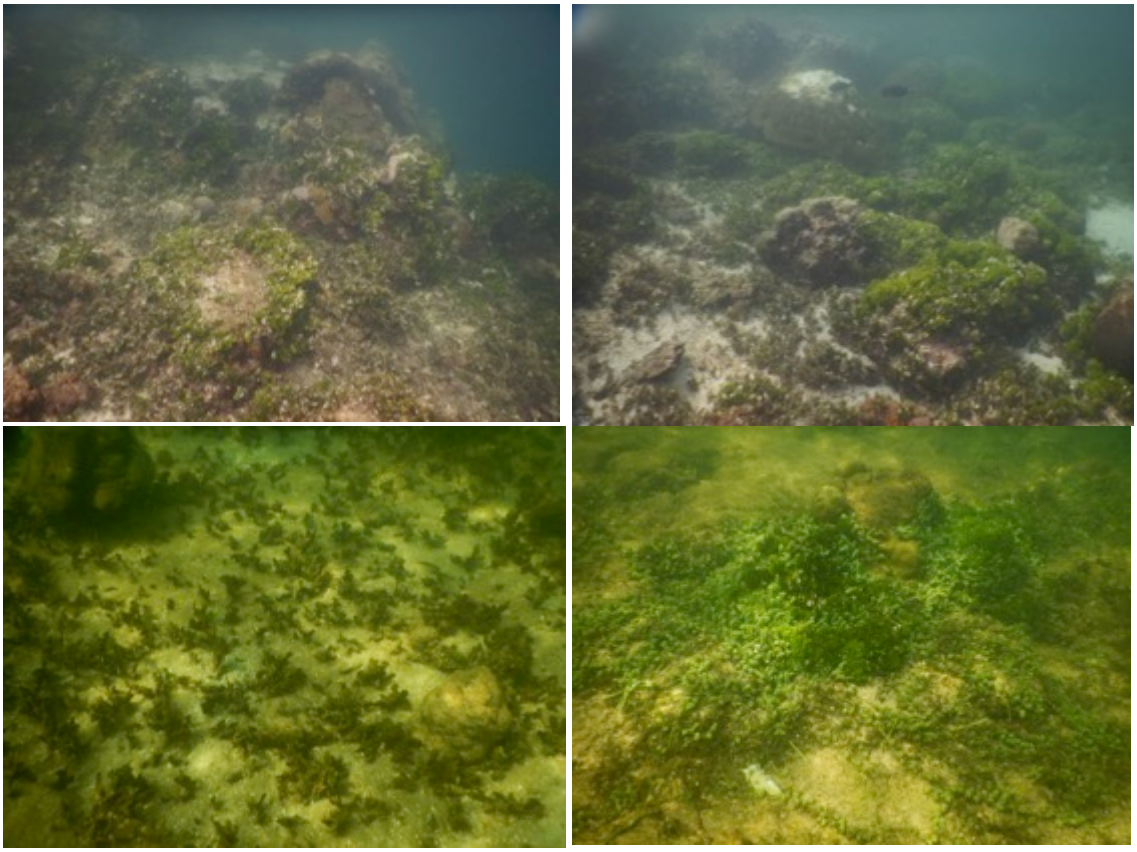
Hard coral morphological forms (size, structure) throughout FD Sites 4 were relatively homogenous and reflect the ecosystem parameters within the area. Hard coral species diversity and morphology remained similar in each of the reef zones. Hard coral sub massive and massive (e.g. *Porities sp.*, *Favites sp.*, *Monitipora sp., Lobophyllia sp., Goniopora sp.)* forms dominated all reef areas assessed. Their dominance is a direct result of the environmental parameters associated with this site. Limited numbers of hard coral digitate (e.g. *Acropora sp., Pocillopora sp., Porities sp.*), branching (e.g. *Acropora sp*., *Pocillopora sp, Millepora sp*) and solitary (e.g. *Fungia sp*. and *Heliofungia sp*.) morphological forms were located throughout the assessment site (Figure 30).

Figure 30: Hard coral diversity located at FD Site 4.

Soft coral colonies (e.g. *Lobophytum sp*., *Sarcophyton sp., Sinularia sp.)* and anemones and their associated clown fish were not recorded at FD sites 4.

Marine macro algae were located throughout the assessment site predominately within the shallow marine waters associated with the outer sections of the subtidal reef flat, reef crest, reef edge and upper reef slope. Macro algal population densities and benthic coverage were abundant throughout the site assessed with percent coverage ranging from 5 – 50%. Macroalgae species assemblages throughout FD Site 4 were dominated by several species of calcium carbonate green algae (*Halimeda sp.*) (Figure 31 a, b & c) and the green algae (*Caulerpa racemosa*) commonly known as sea grapes (Figure 31 d). Whilst brown algae (*Sargassum* sp., *Padina sp*.), filamentous green and blue green algae recorded low levels of abundance. No sea grass or mangroves were located within this assessment site.

Figure 31: Examples of marine macro algae located within the shallow reef areas associated with FD Site 4.



Finfish population numbers and species diversity was low with only a few individuals and species identified during the assessment. The absence of fish during the survey may be attributed to the time of the assessment and tidal height, however it may be a direct result of fishing pressure. Finfish species that were identified during the assessment were dominated by reef dwelling plankitvores (small fish) and herbivores (e.g. Acanthuridae, Scaridae) and there was a noticeable lack of predator reef fish.

Marine invertebrates numbers were extremely low during the assessment. Several individual sea starfish (*Linckia laevigata*) were located within the reef edge zone (Figure 32 a). There were no crown of thorn starfish - COTS (*Acanthaster planci*) located nor any commercial mollusk (e.g. gastropod snails – *Trochus niloticus* or bivalves - giant clams).

The absence of predator finfish, the small size of individual finfish present and absence of subsistence and commercially valuable invertebrates indicates a high level of resource harvesting and/or an environment not conducive to support these resources. It is perceived that the former suggestion is currently operating within these reef areas.

Evidence was located throughout FD Site 4 of hard coral mortality (recent and past events) (Figure 32 b) predominantly associated with sub massive forms resulting from environmental conditions (siltation - smothering) and recent death of section of coral heads (Figure 32 c and d). There was no direct evidence of the cause of this mortality recorded.

Figure 32: Starfish (a), hard coral mortality (b) and hard coral damage or disease located during the marine assessments of FD Site 4.

The marine benthic environment associated with the patch reef system contained limited anthropogenic rubbish, old machinery or physical damage of the reef from

human activities. The patch reef location within the Lelu harbor may reduce the chance accumulation of waste material due to the natural water circulating patterns.

4.2 Benthic Dive Site Assessments (DS 1, 2, 3, 4, 5, and 6) within Lelu Harbor and its Reef Channel.

The deeper water subtidal biological and non-biological marine benthic resources and environment located within Lelu Harbor (southern side) and its channel associated with the proposed submarine cable alignment were assessed using SCUBA. Dive depths ranged from 14 m (SD 6) through 45 m (SD 5). The outer reef channel descends rapidly to significant oceanic depths.

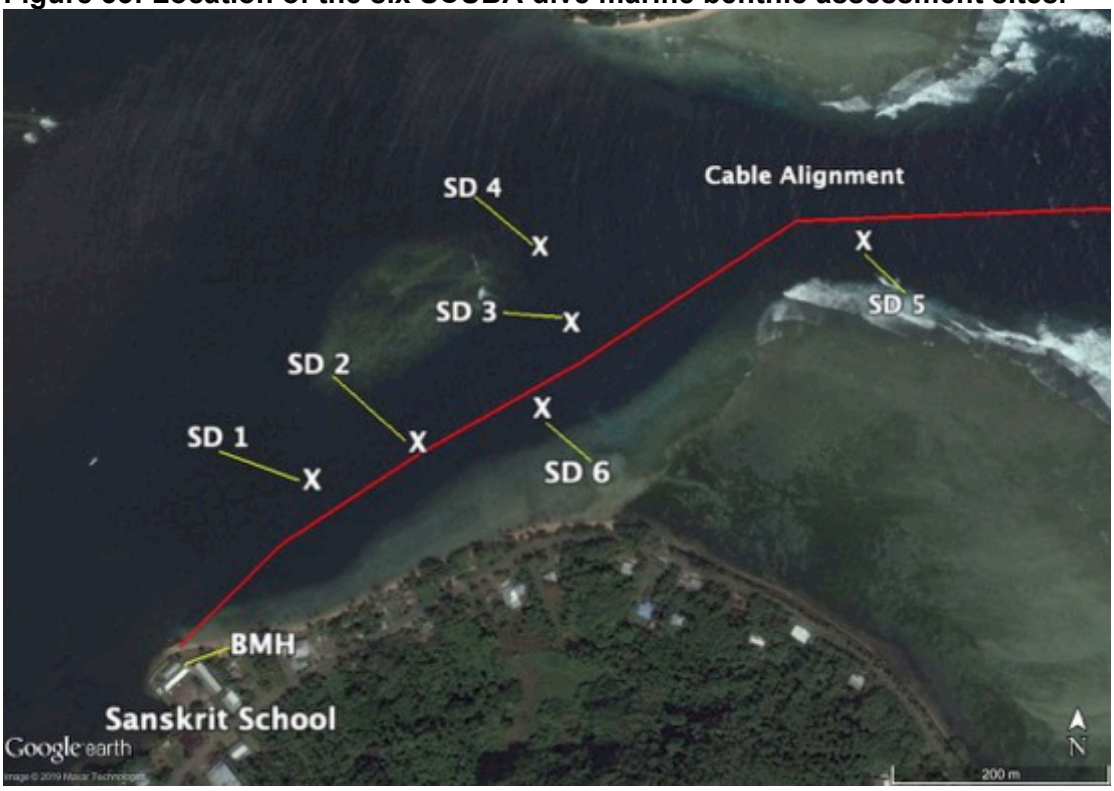
In total, six SCUBA dives (SD 1, SD 2, SD 3, SD 4, SD 5 & SD 6) were undertaken along the proposed submarine cable alignment within the projects Area of Influence. Table 2 provides the GPS location and general description of each dive assessment site. Figure 33 shows the location of the dive sites.

Table 2: Location and summary description of the six SCUBA Dive Sites (SD 1, 2, 3, 4, 5 and 6) undertaken during the marine benthic substrate assessment within Lelu Harbor.

SCUBA Dive Site 1	$05^0$19'32.7'N $163^0$01'59.7'E. ➢ Located inside and on the southern side of the Lelu harbor to the south in close proximity to the proposed cable landing site. ➢ Maximum depth of dive 20 m.
SCUBA Dive Site 2	$05^0$19'35.1'N $163^0$01'67.2'E. ➢ Located inside and on the southern side the Lelu harbor to the south directly adjacent to the south western end of the small reef located within the harbor in close proximity to the proposed cable landing site. ➢ Maximum depth of dive 15 m.
SCUBA Dive Site 3	$05^0$19'40.0'N $163^0$01'76.9'E. ➢ Located inside and on the southern side of Lelu harbor adjacent to the eastern end of the small reef located within the harbor towards the main channel. ➢ Maximum depth of dive 23 m.
SCUBA Dive Site 4	$05^0$19'48.2'N $163^0$01'75.0'E. ➢ Located inside of the Lelu harbor directly in front of the small reef located within the harbor towards the main channel. ➢ Maximum depth of dive 33 m.
SCUBA Dive Site 5	$05^0$19'45.6'N $163^0$01'87.3'E. ➢ Located inside of the Lelu harbor within the channel. ➢ The dive undertook a rectangle pathway covering a considerable area from the reef lower slope through to the sea floor. ➢ Four GPS locations points were recorded, these include: the start ($05^0$19'45.6'N $163^0$01'87.3'E), directly adjacent and into the channel ($05^0$19'47.8'N $163^0$01'87.8'E), northward parallel to the reef edge ($05^0$19'49.8'N $163^0$01'89.9'E) and southwards to the base of the lower reef slope ($05^0$19'46.4'N $163^0$01'96.6'E ➢ Maximum depth of dive 45 m.
SCUBA Dive Site 6	$05^0$19'36.3'N $163^0$01'75.5'E. ➢ Located inside and on the southern side of Lelu harbor adjacent to the southern shoreline within the harbor towards the main channel.

	➢ Maximum depth of dive 14 m.

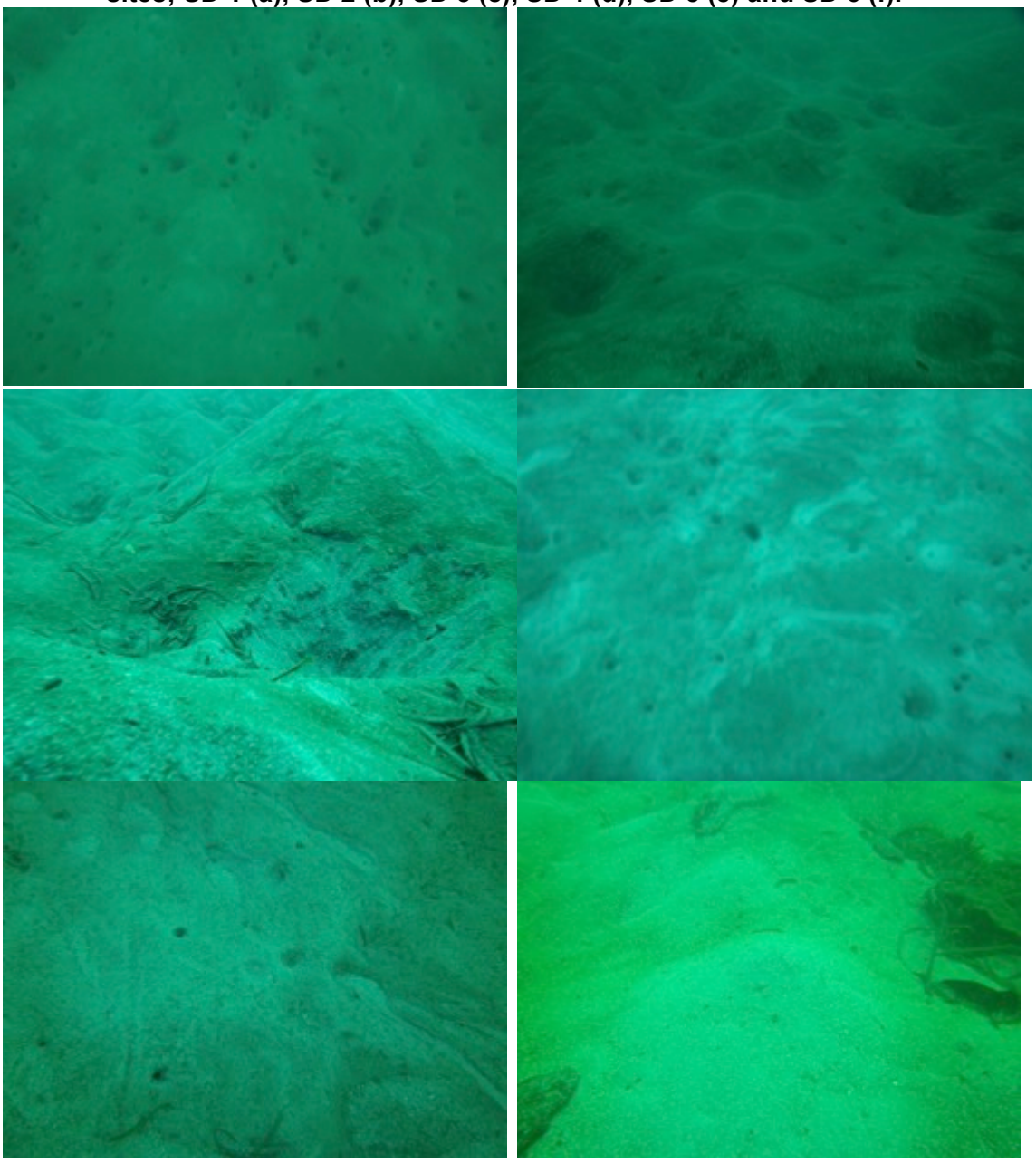
Figure 33: Location of the six SCUBA dive marine benthic assessment sites.



The subtidal seabed benthic substrate descends gradually from the western side of the harbor towards the channel (east) and beyond and is boarded by a distinct intertidal short and relatively steep reef slope dominated by hard corals to the sea floor towards the channel.

The seabed substrate is relatively homogenous throughout the assessed sites and is characterized by a bottom layer of coarse sand and silt derived from terrigenous and coral reef origins with a noticeable top layer of fine sediment - silt (Figure 34). The fine layer of terrigenous sediment (silt) decreases towards the channel (west to east) and is replaced predominately by sand towards the center of the channel and beyond. However, fluctuations in the depth of the sediment layer and resulting water turbidity is directly related to both tidal and weather conditions prevailing at any given time, with significant increases in water turbidity and sediment deposition during out going tides associated with heavy rainfall (discharging from streams).

Figure 34: Representative benthic substrate photos of the six dive assessment sites; SD 1 (a), SD 2 (b), SD 3 (c), SD 4 (d), SD 5 (e) and SD 6 (f).

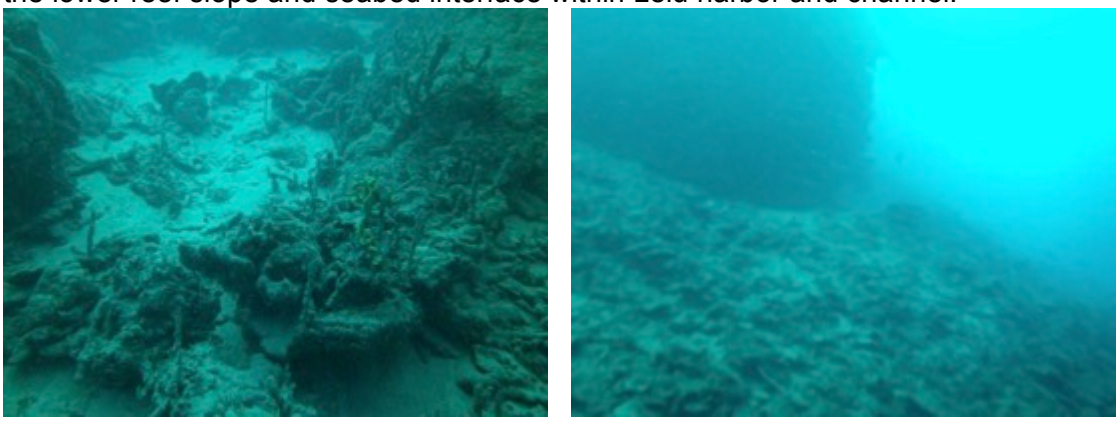


The prevalence and relatively high level of suspended silt and sand based substrate (refer Figure 33) located at all deep water assessment sites has a significant detrimental effect on recruitment and survival of sessile benthic marine life. Resulting in no sessile benthic invertebrate species (e.g. hard and soft corals) recorded at any of the dive assessment sites directly attached to the substrate. Similarly, there was a general absence of seafloor surface mobile benthic sedentary invertebrates (e.g. mollusks, crustaceans, echinoderms). Burrowing marine worms (polychaetes) were present at all dive sites assessed, albeit in low population numbers. Finfish were absence at the sea floor for all assessment dives. These animals are highly mobile and are expected to periodically and continually move through this area. The paucity of hard substrate excludes those finfish species that require reef protection.

Coral rubble and/or fragmentation (up to 0.2 m diameter) were not recorded at any of the dive sites benthic assessment site locations, however were recorded at all sites

in close proximity to the lower reef slopes with increased presences within the channel at shallow depths (Figure 35).

Figure 35: Representative benthic coral rubble and reef fragments associated with the lower reef slope and seabed interface within Lelu harbor and channel.



Of note, a small number of large (4 plus meter circumference) *Porities sp.* coral heads were located at depths of 30-40 m at SD 5 within the southern side of the Lelu channel. In addition a larger number of remnant in situ coral heads (bommies) were recorded possibly indicating evidence on increased sedimentation and turbidity levels in more recent times resulting in the death of these large and old corals (several hundreds of years in some cases).

The deepwater benthic substrate associated with the proposed submarine cable alignment is essentially devoid of coral reefs and associated resources. Coral sand and a fine layer of silt dominate the substrate throughout the area of influence within Lelu Harbor and channel. There are no marine or coastal designated protected areas or areas of significant biodiversity, endangered, threatened, endemic or critically important species or habitats within the projects direct area of influence and the area does not possess any sites of cultural, customary or heritage significance.

It is however noted that through anecdotal information (literature review and stakeholder discussions) there is the potential that unexploded ordnances (UXO) resulting from WWII aerial bombing of Lelu Island and surrounding harbor may be present in the seabed. Due diligence is required when laying the cable needs to be undertaken to prevent inadvertent contact with UXO.

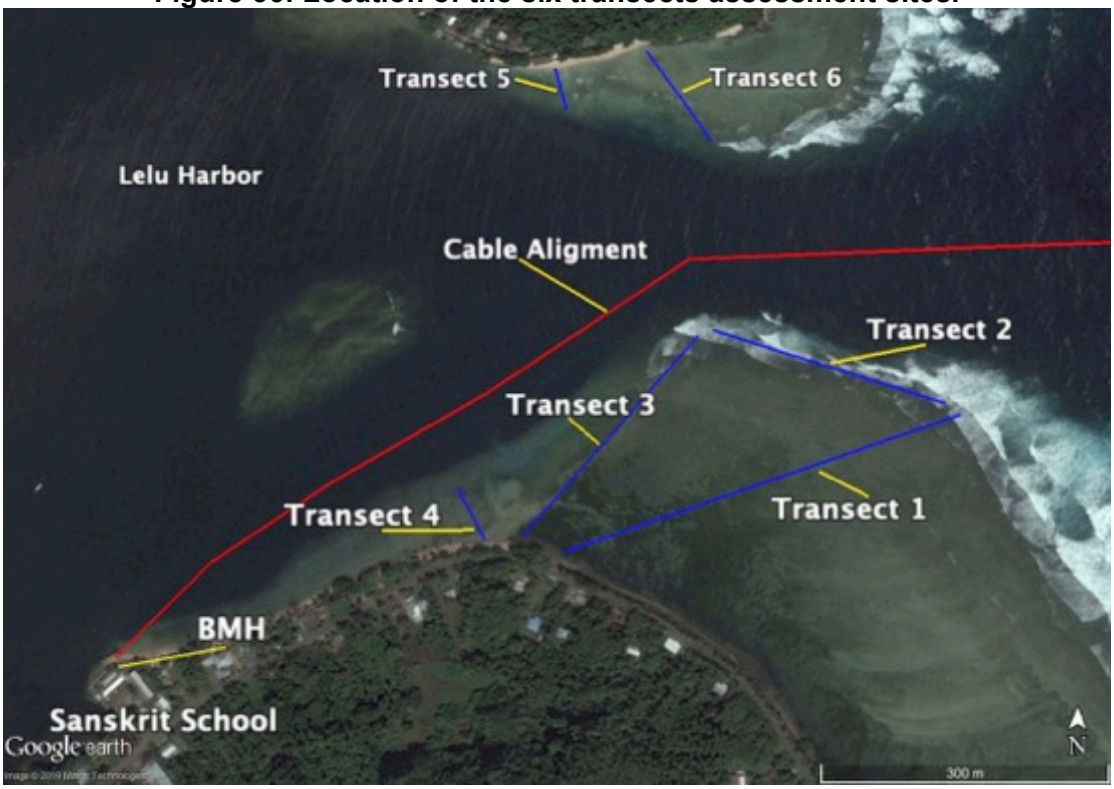
4.3 Benthic Reef Flat Transect Assessment Sites (TR 1, 2, 3, 4, 5, and 6) either side of Lelu Harbor Reef Channel.

The shallow water intertidal reef flat biological and non-biological marine benthic resources and environment located either side of the Lelu Harbor channel (northern and southern sides) were assessed utilizing standard benthic transects. A total of Six (6) benthic transects were undertaken from the shoreline to the outer reef edge, four (TR 1 - 4) and two (TR 5 and 6) transects undertaken on the southern and northern intertidal reef systems respectively within the Lelu harbor and all are adjacent to the proposed submarine cable alignment. All transects were undertaken during low water with the majority of the reef system exposed during the assessment. All transects had an assessment total width of 4 m. Table 3 provides the start and finish GPS location, linear length (m), total area (m^2) assessed and a general description of each transect assessment site. Figure 36 shows the location of the six transect assessment sites.

Table 3: Location (GPS), linear length (m), total area (m^2) and summary description of the six intertidal reef flat transect sites (TR 1, 2, 3, 4, 5 and 6) undertaken during the marine benthic assessment within Lelu Harbor.

Transect Site 1	Start: $05^0$19'17.58'N $163^0$01'48.95'E. Finish: $05^0$19'22.79'N $163^0$02'04.23'E. ➢ Length 500 m with an assessment area of 2,000 m^2. ➢ Located on the southern reef flat of Lelu harbor originating from the shoreline directly east to the reef edge, approximately 230 m south of the inner entrance of Lelu channel.
Transect Site 2	Start: $05^0$19'23.37'N $163^0$02'03.64'E. Finish: $05^0$19'26.17'N $163^0$01'54.84'E. ➢ Length 280 m with an assessment area of 1,200 m^2. ➢ Located on the southern reef flat of Lelu harbor running parallel and directly adjacent to the reef edge within the outer reef flat (within the wave zone) of the channel.
Transect Site 3	Start: $05^0$19'18.13'N $163^0$01'47.64'E. Finish: $05^0$19'26.18'N $163^0$01'54.24'E. ➢ Length 320 m with an assessment area of 1,280 m^2. ➢ Located on the southern reef flat of Lelu harbor originating from the shoreline directly south and parallel to the reef edge boarding the inner reef system of Lelu harbor.
Transect Site 4	Start: $05^0$19'17.99'N $163^0$01'46.16'E. Finish: $05^0$19'20.07'N $163^0$01'44.98'E. ➢ Length 70 m with an assessment area of 280 m^2. ➢ Located on the southern reef flat of Lelu harbor originating from the shoreline and running directly north to the reed edge well within the Lelu harbor.
Transect Site 5	Start: $05^0$19'38.61'N $163^0$01'48.55'E. Finish: $05^0$19'36.49'N $163^0$01'49.19'E. ➢ Length 70 m with an assessment area of 280 m^2. ➢ Located on the northern reef flat of Lelu harbor originating from the shoreline directly south towards the reef edge of the inner Lelu harbor channel.
Transect Site 6	Start: $05^0$19'39.57'N $163^0$01'52.59'E. Finish: $05^0$19'35.02'N $163^0$01'55.26'E. ➢ Length 160 m with an assessment area of 640 m^2. ➢ Located on the northern reef flat of Lelu harbor originating from the shoreline directly south towards the reef edge of the Lelu harbor channel.

Figure 36: Location of the six transects assessment sites.



The intertidal reef flat either side of the Lelu channel are extensions of the islands large shallow water fringing reef system that is dominated by high wave energy environments seaward receiving oceanic swells, an extensive shallow water intertidal hard substrate reef flat that is boarded shore wards by sand beaches derived by both terrigenous and coral reef origins.

The reef flat adjacent to and south of Lelu harbor channel is wider and more extensive that the northern reef flat. Both reef flats are exposed during high spring low tides, are flushed twice daily by tidal movement and are influenced by oceanic swells, currents and waves. Periodic inputs of decreased salinity and high levels of suspended sediments occur during inclement tropical whether. Both reef flats are utilized daily for subsistence fishing and gleaning activities and the shoreline have been significantly altered through past and present anthropogenic actions including shoreline reclamation and substrate extraction (sand).

The reef flat substrate at both the southern (TS 1, 2 3 & 4) and northern (TR 5 and 6) transect sites posses similar benthic substrate profiles. Each site has a sand beach shoreline (Figure 37a), an extensive relatively homogenous reef flat that is composed of fine silt and coral derived sand interspersed with coral rubble inshore (Figure 37b), a small but distinctive back reef coral rock accumulation area (derived from wave action) (Figure 37c) less dominated on the northern reef flat due to less wave action and a hard scoured outer reef flat in areas that are influenced by wave action (Figure 37d).

Figure 37: Representative photos of the different substrate types located on the intertidal reef flat systems adjacent to the submarine cable alignment within Lelu harbor and channel.

The reef flat is relatively flat throughout its entire area, however small vertical relief patches are found throughout both intertidal assessed areas which in general container higher levels of sediment accumulation.

The inshore intertidal areas of both reef flats are dominated by healthy sea grass beds, dominated by two species *Enhalus acrorides* and *Thalassia hemprichii* which are more pronounced on the southern reef flat, especially the intertidal areas within the harbor itself in close proximity to the shoreline (Figure 38a). Similarly, the reef flat areas support healthy populations of several species of macroalgae (*Sargassum sp.*, *Padina Sp*.,).

Hard coral live percentage coverage was extremely low for all transects associated with the southern assessment sites with only a very small number of small isolated coral heads (*Porities sp.)* (Figure 38b) located towards the outer and deeper sections of the reef flats. Slightly higher population numbers of hard coral colonies were recorded for the northern transect sites which were all located in the outer subtidal reef flat areas associated with the reef edge in deeper water. No soft coral colonies were recorded at any transect.

Invertebrate sessile animal populations (gastropods, bivalves mollusks) were recorded in all transects albeit in very low numbers, especially those species that have subsistence, medicinal or commercial value. Small populations of the small very low valued black sea cucumber (*Holothuria atra*) were located in the shallow intertidal areas in both areas, whilst the commercial sea cucumber *Actinopyga mauritiana* (Figure 38c) was recorded only once on the outer reef flat area of transect 2 (wave zone).

Finfish stocks were extremely low during the assessment, it is expected that during high tide populations of algae feeding species of fish would increase, however these would be expected to be juveniles due to the habitat present and high fishing pressure in this area.

A significant amount of anthropogenic material and rubbish was located during the transect assessments with areas closer to the shoreline and harbor possessing higher percentage (Figure 38d).

Figure 38: Representative photos of the marine resources located on the intertidal reef flat during the transect assessment of the northern and southern reefs adjacent to the Lelu harbor channel.

4.3.1 Submarine Cable Landings Site – Beach Man Hole

The terminal end of the submarine cable alignment (Beach Man Hole – BMH) will be located within the boundary of the Sanskrit Elementary school land parcel and the Lelu harbor southern foreshore (Figure 39). This land parcel is owned by the State and is on reclaimed foreshore land.

Figure 39: Location of the project submarine terminal end – Beach Man Hole.

The submarine cable will enter the site (BMH) (Figure 40 a & b) directly from the southern side of Lelu harbor along the sea floor passing through both subtidal and intertidal benthic substrate zones.

The benthic substrate associated with the terminal end of the cable include a coral sand mud dominated benthic substrate with small coral fragments and rocks (Figure 40 c & d) located closer to the intertidal shoreline. The area is tidally flushed and possesses a fluctuating water salinity that is a result of tidal movement and inputs of freshwater from the surround streams and land runoff entering the harbor.

Figure 40: Shoreline (a & b) and benthic substrate associated with the submarine cable terrestrial landing site.

There were no hard or soft coral colonies located directly adjacent to and opposite the proposed cable landing site. Macroalgae, predominately brown algae (*Sargassum* sp., *Padina sp*.) and to a much lesser extent colonies of calcium carbonate green colonies (*Halimeda sp.),* filamentous green and blue green algae were recorded in very low populations densities within the shallow intertidal reef areas to the east of the proposed landing site. Similarly, hard coral sub massive and massive colonies (*Porities sp*.) were recorded along the shoreline to the east (60 m) of the BMH, these hard coral colonies are expected to be well outside the area of influence of the project.

Directly in front of the submarine terrestrial landings site within the intertidal and subtidal reef flat rests a sunken steel vessel (old barge) (Figure 41). Shallow water investigation of the vessel identified a population of tropical rock oyster (*Crassostrea echinata)* attached to the frame however there was no evidence of hard or soft corals. The marine environmental parameters prevailing at this site are not conducive to the recruitment, growth and survival of hard and soft corals. The exact termination

point (BMH) will be finalized in due course, however it is advise that due to the location of a sunken vessel directly in front of the land parcel consideration for the cable to enter east of this vessel is recommended.

Figure 41: Sunken vessel adjacent to the submarine cable landing site.

5.0 POTENTIAL IMPACTS TO THE MARINE ENVIRONMENT ASSOCIATED WITH THE SUBMARINE CABLE ALIGNMENT - DEPLOYMENT

5.1 Key Findings of the Marine Assessment

The key findings of the marine benthic assessment of the shallow water submarine cable alignments direct and indirect Area of Influence for the island of Kosrae are summarized below and include:

The Marine Substrate (sea floor):

- The seabed substrate associated with the proposed submarine cable alignment path is relatively homogenous throughout the area assessed, has a range of water depth between 14 and 45 m and is characterized by a bottom layer of coarse sand derived from terrigenous and coral reef origins with a fine silt top layer.
- The presence of coral fragments, rocks and bounders associated with the sea floor within the proposed cable alignment direct area of influence are rare and most likely buried due to sedimentation deposition.
- The depth of the silt layer decreases towards Lelu harbor channel and is replaced predominately by sand towards the center of the channel and beyond, however fluctuations in the depth of the sediment sand silt layer and resulting water turbidity is directly related to tidal and weather conditions prevailing at any given time.
- The relatively high level of suspended silt and sand based substrate located at all assessment sites has a significant detrimental effect on the ability of sessile benthic marine resources to settle (recruit) and survive in these area.
- No sessile (non motile) benthic invertebrate species were recorded at any of the deepwater substrate dive assessment sites located within the proposed submarine cable alignment pathway.
- Mobile benthic invertebrates and vertebrates (including finfish) recorded very low population and species numbers throughout the areas assessed. Marine worm (Polycheate) burrows were located at all dive assessment sites. These invertebrate resources are highly mobile and adaptive to environmental disturbances. As such these invertebrates would be expected to relocate if the benthic substrate and sediment profile is impacted.
- Anthropogenic garbage, machinery parts and infrastructure equipment were located on the sea floor in all assessment sites.
- There is a possibility of Unexploded Ordnances (UXO) associated with the sea floor within the cable alignment pathway. The likelihood of their presences in unknown. Investigations should be undertaken.

The Reef Systems:

- There are no coral reef systems nor hard coral communities located within the projects direct Area of Influence.
- Coral reef systems are located within the projects potential indirect area of influence. These reef systems are healthy and maintain diverse invertebrate benthic resource assemblages and are located on either side of the Lelu channel, along the margins of the outer sections of Lelu harbor and patch

reefs within the harbor and as such are adjacent to the proposed cable alignment.

- These coral reef systems include a distinct zonation; shallow water intertidal reef flat that is exposed during low spring tides (varying in width 75 m – 280 m either side of the channel), subtidal reef flat (varying in width 10 - 30 m), distinctive reef edge and crest (3-10 m width), and upper and lower reef slope (5-10 m width) which for the most part have a vertical drop of between 30 - 80% (the southern side of Lelu harbor is almost vertical wall) that terminates directly onto a sand silt dominated seabed with depths ranging between 8 m in close proximity to the BMH through depths in excess of 45 m within the Lelu channel.
- Coral fragments, rocks and boulders are located in close proximity to the reef systems. They are all but absent within the channel and harbor associated with the proposed cable alignments area of influence.
- All reef sites assessed possessed a well developed intertidal and shallow water subtidal coral reef ecosystem.
- Hard coral percentage live coverage, morphological form, species diversity and abundance in general were similar throughout the sites assessed reflected the natural environmental forces affecting the different reef locations. A general decrease in these coral parameters was recorded from the entrance to the Lelu channel through to the inner harbor.
- The channels southern reef system recorded higher hard coral percent coverage, species diversity and a larger range of morphological forms than the northern channel reef site. Both channel sites recorded considerably higher live reef parameter levels that those recorded within the harbor patch reef and southern harbor reef margins in close proximity to the cable landing site (BMH).
- The cable marine landing site is devoid of a hard coral reef system rather is dominated by a sand silt benthic substrate that does not support benthic sessile invertebrate or vertebrate populations.
- Hard coral percent live coverage for the northern and southern channel reef systems for the intertidal reef, reef crest and edge and reef slope varied between 0-2 % and 0–2%, 0-10 % and 0–25%, and 5-80 % and 10–50%, respectively. The patch reef assessed recorded 0-10%, 0-15%, 5-25% coverage for the above parameters.
- Hard coral sub massive and massive (e.g. *Porities sp.*, *Favites sp.*, *Monitipora sp., Lobophyllia sp., Goniopora sp.)* and to a lessor degree digitate (e.g. *Acropora sp., Pocillopora sp., Porities sp.*), small branching (e.g. *Acropora sp*., *Pocillopora sp, Millepora sp*), encrusting (e.g. Acropora sp., *Echinophora sp., Turbinaria sp.)* and solitary (e.g. *Fungia sp*. and *Heliofungia sp*.) morphological forms dominated the subtidal reef flat, reef edge, crest and upper and lower reef slope at all assessment sites.
- The large sub massive and massive hard coral “bommie or coral head” morphological forms (predominately *Porities sp*.) were abundant at all sites accessed with a number of large colonies in excess of 4 m circumference located along the southern channel reef slope.
- Both remnant and newly recruited hard coral colonies of varying sizes were located at all sites, albeit at a lower level within the patch reef, providing direct evidence of natural hard coral recruitment is active in these areas.
- There was an absence of soft corals at all sites assessed.
- The intertidal reef systems either side of the channel extending into the harbor possessed extensive and healthy sea grass beds dominated by two species (*Enhalus acrorides* and *Thalassia hemprichii*). No sea grass was

recorded within the area of influence of the proposed submarine cable alignment.

- Marine macro algae density, coverage and diversity recorded low densities at all sites with the largest percent coverage recorded within the subtidal reef flat on top of the patch reef within the harbor. The dominant macro algae recorded at all sites was several species of calcium carbonate green algae (*Halimeda sp.*), whilst the patch reef possessed healthy densities of the green algae (*Caulerpa racemosa*) commonly known as sea grapes.
- The inner shoreline sections of Lelu harbor support an extensive and diverse mangrove forest, however these trees are well outside of the projects direct or indirect area of influence and no impacts are expected from the projects activities.
- Finfish population numbers and species diversity was low at all sites assessed. Species that were present were juveniles and include reef dwelling plankitvores (small fish), herbivores (e.g. Acanthuridae, Scaridae) and there was a noticeable lack of predator reef fish.
- Very low numbers of reef associated invertebrates (apart from corals) were recorded at all assessed sites. Those that were recorded have no or little subsistence or commercial value (e.g. non commercial sea cucumbers).
- Reasonable levels of rubbish (e.g. plastic and glass bottles), machinery and old equipment were located on the substrate throughout the marine areas assessed. These should be removed.
- Several adult individual Crown of Thorns starfish (COTS) and their distinctive hard coral feeding scars were located during the assessment. The southern reef system recorded the highest numbers (5), however as these species are cryptic and generally nocturnal it is likely that the population on these reefs is higher than recorded during the assessment.
- There was no hard coral bleaching, however there was small scale evidence of disease associated with the hard coral communities at both the northern channel reef and patch reef assessment sites.
- 5 marine green turtles (*Chelonia mydas*) were recorded swimming within the channel and outer harbor during the assessment. These individuals were sub adults and were most likely foraging on the reefs. These animals are highly mobile and as such they would not be negatively impacted during the deployment of the cable. There has been no recorded turtle nesting on the shoreline beach of Lelu harbor for well over 4 decades.
- There were no threatened, endangered or endemic hard coral species located during the assessment, nor any State, national or international endangered or protected species (apart from the turtle discussed above).
- There are no marine or coastal designated marine protected areas or areas of significant biodiversity within or in close proximity to the proposed submarine cable alignment. The patch reef assessed has been discussed by the state government as a potential site for fisheries management area but has yet to be formally designed. It is expected that the deployment of the submarine cable will have no direct or indirect impact on the benthic resources associated with this patch reef system.
- The proposed cable alignment will not impact any State or National sites of cultural, customary or heritage significance. The historical plane and vessel wrecks are located well outside the proposed cable alignment.
- The benthic substrate associated with the proposed cable alignment is dominated almost exclusively of sand and silt benthic substrate and as such the benthic habitat within the project direct area of influence can be considered to have very low habitat and ecological value to the marine ecological systems of Lelu harbor and surrounding marine ecosystem.

5.2 Key Environmental Impacts

The proposed scope of works associated with the deployment of the submarine cable entering Lelu channel traversing through the southern side of Lelu harbor and terminating at the terrestrial landing site at Sanskrit school will result in a very small marine environmental footprint both above and below the water.

Impacts on the marine environment and coastal waters associated directly with and surrounding the submarine cable alignment are expected to be very minor, localized to the immediate footprint of the works, and easily managed through standard deep sea cable laying engineering good practice mitigation measures. There are no threats to the area's marine and coastal biodiversity associated with the project. As such the potential impacts of the works on the marine environment are considered to be minor, temporary, easily mitigatable and overall insignificant.

The potential impacts of the project on the marine biological environment include:

(i) Localized and temporary increased suspended sediment levels adjacent to and either side of the submarine cable alignment areas potentially affecting marine habitats and associated resources during construction activities. Tidal fluctuations will predict the movement of sediment.

(ii) Spillage/leakage of oil and other pollutants into the marine environment from plant and equipment used during the deployment of the submarine cable (construction phase) of the project.

Benthic habitats associated with the environmental footprint directly within and adjacent to the submarine cable alignment comprises almost exclusively of sand/silt substrate (some coral rubble and rock in shallow areas) with a paucity of benthic sessile invertebrates. As such the proposed scope of works will have a negligible potential impact on these habitats, its resources and is acceptable.

There is potential for localized and temporary increased suspended sediment levels in the marine environment during the disturbance of the sea floor as a result of the cable deployment. Such impacts are expected to be very minor due to i) the low habitat value of the benthic environment, ii) prevailing high suspended sediment conditions in the area during periods of heavy rain and/or rough sea conditions, and iii) the limited physical construction activities proposed.

5.3 Potential Impact Mitigation Measures

The potential impact of increased suspended sediment levels from the works can be further minimized through implementation of the following mitigation measures during the construction phase of the project:

(i) Deploy silt curtain/s around the termination location (shoreline adjacent to the BMH) of the submarine cable during all construction and redevelopment activities to directly manage and reduce the dispersion of benthic substrate (silt) disturbed during construction, and

(ii) Ensure due diligence when operating machinery during all work activities to prevent and manage petrochemical spillage and contamination of the waters associated with the project.

The contractor will be required to ensure all equipment is properly maintained and to follow all necessary precautions to prevent spillage of petrochemicals into the marine environment as set out in the hazardous materials section of the projects EMP.

Provided such measures are properly implemented the potential impacts on the marine environment will be insignificant.

The overall potential impact of the works on the marine biological environment is expected to be very minor, localized and overall insignificant provided standard mitigation measures associated with good engineering practice as identified above are implemented. Furthermore due to the nature of potential minor impacts of the scope of works it is recommended that no specific marine monitoring program is required other than close supervision of the work to ensure that the above recommended mitigation measures are implemented and effective throughout the marine construction works.

6.0 BIBLIOGRAPHY

English, S., Wilkinson, C. & Baker, V., (Ed). 1997. Survey manual for Tropical Marine Resources, 2nd Edition. Australian Institute of Marine Science publication. 390pp.
Segal, Harvey. G., 1989. Kosrae: The Sleeping Lady Awakens. Kosrae State Tourist Division. 316 pp.
SPC, 2016. SPC Fisheries Address Book. 80pp.