Preliminary field observations of Muri shoreline and lagoon

Fieldwork undertaken by Eddie Beetham and Tracey Turner

31 October 2016 – 5 November 2016

Outline of work undertaken

A total of 13 beach profile surveys were undertaken along a 1.5 km stretch of the Muri Lagoon shoreline to evaluate the contemporary beach and lagoon morphology. Survey locations extended from the Nautilus Hotel (adjacent to Motu Taakoka) to Kura's Kabanas (adjacent to the northern tip of Motu Oneroa. See **Figure 1** for a map of the shoreline with profile locations. An Auto Level (Dumpy) and staff were used to capture elevation and bathymetrical data of the shoreline and lagoon. Where possible a fixed structure was used as a landward benchmark (e.g. sea wall), and the GPS coordinates of the benchmark, tripod location, and seaward limit of survey were recorded using a Trimble Juno (X symbols in **Figure 1**). Surveys can be grouped into three geographical zones: (1) South of Nukuoure Park rugby field (n=6); (2) the rugby field (n=5); and (3) North of the rugby field (n=2). Profile surveys were reduced to mean sea level (MSL) by sampling the water line (and time) then using the Australia Bureau of Meteorology tide prediction chart to interpolate the MSL offset.

To complement the beach profile surveys, key shoreline features were mapped (via Trimble). Key features, such as: natural shoreline, erosion scarp, engineered structures, and ad-hoc armour between the Nautilus and Kura's Kabanas were recorded. See **Figure 15** for the consolidated map. GPS maps of the Motu edge of vegetation (island boundary) were also undertaken. A GPS map of the sandbar between Koromiri and Oneroa was surveyed.

All raw data, processed data, and photos associated with the shoreline assessment were passed on to Muri Environment Care Group to assist with the preparation of their next proposal for funding.

Map of Muri area showing survey profile locations

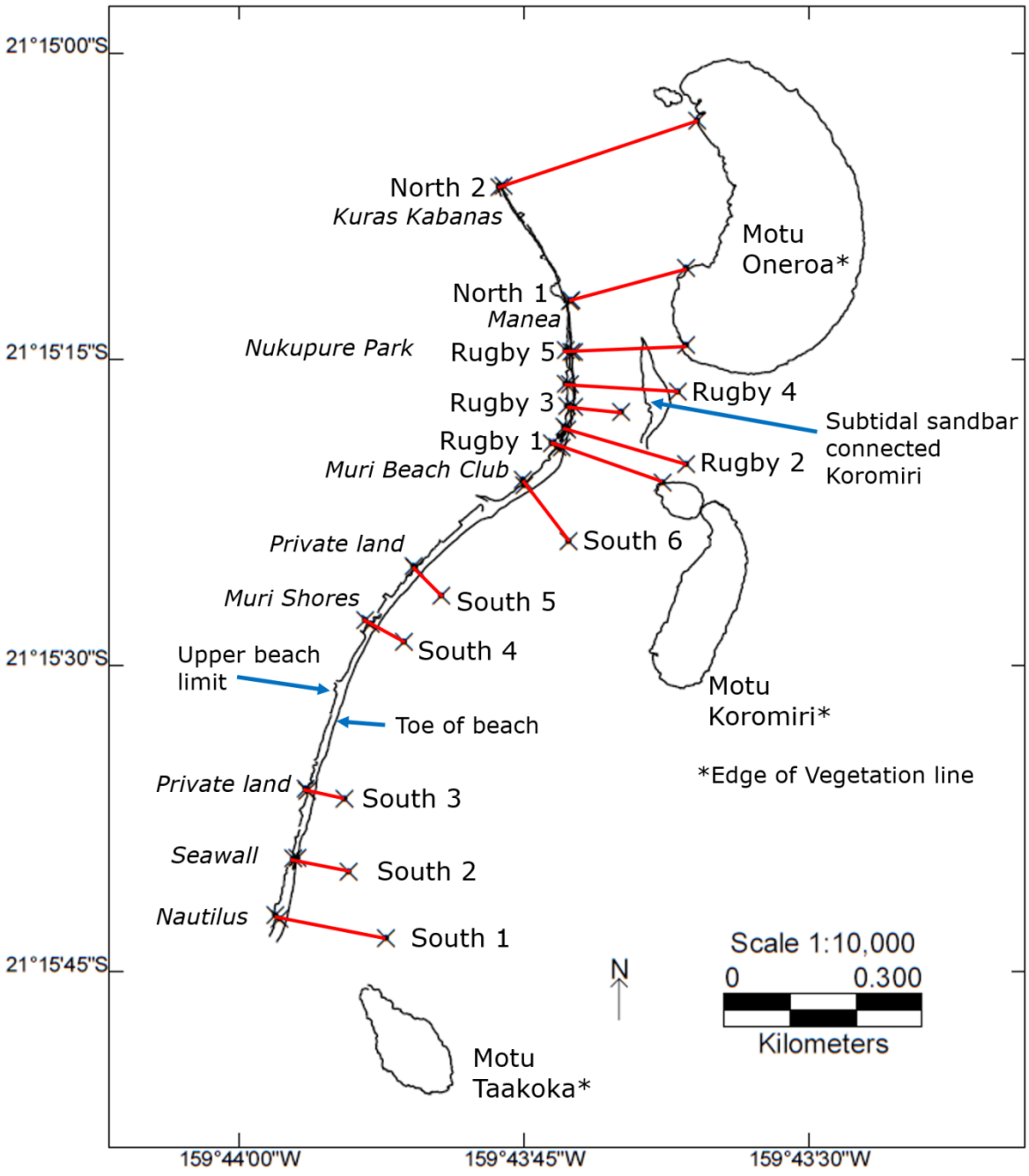

Figure 1: Outline of Muri Lagoon area. Shoreline profile transects are indicated by red lines.

Profile set 1: South of rugby field

South 1: Nautilus resort (wide beach, planted dune shoreline)

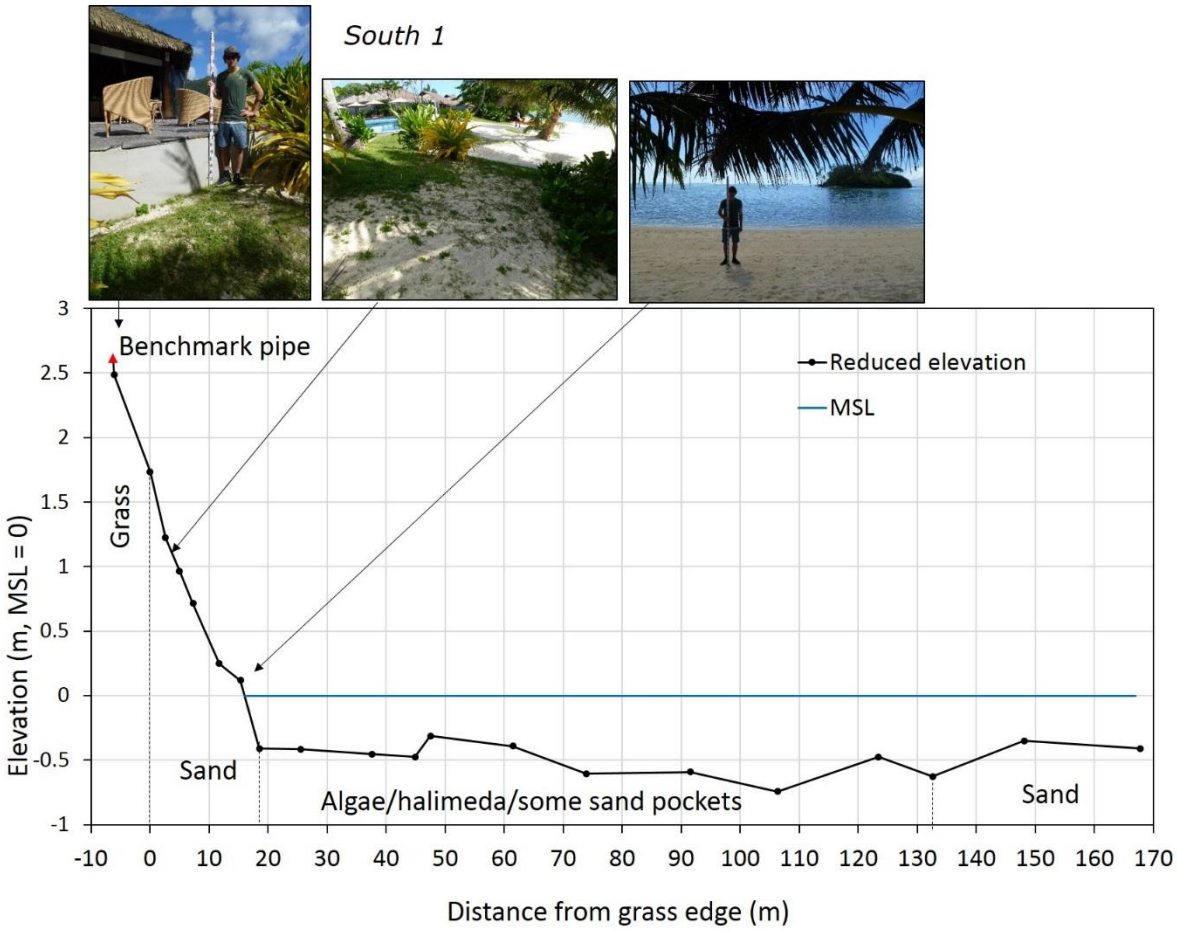

Figure 2: South 1 profile, with elevation relative to MSL = 0 m.

Benchmark: Pipe in Nautilus café wall (see top left photo)

Bearing: 101°

End location: in lagoon north of Motu Taakoka

Summary: Grass covered upper beach at resort transitions into 20 m wide sandy beach comprised of medium grain sand. Lagoon is covered in algae with a strong presence of Halimeda and some sand pockets. Average lagoon depth approximately 0.5 m.

South 2: Private seawall (no beach)

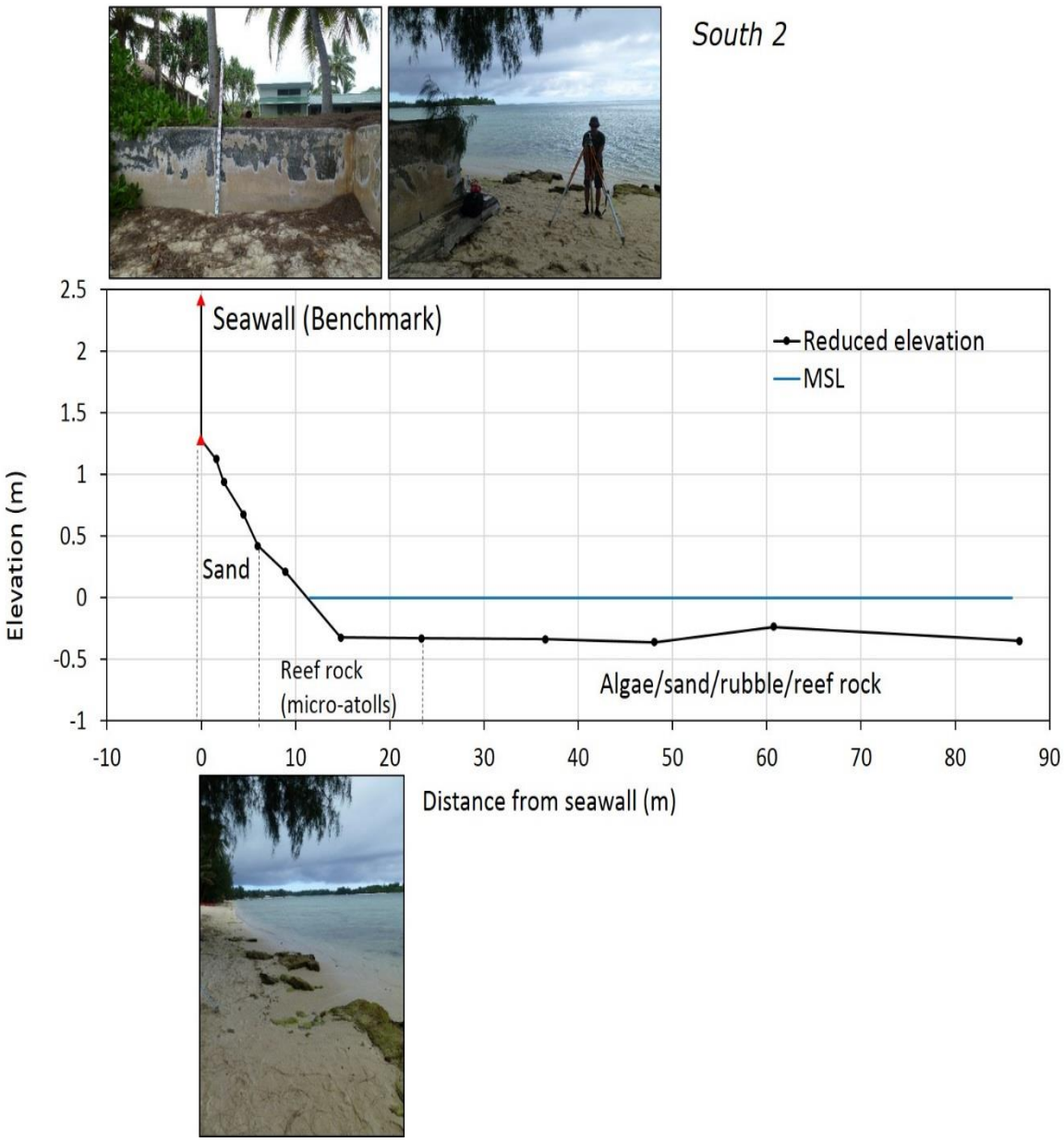

Figure 3: South 2 profile with elevation reduced to MSL = 0 m.

Benchmark: Crack in seawall (see top left photo)

Bearing: 103°

End location: In lagoon, approximately 85 m from beach

Summary:

Seawall extends seaward, very close to mean sea level contour resulting in no effective beach space. Beach toe is characterised by a field of fossil micro atoll

formations that lead into the lagoon which has some sand and rubble pockets amongst more reef rock. Lagoon is heavily covered in algae.

South 3: Residential property (eroding vegetation)

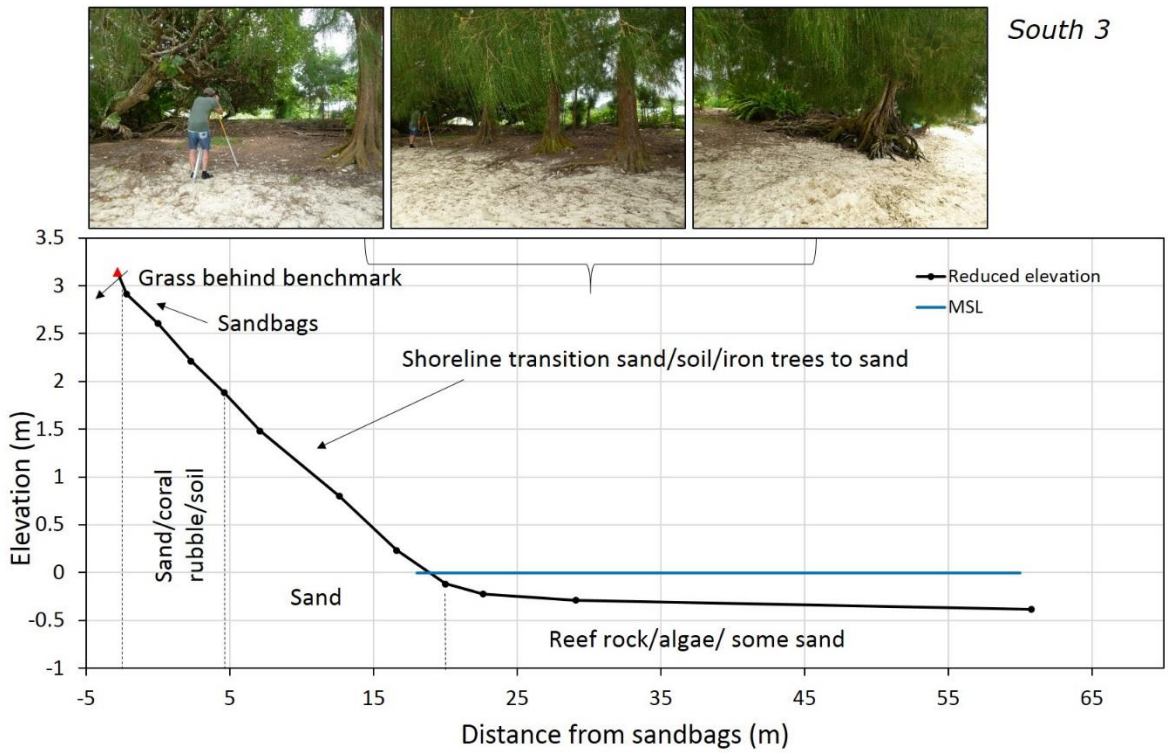

Figure 4: South 3 profile with elevation reduced to MSL = 0 m.

Benchmark: Coral boulder in hedge between properties (see top left photo)

Bearing: 104°

End location: In lagoon, 45 m from beach

Summary:

Local property with seemingly natural shoreline characterised by trees (with some root level erosion) with a soil layer over upper beach sand transitioning in to a 10 m wide sandy beach. Inner lagoon is characterised by reef rock, algae with some sand pockets.

South 4: Muri Shores (set-back sandy beach)

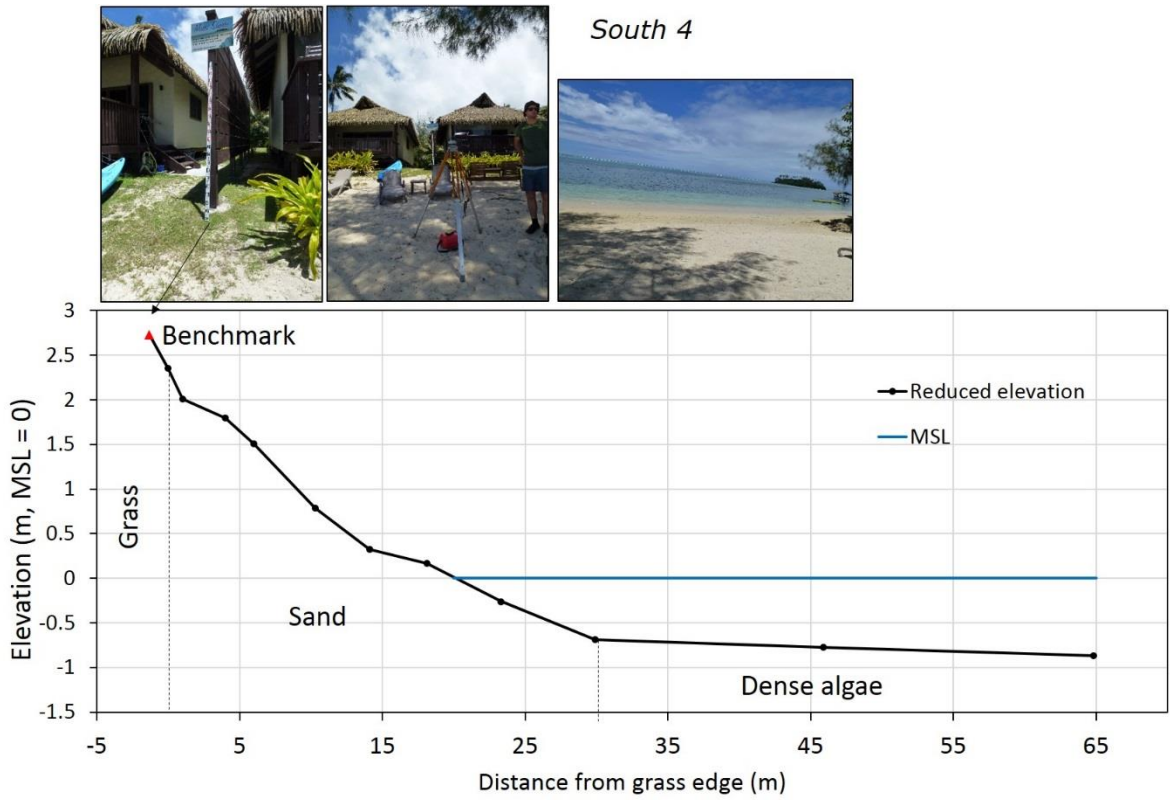

Figure 5: South 4 profile with elevation reduced to MSL = 0 m.

Benchmark: Fence between bure 2 and 3 (see top left photo)

Bearing: 118°

End location: In lagoon, 45 m from beach

Summary:

Set-back sandy beach, approx. 20-30 m landward of neighbouring properties engineered shorelines. No vegetation to stabilise shoreline sediment. Sandy beach area extends 18 m width (above MSL). Lagoon characterised by a gradual slope reaching a depth of 0.9 m 45 m from the beach toe. Very dense algae cover.

South 5: Residential property (eroding vegetation)

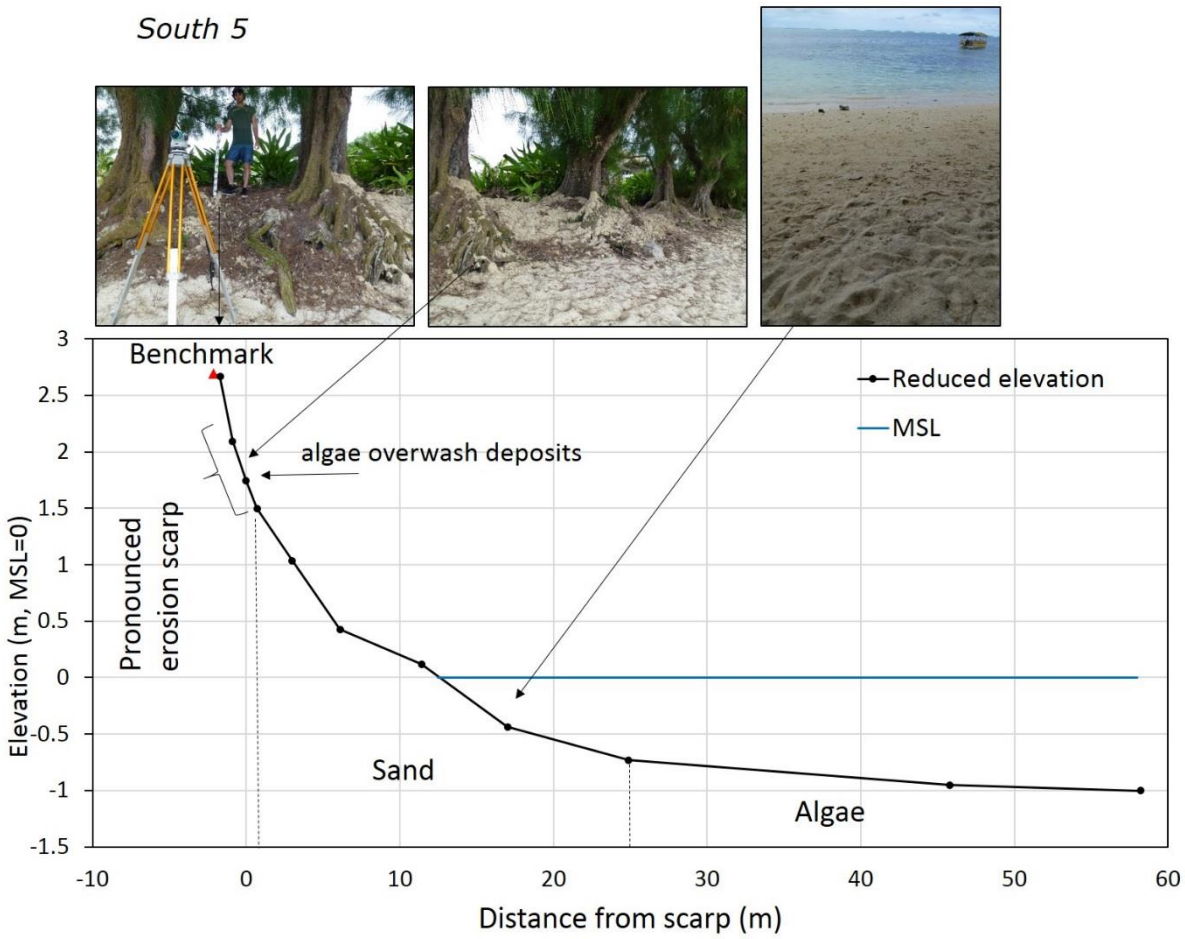

Figure 6: South 5 profile with elevation reduced to MSL = 0 m.

Benchmark: Between trees (see top left photo)

Bearing: 137°

End location: In lagoon, 40 m from shoreline.

Summary:

High level of erosion evident on trees at shoreline, with vertical scaring up to 1 m and undercutting of tree base / root system. Sandy beach approximately 12 m wide (above MSL). First 10 m of lagoon is shallow and sandy, remaining seaward section of lagoon is covered in thick algae.

South 6: Muri Beach club (wide sandy beach)

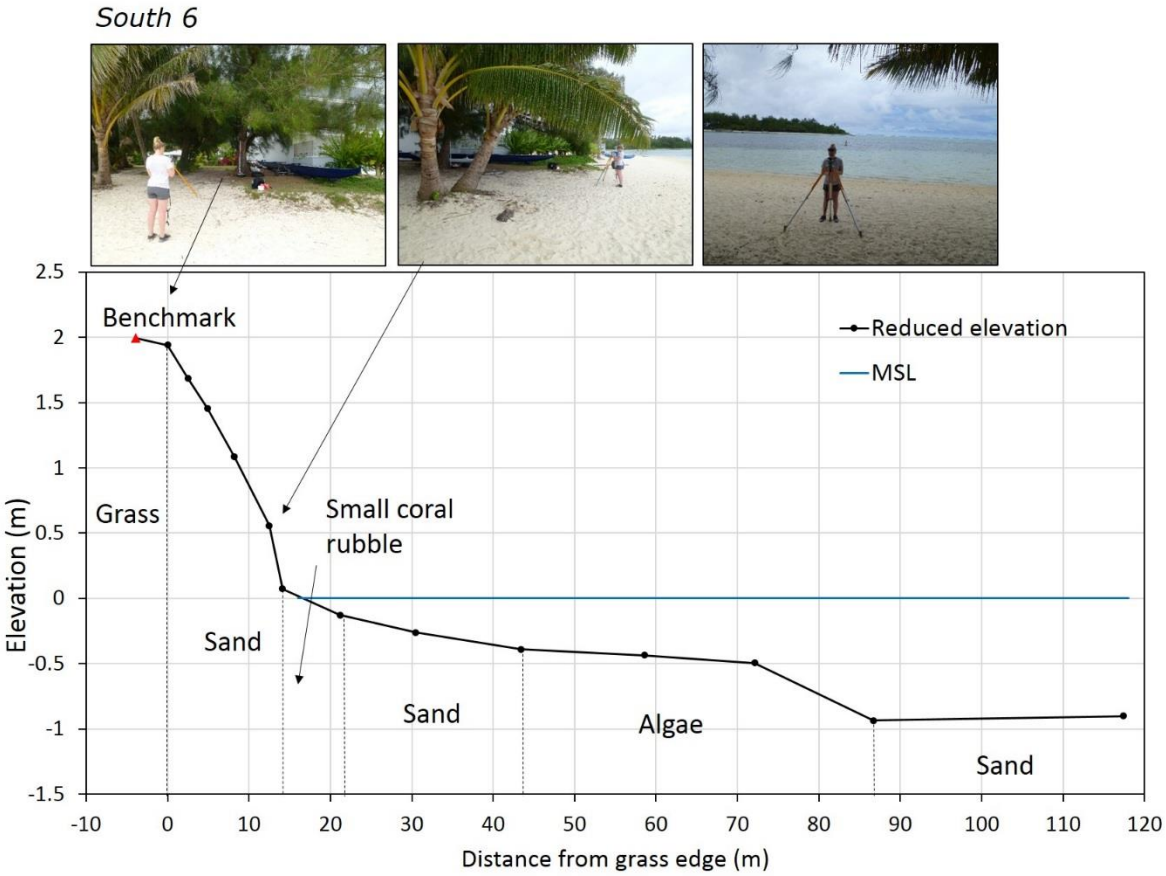

Figure 7: South 6 profile with elevation reduced to MSL = 0 m.

Benchmark: Coconut tree near south wall of muri beach club (see top left photo)

Bearing: 142°

End location: In lagoon, approximately 100 m from the beach face.

Summary:

Tree covered grass area transitions into 40 m wide sandy beach area that slopes into the lagoon. Lagoon is initially sandy without algae but algae cover a prominent through the mid lagoon shoreward of the deeper section near the end of the survey.

Profile set 2: Nukupure Park (rugby field)

Rugby 1: South of driveway (geomorphic transition zone)

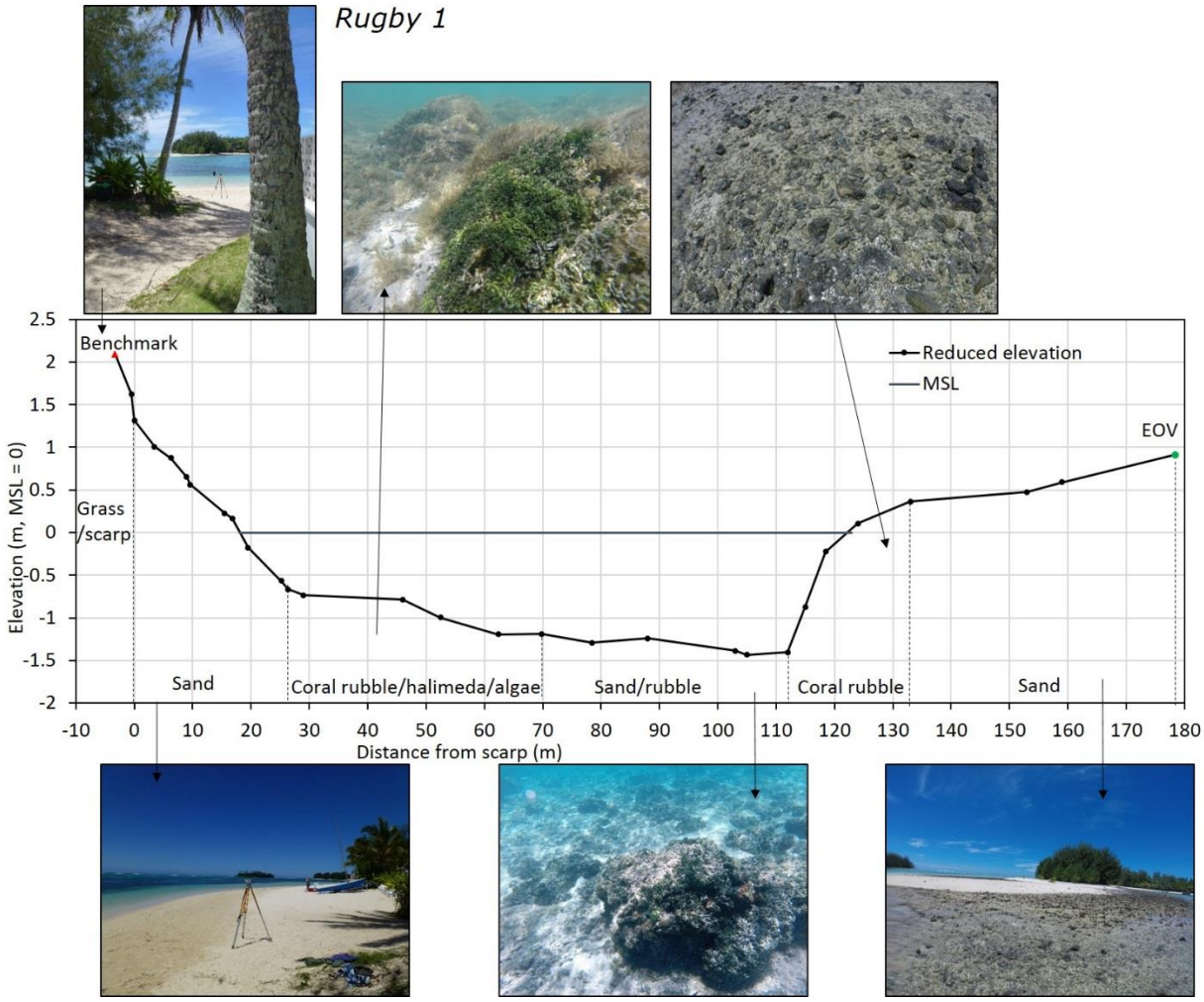

Figure 8: Rugby 1 profile with elevation reduced to MSL = 0 m.

Benchmark: Coconut tree next to Muri Beach Club wall (top left photo)

Bearing: 109°

End location: leeward shore of Motu Koromiri

Summary:

Sandy beach face (18 m wide, above MSL) leads into a lagoon that becomes progressively deeper until reaching the leeward shore of Koromiri. Max depth 1.5 m below MSL in channel near Koromiri. Shallower side of lagoon covered in algae, with coral rubble, halimeda and some porites corals. Profile crosses a driveway area (top left photo). The survey site is valuable because it marks a transition point. To the South of this survey point, the beach is wider, but

characterised by strong tourist development. To the North, lies the Rugby Field, which has a narrower beach face, and is characterised by ad hoc attempts to armour the shoreline from erosion. Markers of erosion are pronounced directly North of this survey location.

Rugby 2: Picnic tables (ad-hoc beach armour)

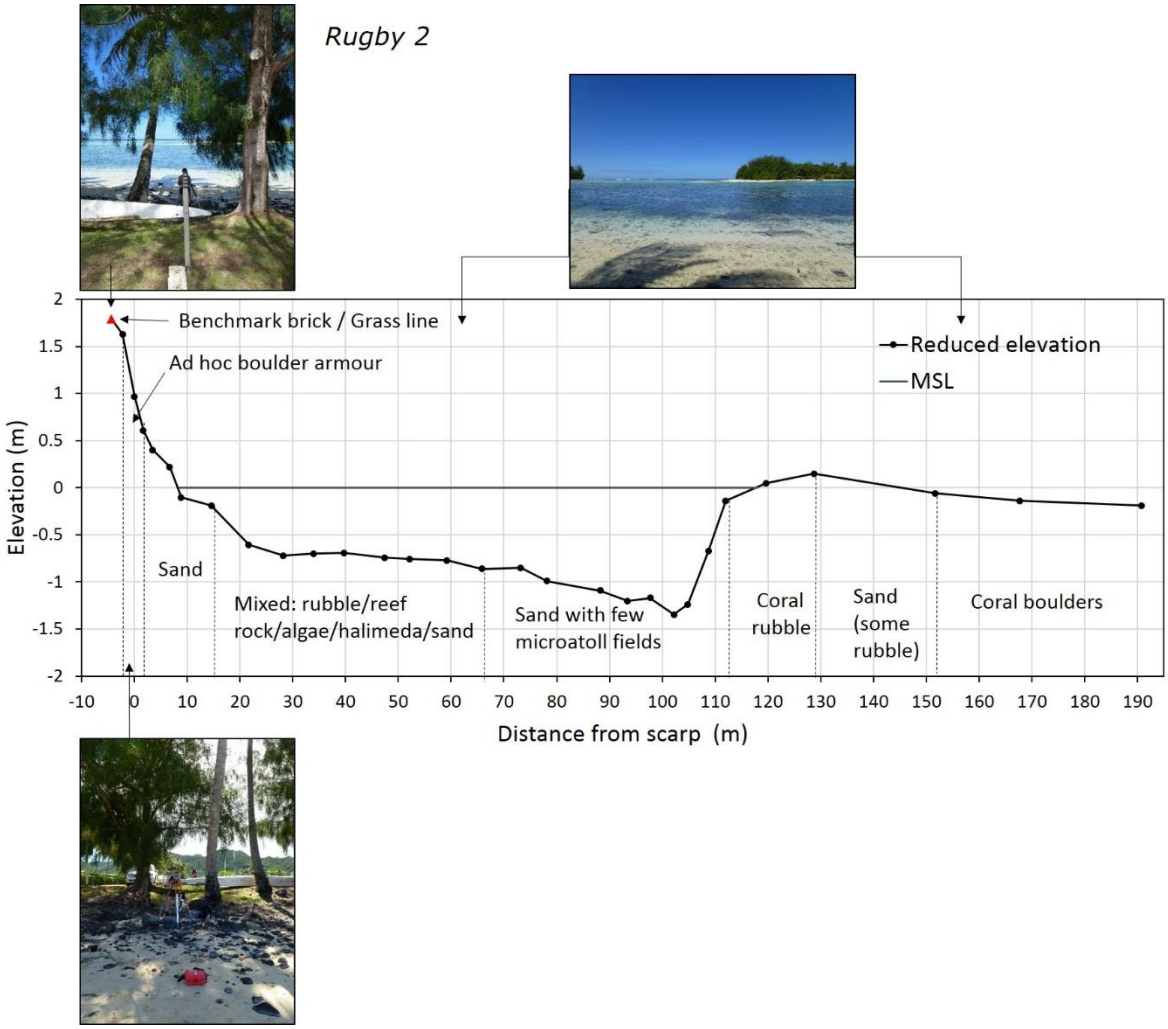

Figure 9: Rugby 2 profile with elevation reduced to MSL = 0 m.

Benchmark: Concrete block (see top left photo, possibly an old picnic table)

Bearing: 106°

End location: in lagoon leeward of spit / sandbar extending from of Koromiri

Summary:

Upper beach face has remains of an ad-hoc rubble armour structure (mix of gravel, pebble and boulder size material). No real sandy beach area above MSL.

Lagoon has thick, wide area of algae, with a high presence of Halimeda and some coral (micro-atoll fields) amongst sand and rubble sections. The lagoon is deepest (1.4 m below MSL) just before the sandbar feature that extends in a South direction from Koromiri to Motu Oneroa. The section of the spit near MSL is approximately 50 wide. New coconut seedlings on the leeward side of Motu Koromiri suggest that the island is prograding South West from the Motu.

Rugby 3: Tip of red canoe (ad-hoc beach armour)

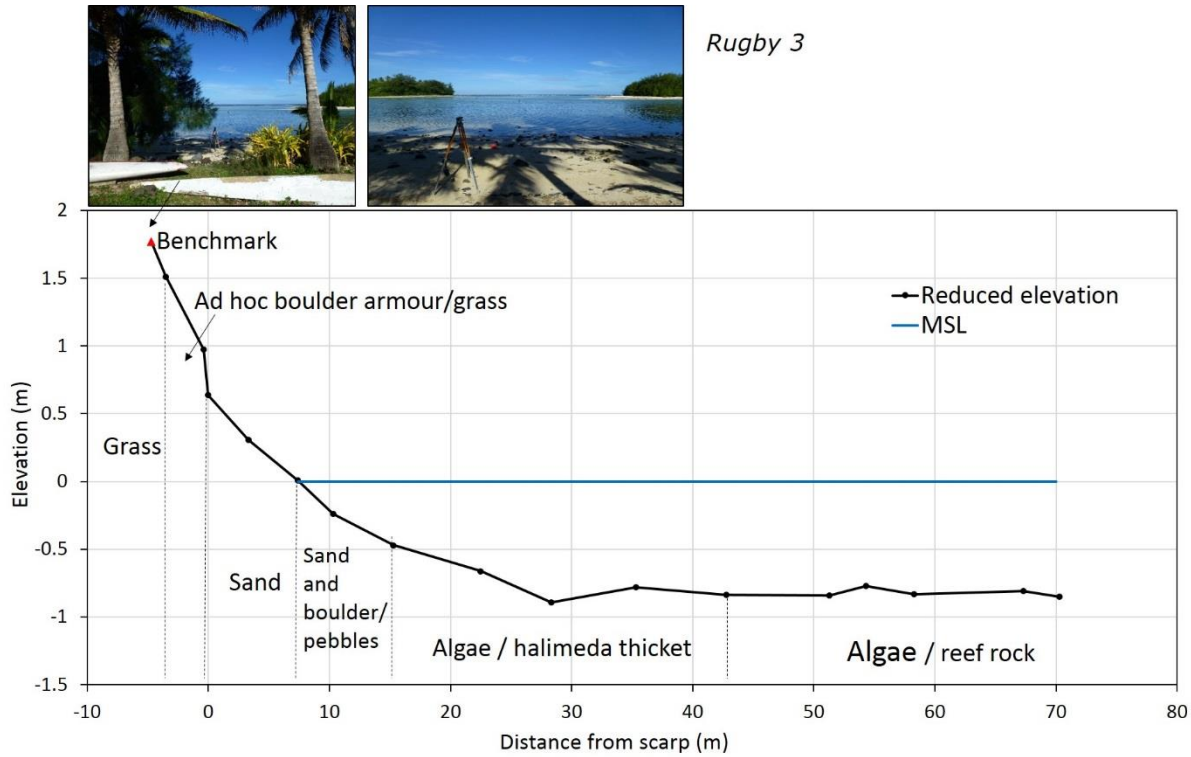

Figure 10: Rugby 3 profile with elevation reduced to MSL = 0 m.

Benchmark: Tip of red canoe (see top left photo)

Bearing: 96°

End location: In lagoon shoreward of sandbar extending from Koromiri to Oneroa (see **Figure 1**).

Summary:

Shoreline characterised by erosion scarps and exposed Ironwood Tree root systems with remains of an ad-hoc rubble armour structure (mix of gravel, pebble and boulder size material). No sandy beach area before the lagoon. Line of pebble sized material formed at beach toe (likely washed off the ad-hoc

rampart) that extends 150 m to the north (see Fig. 15). Surveyed area of the lagoon characterised by algae, halimeda and reef rock approximately 0.8 m below MSL.

Rugby 4: In line with Southern tip of Oneroa (ad-hoc beach armour)

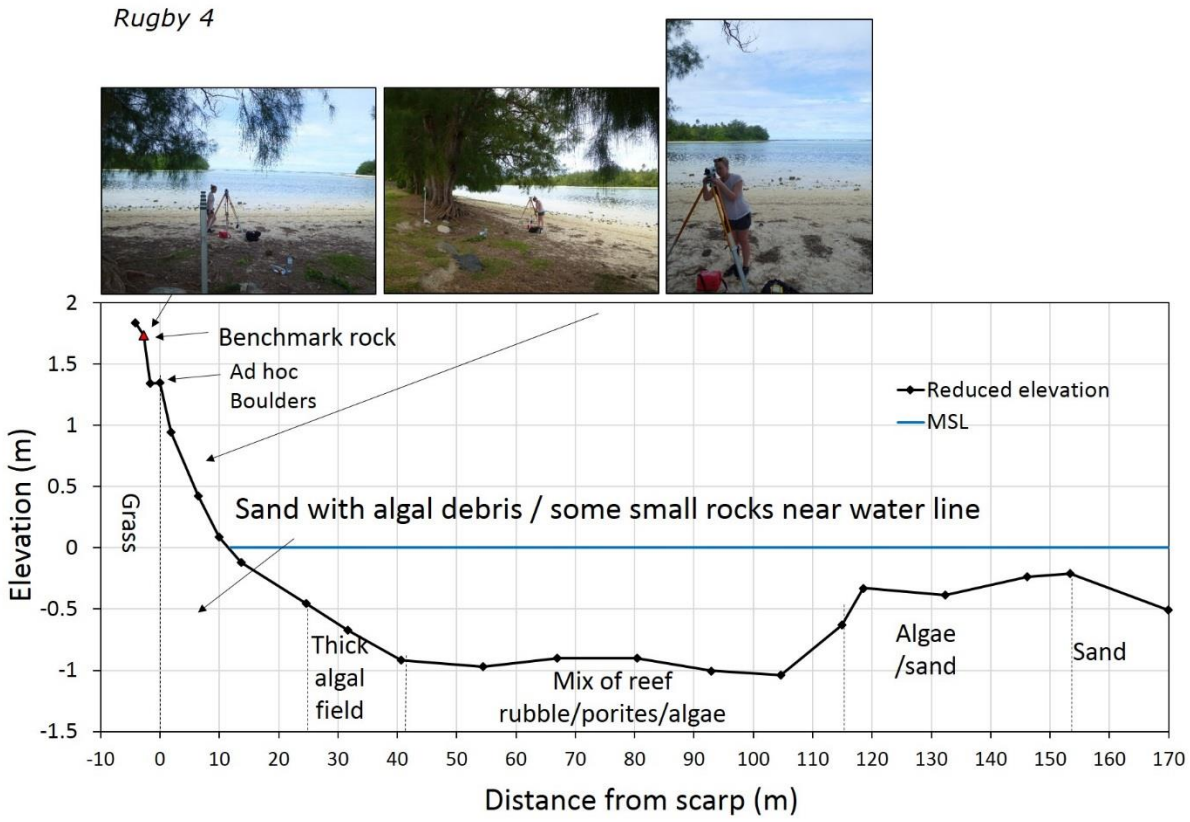

Figure 11: Rugby 4 profile with elevation reduced to MSL = 0 m.

Benchmark: Rock on erosion scarp, in line with southern tip of Motu Oneroa.

Bearing: 93°

End location: In lagoon leeward of sandbar extending from Koromiri **(see Figure 1).**

Summary:

Shoreline characterised by erosion scarps and exposed Ironwood Tree root systems with remains of an ad-hoc rubble armour structure (mix of gravel, pebble and boulder size material). No sandy beach area before the lagoon. Line of pebble sized material formed at beach toe. Lagoon between shoreline and

sand bar characterised by algae, halimeda and some coral, with a mean depth approximately 0.9 m below MSL and no pronounced channel. Sandbar heavily colonised by algae.

Rugby 5: North end of Nukupure Park (ad-hoc beach armour)

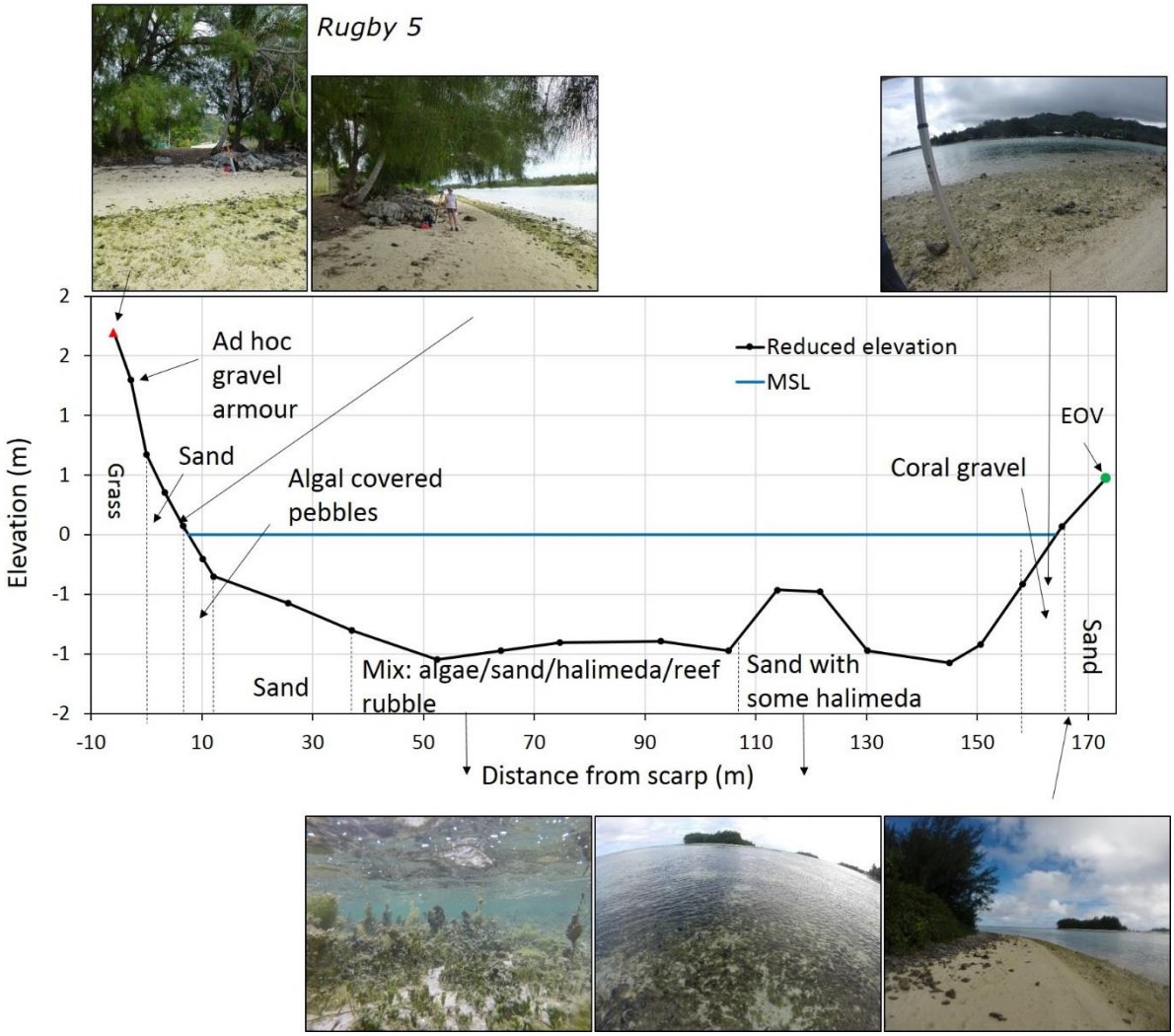

Figure 12: Rugby 5 profile with elevation reduced to MSL = 0 m.

Benchmark: Large palm at landward end of

Bearing: 87°

End location: Leeward shoreline of Oneroa

Summary:

Northern section of the rugby field has boulder sized aggregate material scattered in an ad-hoc attempt to prevent erosion. Marked erosion was observed on the shoreline, with undercutting and scaring of Ironwood trees. Beach toe

characterised by pebble size material initially used for shore protection that has washed off the berm and is being transported northward. No sandy beach face. Lagoon becomes gradually deeper for 30 m before reaching a thick algae zone, with some halimeda, sand, rubble and coral. Profile crosses the spit / sand bar feature that extends off of Motu Koromiri that is separated from Oneroa by a 20 m wide, 1 m deep channel.

Profile set 3: North of rugby field

North 1: Manea Beach (engineered boulder rampart)

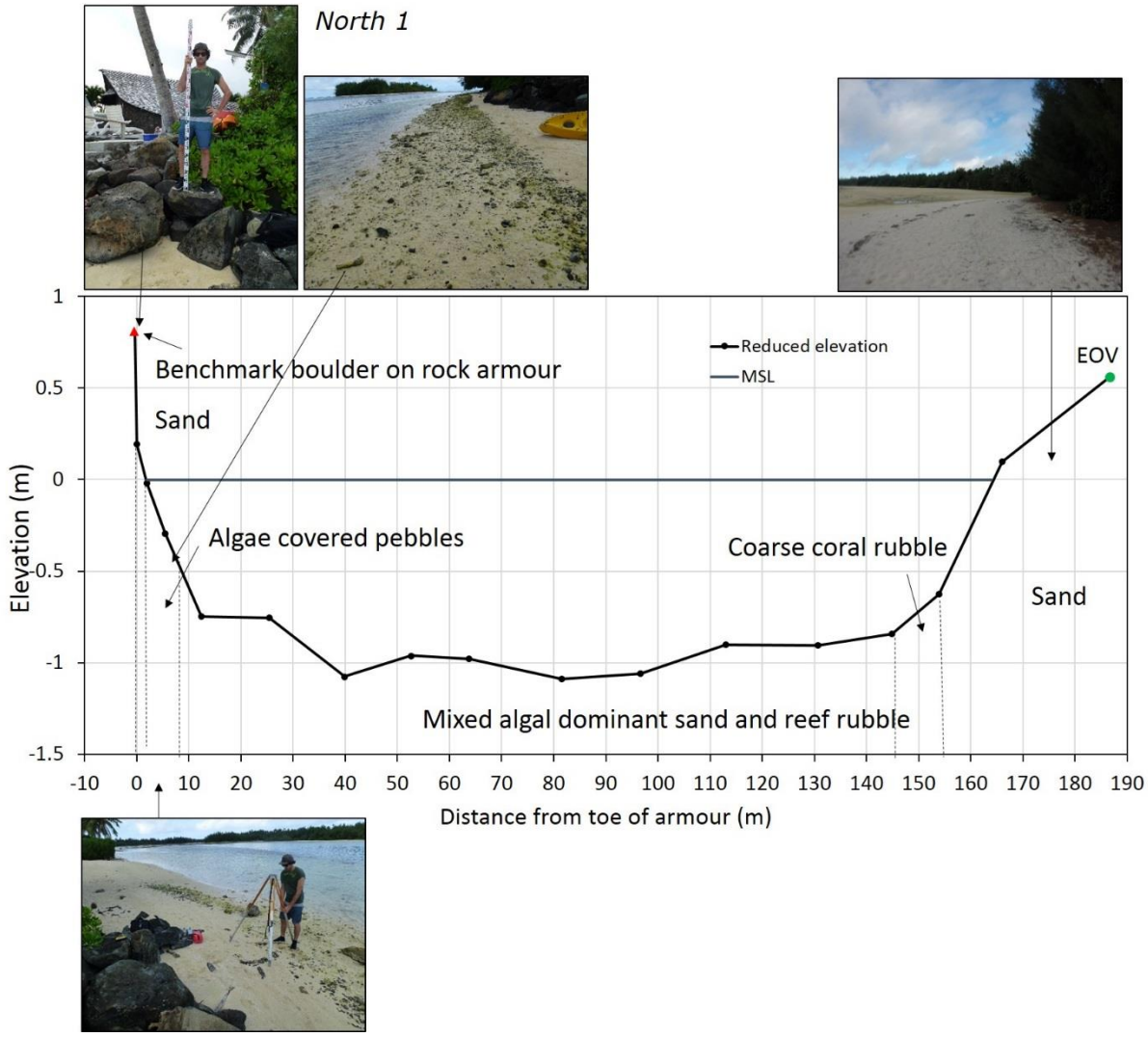

Figure 13: North 1 profile with elevation reduced to MSL = 0 m.

Benchmark: Rock on rubble rampart, north of white steps (see top left photo)

Bearing: 72°

End location: Leeward shore of Oneroa

Summary: Armoured shoreline with narrow sandy beach area. Shoreline quickly transitions into lagoon with a mean depth approximately 1 m below MSL. Lagoon floor is covered in algae with patches of sand and rubble. Leeward shore of Oneroa is initially rubble dominant then becomes sandy. Oneroa is 162 m away from mainland (MSL contour).

North 2: Kuras Kabanas (erosion on seaward spit shoreline)

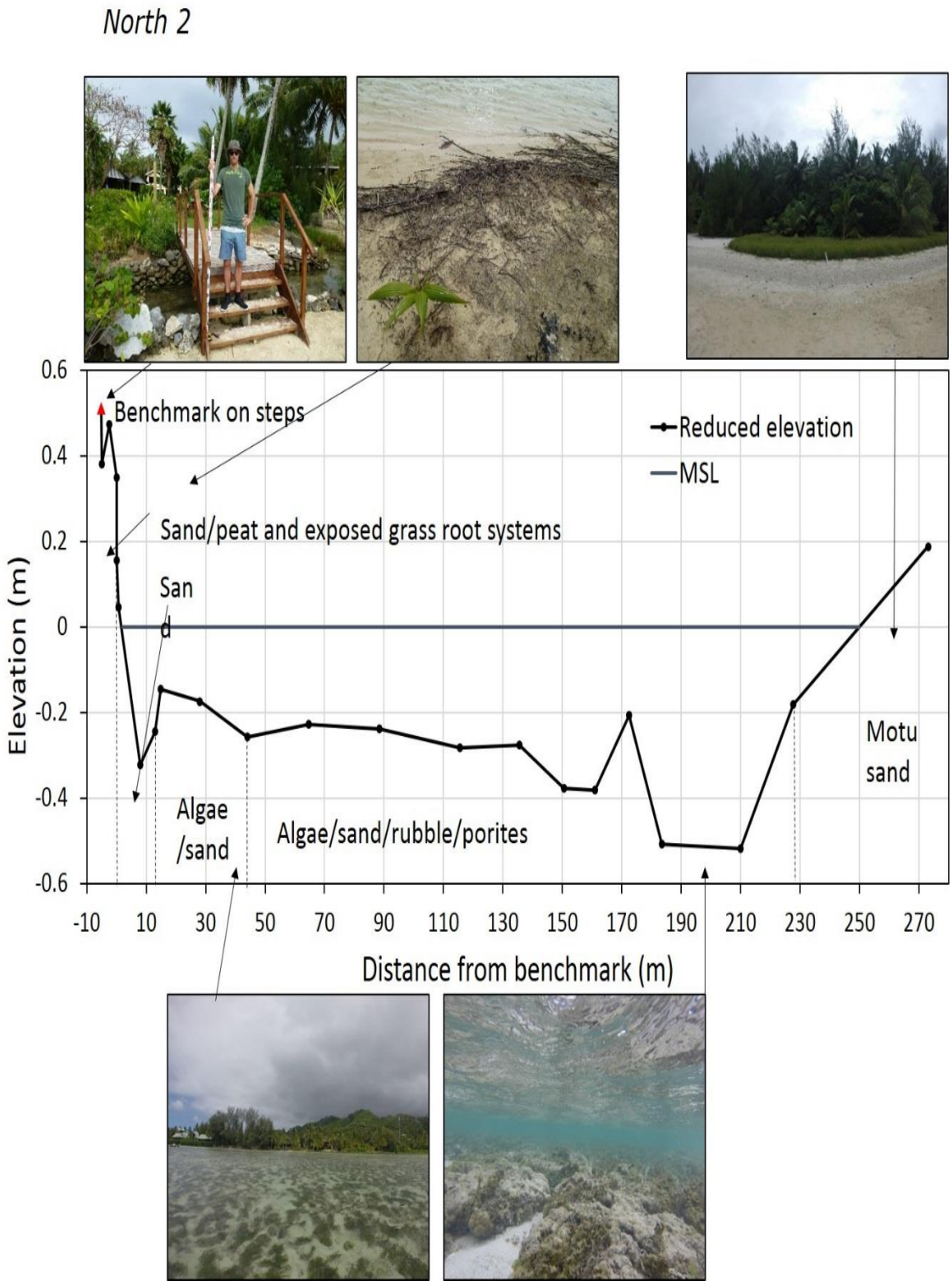

Figure 14: North 2 profile with elevation reduced to MSL = 0 m.

Benchmark: Third step seaward side of bridge, south side (see top left photo)

Bearing: 71°

End location: Leeward shore of Oneroa

Summary: Low elevation spit feature (seaward of stream) has marked vegetation (grass) erosion. Shoreline scars into lagoon, with the landward section characterised by algae and sand. The lagoon becomes gradually deeper towards Oneroa, characterised by algae, sand, rubble and some porites coral. Deepest section of lagoon is near Oneroa, approximately 0.5 m below MSL. Distance between Oneroa and mainland at the MSL contour is 248 m.

Map of Muri Shoreline features

The area between Kura's Kabanas and Nautilus was mapped to identify areas of the shoreline erosion. Attention was given to engineering structures, ad-hoc coastal defence attempts, and beach sections wide enough for public recreation purposes (**Figure 15**).

Within the 1,500 m long study area, 42% of the shoreline was characterised by marked erosion of trees or other vegetation. Areas with pronounced erosion include Nukupure Park and a number of private properties north of the sailing club. The base of Ironwood trees at Nukupure Park are heavily scarred, showing the root systems. Large trees north of Muri Shores have erosion scarps ranging between 1-1.5 m high and are undercut by up to 2.5 m.

A number of resorts and other accommodation developments / services on the beach front have introduced hard engineering structures. These include large bounder ramparts, concrete or wooden seawalls and gabion basket walls and collectively account for 27% of the surveyed area.

The section of beach directly south of the rugby field boasts a wide sandy beach that is suitable for public recreation, even though resort boundaries overlap the upper section of beach face. This area accounts for 27% of the total surveyed shoreline.

Poorly designed *Ad-Hoc* coastal defence features have been implemented across 11% of the shoreline, mostly associated with private and public beach front land. These include pebble, gravel and boulder size rocks at the rugby field, an attempted groyne made of logs and rocks south of the rugby club and large boulders in front of tree outside Koka Lagoon Cruse. This ad-hoc attempt has likely exacerbated erosion in areas, especially the loose rocks on the rugby field. A few small accommodation providers (4% of survey) have a sandy beach that is set-back 20-30 m landward of neighbouring properties that have engineered shorelines. These set-back beaches preserve the 'natural' shoreline characteristics but are not vegetated, suggesting natural vegetation has been removed to facilitate access and beach views. Private land also shows evidence of attempts to protect the shoreline from erosion, with ad-hoc sandbagging, and the placement of large coral boulders around well-established tree roots (such as large coconut palms) in an attempt to prevent overtopping.

The Nautilus resort has a well implemented shoreline planting / dune engineering system that is set-back from the water line and provides a 'natural' beach-scape while allowing for a public sandy beach above high tide. This section accounts for 8% of the survey area. Further, the resort has respected existing vegetation, and planted new shrub species in between well-established palms and other trees.

Table 1: Results of shoreline features analysis showing the proportion of Muri Beach that is characterised by erosion and other anthropogenic influences.

Shoreline state	***Sum distance (m)***	***Percent of area***
Erosion	626	42%
Hard engineered	411	27%
Wide sandy beach	397	27%
Ad-hoc defence	158	11%
Soft engineering	118	8%
Set-back sandy beach	63	4%
Total shoreline	**1497**	

Note: percent area exceeds 100% because there is overlap between areas that show erosion and also contain ad-hoc defence structures.

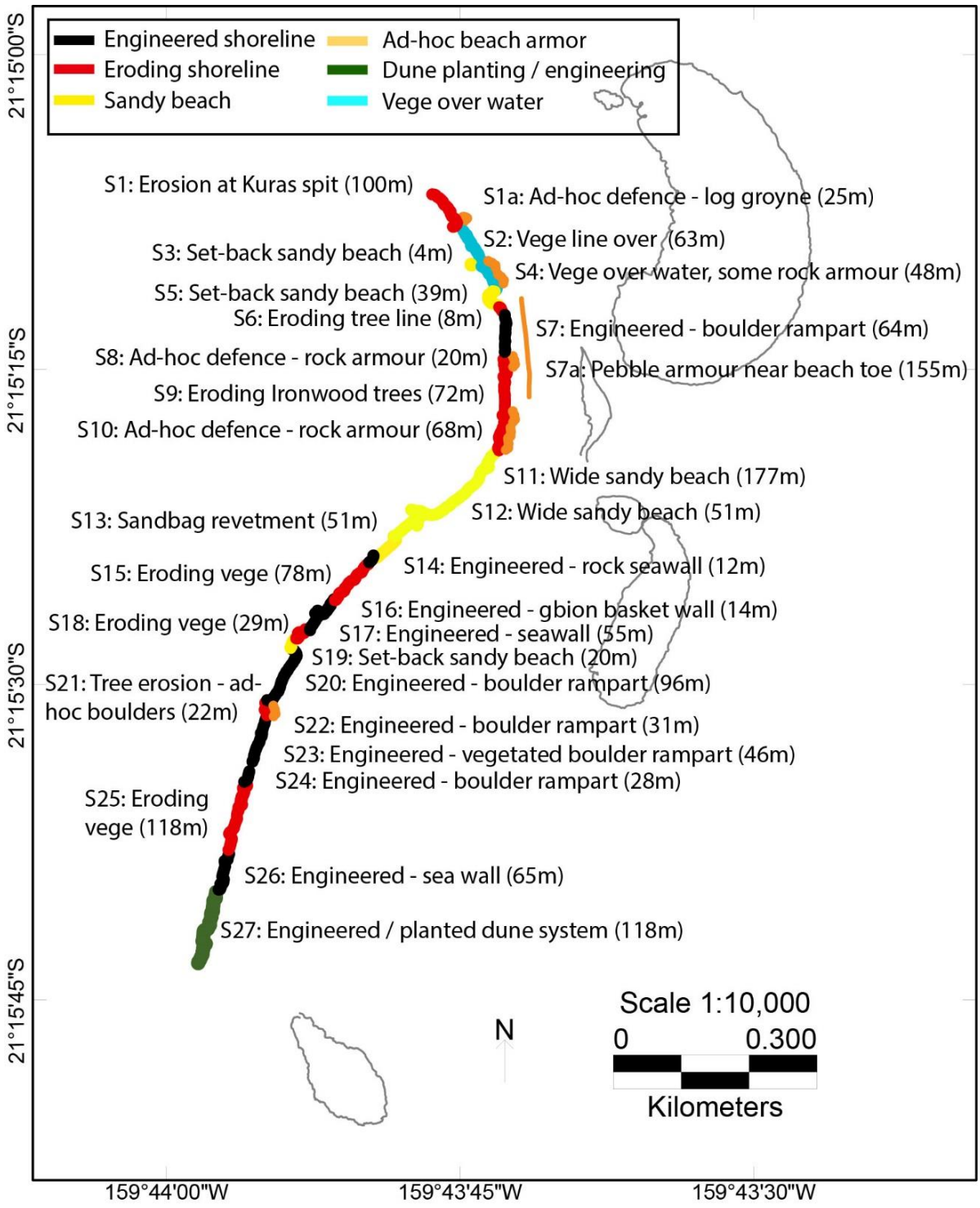

Figure 15: Map showing shoreline characteristics

Summary of findings

Erosion was observed on 42% of the 1.5 km wide survey area, including most shoreline areas without engineering structures and areas with reasonably natural shorelines.

Beach erosion is possibly exacerbated in areas where shrubs have been removed to facilitate beach access / lagoon views. Further, the onshore flow of sediment is likely being blocked by the thick macroalgal cover in the lagoon. Thick algae cover assists sediment deposition in the lagoon and significantly limits sediment suspension, possibly preventing new sediment being deposited on the shoreline. Visual observations in the lagoon on a strong current day (Nov 2) revealed no suspended sediment in the water column even though the current was approximately 0.4 – 0.6 m/s. In addition, a large sand-bar is forming between Koromiri and Oneroa, potentially blocking onshore directed sediment transport in the rugby field region, especially because it is covered in algae. There is strong evidence of sediment accumulation, and shoreline progradation, on the leeward aspects of Motu Koromiri and Motu Oneroa.

While the algal bloom has been a problem off and on over the last few years, observations of the latest bloom show that the algae is well-established, with root systems extending deep (>20cm) into the lagoon sediment reserves. The interplay between algae and sediment immobility is likely to create a positive feedback that will lock sediment into the lagoon and assist further algae colonisation. As sediment is immobilised by the algae, the lagoon decreases in depth. Shallower water is likely to result in warmer lagoonal temperatures, thus enhancing algal growth, and preventing coral establishment.

While it is clear that the latest algal bloom is a result of a variety of issues (septic tank seepage being a main concern in Muri, along with tourist development), the recent El Nino event (2015-2016) may have promoted algal growth due to prolonged elevation of sea surface temperatures and a slight reduction in sea level that was observed across the SW pacific.

It is likely that erosion is further assisted by upstream coastal defence structures and ad-hoc structures that prevent sand deposition.

A confident solution to the erosion issue requires more thorough research (**see below**) and a multi-faceted response to the issues discussed above. However, some recommendations include:

- **Removal of ad-hoc shoreline armour material (pebbles and boulders). These loose material may be assisting the removal of sand material from the shoreline during events where small waves wash up on the beach. For an area such as Nukupure Park, a hard engineering solution is not recommended because these structures often limit the formation of a recreational beach.**
- **A vegetated beach nourishment solution may be more suitable for Nukupure Park, to improve recreational amenities and protect the shoreline from further erosion.**
- The shoreline at Nautilus resort is a good example of successful soft-engineering of the shoreline using sculpted dunes and extensive planting of vegetation.
- At Nukupure Park nourished sediment will be required to build up the beach (vertically, landward and seaward) for this to be effective. Stabilising shrubs should be planted to assist deposition and prevent easy erosion.
- A similar approach could be adopted for those aspects of Muri Beach that have not utilised engineered structures to protect their shorelines.
- Following further research (see below), the lagoonal algae must be addressed, and eventually removed, to re-establish natural sediment connectivity between the lagoon and island shorelines.

Recommendations for future research

Research

More data is required before a best-practise solution can be established for the coastal erosion issue at Muri shoreline, and the other associated issues including algal bloom and lagoon infill. Future research should extend beyond the area we sampled in this document and include at least the area north to the Avana harbour.

Recommendations for further research include:

- **Full scale 'state of the lagoon' benchmark survey including data on:**
    - Bathymetry.
    - Sedimentology (identifying sediment transport routes, sediment type etc).
    - Ecological mapping (a thorough assessment of the algal extent, coral, and fish habitats).
    - Hydrodynamic circulation and flushing.
- **Regular monitoring**

The best way to understand how a nautral sustem works is to collect regular, comparable data to quantify change and natural flux. Regular monitoring, with surveys 1 to 2 times per year will significantly assist management of the Muri beach and lagoon area.

    - Beach and lagoon profile surveys (can repeat surveys we did)
    - Water testing (need to understand conditions that promote algae and establish monitoring thresholds)
    - Ecological surveys (monitor algae colonisation, types of algae, coral cover)
    - Motu and sand bar migration (GPS or drone surveys of Motu toe of beach and sand bar extension will assist understanding sediment flow in the lagoon.