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IMPACT ASSESSMENT- REMOVAL OF CHU ZAI FA NO. 1 LEONE, AMERICAN SAMOA

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1. Method

There are two main survey areas in Leone to assess the damage resulting from the removal of the ship (Figure 1).

Two main survey areas (indicated by the dotted line):
A. Shipwreck removal path - from boat to shore (RP)
B. High value area between shipwreck and gravel island (HVA)

Two surveys were conducted in the bay (October 1st, 2019 (pre) and March 26th, 2020 (post)). The surveys assessed reef fish diversity (pre and post), coral demography (pre and post in HVA), and benthic community assemblage (pre and post).

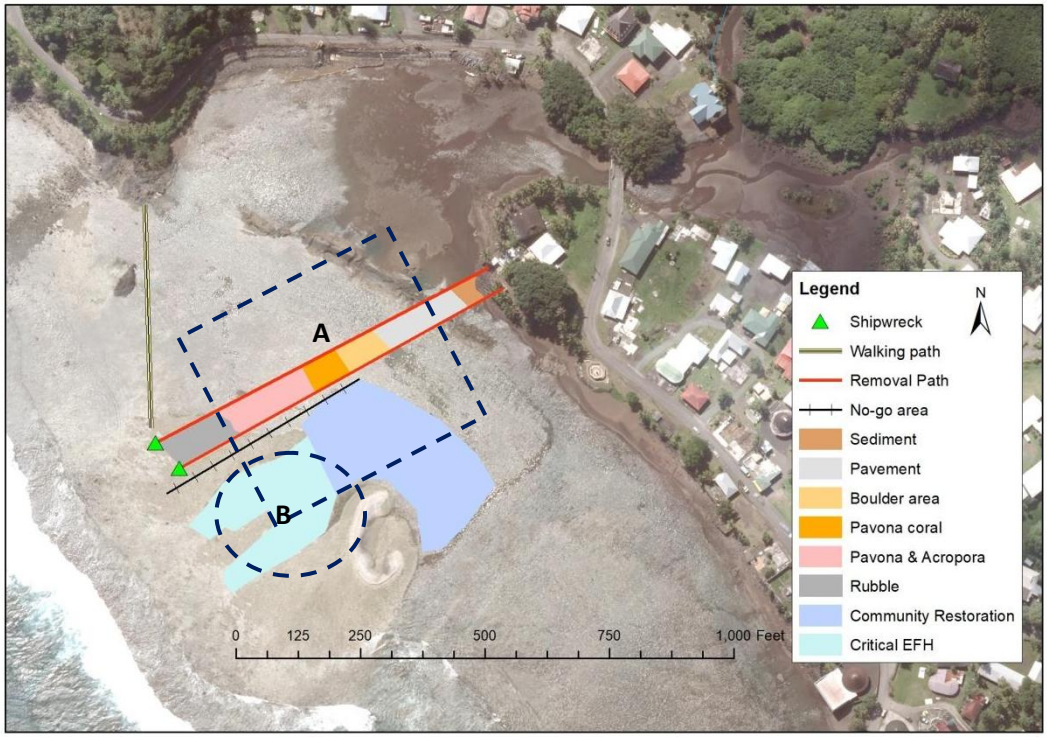

Figure 1. Survey location showing basic habitat delineations and priority survey areas A and B.

1a) Shipwreck removal path

Reef fish assemblage
Fish surveyor enters water and conducts reef fish survey. 3-minute timed swim survey around each of 3 sections:(1) Pavement, (2) Boulder area + *Pavona*, (3) *Pavona* & *Acropora*

Transect starting coordinates are identified using pre-loaded GPS coordinates:

T1 Start	-14.33785	-170.78827
T2 Start	-14.3379	-170.78822
T3 Start	-14.33797	-170.78816

Each surveyor lays a 100m transect each from the shore heading to the shipwreck. A total of 3 x 100m transects are laid parallel to each other (Figure 2).

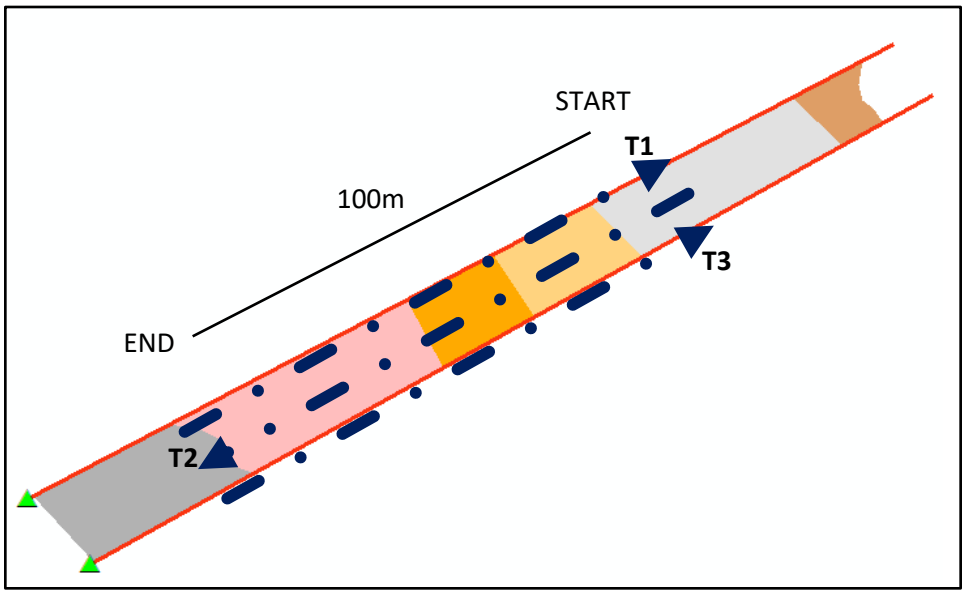

Figure 2. Survey area A showing the location of the 3 x 100m transects

GoPro Video

A GPS coordinate is taken at the beginning and end of each transect, and the waypoint number and transect number are recorded. A total of 6 points is recorded in total using the swimming path as shown in Figure 2 above. One video per transect is taken and can be used to visually determine any damage.

Benthic assemblage photo quadrats

Using the swimming path (Figure 2) a photo is taken every 1m along the three 100m transect lines at the same distance from the substrate for each photo.

1b) High value area

To begin surveying the high value area, 3 x 50m transects are laid as shown in Figure 3:

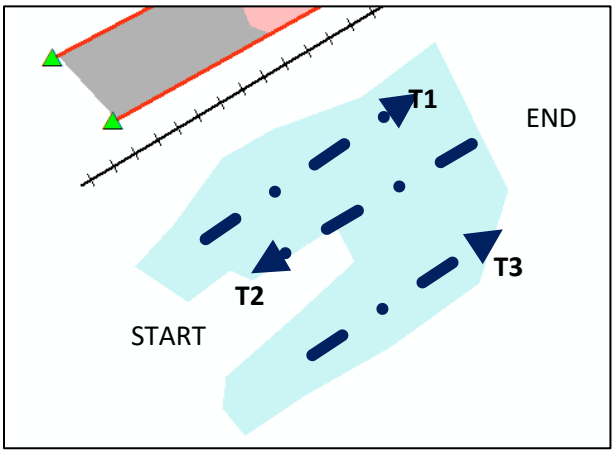

Figure 3. Survey area B showing the location of the 3 x 50m transects

Reef fish assemblage

The fish surveyor conducts 3 x 3-minute timed swim fish surveys along the transect areas. In addition, all *Acropora* table corals within the area are counted and measured using the following 3 size bins: 0-20cm, 21-50cm, >50cm.

GoPro video

Video is taken along each transect using the same method from survey method A.

Benthic assemblage photo quadrats

Photos are taken every 1 meter along the 3 transects using the same method from survey method A.

Coral demography

A 1m x 1m quadrat is randomly placed every 5m along the first 25m of the transect (5/transect; 15/total). Coral will be identified to species level, growth form is assigned and length and width/height are measured to the nearest centimeter.

2. Results

2a) Benthic community assemblage

The benthic substrate of reef flats recorded during pre-removal surveys of site A (removal path) and site B (high coral value) revealed that these areas are dominated by hard coral and crustose coralline algae (Figures. 4-5). An average of 48.9% of site A and 57.8% of site B was covered with live hard corals, and 18 % of site A and 21.9% of site B by crustose coralline algae. Benthic surveys conducted after the removal of the ship revealed that hard coral and turf algae dominated the benthic substrates in both site A and B (Figures 4-5). An average of 53.8% of site A and 51.3% of site B was covered with live hard corals, and 37.9 % of site A and 9.9% of site B by turf algae. In site A, there was a 12% decline in crustose coralline algae and an increase in turf algae. Overall, mean cover did not vary between pre and post-surveys.

The highest coral cover in site A was *Acropora* sp. (50.3%) but was also the lowest coral cover in Site B (Figure 6). *Pavona* sp. (18.83%) was the highest coral cover in Site B, yet not present in site A. *Leptastrea* sp. was only present in site B and *Favia* sp. in site A. *Acropora* sp. (42.4%) still comprised the highest coral cover in site B, and the lowest in site A (Figure 7). *Pavona* sp. (30%) also continued to represent high cover in site A, and very low in site B (1%). An average of 34% of *Acropora* sp. were partially bleached in site B, and just 1% in site A. There was no occurrence of bleaching in site B.

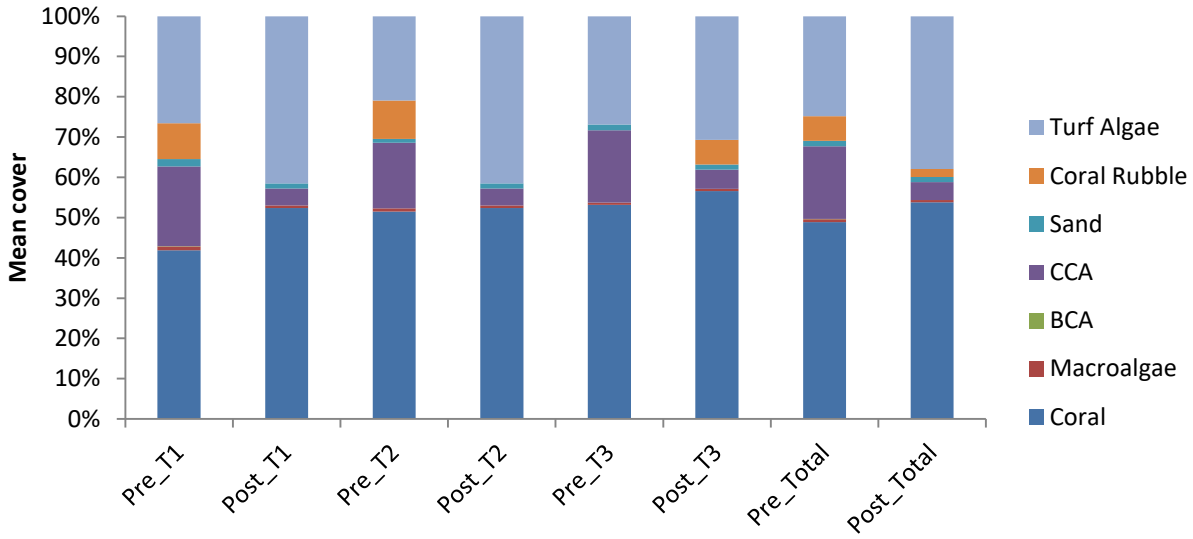

Figure 4. Mean percent cover of major benthic categories at reef fleet in Leone recorded along site A. Note that BCA = branching coralline algae, CCA = crustose coralline algae

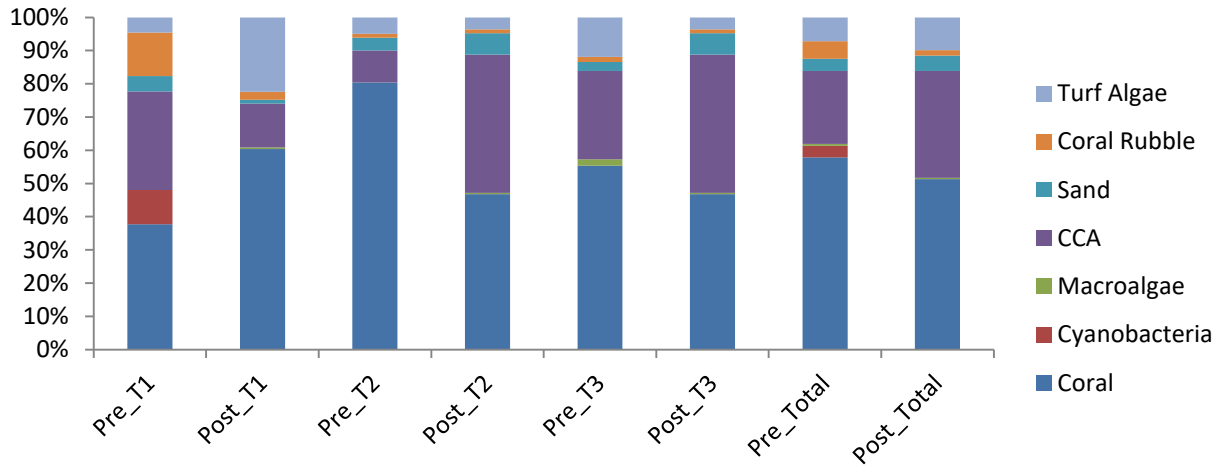

Figure 5. Mean percent cover of major benthic categories at reef fleet in Leone recorded along site A. Note that CCA = crustose coralline algae

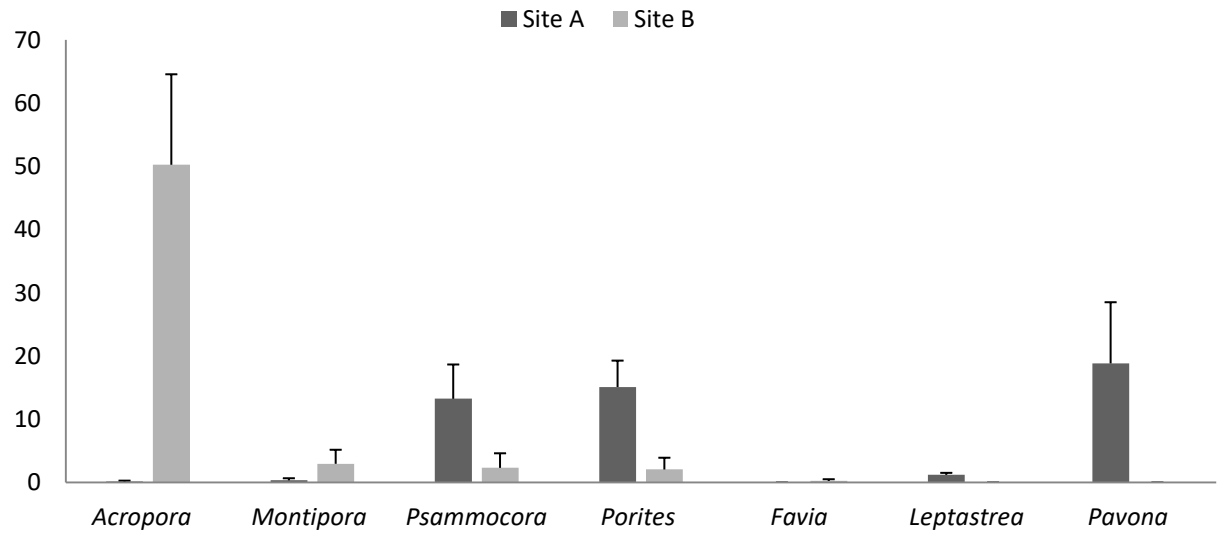

Figure 6. Mean (±SE) of coral genus at reef flat in Leone along site A and site B.

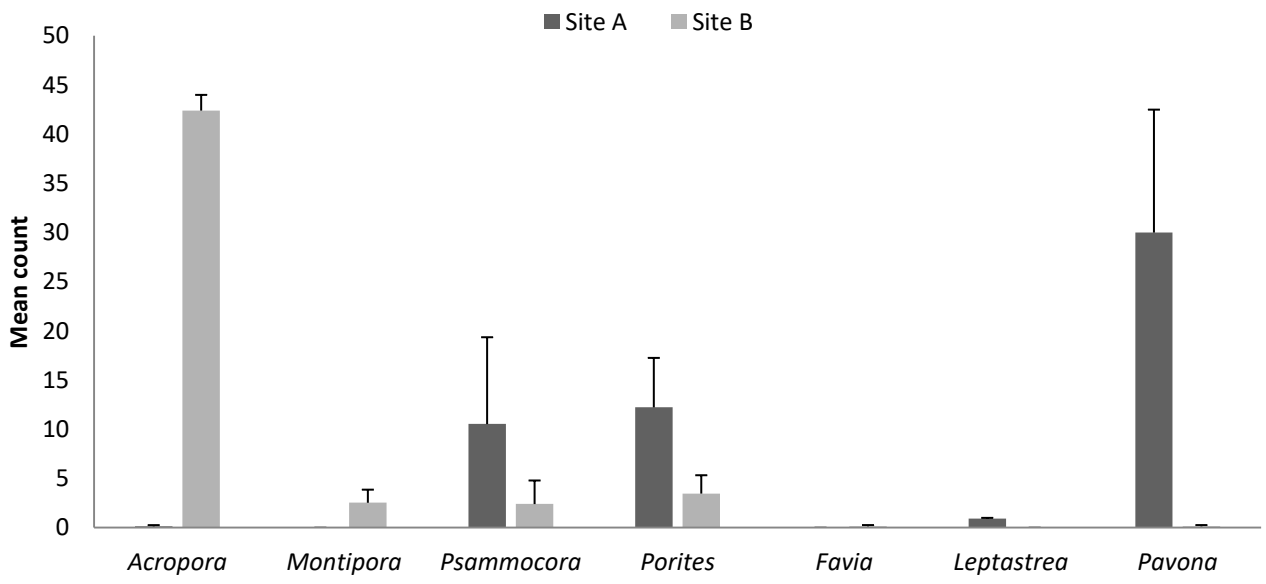

Figure 7. Mean (±SE) of coral genera recorded in Leone at site A and site B.

2b) Coral demography

Coral species diversity was low in both areas, but this was expected by the surveyors based upon previous work in the area, and the environmental conditions of Leone. Overall, the abundance of corals was greater in the removal path area, but this was dominated with *Porites* spp. (massive), *Pavona frondifera* and *Acropora* sp. Coral presence declined as the rubble-dominated section of the bay was approached. The branching acroporids remained intact with no visible evidence of direct physical damage (Figures 8-9).

No physical damage was observed in the high value area between the pre and post surveys (Figure 9). Although fewer corals were recorded during the post-survey, this is likely a result of quadrat placement rather than coral mortality from the shipwreck removal process. All of the fragile and critically important acroporid tables were intact throughout the area (Figure 8).

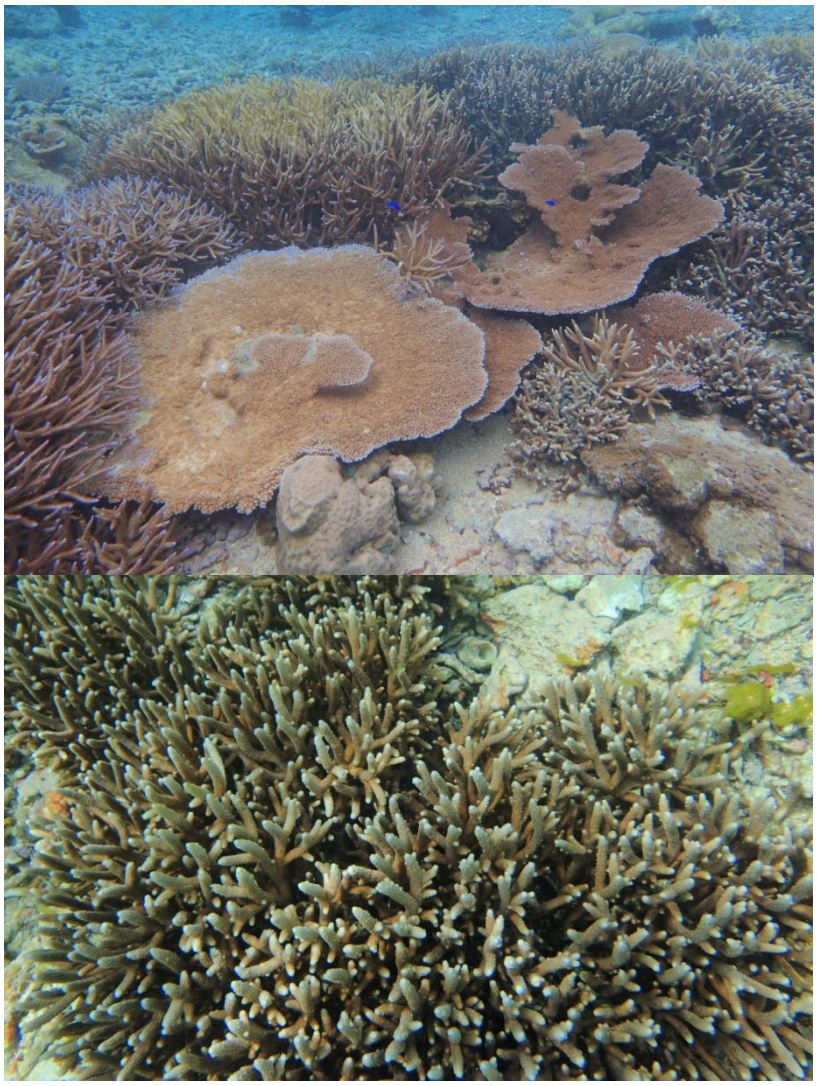

Figure 8. Intact acroporid tables and branching species following the removal of the shipwreck

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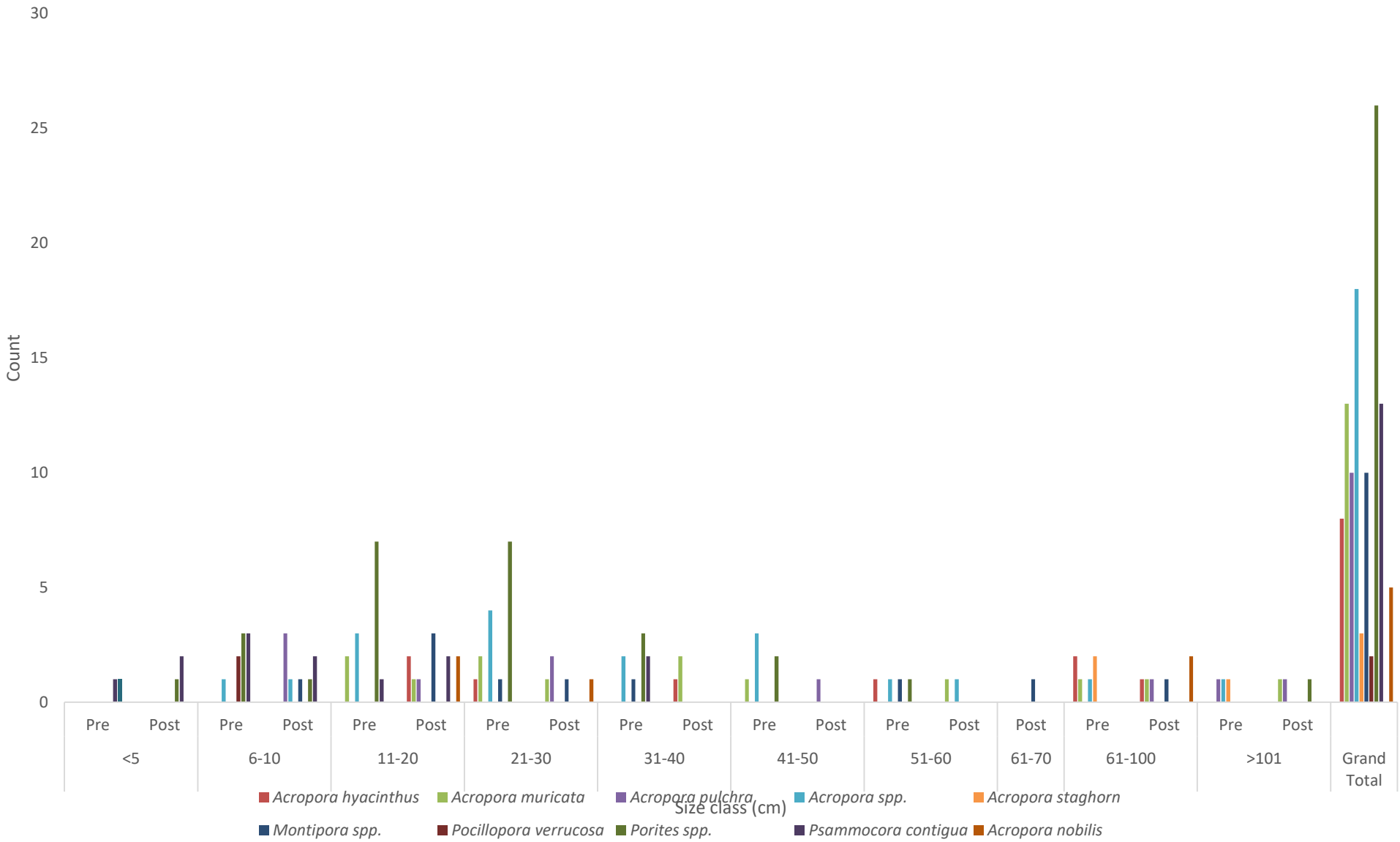

Figure 9. Genera and their size class (cm) recorded in site B (high value area) of Leone.

2c) Reef fish

Reef fish diversity remained fairly consistent between the two survey periods. In the pre-survey, a total of 57 species of fish were recorded and a total count of 987 individuals (Figure 8). The post-removal survey recorded slightly higher number of fish, 1032 individuals but a lower diversity (36 species; Figure 9). As there was no decline in habitat due to physical damage, this is not likely to be a significant result or impact for the fish assemblage in Leone Bay. Fish in Leone are comprised mainly of small-bodied fishes, such as surgeonfish, damselfish, and butterflyfish. This is to be expected given the type of habitat, and corals and how shallow the area is. However, small-bodied groupers were also observed which indicates how important this area is as a nursery habitat.

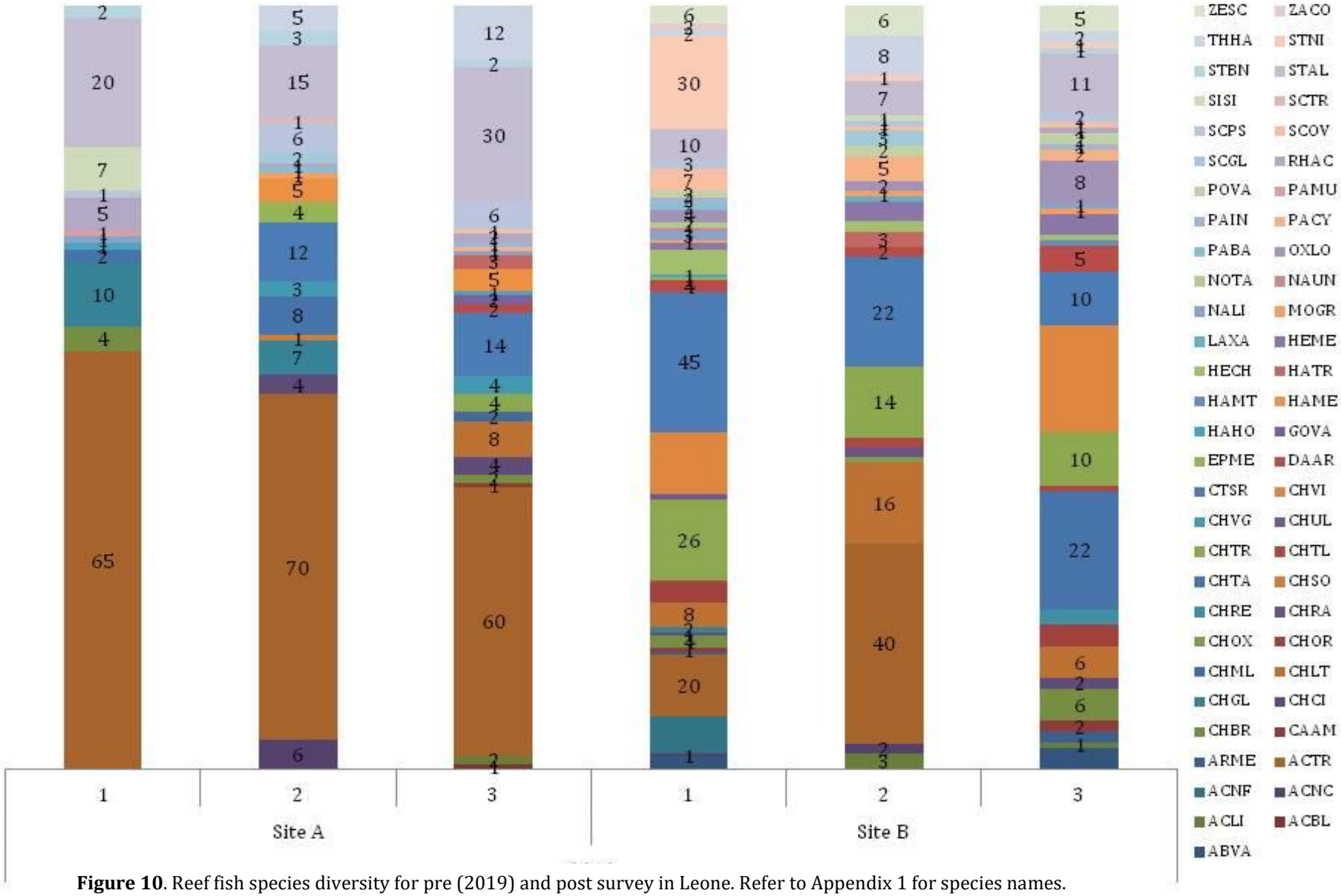

Figure 10. Reef fish species diversity for pre (2019) and post survey in Leone. Refer to Appendix 1 for species names.

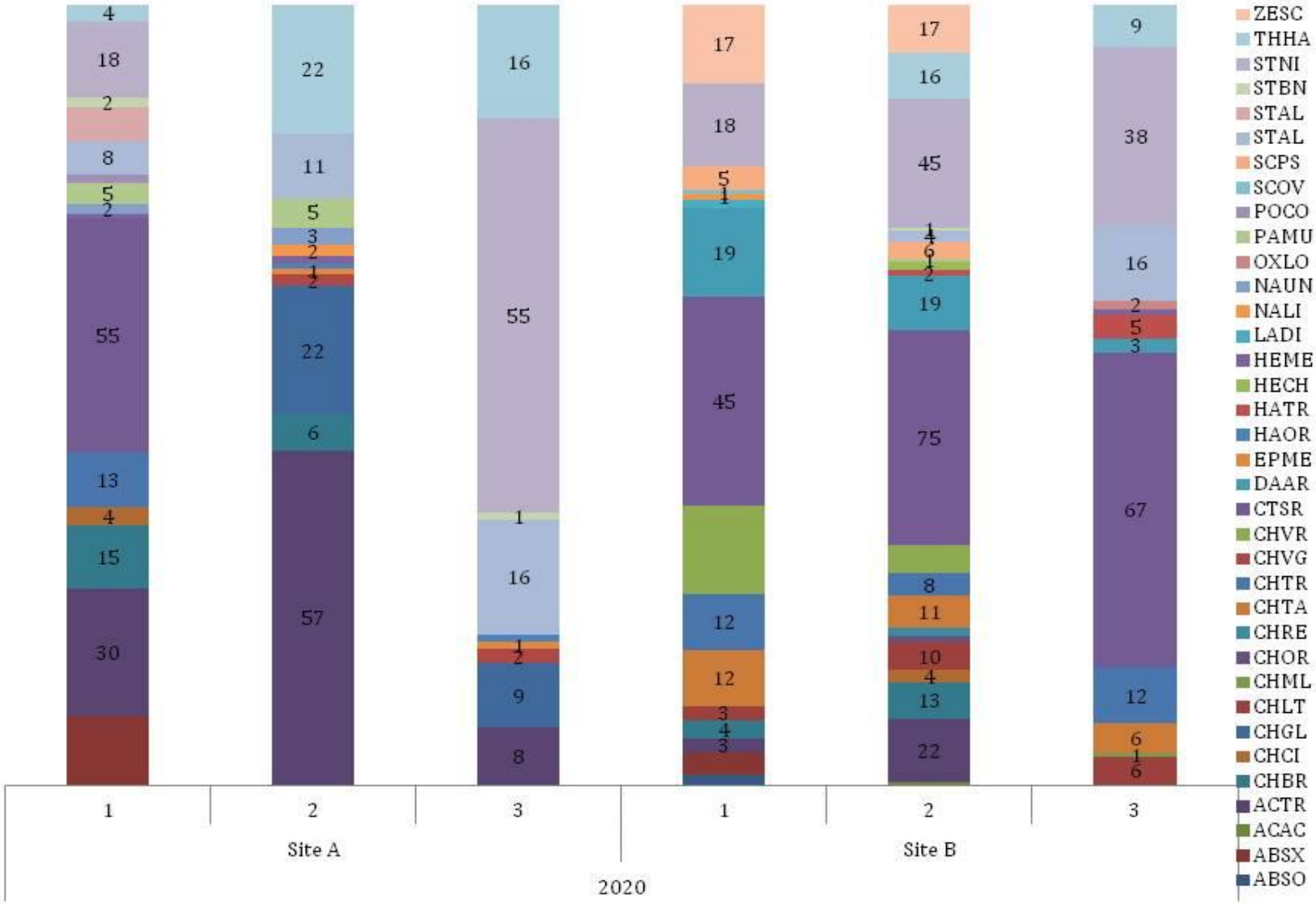

Figure 11. Reef fish species diversity for post (2020) and post survey in Leone. Refer to Appendix 1 for species names.

2d) Shipwreck debris

A substantial amount of shipwreck debris was recorded around the removal path area (Figure 12). Coordinates for the locations of some of the larger pieces of fiberglass and pipes were taken. Leaving the debris can result in direct physical damage to the corals, and abrasion of delicate coral tissue. Refer to Section 4 for recommendations.

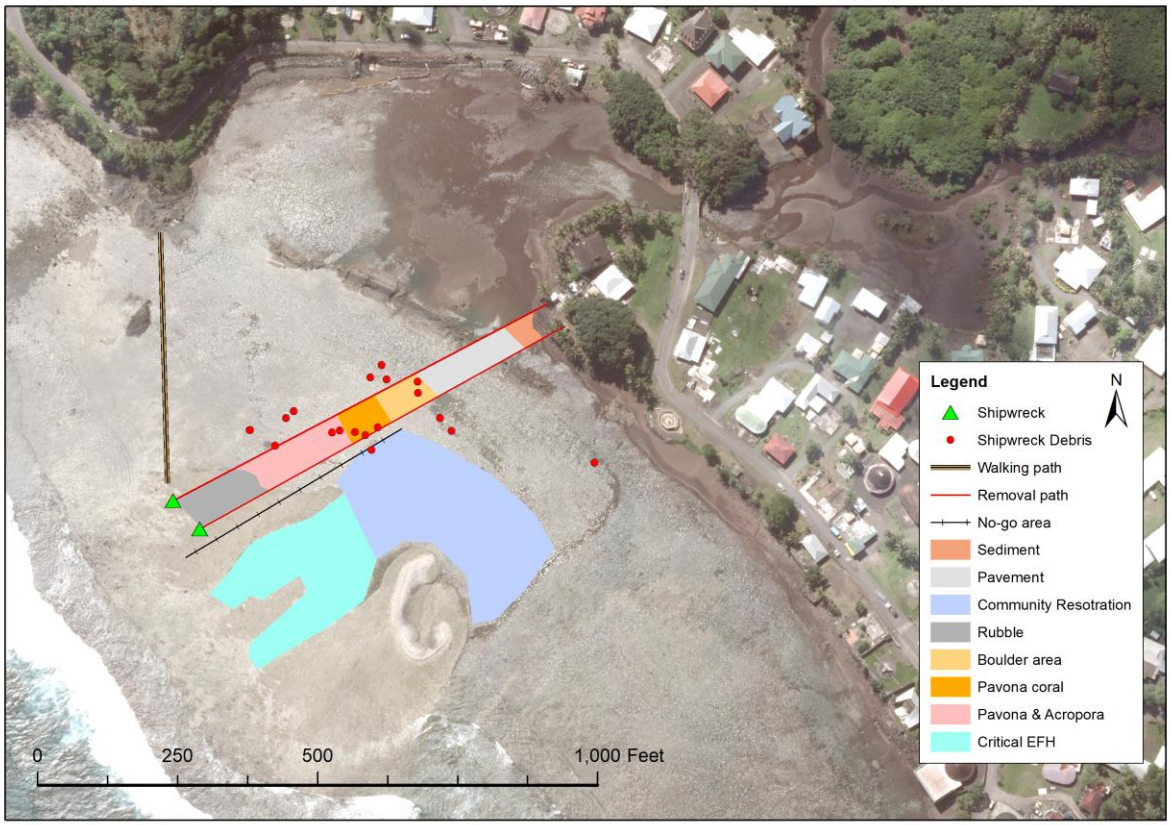

Figure 12. Map of survey area and their habitat characterizations with locations of shipwreck debris (indicated by red circles).

3. Discussion

A visual assessment of the entire Leone Bay area revealed low to no levels of physical impact damage from the shipwreck removal process. In the removal path area, only one small *Porites* sp. colony appeared to have been turned over. There was no other evidence of direct contact, fragmentation and/or abrasion of any coral tissue. In the high value area, all acroporid tables remained intact, and the large thickets of *Acropora muricata, A. aspera, A.* sp. and *A. nobilis* also showed no evidence of physical breakage. This assessment was confirmed by results of the coral demography and benthic community assemblage surveys. Both revealed little to no change between coral and benthos between the pre and post-surveys.

However, in the high value area there was a high rate of coral mortality on the majority of branching acroproid colonies which is likely due to a combination of high-water temperatures and extremely low tides that resulted in coral bleaching and long exposure rates, and not a result of the shipwreck removal process (Figure 13).

Figure 13. An example of bleached acroporid colonies at Leone Bay. Note that this is not a result of the shipwreck removal process.

4. Recommendations

While physical damage has been minimal; a very high quantity of large ship debris remains within the bay (Figure 14). Debris includes large pieces of metal and fiberglass, as well as poles and pipes. Some pieces have begun being cemented into the reef and associated pavement. However, many pieces of debris are unattached and they have the potential to cause significant damage to the corals through direct contact, and resultant breaking of colonies, as well as abrasion of tissues.

We highly recommend that H&H conduct a thorough clean-up of the entire bay area to remove all debris and prevent future damage to the reef.

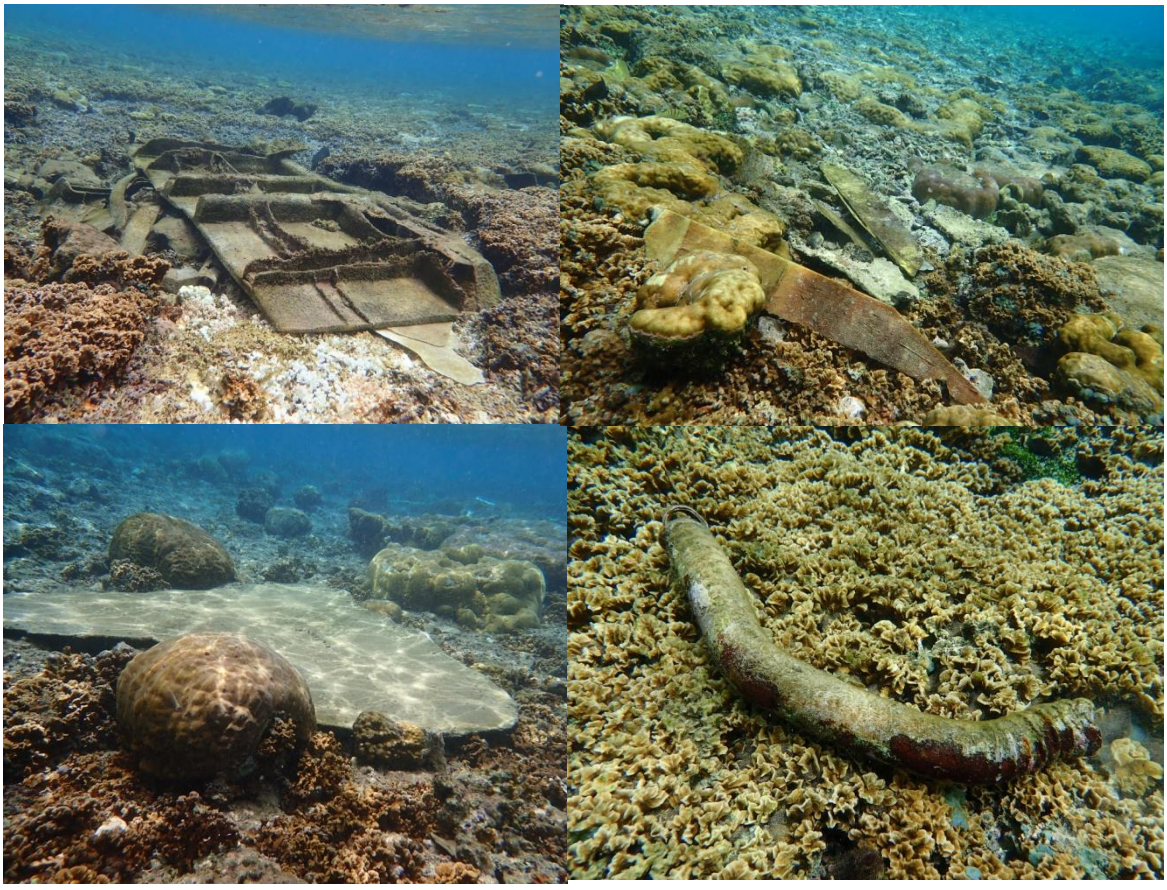

Figure 14. Examples of the extensive debris from the shipwreck and removal process that remains on the corals in Leone.

5. Conclusion

Overall, the removal effort by H&H has resulted in minimal physical damage to the corals in Leone. We commend their effort, transparency and their hard work to ensure that damage was prevented and minimized, and we further appreciate the involvement of local agencies throughout the entire process. However, we recommend a dedicated debris removal effort to prevent any physical damage from occurring.

6. Appendix 1: Reef fish code and species name

CODE	Fish Species
ABVA	Abudefduf vaigiensis
ACBL	Acanthurus blochii
ACLI	Acanthurus lineatus
ACNC	Acanthurus nigricans
ACNF	Acanthurus nigrofuscus
ACTR	Acanthurus nigrofuscus
ACTR	Acanthurus triostegus
ARME	Arothron meleagris
CAAM	Canthigaster amboinensis
CHCI	Chaetodon citrinellus
CHLT	Chaetodon lunulatus
CHML	Chaetodon melannotus
CHOR	Chaetodon ornatissimus
CHRA	Chaetodon rafflesi
CHRE	Chaetodon reticulatus
CHTR	Chaetodon trifascialis
CHUL	Chaetodon ulietensis
CHVG	Chaetodon vagabundus
CHOX	Cheilinus oxycephalus
CHCI	Cheilinus sp
CHTL	Cheilinus trilobatus
CHSO	Chlorurus sordidus
CHVI	Chromis viridis
CHBR	Chrysiptera brownriggii
CHGL	Chrysiptera glauca
CHTA	Chrysiptera taupou
CTSR	Ctenochaetus striatus
DAAR	Dascyllus aruanus
EPME	Epinephelus merra
GOVA	Gomphosus varius
HAHO	Halichoeres hortulanus
HAMT	Halichoeres margaritaceus
HAME	Halichoeres melasmapomus
HATR	Halichoeres trimaculatus
HEME	Hemigymnus melapterus
HECH	Heniochus chrysostomus
LAXA	Labropsis xanthonota

MOGR	Monotaxis grandoculis
NALI	Naso lituratus
NAUN	Naso unicornis
NOTA	Novaculichthys taeniourus
OXLO	Oxymonacanthus longirostris
PABA	Parupeneus barberinus
PACY	Parupeneus cyclostomus
PAIN	Parupeneus insularis
PAMU	Parupeneus multifasciatus
POVA	Pomacentrus vaiuli
RHAC	Rhinecanthus aculeatus
SCGL	Scarus globiceps
SCOV	Scarus oviceps
SCPS	Scarus psittacus
SCTR	Scarus tricolor
SISI	Siganus spinus
STAL	Stegastes albifasciatus
STNI	Stegastes nigricans
STBN	Stethojulis bandanensis
THHA	Thalassoma hardwickii
ZACO	Zanclus cornutus
ZESC	Zebrasoma scopas