INVASIVE SPECIES CONTROL PROJECTS (R1 SMALL GRANTS)
FY 2014 FINAL REPORT

Project Title: Corallimorph control and eradication at Palmyra Atoll NWR

Station: Palmyra Atoll National Wildlife refuge

Contact Person: Amanda Pollock

Project Description:
The coral reefs at Palmyra Atoll National Wildlife Refuge (Palmyra) are under attack from an invasive corallimorph, *Rhodactis howesii*, an anemone like species that is out competing corals and smothering the reef. *R. howesii* were seen increasing in number on the western terrace of Palmyra after a long-line fishing vessel wrecked in the area in 1991. Available data including two surveys of the infestation in 2007 and 2011 suggests the vessel is fueling the growth of *R. howesii* perhaps by releasing iron, a limited element in seawater. The corallimorph is currently spreading over once pristine coral reefs, killing and smothering corals and turning an area once rich in species diversity into a monotypic blanket of corallimorph. Recent surveys in 2011 show that *R. howesii* has now spread over 250 acres of reef smothering corals across the western terrace and on the north and south fore reefs of the atoll. The speed at which the corallimorph is spreading poses a serious threat to the health of the reefs surrounding Palmyra and the coral reef ecosystem as a whole. In the past few years several control and eradication methods have been trialed, three of which have been proven successful. One of these (Tarp method) involves killing all organisms on the benthos using bleach and tarps and would be suitable for eradication in areas where corallimorph cover exceeds 60%. Pilot studies using this method show that once cleared from the substrate, corallimorph do not recover for at least a year. A second method (focal treatment) involves killing individual corallimorph using calcium bicarbonate and is more suited to eradication in areas where corallimorph cover is equal to that of corals (thereby limiting collateral damage). Pilot studies also reveal that reef fish will eat corallimorph. We hypothesize, therefore, that if large enough areas are treated, local predators will limit corallimorph densities and allow recovery of the reef.

Invasive Species Targeted: *Rhodactis howesii*

Project Completion Date or Estimated Completion Date:
This is an ongoing project with many stages. The first stage included the removal of the Hui Feng No. 1 ship wreck, which was completed in January 2014. The second stage of the project is to remove and control the corallimorph which has spread over the western terrace. Due to a lack of refuge staffing in 2013, the corallimorph removal phase has been delayed a bit, and a corallimorph control and removal trip was undertaken in September of 2014. This was the first of many corallimorph control and removal trips planned for the future, with a project completion date in 2018. Essential Fish Habitat consultation with the National Marine Fisheries Service may be needed (among other permits) for a large removal and control action, and the Service is looking into this requirement.

Project Results:
The ultimate goal of the corallimorph control project is to scale up initial control efforts by treating 20 acres at the periphery of the expansion with focal treatment, and 10 acres in select portions of the high density areas using tarp method. This project is in the beginning phase of field work and will continue to evolve. Focal treatment in high coral cover areas continues at site RT-10 with great results. Removal patches that were treated in the winter of 2012 show coral tissue regrowth and little to no corallimorph regrowth. Work was also done on the genetics of the corallimorph and quantifying the densities around

the wreck itself. These removal sites were monitored throughout 2013 and 2014 and continued to look good with Crustose Coralline Algae (CCA) and turf algae recruiting to the bare substrate left when the corallimorph was removed, showing efficacy of control measures. In September of 2014 a team of divers employed tarping and spot treatment techniques to remove corallimorph in the heart of the infestation area, near where the wreck used to sit. The team conducted a large-scale, replicated corallimorph removal and coral restoration experiment. The purpose of this experiment was to investigate the recovery/succession of corals and other benthic reef organisms, such as CCA, in cleared plots over time following full corallimorph removal. As well as recovery/succession of corals and other benthic reef organisms in cleared plots over time following full corallimorph removal & coral transplantation into the cleared areas. The experiment also aims to determine whether coral spatial arrangement affects recovery rates, by using three different transplant configurations; random, aggregate and aggregated by species. Throughout the experiment and restoration effort several factors will be measured including; coral recruitment, natural settlement, net reef growth and calcification, and coral growth rates. Prior to removal actions experiments were run to determine the proper removal agent and dosage. Fifteen 12 x 12 ft plots were established, with three 3 plots per treatment and 5 treatments. Twelve of these plots received granulated chlorine, were covered with a black tarp and the edges sealed with sand bags for 48 hours to kill the corallimorph. This technique was only used in areas of 100% corallimorph cover. All plots were marked with stainless steal pins at the four corners, a marker float, and photographed before and after treatment. Three plots were left untreated as control plots. A total of 1728 ft2 have been cleared of corallimorph around the former wreck site. Calcification and Accretion Units (CAU) were deployed at all plots to measure the recruitment of benthic organisms at the sites. Nine of the twelve sites that were treated to remove the corallimorph were also deemed restoration sites where three species of coral and CCA were transplanted into cleared areas. The remaining three removal plots were used as removal controls (figure 1.) Corals were transplanted into cleared plots in three different configurations; random, aggregated, and aggregated by species (figure 2). The removal plots were resurveyed in October 2014 and the transplanted corals were looking healthy. The removal plots were no longer white as seen in the figures below, alga and CCA had begun to recruite to the cleared substrate and the plots were now starting to show the colors of reef life.

Work was done in July and August of 2013, in collaboration with the Scripps Institution of Oceanography, on mapping the extent of the corallimorph with photomosaic methods to develop a high resolution map of the western terrace, and the existing magnitude invasion of the corallimorph (see appendix 1). The same area was resurveyed and mapped again in August of 2014, and these surveys will continue for several years. These annual surveys and maps will give the Service a high revolution view of the state of the Western Terrace, and show the effects of the removal of the corallimorph as well as the recovery of the reef community.

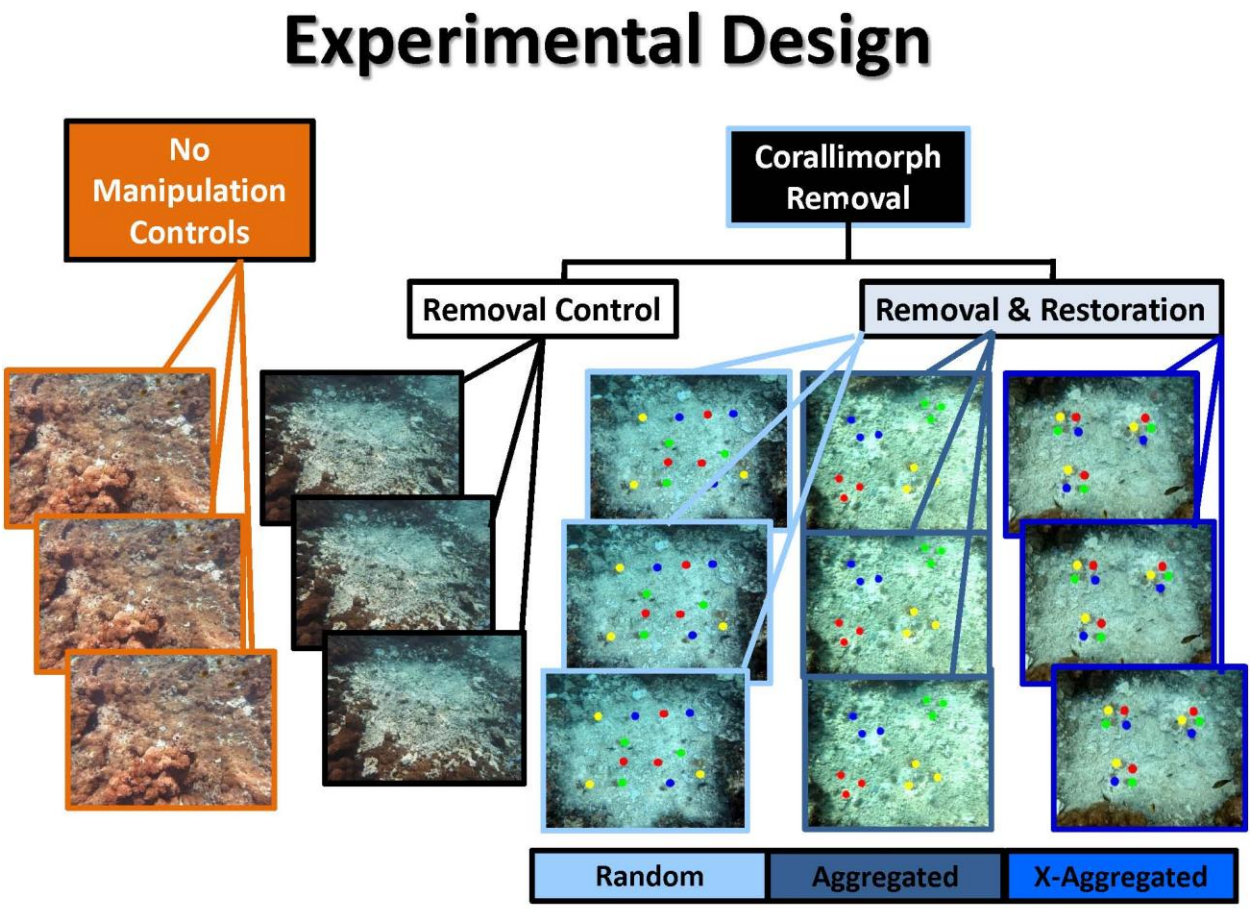


Figure 1. Experimental design for restoration efforts after corallimorph removal.

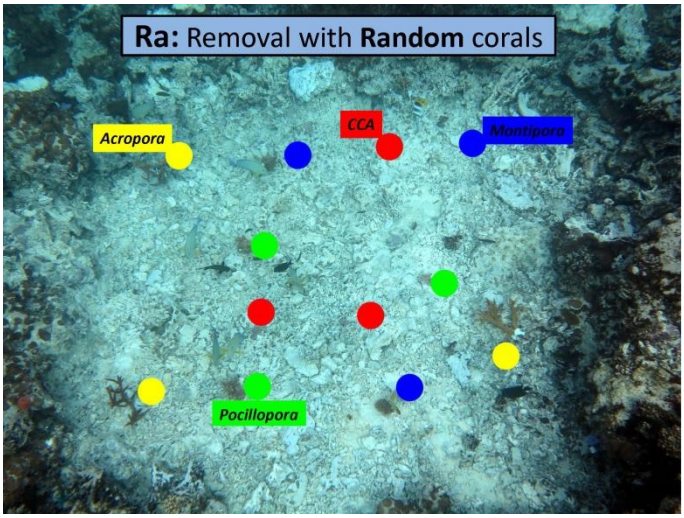
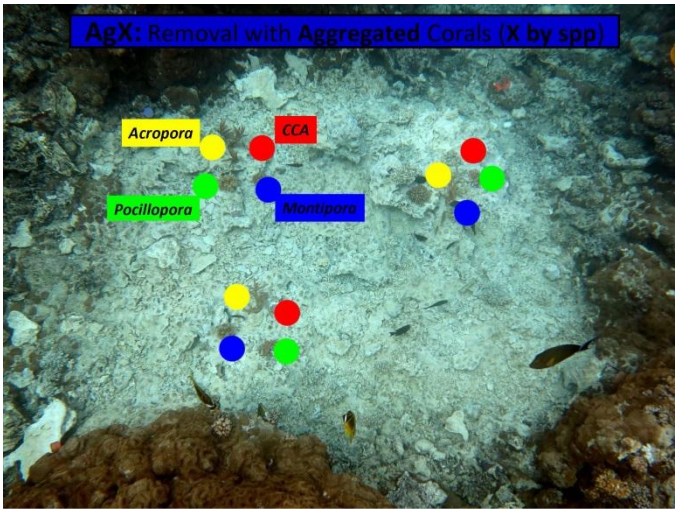


Figure 2a.



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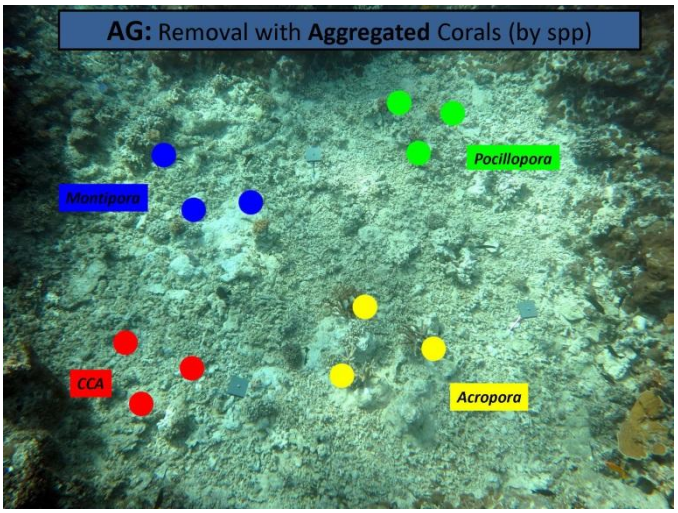


Figure 2c.

Figure 2. Experimental design of transplanted corals. Corals and CCA were transplanted into cleared plots in three different configurations; 2a) random, 2b) aggregated, where clumps of CCA and different species of coral are aggregated together creating three different mixed species clusters, and 2c) aggregated by

species, where like species of coral and the single species of CCA were aggregated creating four different single species clusters.

Figure 3. Corallimorph removal plot with tarp sealed with sand bags.

Figure 4. Corallimorph removal plot after treatment with CAU and transplanted corals.

Number of Acres Treated: 1.5
This is very labor and time intensive work and requires SCUBA diving. Although only a small area has been treated, this will lead the way for larger removal efforts and because removal in treatment plots is 100% there is a large impact to the surrounding area.

Number of Acres Inventoried and/or Mapped: 22 acres of the western terrace have been mapped for both coral cover and invasive corallimorph cover in 2013, and these 22 acres were resurveyed and mapped again for changes in coral reef community composition in August of 2014. This has been done in conjunction with the Inventory and Monitoring grant.

Total Grant Amount: $40,000

Breakdown of Expenditures:

Category	**Total $ Spent**	**% of Total Grant**
Equipment/Supplies	0	0
Chemical	0	0
Biocontrol Agents	0	0
Travel	40,000	100
Biotech/Contractor Salary	0	0
Restoration Materials	0	0
Other (Describe)	0	0
TOTAL	40,000	100

Due to a lack of staff to carry out the intended work in 2013, 100% of the grant was put into a future plane flight with Ashville Jet Charters. This flight was used to bring a team of divers down to Palmyra in August and September of 2014 to participate in control and removal efforts. The cost of one round trip flight to Palmyra from Honolulu is $40,000.

Appendix 1

Palmyra Atoll 30 day report to USFWS – Gareth J. Williams (email: gareth@ucsd.edu)

Trip dates: July 22nd – August 14th 2013

Team members: Gareth J. Williams (Team Lead, post-doc SIO), Jesse Tootell (SIO volunteer)

Activity: Benthic community mapping surrounding the longliner

Background: The goal of this project was to document baseline benthic community conditions surrounding the longliner shipwreck on Palmyra Atoll prior to the removal of the longliner shipwreck later this year. While many institutions belonging to the Palmyra Atoll Research Consortium (PARC) have long-term monitoring data pertaining to benthic and reef fish communities, we wanted to capture focused data on benthic communities in the immediate vicinity of the wreck at a spatial scale never before captured. The reef surrounding the wreck has undergone a phase shift from coral-dominated communities to domination by the corallimorph *Rhodactis howesii*. We anticipate the removal of the shipwreck will affect community dynamics in the region and, as such, this project aimed to provide large-scale baseline information on benthic community structure, with the goal to complete follow-up surveys over time.

Methods: We designed a towed camera system that is constructed from lightweight aluminum speedrail (Fig. 1). The system is dragged approximately 8 m behind a boat on a pulley system to allow the raft to remain on a steady trajectory as the boat maneuvers. The raft sits approximately 50 cm below the water surface to escape bubbles and is towed at idle speed using a 20hp motor (~2km/hr). The system employs two arrays of GoPro Hero3 cameras (black edition); each array has four cameras recording high-definition video (1080p, 127° field of view, 48fps). A third array is also kept on the boat as a back-up system, or for use when either one of the two arrays run out of battery/memory. Plots were established using temporary buoys in each of four corners within a 100 x 100 m area. The camera system (nicknamed "PhotoMEGAraft") was towed in a double lawnmower pattern across the area, trying to ensure 80 – 90% overlap between successive passes (Fig. 2).

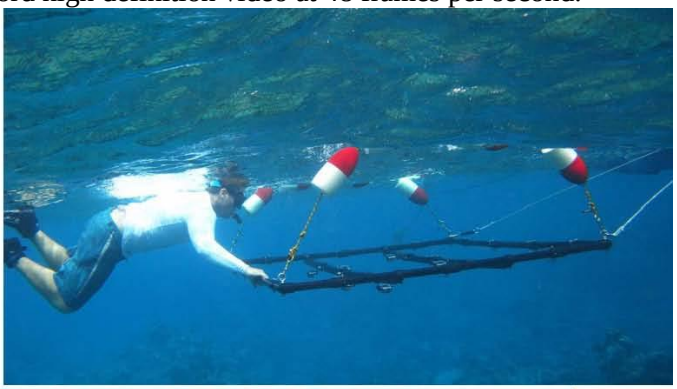
Summary statistics: We completed a total of seven plots, totaling approximately 90,000 m^2 of reef. Summary statistics are as follows:

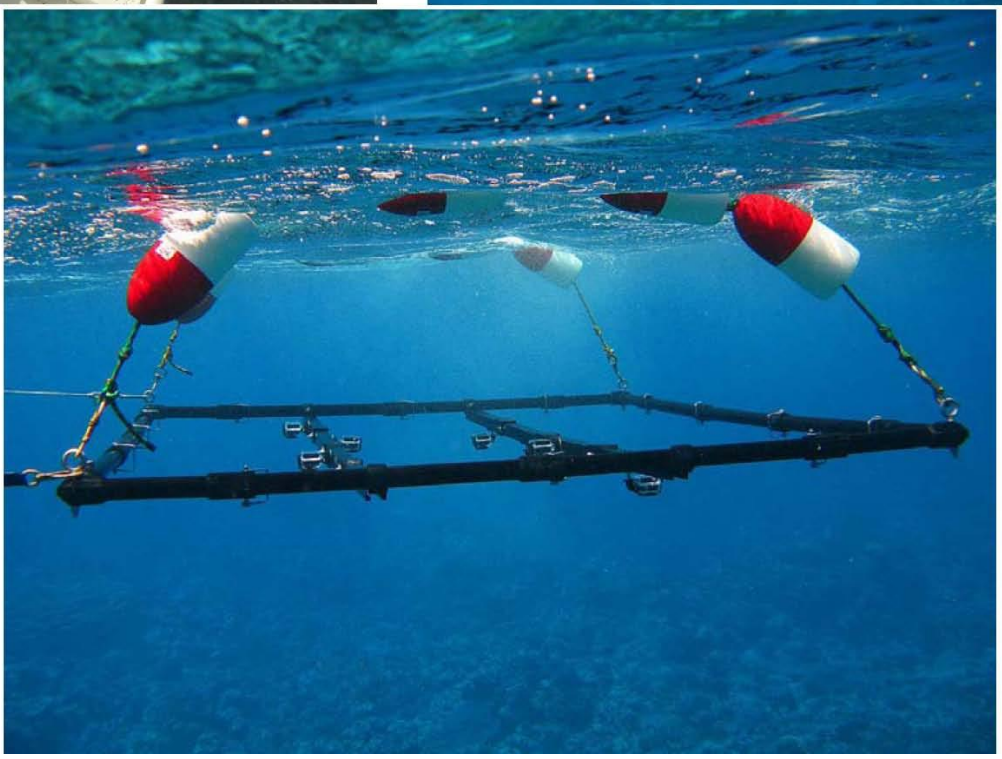
Total time towing: **37 hr**

Total distance towed: **80.2 km** Total area covered: **~90,000 m²**

Total memory stored: **6 TB**

Figure 1. Towed GoPro camera benthic mapping system ("PhotoMEGAraft") in action on Palmyra's shallow western terrace habitat adjacent to the longliner shipwreck. The system consists of two arrays, each using 4 GoPro Hero3 cameras, which record high definition video at 48 frames per second.





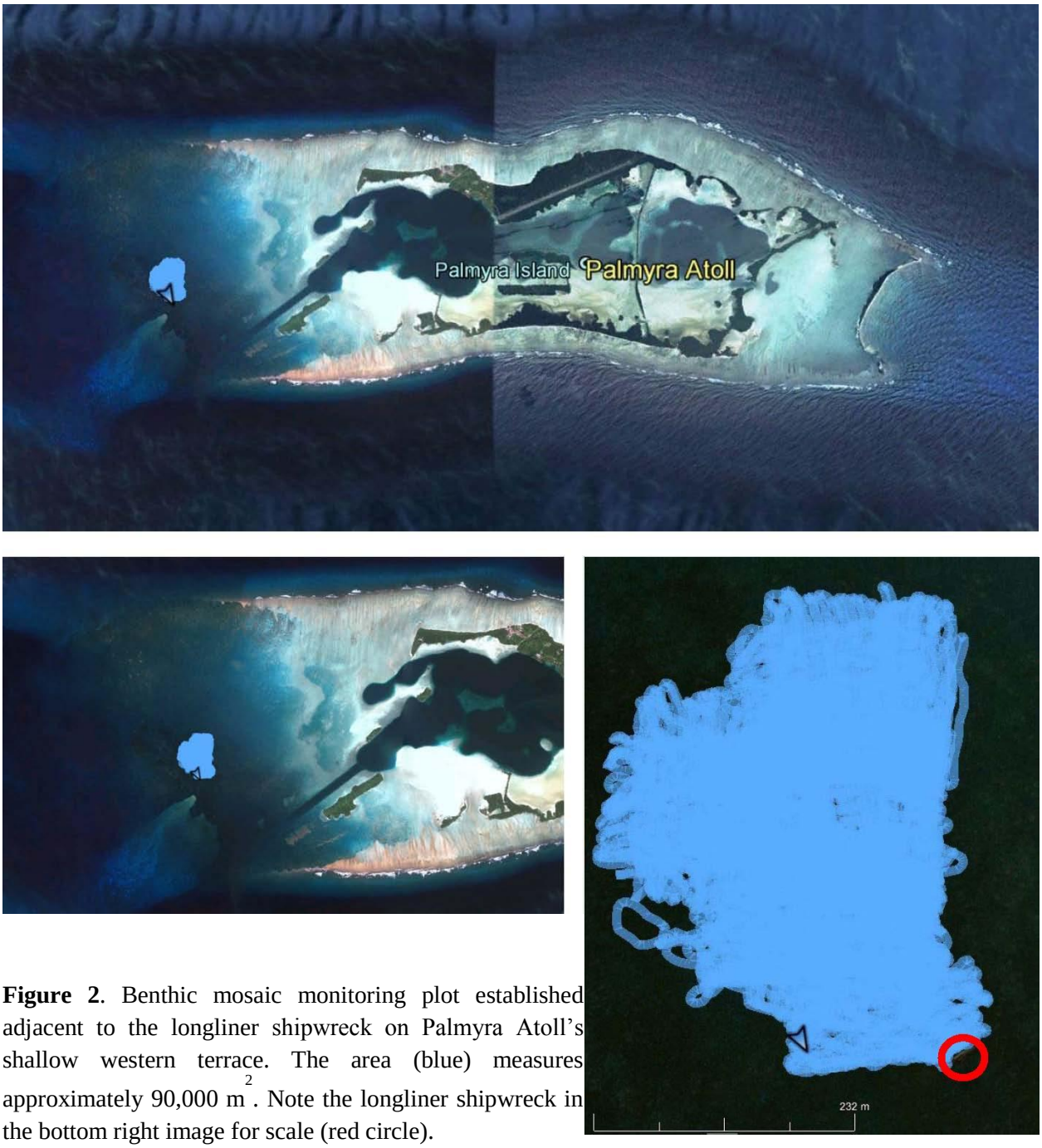


Figure 2. Benthic mosaic monitoring plot established adjacent to the longliner shipwreck on Palmyra Atoll's shallow western terrace. The area (blue) measures approximately 90,000 m^2. Note the longliner shipwreck in the bottom right image for scale (red circle).

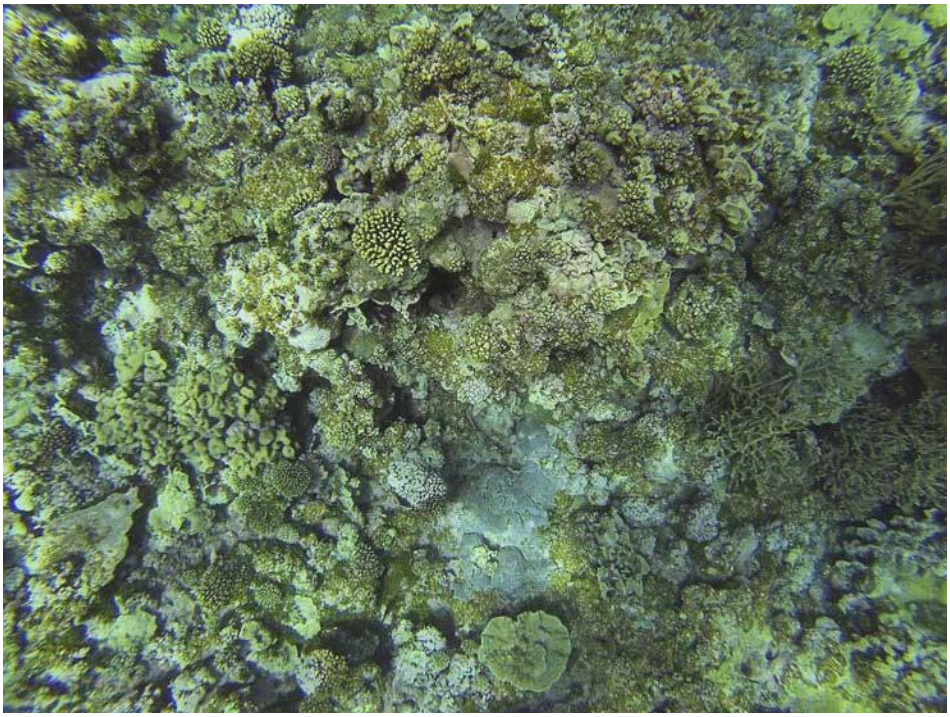


Figure 3. Example frame-grab from the high-definition video showing the high resolution of the images and the high coral cover in protected pockets close to the shipwreck.

Initial results: Despite the assumed total devastation of reef-building organisms within the close vicinity of the wreck, we did observe small patches (~25 m^2) of reef dominated by hard corals and crustose coralline algae within a ~400 m radius (Fig. 3). Qualitatively, species such as *Porites rus*, not a common competitor on Palmyra's reefs, and Fungiid corals appear to be strong competitors against the *Rhodactis* even extremely close to the wreck's location. We also noted that the survival of coral patches lends to the idea that resilience may be reinstated if the *Rhodactis* beds can be broken up into a more patchy landscape, thus allowing the more resistant coral species to regain competitive advantage.

Future goals: The benthic mosaic will be created with our collaborators at the University of Miami in the coming months to form a large (60,000 – 90, 000 m^2) continuous image of the reefs surrounding the longliner wreck. This image, which we will provide to USFWS, will provide a baseline prior to the wreck removal. We aim to complete follow-up surveys over time (2014, 2015) to identify if removing the wreck has an immediate appreciable effect on benthic dynamics in the region. Furthermore, the time point zero image will initially be analyzed in a grid formation (e.g. 5 x 5 m grids) to provide spatially explicit information about the pattern of coral versus *Rhodactis* patches within the area. This information will be an essential component in designing a successful partial-eradication plan for the *Rhodactis* beds if eventually proposed in order to optimize efforts.