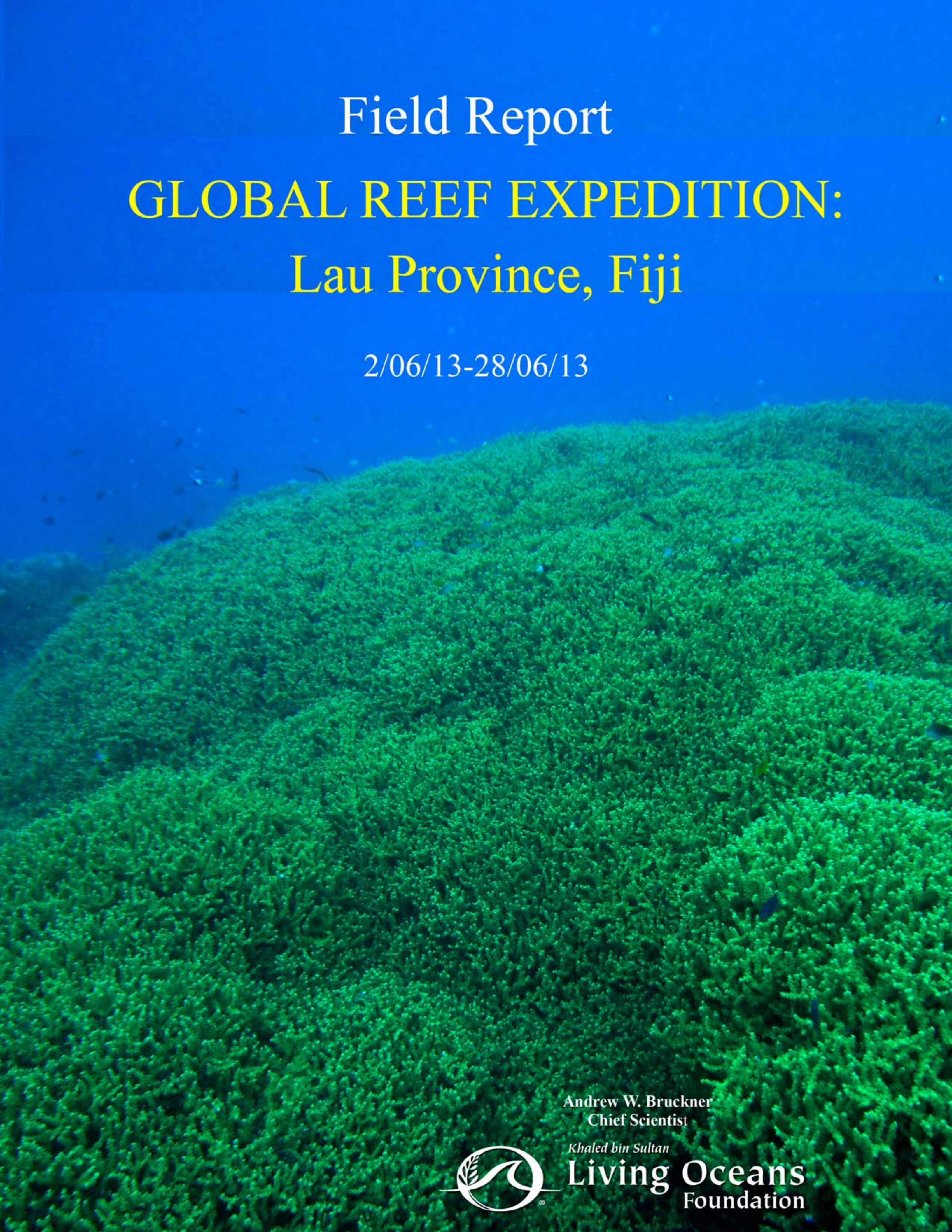


Field Report

GLOBAL REEF EXPEDITION: Lau Province, Fiji

2/06/13-28/06/13

Andrew W. Bruckner
Chief Scientist

Khaled bin Sultan
Living Oceans
Foundation

Front cover: An unusually large monospecific assemblage of *Galaxea horrescens* within a lagoonal reef in the northeastern corner of Vanua Balavu lagoon. Photo by Andrew Bruckner.

Back Cover: Complex *Acropora* community on the top of a Pinnacle off Moala, Lau Province. Photo by Anderson Mayfield.

Khaled bin Sultan Living Oceans Foundation
8181 Professional Place
Landover, MD, 20785 USA
Philip G. Renaud, Executive Director

http://www.livingoceansfoundation.org

This field report summarizes the activities undertaken by the Khaled bin Sultan Living Oceans Foundation in Fiji. It was developed as one of the products of the Global Reef Expedition: Lau Province, Fiji research mission to meet one of the requirements of the research permit approved by the Ministry of Education, Natural Heritage, Culture & Arts, RA 10/13 dated 11 April 2013.

May 5, 2014.

Citation: Global Reef Expedition: Lau Province, Fiji. Field Report. Bruckner, A.W. (2014). Khaled bin Sultan Living Oceans Foundation, Landover MD. 33 pp.

The Khaled bin Sultan Living Oceans Foundation (KSLOF) was incorporated in California as a 501(c)(3), public benefit, Private Operating Foundation in September 2000. KSLOF headquarters are in Washington DC. The Living Oceans Foundation is dedicated to the conservation and restoration of oceans of the world, and champions their preservation through research, education, and a commitment to *Science Without Borders*®.

For more information, visit http://www.lof.org and http://www.globalreefexpedition.com. Also on Facebook: https://www.facebook.com/livingoceansfoundation Twitter: https://twitter.com/LivingOceansFdn

EXECUTIVE SUMMARY

Between, 2 June 2013 – 28 June 2013, the Khaled bin Sultan Living Oceans Foundation conducted a research mission to the Lau Province of Fiji as part of the Global Reef Expedition. The research focused on coral reefs surrounding 11 islands: Totoya, Matuka, Moala, Fulaga, Kobara, Vanua Vatu, Nayau, Tuvuca, Cicia, Mago and Vanua Balavu. The project was conducted in partnership with the Wildlife Conservation Society of Fiji, Lau Provincial Office and Fiji Department of Fisheries, with involvement of scientists from the University of the South Pacific, Fiji Department of Fisheries, Nova Southeastern University, University of the Azores, University of the Philippines, NOAA/University of Miami, Wildlife Conservation Society, National Museum of Marine Biology and Aquarium of Taiwan, Reef Environmental Education Foundation (REEF), and Victoria University. Roko Sau Joesefa Cinavilakeba (Pacific Blue Foundation and Vice Chairman of the Lau Provincial Council) and Roko Laitia Raloa (Lau Provincial Office) provided assistance with traditional protocols, meetings and deliberations with the Chiefs, Council and elders on each island, and education activities.

The objectives of the mission were to:

1) Identify and characterize shallow marine habitats and develop habitat and bathymetric maps:
2) Evaluate the composition, structure and health of coral reefs using a standardized assessment protocol;
3) Assess the diversity, abundance and population structure of fishes, corals and other invertebrates, and algae, including commercially valuable species;
4) Document the impacts of broad scale disturbances and patterns of recovery with emphasis on storm damage and crown of thorns predation impacts;
5) Evaluate the effects of environmental stressors on coral health;
6) Characterize the composition of symbionts (zooxanthellae) inhabiting colonies of *Pocillopora*, how they vary depending on environmental parameters, and how the variation effects photosynthetic efficiency; and
7) Measure ocean chemistry (pH) and effects on coral growth.

Groundtruthing: A total of 2,273 sq. km of WorldView 2 satellite imagery was acquired. To characterize shallow marine habitats, 787 videos (drop cameras) and 3,037,823 depth soundings were taken across the 11 islands, covering a distance of 798.2 km. Georeferenced WorldView-2 imagery was used to plan bathymetric tracks to sample habitat locations of interest to drop video cameras. The bathymetric information will be used to calibrate a model which will assign a depth value to each pixel in the imagery data. Similarly, information from the camera drops will be used to assign a habitat type to the imagery data. Together, detailed maps of bathymetry and habitat type will be produced for the three locations visited.

Coral Reef Assessments: Surveys were conducted across 11 islands. A total of 416 fish transects, 420 benthic surveys, 198 coral assessments and 417 phototransects were completed in 70 locations from 5-30 m depth. Over 29,625 corals, 4 cm diameter and larger were examined. A total of 448 species of reef-associated fish were identified during roving surveys. All roving surveys were entered by dive location into the REEF database.

Coral Reef Research:

- Crown of thorns (COTS) removal: A total of 212 starfish were collected from one outbreak noted at Cicia. These animals were 11-36 cm in length (mean=26 cm).
- Ocean Acidification: Water samples, coral coring and measurements of water chemistry were undertaken to evaluate effects of recent changes in ocean chemistry. A total of 273 cores were collected at 10-12 m depth off the 11 islands. These included *Porites lobata, Goniastrea, Pavona clavus, Goniastrea, Favia stelligera, Cyphastrea serailia, Platygyra, Montipora, Diploastrea Porites lobata* and *Pavona clavus*.

These will be sectioned and examined using a CT scan to quantify variations in coral growth rates and relationship with ocean chemistry.

- Sediment: A total of 181 sediment samples were collected to characterize sediment composition and grain size. In the lab, samples are analyzed using a Camsizer® instrument to determine the size and shape of sediment grains.
- Coral health: Tissue samples from 148 colonies of *Pocillopora damicornis* and *Pocillopora* spp. were collected to assess subcellular levels of stress. Simultaneous measurement of light, salinity, temperature, depth, time and appearance of sampled corals. In the lab tissue will be examined for changes in gene/protein biomarker expression in response to differences in the environment. In addition, a genetic analysis of the unidentified *Pocillopora* samples will be undertaken to validate the species.
- Coral symbiont composition and relationship with photosynthetic efficiency: A total of 484 samples of *Pocillopora* (11 species) were collected from 11 islands for symbiont characterization. On each reef representative samples spanned the depths of the reef (generally 5-30 m). The photosynthetic efficiency, through measurements of fluoresce was assessed for a subset of these colonies from 10 m depth through day and night measurements using a PAM fluorometer.
- Coral metabolomic studies: Tissue samples (n=60) from *Porites*, *Pocillopora, Acropora, Montipora, Seriatopora,* and *Stylophora* were collected between 5-30 m depth in two locations to evaluate the identity, composition and quantity of the primary metabolites transferred from the symbiont to the coral host. Samples were frozen in liquid nitrogen and transported to University of Victoria for analysis.

Fig. 1. Crown of thorns starfish (*Acanthaster planci*) were collected from Cicia, at a site experiencing an outbreak. All starfish were measured and sampled before being destroyed.

Summary of general observations

Habitat structure

- Diverse reef types. Fore reef communities often had a barrier reef with a reef flat leading to a series of pinnacles that drop near vertically to 15-20 m depth, followed by a more gradual slope. The walls and pinnacle faces often had undercut ledges and small caves. Most islands were associated with deep lagoons which contained patch reefs, coral bommies and well developed back reef communities
- Extensive coral habitat. Shallow water areas had a well developed Acropora zones consisting of multiple canopy layers constructed of table acroporids. Gently sloping surfaces especially at the edge of the vertical wall often had a rich branching coral community consisting of thickets of staghorn and bottlebrush acroporids, *Pocillopora*, *Hydnophora, Stylophora, Seriatopora* and other taxa. Vertical surface often had a rich plating coral community dominated by *Pachyseris, Merulina*, *Echinopora*, *Turbinaria*, *Montipora* and *Echinophyllia* intermixed with soft corals while the bases of some pinnacles had extensive assemblages of plating and foliaceous corals
- High relief. The pinnacles were separated by deep channels. On horizontal and gently sloping fore reef areas there were small boulders, mounds and overlapping sheets of table acroporids, often forming a canopy 1-2 m in height.
- Interconnected habitats. Fore reef areas were interconnected with lagoonal habitats by a deep channel. Lagoonal areas had extensive grassbeds and often diverse mangrove communities.

Invertebrate Species assemblages

- Diverse soft corals. As in other locations in Fiji, fore reef communities, especially on vertical surfaces of pinnacles and walls are carpeted with a diverse assemblage of soft corals (especially *Dendronepthya)*, as well as branching gorgonians and sea fans. Shallow reef communities and the upper surfaces of pinnacles that were damaged or degraded had large mats of leather corals, and several deep reef communities were dominated by carpets of *Xenia*.
- High diversity of reef building corals. In addition to diverse *Acropora* communities, less common corals such as *Plerogyra*, *Physiogyra*, *Blastomussa*, *Cantharella*, *Caulastrea* and *Euphyllia* were recorded.
- Unusually large single species assemblages. In addition to thickets of acroporids, large monospecific stands of foliose *Montipora, Turbinaria, Pachyseris, Echinophyllia* and other taxa, stands of branching *Galaxea* and *Porites cylindrical*, columnar *Porites rus* and *Pavona clavus*, and other corals were found in both lagoonal and fore reef habitats
- Well developed deep water coral communities. At the base of pinnacles and continuing down the fore reef slope reefs often had very high cover of living corals. These were spatially variable, however, as about 50% of the deeper reefs were damaged and lacked extensive coral communities; instead these were dominated by *Xenia*, macroalgae and/or cyanobacteria.
- Diverse *Acropora* communities. In shallow water and at mid depths these were often dominated by tabular growth forms consisting of large, old colonies with multiple canopy layers.
- High diversity of motile invertebrates: In addition to periodic observations of lobsters, large crabs, Octopus, squid, gastropods (e.g. helmet snails, trumpet triton, spider conch), and giant clams, at least nine species of sea cucumbers were noted. These were most common below 15 m depth (and commercially valuable species were found in areas distant from villages), but in general consisted of low abundances.

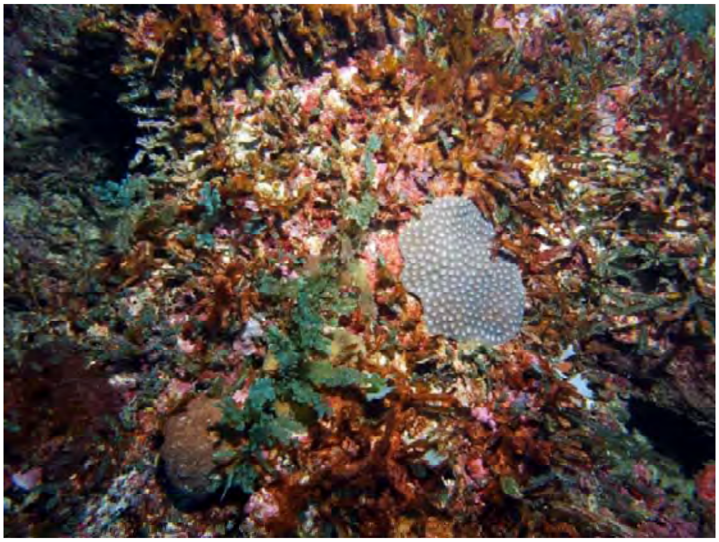
Fish communities

- Small-bodied fishes such as damselfish, butterflyfish and wrasses consistently made up the majority of the fish diversity at survey sites in Fiji. A large proportion of the total species identified (448) were from highly cryptic fish groups such as gobies and blennies.
- Despite high species richness, large individuals of important functional groups such as herbivores (parrotfishes and surgeonfishes) and piscivores (groupers, snappers and sharks) were few. Consequently, biomass of these groups was also much lower.
- Significant variations in species assemblages and biomass, especially of fishes that are preferred food species (e.g. target species), were seen between islands and reefs.
- In Totoya, reefs surveyed inside the lagoon which were part of the MPA had more structural complexity compared to the adjacent site at the forereef. There were more large-sized fishes such as parrotfishes, surgeonfish, and groupers, and a higher biomass, inside the lagoon, compared to the forereef.
- In Matuka, fish were very abundant at the top of the coral pinnacles, mainly surgeonfishes, some breams and snappers. Sharks were not recorded in the transects and other large predators such as groupers, snappers and jacks were very few in number.
- In Moala, fish communities were characterized by high abundance of small bodied fish such as damselfishes, anthias and wrasses. There was a good variety of parrotfishes, surgeonfishes and unicornfishes but these were generally few in number. Fish on the tops of pinnacles were not as concentrated as that observed at Matuka and Totoya sites.
- In Fulaga, the number of species and abundance of fish was higher than any of the sites visited in the previous three other atolls. The habitat was fairly different in having steep walls with clear water. Prevalent species associated with these habitats included varieties of *Chromis*, *Pseudanthias* and *Naso*, and a number of new species were recorded.
- Kobara Atoll had a high abundance of damselfishes, parrotfish and surgeonfish but the fish were all small in size. Very few groupers or other top predators were observed.
- Vanua Vatu exhibited very poor fish biomass and diversity. The only larger fish recorded were in shallow areas.
- Nayau and Tuvuca both exhibited a very rich fish diversity with high abundance of target fish, especially at shallower sections of the reef such as the reef crest.
- Cicia had a high fish diversity, but biomass was low except for two sites.
- Mago Island had a low biomass and diversity of fish overall.
- Most sites off Vanua Balavu had a low diversity and biomass of fish with few large target species. Some reefs did have a number of sharks. Notable differences in fish communities were noted within one MPA within the lagoon, but an adjacent site (also protected) was unremarkable.

Fig. 2. Groupers were rarely seen except in a few locations.

Reef condition

- Many reefs had an unusually high cover of macroalgae, especially in deeper water. This was dominated by several species of *Caulerpa, Tidymania, Lobophora,* and *Halimeda*. Dense communities of *Caulerpa* and *Halimeda* were seen on vertical surfaces.



High cover of cyanobacteria was noted in many deeper locations (below 15 m) especially on horizontal and gently sloping surfaces. The cyanobacteria covered the substrate and was overgrowing submassive corals.

Fig. 3. Macroalgae and cyanobacterial mats covered much of the substrate in deeper water and could be found engulfing and overgrowing corals, such as the *Diploastrea* shown here.

- Crown of thorns starfish (COTS) were present on many islands, but rare. The only exception was an outbreak limited to a single reef in Cicia. Hundreds of COTS were found in very shallow water. These were decimating acroporids and other species on the reef flat, sides of Pinnacles and at the base of pinnacles to about 15 m depth.
- The most significant corallivore was the snail *Drupella.* While these snails were not at high enough abundances to kill entire colonies, from 5-25% of the corals (primarily *Acropora, Montipora* and *Pocillopora*) had lesions from snails.

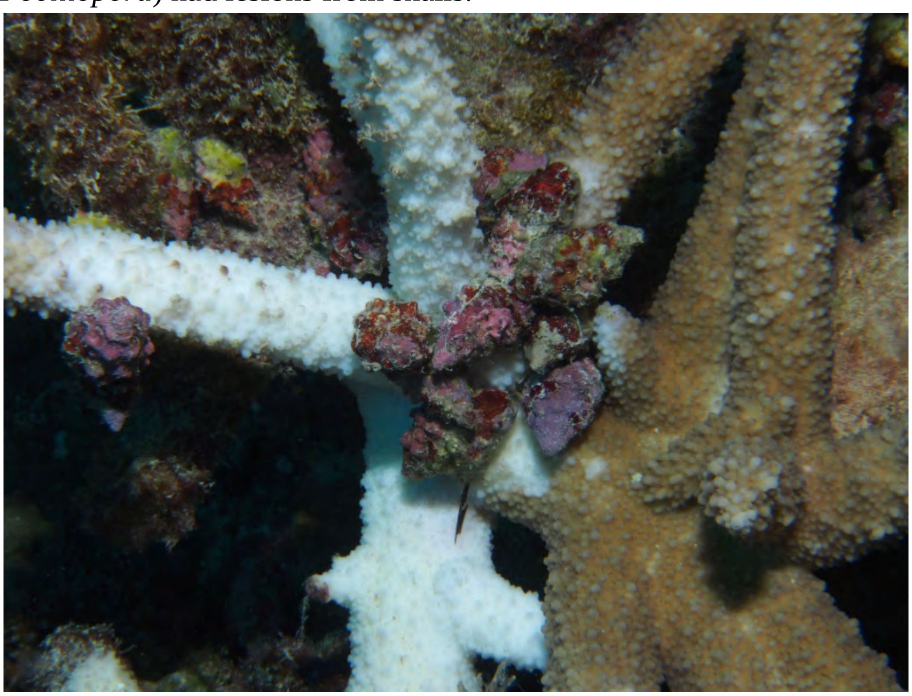


Fig. 4. Staghorn coral (*Acropora*) with an aggregation of *Drupella* snails. The white areas are coral skeleton devoid of tissue.

- Coral diseases present included white syndrome, yellow band disease and pink line syndrome, but prevalence low. There was also a number of areas affected by a disease of crustose coralline algae.

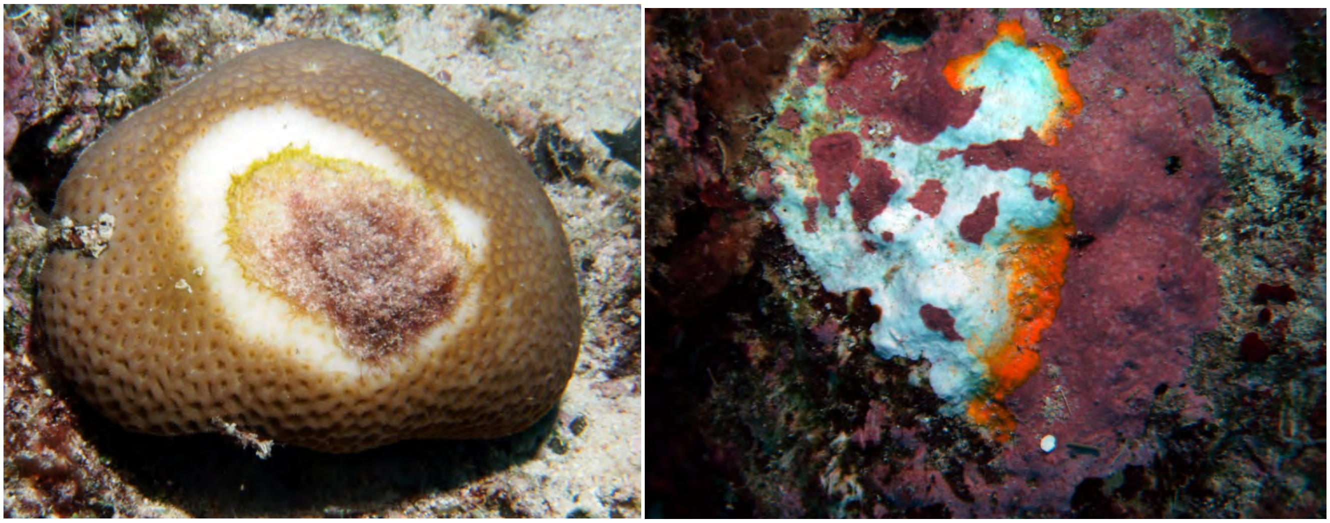


Fig. 5. Diseases of reef organisms. *Goniastrea* with yellow band disease (left) and crustose coralline algae with lethal orange disease (right).

- Bleaching was rare. Only individual pale or bleached corals were found.
- High number of damselfish algal lawns were recorded on corals. Considerable damage to fore reef and lagoonal reef communities was attributed to *P. lacrymatus* damselfish algal lawns.

Fig. 6. Damselfish algal lawn carpeting the reef.

- Some fore reef areas showed signs of physical damage, including overturned corals and large piles of rubble.
- Damaged areas show high recruitment of faster growing corals such as *Pocillopora*, *Acropora*, and *Stylophora*.

Research Completed

1. Habitat mapping and groundtruthing:

Using multispectral satellite imagery obtained from DigitalGlobe WorldView 2 satellite, high resolution bathymetric maps and habitat maps are being created for shallow coral communities. Groundtruthing efforts necessary to develop these maps focused on aerial surveys of each island's coastline and adjacent shallow marine habitat, continuous bathymetry measures, drop camera analysis, characterization of sediment and hard substrates and habitat features using two acoustic sub-bottom profiling equipment (Stratabox and Hydrobox) and fine scale photo-transect surveys.

Satellite imagery

A total of 1703 sq km of WorldView 2 (8 band) satellite imagery was acquired for this project (Table 2). The satellite images had a spatial resolution of 2-m by 2-m (i.e., each pixel covers a 4-m^2 area) enabling real-time navigate in the field to locate features of interest and to avoid dangerous features (e.g., emergent reefs). In order to navigate, the team used the scenes in conjunction with a differential GPS device (dGPS). The imagery is being used with ground truth data to create bathymetric and benthic habitat maps.

Benthic Video

An underwater video camera attached to a cable, called a drop-cam, was used to gather video on the benthic composition at each survey site. At each point, the drop-cam was held from the survey boat enabling it to 'fly' along the sea floor as it records video for 15 to 60 seconds. During this time, the laptop operator watched the video in real-time and guided the drop-camp operator to raise or lower the camera. In this manner, we were able to prevent damage to marine life. The video was recorded on a ruggedized laptop, and the geographic position, time, date, boat heading, and boat speed were burned into the video. Drop-cam deployment was limited to depths above 40 m due to the limited length of the tether cable (50 m). The acquired videos are being used to create the benthic habitat maps by providing the necessary information for the development of a habitat classification scheme and training of classification models.

Acoustic depth soundings

Depth soundings were gathered along transects between survey sites using Hydrobox, a single-beam acoustic transducer, developed by Syqwest. The instrument emits 3 pings per second. Depths were estimated based on the time the return-pulse's reaches the sounder's head. Geopositional data were simultaneously acquired by the dGPS unit. The estimated depth values and their geographic location were recorded in the ruggedized laptop. The soundings were used to train a water-depth derivation model, which is based on the spectral attenuation of light in the water column. The final topographic map will have the same spatial resolution as the satellite imagery. An average of 100,000 acoustic depth soundings was gathered during a full work day.

Acoustic sub-bottom

Profiles of the seafloor's sub-bottom were also gathered along transects using the Stratabox acoustic sounder, also developed by Syqwest. Similar to the bathymetric soundings, the sub-bottom profile emits an acoustic ping which reflects off the seafloor. However, the pulse has a lower frequency (3.5 Khz) enabling it to penetrate the seafloor. The instrument provides observations on stratal geometry beneath the seafloor along the transect lines, allowing estimates of Holocene reef-growth and sediment accumulation to be made. Geopositional data for each ping was simultaneously acquired by dGPS unit; it was recorded in the SEGY file. Profiles were run shore-perpendicular to capture the geometry of the bank flanks and span a depth range of 300 m to 5 m. Total transect length varies with the slope's angle; steeper slopes resulted in shorter transect lines.

Site	Imagery (sq km)	No. dropcams	No. depth soundings	Track length (km)
Totoya	311	105	412,190	130.740
Matuka	168	54	181,378	45.706
Moala	268	157	524,732	124.100
Fulaga	102	58	250,518	71.533
Kobara	76	31	156,591	40.175
Vanua Vatu	41	23	65,708	17.392
Nayau	45	24	82,152	25.427
Tuvuca	78	53	181,574	42.533
Cicia	91	38	96,931	32.159
Mago	57	29	102,444	25.169
Vanua Balavu	1,036	215	983,605	243.290
Total	**2,273**	**787**	**3,037,823**	**798.224**

Table 2. Summary of groundtruthing datasets including total area of satellite imagery acquired, number of deployments of the drop camera, number of depth soundings and total distance covered by the groundtruthing team.

Fig.7. Coral reefs were very complex with a wide variety of habitats including shallow water exposed reef crest and reef flat communities, to spur and groove barrier reef systems, pinnacles, vertical walls, coral bommies and high relief deeper slope communities.

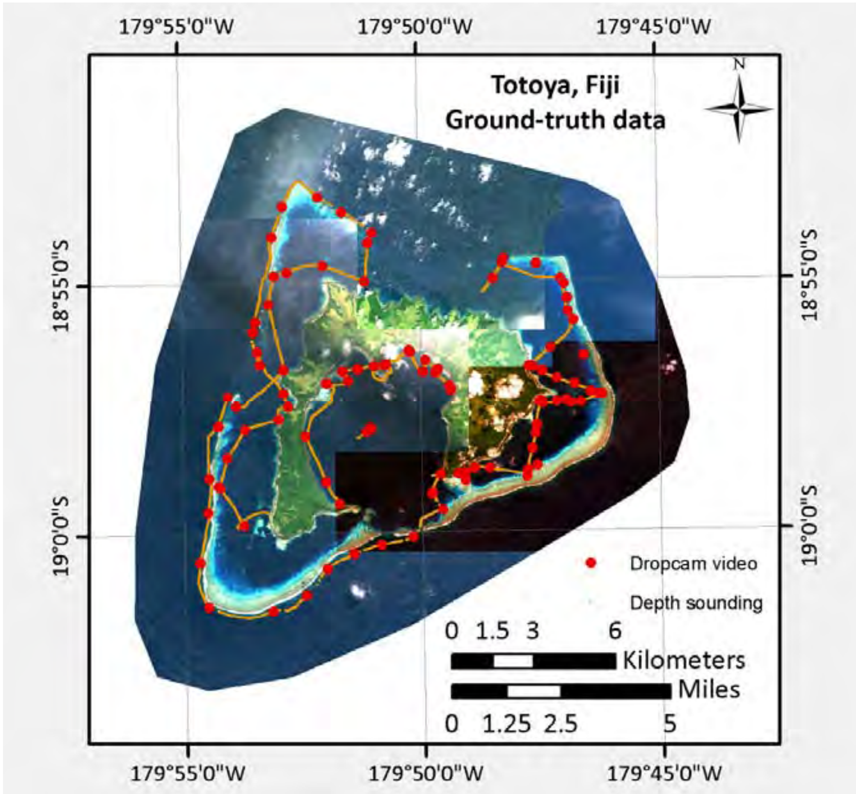


Fig. 7. Groundtruthing track in Totoya, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

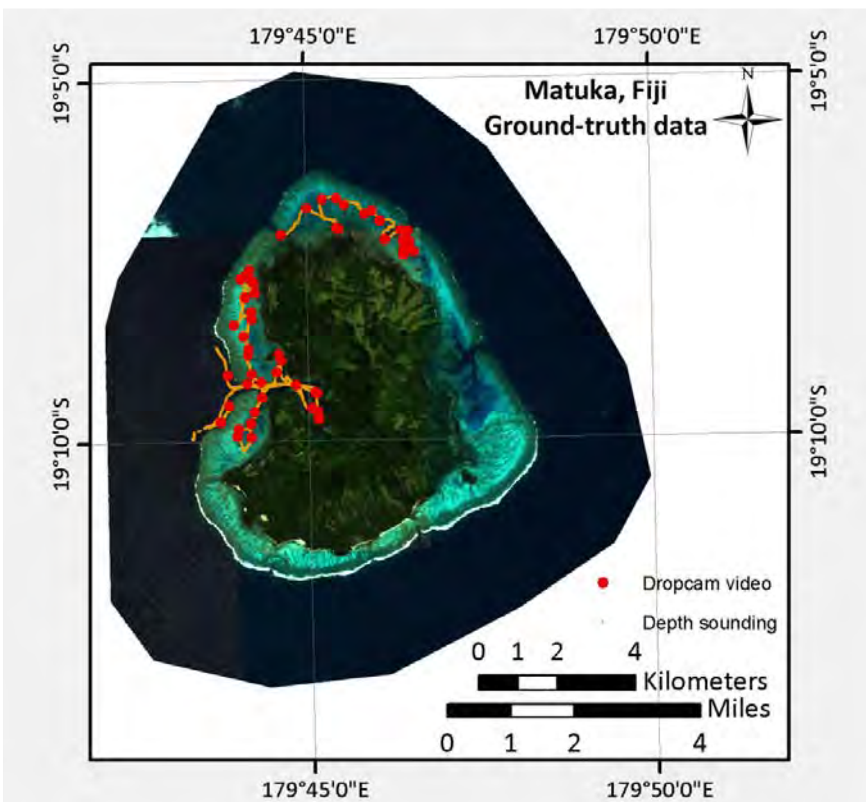


Fig. 8. Groundtruthing track in Matuka, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

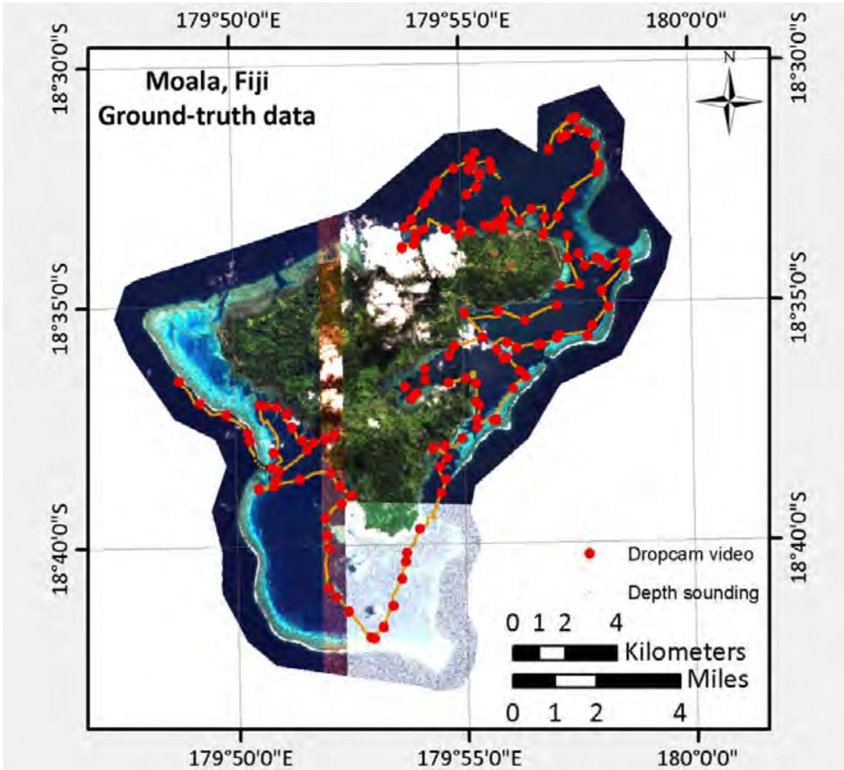


Fig. 9. Groundtruthing track in Moala, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

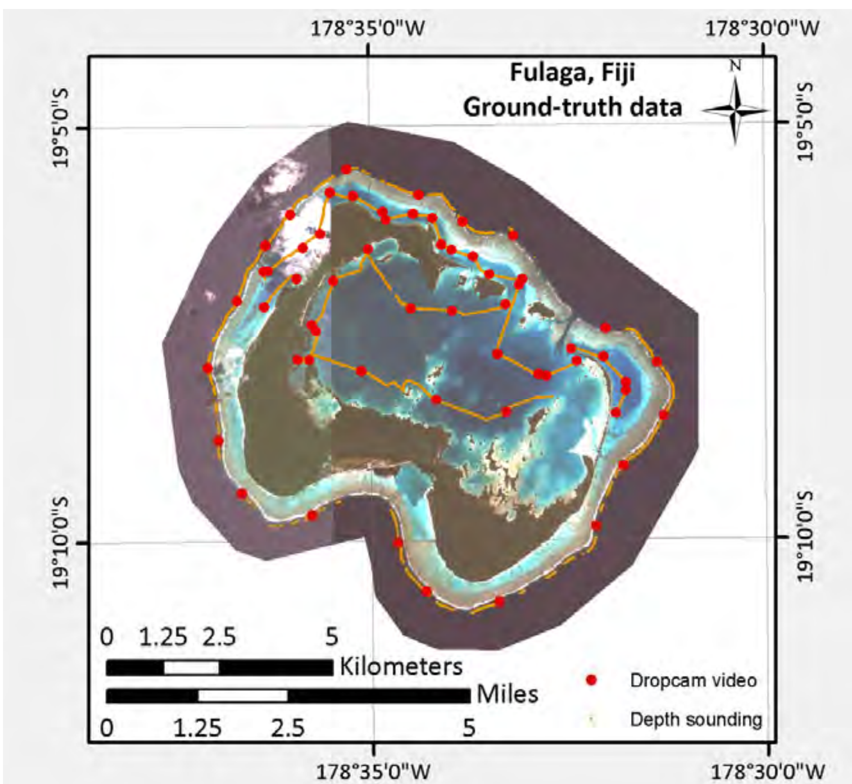


Fig. 10. Groundtruthing track in Fulaga, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

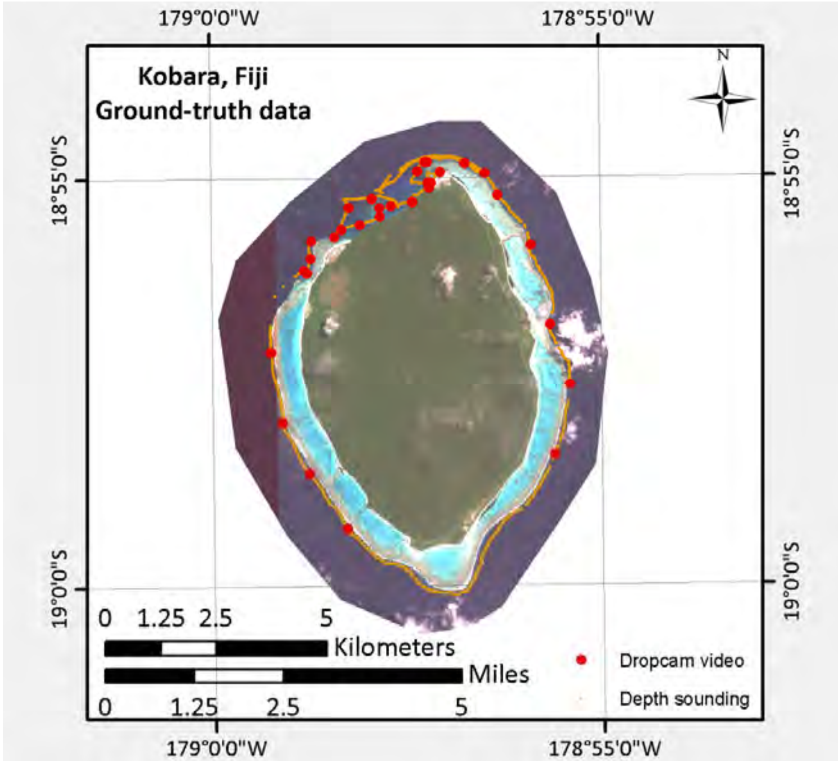


Fig. 11. Groundtruthing track in Kobara, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

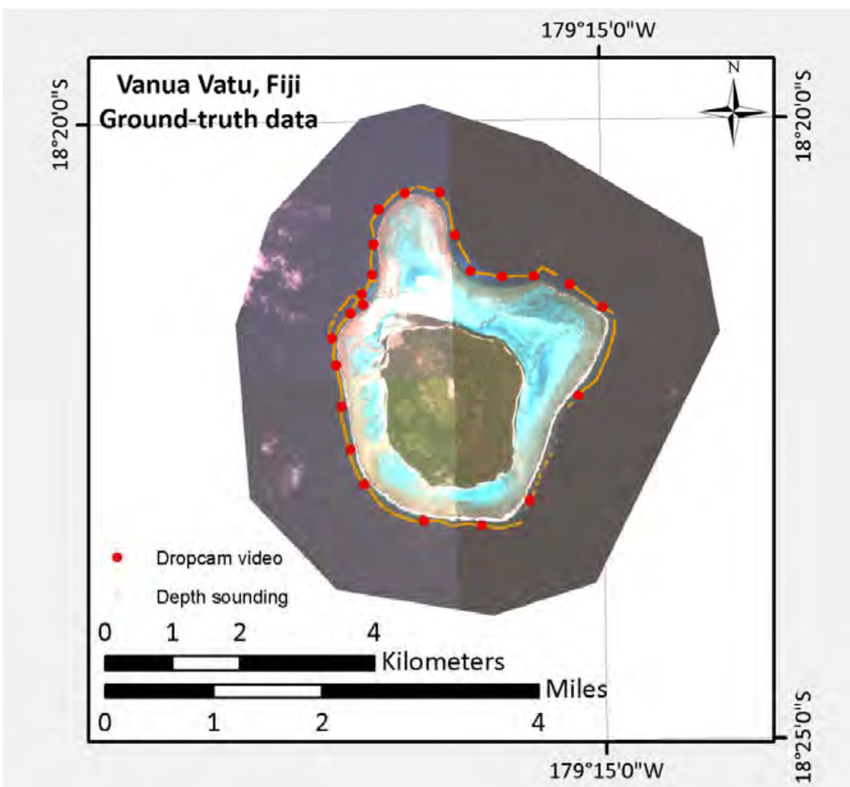


Fig. 12. Groundtruthing track in Vanua Vatu, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

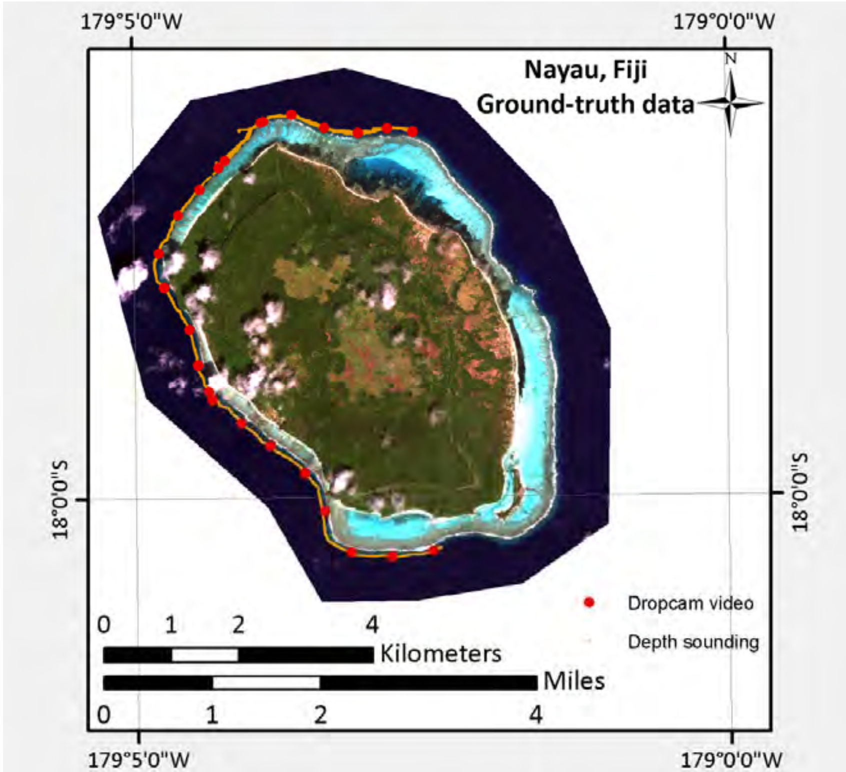


Fig. 13. Groundtruthing track in Nayau, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

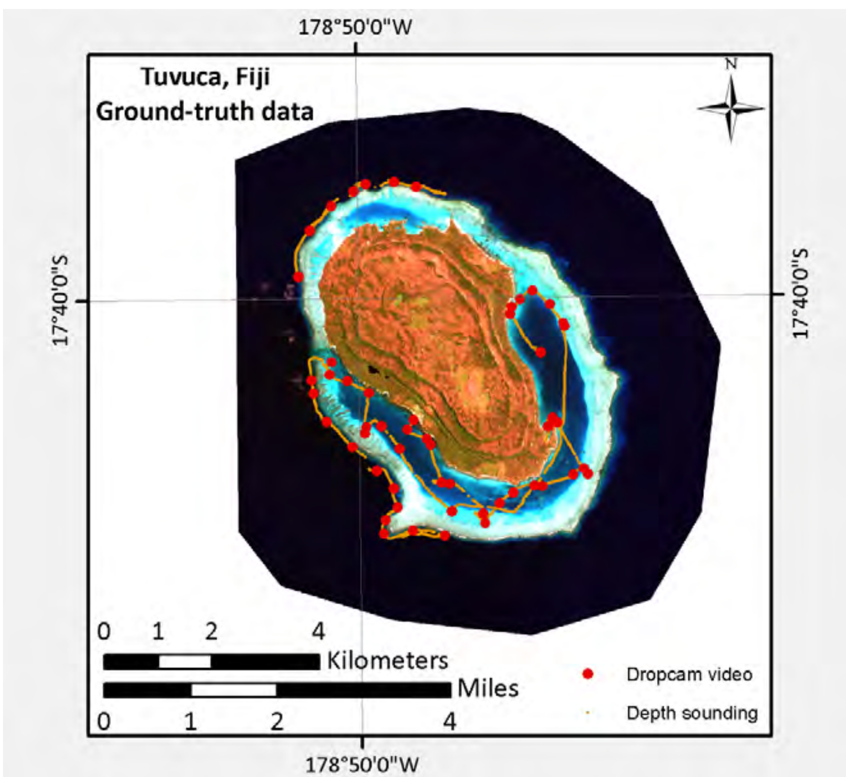


Fig. 14. Groundtruthing track in Tuvuca, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

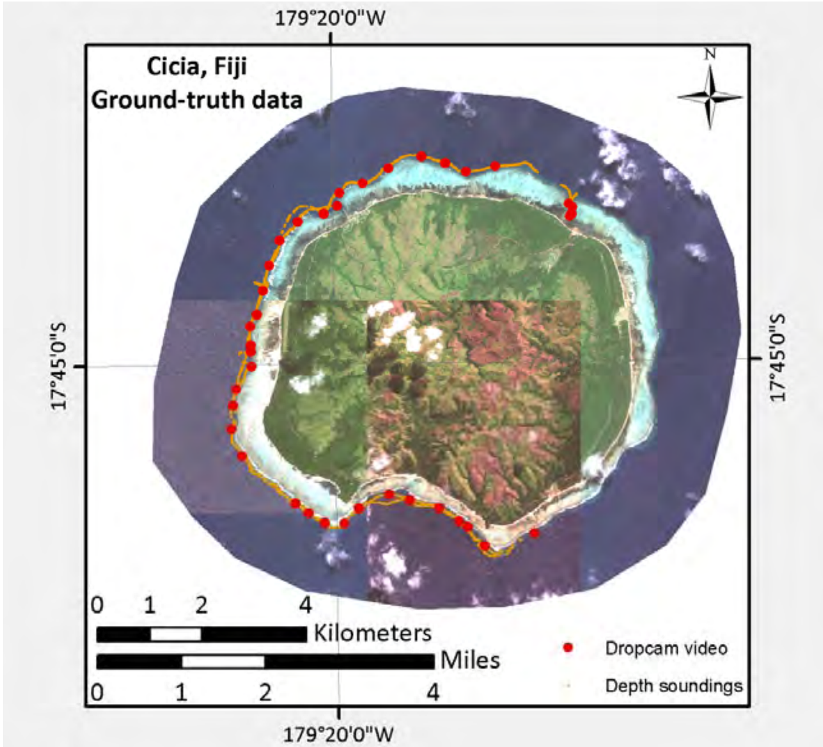


Fig. 15. Groundtruthing track in Cicia, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

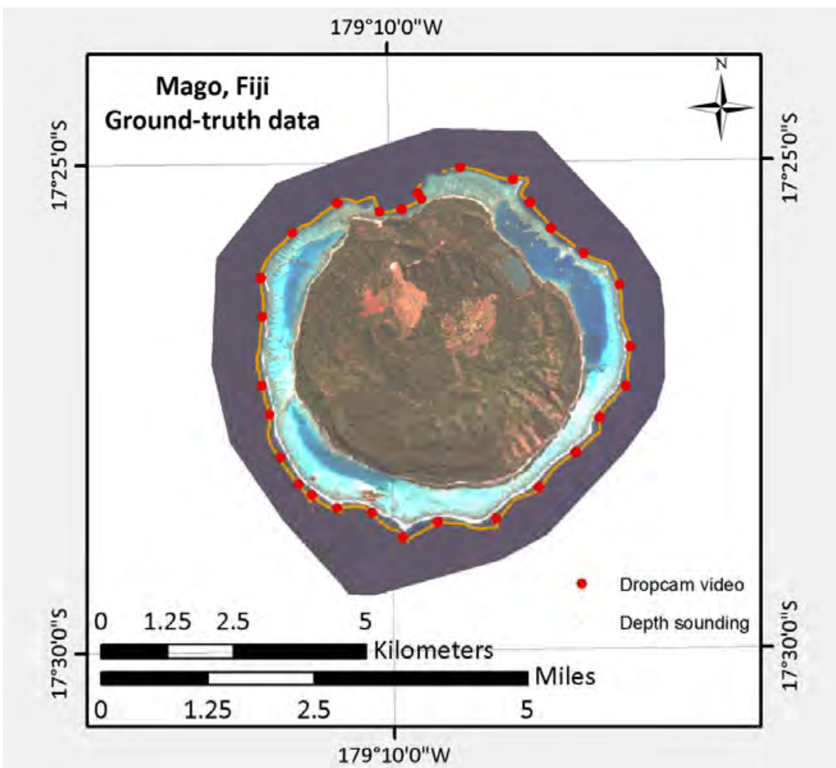


Fig. 16. Groundtruthing track in Mago, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

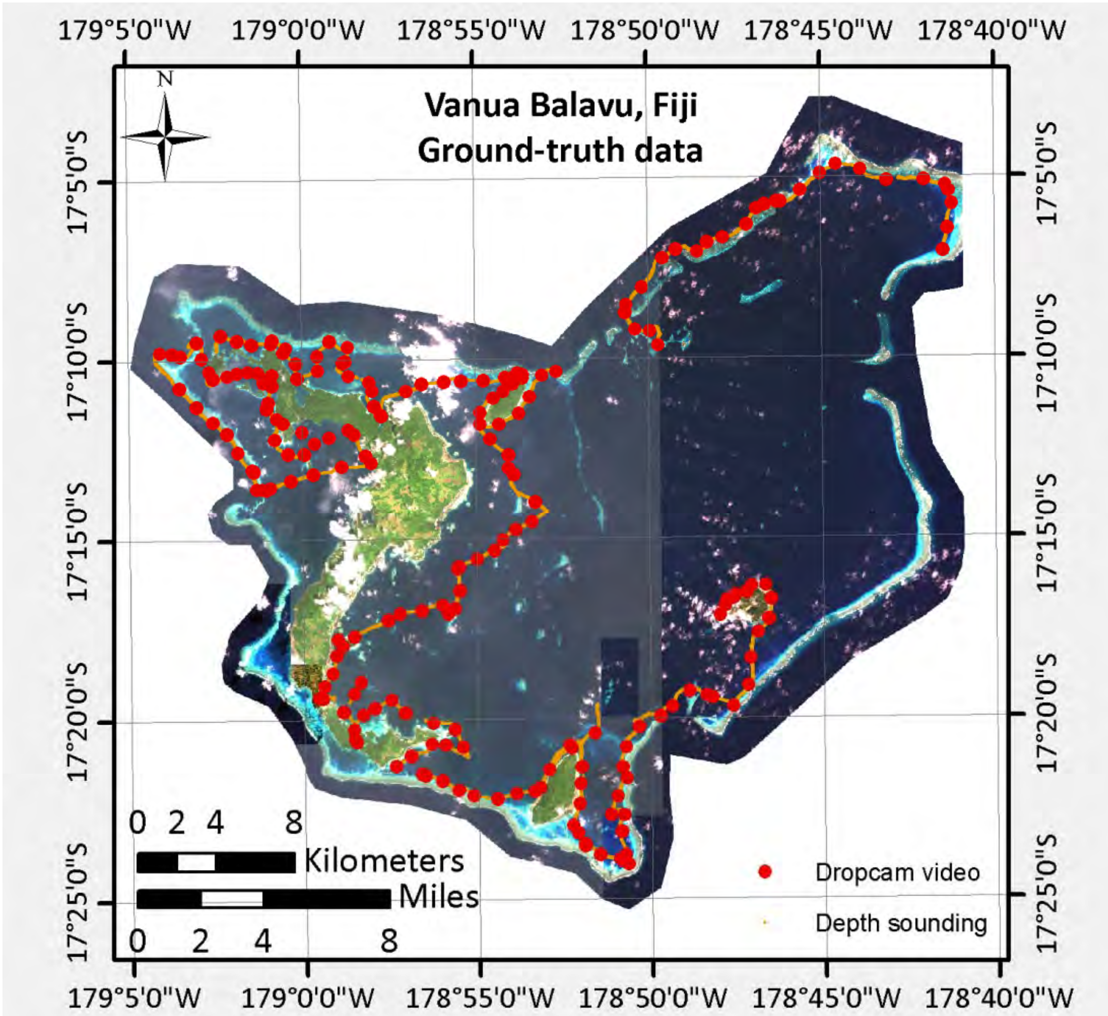


Fig. 17. Groundtruthing track in Vanua Balavu, Fiji showing the track of the groundtruthing vessel and locations of depth soundings and camera deployments.

Fig. 18. A shallow pinnacle off Vanua Balavu. Many reefs had high coral cover with diverse digitate, branching and table acroporids on the pinnacle top. Fish communities were dominated by small body fishes such as wrasses and damselfishes.

2. General Approach of SCUBA assessments:

Fish Assessments

For fish, abundance and size structure was collected for over 200 species of fishes (Appendix 1), targeting species that have a major functional role on reefs or are major fisheries targets. Reef fishes were assessed along 4 m X 30 m belt transects. A T square marked in 5 cm increments was used to gauge fish size. A minimum of 6 transects were conducted by each "fish" diver per site. A roving survey was also completed to assess the total diversity and relative abundance (rare, common, and abundant) of reef fishes at each site.

Benthic cover

Cover of major functional groups (corals identified to genus, sponges, other invertebrates, and six groups of algae including macroalgae, crustose coralline algae, erect coralline algae, fine turfs, turf algae with sediment and cyanobacteria) and substrate type (hardground, sand, mud, rubble, recently dead coral, bleached coral, live coral) were assessed along 10 m transects using recorded observations and/or photographic assessments. Recorded observations involved a point intercept method, whereas the organism and substrate was identified every 10 cm along a 10 m transect (total 100 points/transect), with a minimum of six transects examined per location. When possible, surveys were completed at 30, 25, 20, 15, 10 and 5 m depth.

Photographic assessment

A 10 m long transect tape was extended along depth contours at 30, 20, 15, 10 and 5 m depth. Continuous digital still photographs were taken of the reef substrate from a height of approximately 0.6-0.75 meters above the substrate, using a one meter bar divided into 5 cm increments placed perpendicular to the transect tape as a scale bar. Approximately 20 photographs were taken per transect to allow for overlap between adjacent images with two photo transects (each 10 m in length) per depth. Images were downloaded onto a computer, and benthic community composition, coral cover and cover of other organisms and substrate type, and to determine the size (planar surface area) of corals were analyzed using Coral Point Count (CPCE) software developed by the National Coral Reef Institute (NCRI). Cover was determined by recording the benthic attribute located directly below random points (30-50 points per photograph). Planar surface area was measured by tracing the outline of individual corals.

Coral assessments

A combination of quantitative methods including: belt transects, point intercept transects, radial plots and quadrats were used to assess corals, fish and other benthic organisms. Five measures were recorded for corals: 1) benthic cover (point intercept, see above); 2) coral diversity and abundance (by genus, except certain common species); 3) coral size class distributions; 4) recruitment; and 5) coral condition. Additional information was collected on causes of recent mortality, including signs of coral disease and predation. Assessment of corals smaller than 4 cm was achieved by using a minimum of five 0.25 m^2 quadrats per transect, with each quadrat located at fixed, predetermined intervals (e.g. 2, 4, 6, 8, 10 m), alternating between the right and left side of the transect line. Recruits were identified in both point intercept surveys and belt transects. Recruits were divided into two categories: corals up to 2 cm diameter and larger corals, 2-3.9 cm diameter.

Coral population structure and condition was assessed within belt transects (each 10 m x1), with a minimum of two transects completed per depth. Each coral, 4 cm or larger was identified (to genus at minimum) and its growth form was recorded. Visual estimates of tissue loss were recorded for each colony over 4 cm in diameter using a 1 m bar marked in 1 cm increments for scale. If the coral exhibited tissue loss, estimates of the amount of remaining tissue, percent that recently died and percent that died long ago were made based on the entire colony surface. Tissue loss was categorized as recent mortality (occurring within the last 1-5 days), transitional mortality (filamentous green algae and diatom colonization, 6-30 days) and old mortality (>30 days).

For each coral with partial or whole colony mortality, the cause of mortality is identified if possible. The diagnosis included an assessment of the type of disease, extent of bleaching, predation, competition, overgrowth or other cause of mortality. Each coral was first carefully examined to identify cryptic predators. Lesions were initially diagnosed into four categories: recent tissue loss, skeletal damage, color change, and unusual growth patterns; an individual colony could have multiple characteristics (e.g. color change and recent tissue loss). The location (apical, basal, and medial) and pattern of tissue loss (linear, annular, focal, multifocal, and coalescing) was recorded and when possible a field name was assigned. If an outbreak of coral disease was documented, sampling of the affected corals was undertaken to further characterize the disease (see below).

Motile invertebrates

Large motile invertebrates (urchins, octopus, lobster, large crabs, large gastropods, sea cucumbers) were identified and counted along coral belt transects and benthic point intercept surveys. In addition, one or two divers conducted timed swims at different depths to document the species diversity and abundance of sea cucumbers at each site assessed. This assessment included a documentation of the type of habitat occupied by these organisms. Additional targeted surveys for sea cucumbers were conducted by WCS in lagoonal areas using a manta tow methodology.

Number of Islands	Number of dives	Benthic transects	Fish transects	Coral transects	Corals	Phototransects
11	70	420	416	198	29,625	417

Table 3. Summary of the coral reef assessments. The total number of benthic, fish and coral transects and number of corals assessed in five islands are shown.

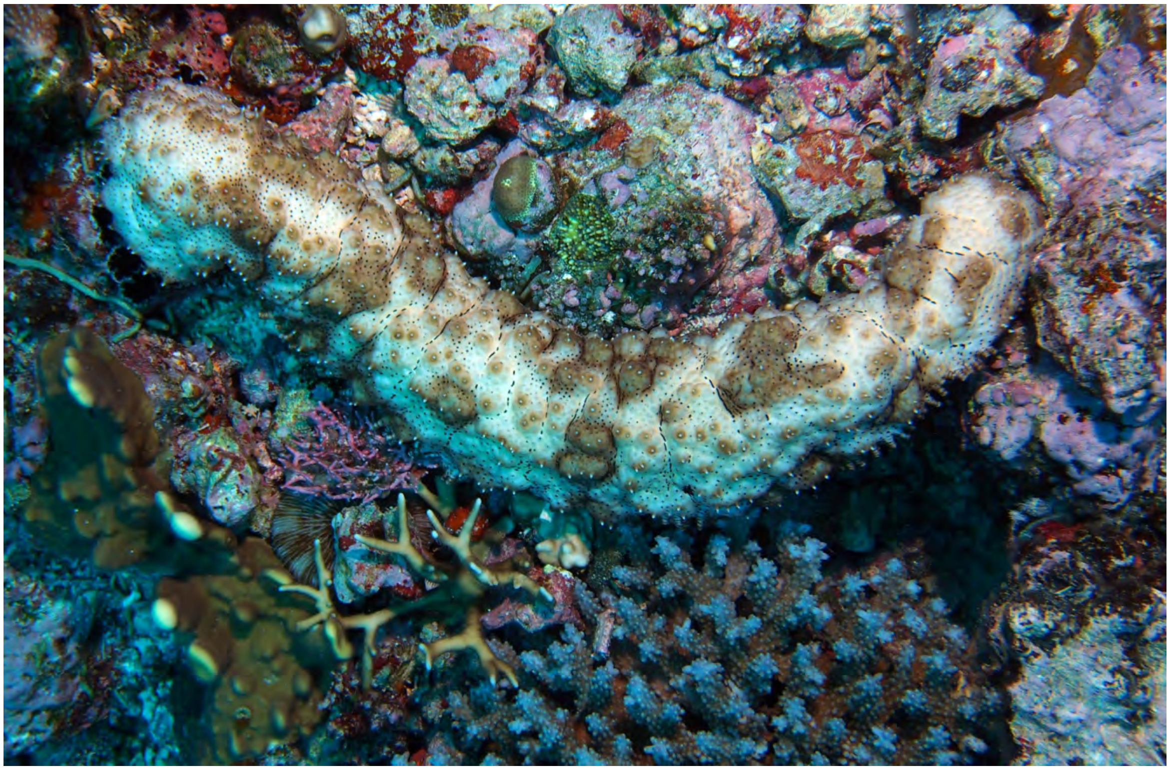


Fig. 19. A high diversity of sea cucumbers was seen on deeper reefs, but abundance was generally low. *Bohadschia graeffei* (above) was one of the more common species.

Table 4. Locations of SCUBA assessments and coral research.

Date	Lat	Long	Site name	Island	Reef zone	Reef type	Exposure
3-Jun-13	-18.996	-179.9032	FJTO01	Totoya	back reef	barrier reef	leeward
3-Jun-13	-18.9728	-179.9068	FJTO02	Totoya	fore reef	barrier reef	leeward
3-Jun-13	-18.9273	-179.8907	FJTO03	Totoya	fore reef	barrier reef	leeward
4-Jun-13	-18.8886	-179.8677	FJTO04	Totoya	fore reef	barrier reef	windward
4-Jun-13	-18.8981	-179.8836	FJTO05	Totoya	fore reef	barrier reef	leeward
4-Jun-13	-18.9976	-179.8473	FJTO06	Totoya	channel	patch reef	currents/swell
5-Jun-13	-19.0032	-179.8485	FJTO07	Totoya	fore reef	barrier reef	leeward
5-Jun-13	-19.023	-179.8808	FJTO08	Totoya	fore reef	barrier reef	leeward
5-Jun-13	-18.9082	-179.7864	FJTO09	Totoya	fore reef	barrier reef	windward
6-Jun-13	-19.1178	179.7382	FJMT10	Matuka	fore reef	barrier reef	leeward
6-Jun-13	-19.1585	179.7304	FJMT11	Matuka	fore reef	barrier reef	leeward
6-Jun-13	-19.1534	179.7401	FJMT12	Matuka	back reef	patch reef	leeward
7-Jun-13	-19.1172	179.7783	FJMT13	Matuka	fore reef	barrier reef	windward
7-Jun-13	-19.129	179.7866	FJMT14	Matuka	fore reef	barrier reef	windward
8-Jun-13	-18.5919	179.97308	FJML15	Moala	fore reef	barrier reef	windward
8-Jun-13	-18.5204	179.96562	FJML16	Moala	fore reef	barrier reef	leeward
8-Jun-13	-18.5325	179.92	FJML17	Moala	fore reef	patch reef	leeward
9-Jun-13	-18.5461	179.9013	FJML18	Moala	fore reef	patch reef	leeward
9-Jun-13	-18.5794	179.8201	FJML19	Moala	fore reef	barrier reef	leeward
9-Jun-13	-18.5577	179.8785	FJML20	Moala	fore reef	barrier reef	leeward
10-Jun-13	-18.5972	179.9337	FJML21	Moala	back reef	patch reef	leeward
10-Jun-13	-18.6168	179.9389	FJML22	Moala	fore reef	barrier reef	windward
10-Jun-13	-18.5575	179.9851	FJML23	Moala	fore reef	barrier reef	windward
11-Jun-13	-19.124	-178.548	FJFU24	Fulaga	lagoonal	back reef	leeward
11-Jun-13	-19.094	-178.5809	FJFU25	Fulaga	fore reef	barrier reef	windward
11-Jun-13	-19.1011	-178.6011	FJFU26	Fulaga	fore reef	barrier reef	leeward
12-Jun-13	-19.1299	-178.6174	FJFU27	Fulaga	fore reef	barrier reef	leeward
12-Jun-13	-19.1411	-178.5706	FJFU28	Fulaga	lagoonal	patch reef	leeward
12-Jun-13	-19.1184	-178.5918	FJFU29	Fulaga	lagoonal	patch reef	leeward
13-Jun-13	-18.9414	-178.9847	FJKA30	Kabara	fore reef	barrier reef	leeward
13-Jun-13	-18.9194	-178.9577	FJKA31	Kabara	fore reef	pinnacles	leeward
13-Jun-13	-18.9136	-178.9455	FJKA32	Kabara	fore reef	barrier reef	windward
14-Jun-13	-18.9545	-178.9874	FJKA33	Kabara	fore reef	barrier reef	leeward
14-Jun-13	-18.9228	-178.9363	FJKA34	Kabara	fore reef	barrier reef	windward
15-Jun-13	-18.3864	-179.2786	FJVV35	Vanua Vatu	fore reef	barrier reef	swellward
15-Jun-13	-18.3439	-179.2803	FJVV36	Vanua Vatu	fore reef	barrier reef	leeward
15-Jun-13	-18.3584	-179.2847	FJVV37	Vanua Vatu	fore reef	barrier reef	leeward
16-Jun-13	-17.9512	-179.067	FJNA38	Nayau	fore reef	barrier reef	leeward
16-Jun-13	-17.9569	-179.0723	FJNA38SN	Nayau	fore reef	reef flat	leeward
16-Jun-13	-17.9759	-179.0767	FJNA39	Nayau	fore reef	fringing reef	leeward
16-Jun-13	-17.9651	-179.0789	FJNA40	Nayau	fore reef	barrier reef	leeward
17-Jun-13	-17.6498	-178.8354	FJTV41	Tuvuca	fore reef	barrier reef	leeward
17-Jun-13	-17.7041	-178.8291	FJTV42	Tuvuca	fore reef	barrier reef	leeward
17-Jun-13	-17.6935	-178.8325	FJTV43	Tuvuca	fore reef	barrier reef	leeward
18-Jun-13	-17.7167	-179.3243	FJCC44	Cicia	fore reef	barrier reef	leeward
18-Jun-13	-17.7238	-179.3386	FJCC45	Cicia	fore reef	barrier reef	leeward
18-Jun-13	-17.7265	-179.3408	FJCC46	Cicia	fore reef	barrier reef	leeward
19-Jun-13	-17.7671	-179.3491	FJCC47	Cicia	fore reef	barrier reef	windward
19-Jun-13	-17.7498	-179.3841	FJCC48	Cicia	fore reef	barrier reef	leeward
20-Jun-13	-17.4785	-179.1672	FJMG49	Mago	fore reef	barrier reef	windward
20-Jun-13	-17.4639	-179.1877	FJMG50	Mago	fore reef	barrier reef	leeward
20-Jun-13	-17.4249	-179.1655	FJMG51	Mago	fore reef	fringing reef	leeward
21-Jun-13	-17.3028	-179.0309	FJVB52	Vanua Balavu	fore reef	barrier reef	leeward
21-Jun-13	-17.1394	-179.0600	FJVB53	Vanua Balavu	fore reef	barrier reef	leeward
21-Jun-13	-17.2376	-179.0386	FJVB54	Vanua Balavu	fore reef	barrier reef	leeward
22-Jun-13	-17.1534	-179.0049	FJVB55	Vanua Balavu	fore reef	barrier reef	leeward
22-Jun-13	-17.1395	-179.0599	FJVB56	Vanua Balavu	fore reef	barrier reef	leeward
22-Jun-13	-17.1715	-178.8871	FJVB57	Vanua Balavu	fore reef	barrier reef	leeward
22-Jun-13	-17.196	-178.8707	FJVB58	Vanua Balavu	patch reef	lagoonal	leeward
22-Jun-13	-17.2419	-178.8556	FJVB59	Vanua Balavu	patch reef	lagoonal	leeward
23-Jun-13	-17.1206	-178.8265	FJVB60	Vanua Balavu	fore reef	barrier reef	leeward
23-Jun-13	-17.1518	-178.8512	FJVB61	Vanua Balavu	fore reef	barrier reef	leeward
23-Jun-13	-17.2824	-178.9267	FJVB62	Vanua Balavu	patch reef	lagoonal	leeward
24-Jun-13	-17.2923	-178.8856	FJVB63	Vanua Balavu	patch reef	lagoonal	leeward
24-Jun-13	-17.2877	-178.9281	FJVB62B	Vanua Balavu	patch reef	lagoonal	leeward
24-Jun-13	-17.3364	-178.86	FJVB64	Vanua Balavu	linear reef	lagoonal	leeward
25-Jun-13	-17.3355	-178.8337	FJVB65	Vanua Balavu	back reef	barrier reef	windward
25-Jun-13	-17.3234	-178.8167	FJVB66	Vanua Balavu	patch reef	lagoonal	leeward
25-Jun-13	-17.2709	-178.7774	FJVB67	Vanua Balavu	back reef	fringing reef	windward
26-Jun-13	-17.1066	-178.6897	FJVB68	Vanua Balavu	patch reef	lagoonal	leeward
26-Jun-13	-17.0895	-178.7692	FJVB69	Vanua Balavu	fore reef	barrier reef	windward
26-Jun-13	-17.1352	-178.7775	FJVB70	Vanua Balavu	patch reef	lagoonal	leeward

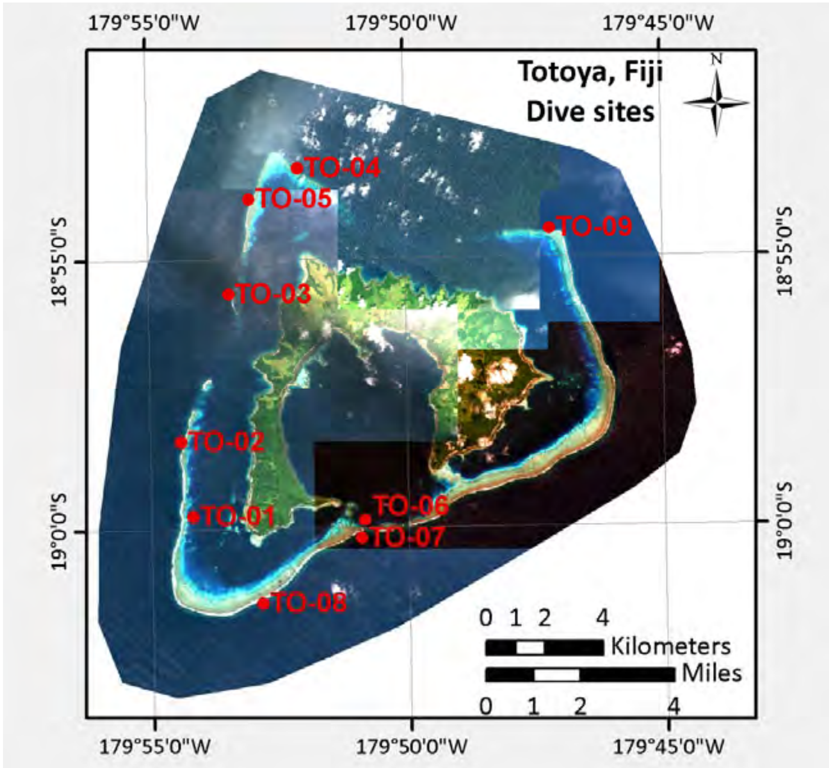


Fig. 20. Locations of SCUBA assessments in Totoya, Lau Province, Fiji.

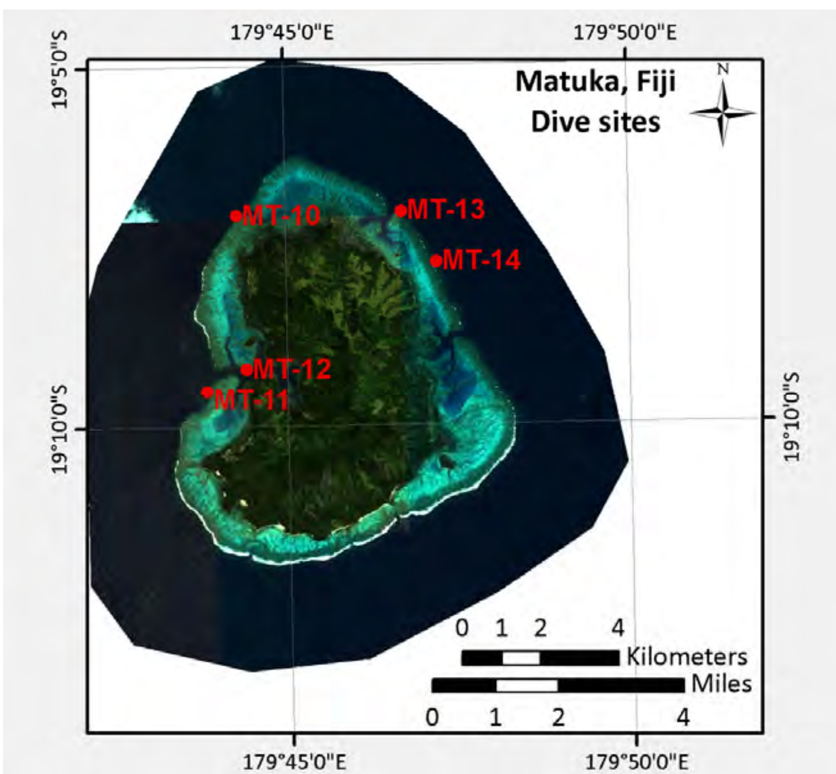


Fig. 21. Locations of SCUBA assessments in Matuka, Lau Province, Fiji.

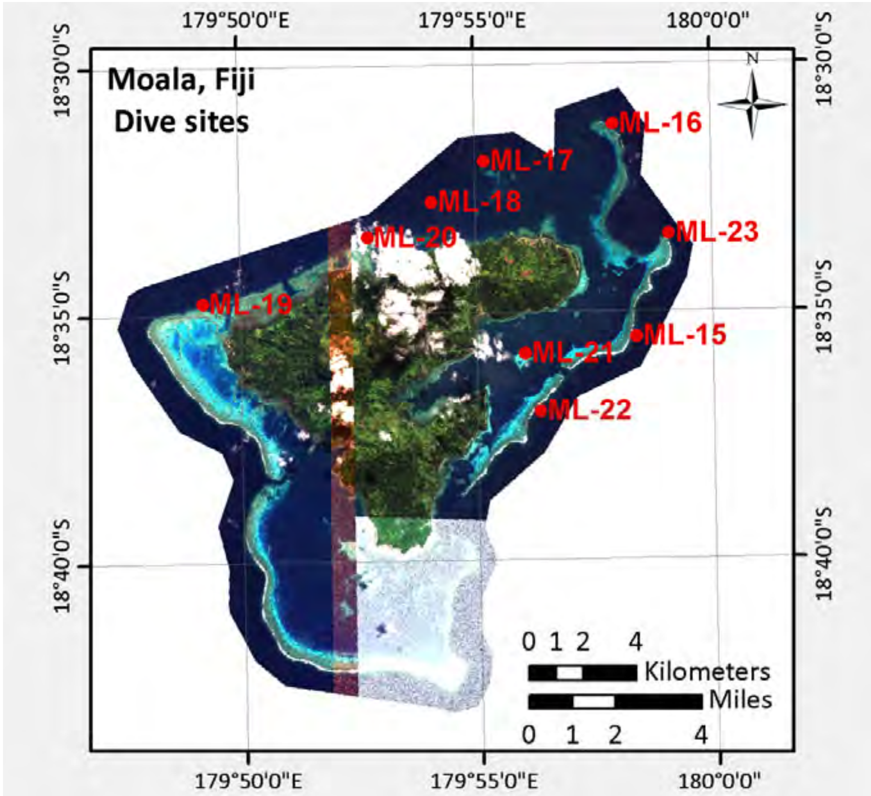


Fig. 22. Locations of SCUBA assessments in Moala, Lau Province, Fiji.

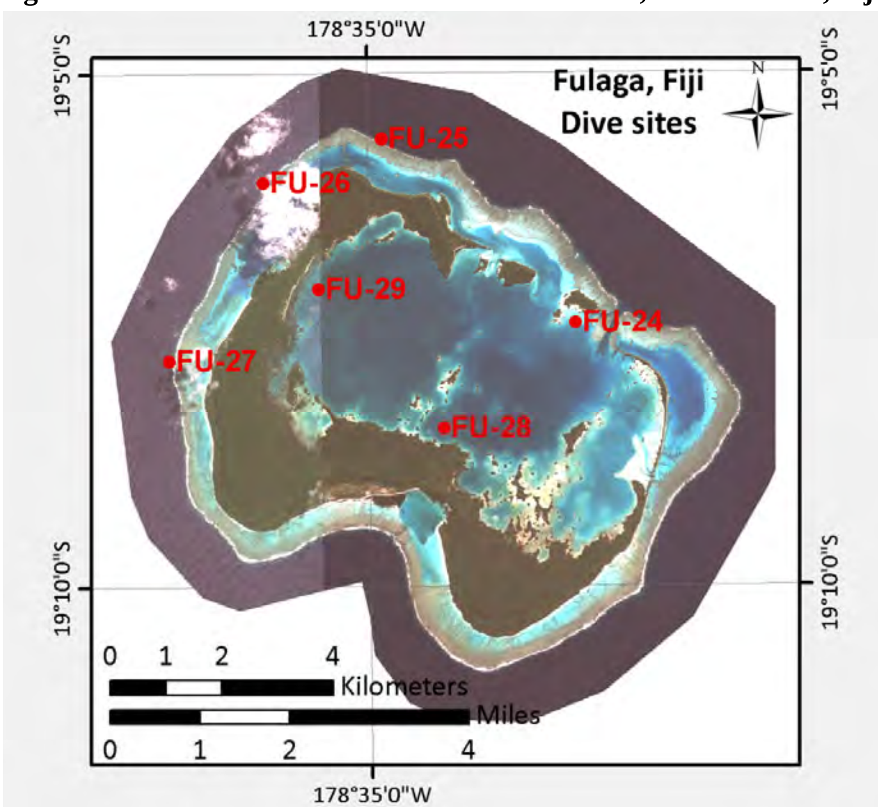


Fig. 23. Locations of SCUBA assessments in Fulaga, Lau Province, Fiji.

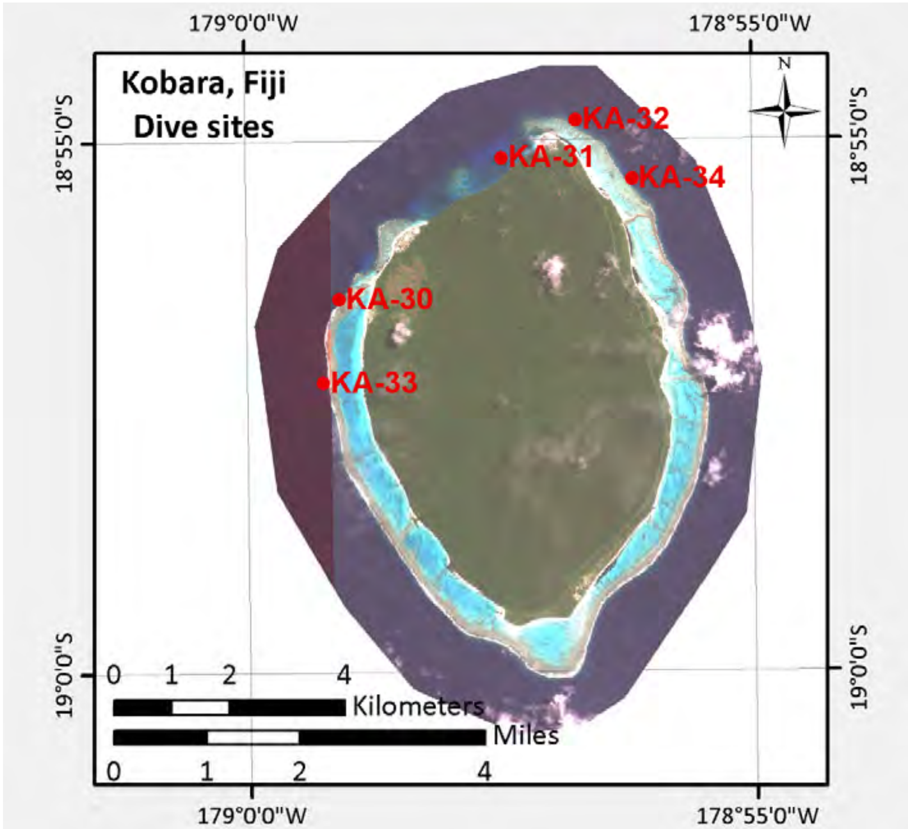


Fig. 24. Locations of SCUBA assessments in Kobara, Lau Province, Fiji.

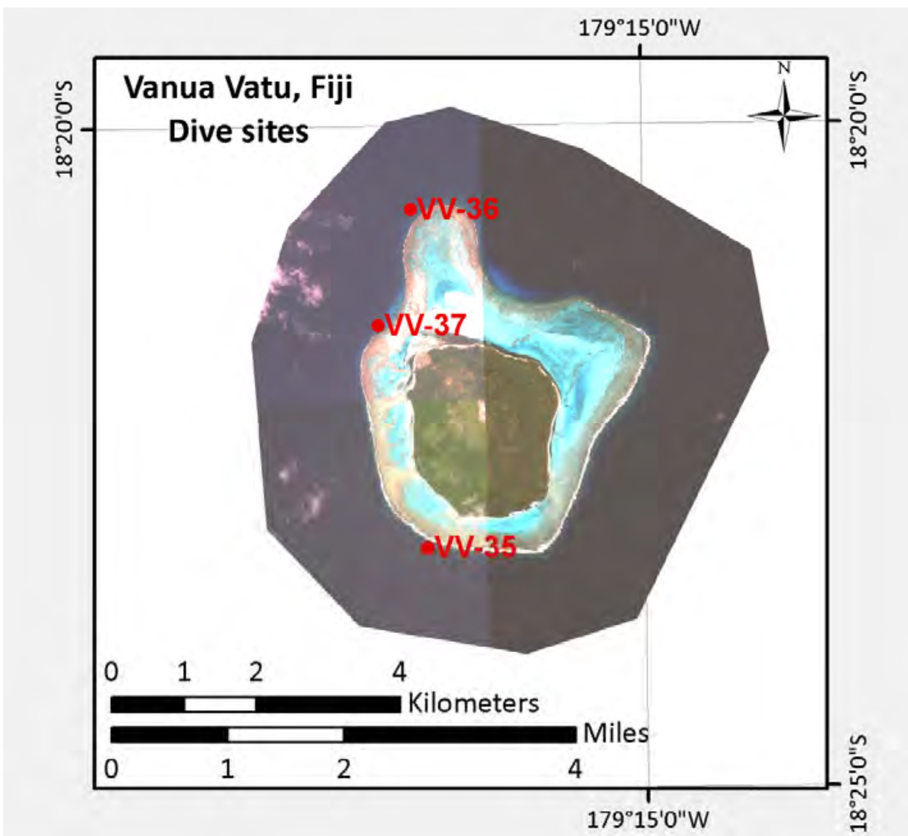


Fig. 25. Locations of SCUBA assessments in Vanua Vatu, Lau Province, Fiji.

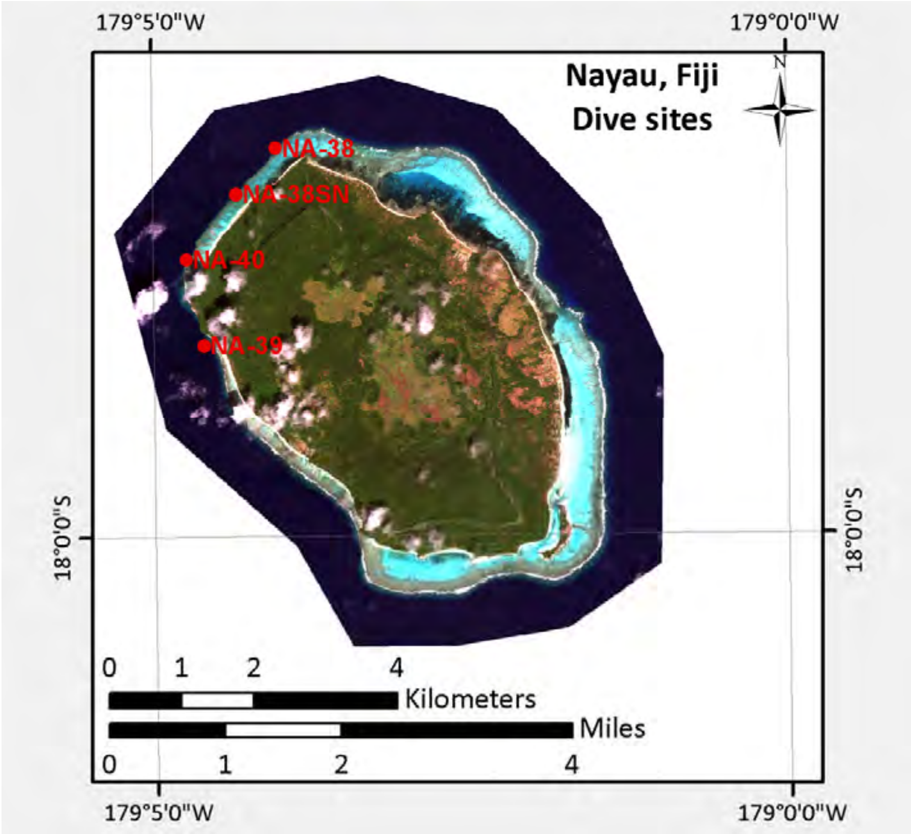


Fig. 26. Locations of SCUBA assessments in Nayau, Lau Province, Fiji.

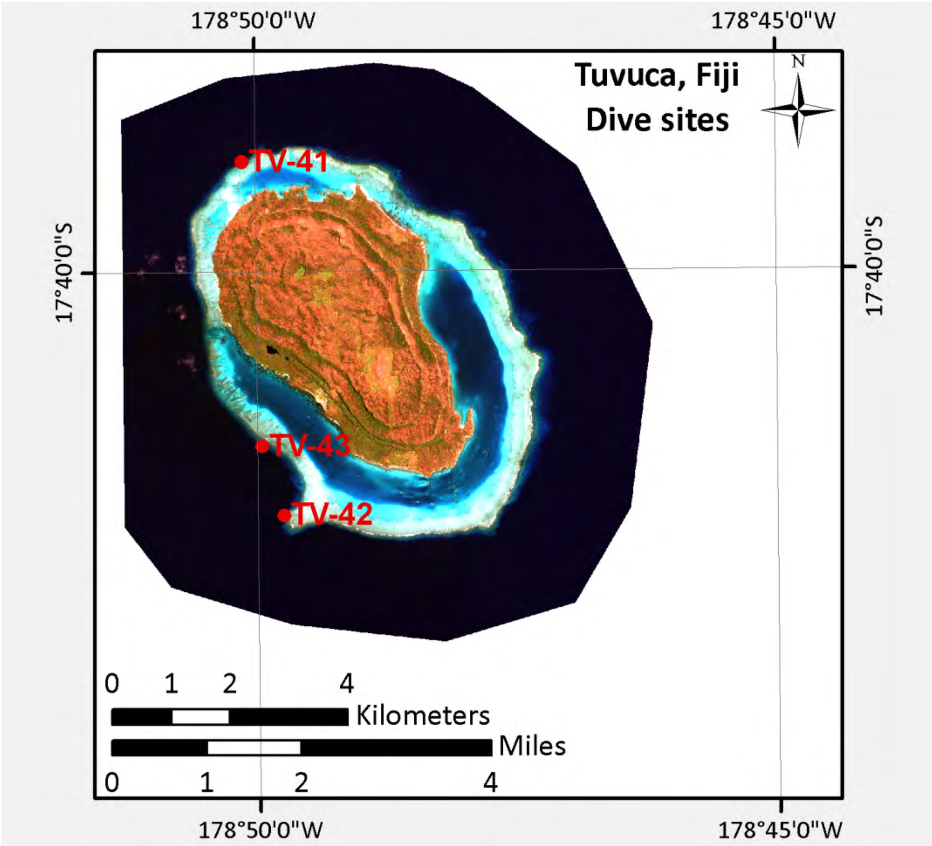


Fig. 27 Locations of SCUBA assessments in Tuvuca, Lau Province, Fiji.

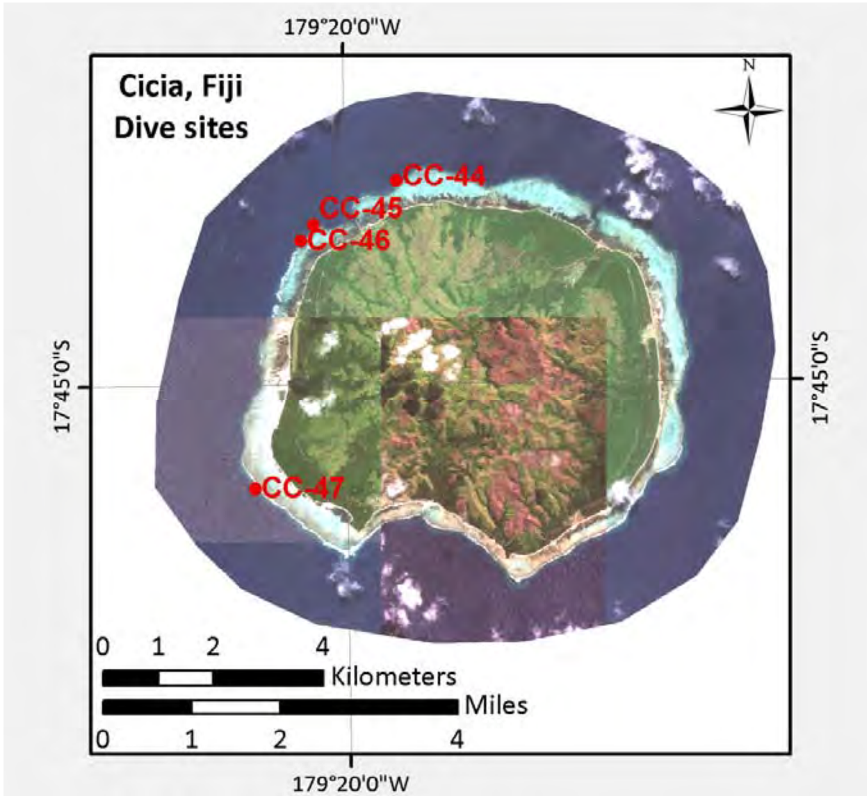


Fig. 28. Locations of SCUBA assessments in Cicia, Lau Province, Fiji.

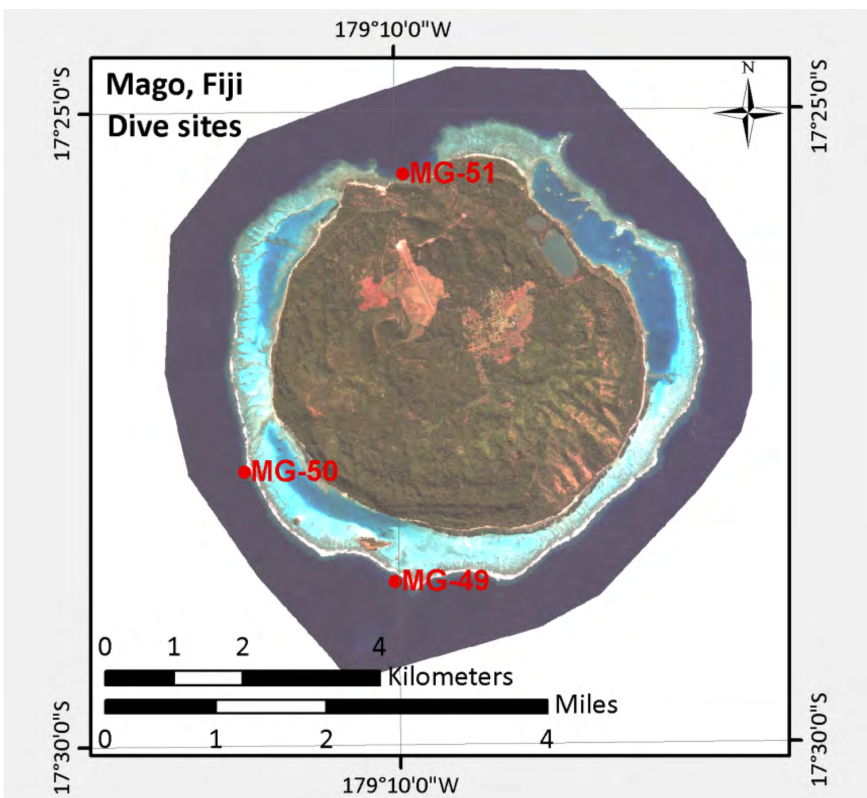


Fig. 29. Locations of SCUBA assessments in Mago, Lau Province, Fiji.

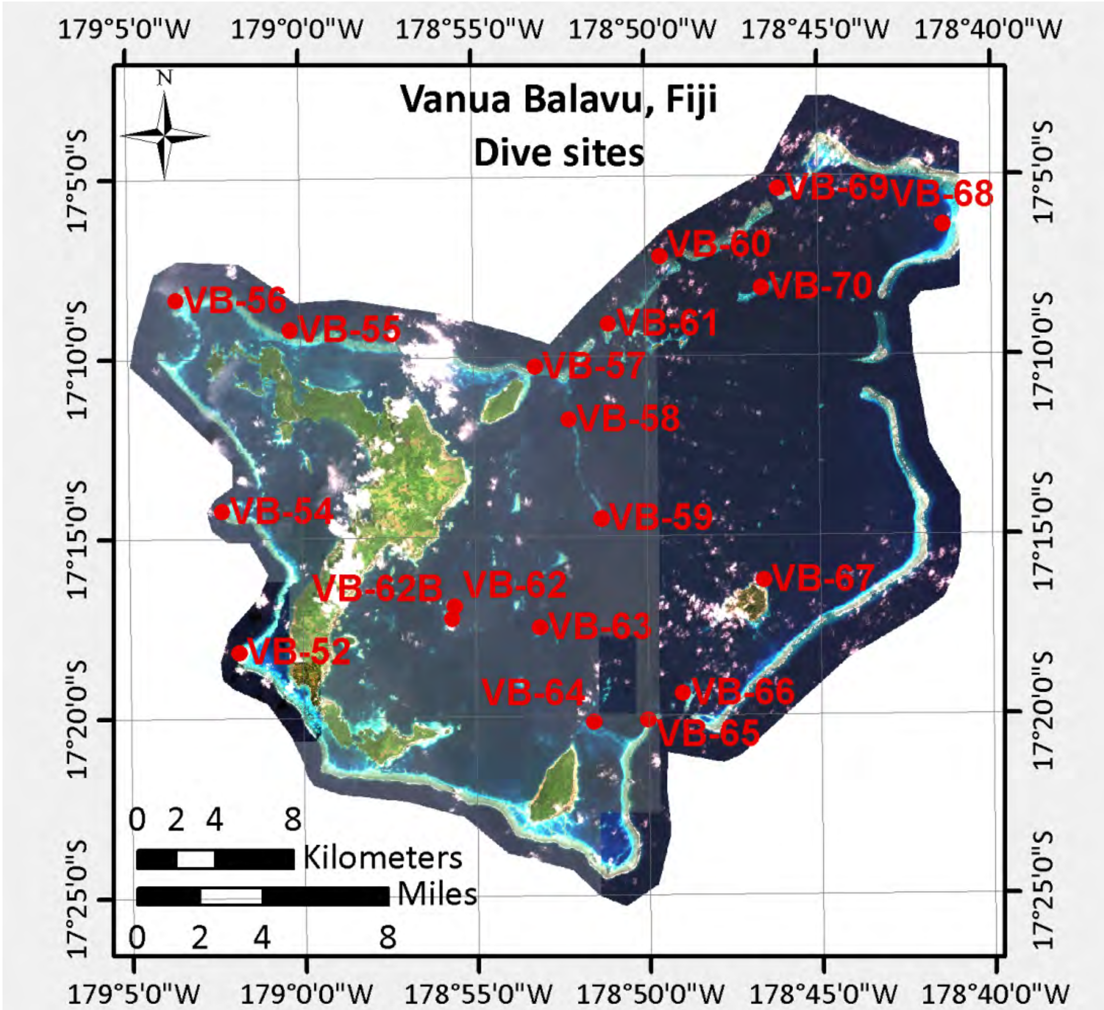


Fig. 30. Locations of SCUBA assessments in Vanua Balavu, Lau Province, Fiji.

Fig. 31. A large foliaceous colony of *Merulina* on the fore reef off Nayau.

3. Coral reef research

Sediment collection:

Sediment samples were collected using two different methods. The first method used SCUBA and concentrates on the sloped outer flanks of the reef, whilst the second employs a grab sampler to investigate the sediment composition inside the reef lagoon. At each sample station, approximately 100 ml of sediment was shoveled by hand into a 125 ml plastic bottle. Stations were selected so that no benthic life is disturbed or injured. Digital pictures of underwater landscapes surrounding the sampling site were also gathered to provide a visual record of the station. Up to ten samples were collected per day.

In the lagoons, sediment was collected using a Petite Ponar® Grabber. The grabber was attached to an electronic winch wound with 50m of braided polyester line. The grabber was slowly deployed over the side of the boat until it settles on the seafloor, causing the winch line to slacken and the grab to shut. Once the grab is retrieved, it was lifted into the boat and the sediment collected. For each deployment, 100 ml of sediment was shoveled by hand into a 125 ml plastic bottle. A maximum of five samples were taken per day.

In the laboratory, the samples were rinsed with a weak bleach solution (30% bleach and 70% tap water) and allowed to set for several days. This process halts biological activity and preserves the sediments. The samples were dried in an oven at low heat (50°-70°c) for 24 hours, and then analyzed using a Camsizer® instrument to determine the size and shape of sediment grains. The data are being used to create sediment maps akin to the benthic habitat maps.

Island	Number of samples
Cicia	16
Fulaga	18
Kobara	9
Mago	5
Matuka	17
Moala	22
Nayau	3
Totoya	28
Tuvuca	15
Vanua Balavu	7
Vanua Vatu	41
Total	181

Table 5. Total number of sediment samples.

Coral symbiont analysis:

This component involved two aspects: 1) sampling colonies of *Pocillopora* from different habitats, depths and locations to characterize their symbionts; and 2) diurnal and nocturnal measurements of the fluorescence of these corals using a PAM fluorometer. In each location the diver started at 30 m and progressively works up to 5 m depth, sampling a minimum of three Pocilloporid corals per depth gradient (5, 10, 15, 20, 25, and 30). Only pocilloporid corals located under randomly generated coordinates from each depth was be sampled, with three representative samples taken from each colony. Corals were separated each by a minimum of 5 m in attempt to avoid sampling ramets of the same genet. For each sampled coral, clippers were used to break off a small fragment of coral tissue (three to four polyps). A photograph was taken of each colony prior to sampling, and colony size was measured in three dimensions (maximum length, width, and height to the nearest 10 cm). A maximum of 30 colonies were collected per species on each reef. Fragments were placed in individual zip-lock bags underwater and then transferred to vials containing DMSO on shore and stored in a -20°C freezer. Typical biopsies were <0.5cm^2 in total surface area. In a subsample of the colonies that were sampled (10 colonies per reef or island, all at 10 m depth), triplicate measurements of fluorescence were taken during the day and again at night using a PAM fluorometer.

	Pocillopora									
Island	***damicornis***	***elegans***	***eydouxi***	***kelleheri***	***ligulata***	***meandrina***	***sp.***	***verrucosa***	***woodjonesi***	**Total**
CICIA	14	2	7	6		1	1	14		**45**
FULAGA	4	1	2	6		2	1	15		**31**
KOBARA	4	7	11	5		4	1	9		**41**
MAGO	2	3	8	6		1	1	9		**30**
MATUKU	12	1	8	4		4		12		**41**
MOALA	8	1	8	9		4	7	14		**51**
NAYAU	6			5	1	2	1	7		**22**
TOTOYA	23	2	17			6	3	24	1	**76**
TUVUCA	9		4	2	1	1		12		**29**
VANUA BALAVU	29		9	16		1	1	34		**90**
VANUA VATU	3	2	9	4		2		8		**28**
Total	**114**	**19**	**83**	**63**	**2**	**28**	**16**	**158**	**1**	**484**

Table 6. Samples collected for *Symbiodinium* assessment during Fiji mission in Global Reef Expedition. All samples (approx. 1 cm^3) are preserved in 20% DMSO solution at -20ºC.

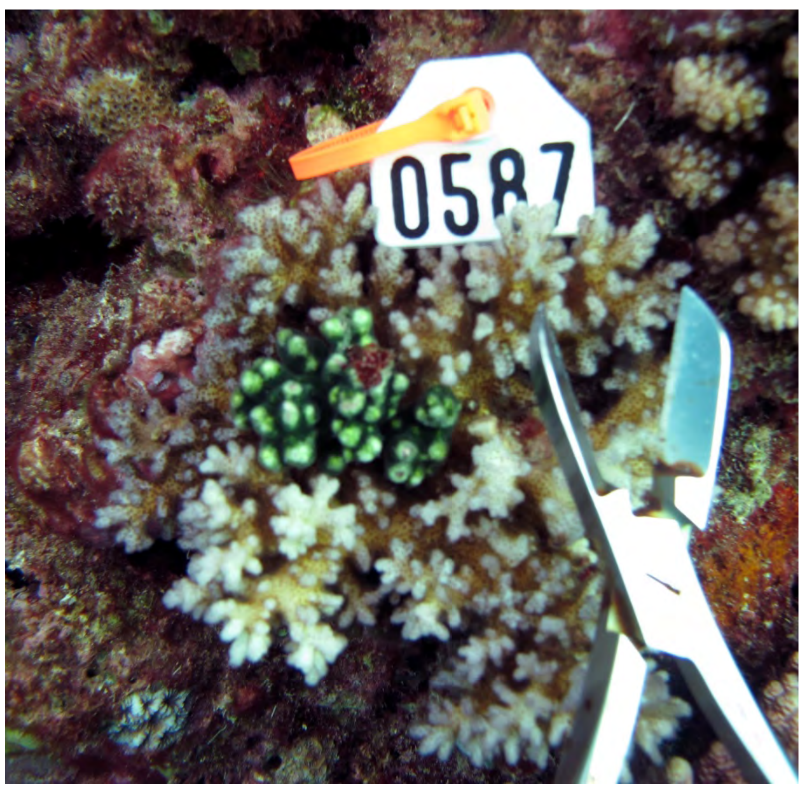


Fig. 32. Removal of a small nubbins from a *Pocillopora damicornis* colony to determine *Symbiodium* composition and for coral health examination. This colony was pale and part was overgrown by a sponge.

Coral health:

This research seeks to understand if it is possible to detect sub-lethal levels of stress in corals using molecular biomarkers. Currently, the only way to know if the corals are stressed is if they show signs of stress (e.g. partial colony mortality) which usually occurs after the environmental conditions have already changed. By using expression levels of certain genes, proteins, and metabolites, an index of health will be developed that can be used to forecast the future condition of a reef and identify a potential environmental perturbation before it manifests through coral mortality. One of the dominant reef building coral genera found throughout the Indo-Pacific, *Pocillopora*, is the model animal that was sampled.

In each location, oceanographic measurements (light, temperature, and salinity) are recorded. Replicate samples of Pocillopora are identified at different depths (5-30 m). The colonies are first assessed for visible signs of stress. A small biopsy (100 mg) consisting of 3-5 polyps is removed from a branch tip. The sample is divided in half: 50% for molecular work, 50% for microscopy. Half the sample is placed in RNALater® or frozen in liquid nitrogen; the other half is fixed in paraformaldehyde and decalcified. All processing is done in the laboratory in Taiwan. Total number of samples collected are shown in Table 7.

Island	Species	Number	Size	Quantity taken (mg)
Totoya	*Pocillopora damicornis*	16	100 mg	1,600
Totoya	*Pocillopora* sp.	4	100 mg	400
Matuku	*Pocillopora damicornis*	9	100 mg	900
Matuku	*Pocillopora* sp.	1	100 mg	100
Moala	*Pocillopora damicornis*	15	100 mg	1,500
Moala	*Pocillopora* sp.	2	100 mg	200
Fulaga	*Pocillopora damicornis*	6	50 mg	300
Fulaga	*Pocillopora* sp.	3	50 mg	150
Kabara	*Pocillopora damicornis*	10	50 mg	500
Kabara	*Pocillopora* sp.	3	50 mg	150
Vanua Vatu	*Pocillopora damicornis*	1	50 mg	50
Vanua Vatu	*Pocillopora* sp.	5	50 mg	250
Nayau	*Pocillopora damicornis*	5	50 mg	250
Nayau	*Pocillopora* sp.	2	50 mg	100
Tuvuca	*Pocillopora damicornis*	8	50 mg	400
Cicia	*Pocillopora* sp.	12	50 mg	600
Mago	*Pocillopora damicornis*	8	50 mg	400
Mago	*Pocillopora* sp.	1	50 mg	50
Vanua Balavu	*Pocillopora damicornis*	37	50 mg	1850
Vanua Balavu	*Pocillopora* sp.	5	50 mg	250
Total		**148**	**sample mass 10 g**	

Table 7. Summary of coral samples collected for biomarker assessment. Samples were fixed in RNALater or paraformaldehyde. After fixation, samples were washed, decalcified, washed again, and transported in buffered saline, so as not to have to transport them in a toxic fixative (i.e., formaldehyde).

Coral metabolomic study:

This study aims to 1) identify and quantify the key metabolites conferred to the host from a range of algal types during intact symbiosis, and 2) determine any variation in the transfer of metabolites associated with key environmental drivers (including those associated with heat stress and bleaching).

Sampling involved 1) the collection of small coral fragments from key species at differing depths and/or reef areas and 2) measurement of key environmental variables at the site (depth, temperature etc). A total of 60 samples from *Porites*, *Pocillopora*, *Acropora*, *Montipora*, *Seriatopora*, and *Stylophora* were collected between 5-30 m depth in two locations for analysis. Each sample was immediately preserved upon returning to the dive boat (snap-freeze in liquid nitrogen) and coral samples were stored in a -80°C freezer until return to land. Samples were then transferred to a dry shipper and transported by air to the lab at Victoria University, Wellington. A metabolomic analysis of samples is being conducted using gas chromatography with mass spectrometry (GC-MS) and molecular analysis by quantitative PCR (qPCR).

Fig. 33. A structurally complex coral community on a pinnacle off Totoya.

Ocean acidification:
This research involved two components, characterizing water chemistry and collecting coral samples to correlate water chemistry to coral growth rates. Water chemistry analysis involved three aspects: 1. Three to four seawater bottle samples (500 ml) were collected from each site visited. Seawater samples were preserved with 2 µl of saturated HgCl2 and sealed with large rubber bands to prevent any changes to the carbonate system before analysis. Total CO_2 (TCO_2) is being measured coulometrically and total alkalinity (TA) measured utilizing a gran titration by Dr. Derek Manzello (NOAA/AOML) in our laboratory in Miami, Florida (USA). 2. An autonomous pH sensor was deployed on the bottom for the duration of our visit to each site. This instrument measured the diel variability in seawater CO_2, to complement the bottle samples obtained. 3. At each dive location, we sampled the water for the duration of a dive to obtain instantaneous measures of TCO2, TA and temperature. These parameters allowed calculation of the carbonate system of seawater (i.e., partial pressure of CO2 (pCO2), pH and Ω).

During each dive, one diver collected small coral cores from massive coral species (*Porites lobata, Goniastrea, Pavona clavus, Goniastrea, Favia stelligera, Cyphastrea serailia, Platygyra, Montipora, Diploastrea*) using a pneumatic drill, to examine long-term patterns in coral growth rates. Up to ten cores were per location (species will depend on local abundance of retrievable cores). These cores are small, approximately 3 cm in diameter and 7 cm in maximum length. All core holes were filled with cement plugs and epoxy to aid tissue recovery of the parent colony. Samples were carried back to Miami and are being assessed using a micro-CT machine to determine linear extension, bulk-density, and calcification.

Fig. 34. A diver removing a small core from a large *Porites lobata* colony on the fore reef off Cicia using a pneumatic drill.

Island	Species	Number	Size	Fixation
Toyota	*Porites lobata*	20	~3cm diam. X 9 cm length	Dry
Toyota	*Pavona clavus*	1	~3cm diam. X 9 cm length	Dry
Toyota	*Goniastria*	4	~3cm diam. X 9 cm length	Dry
Toyota	*Favia stelligera*	1	~3cm diam. X 9 cm length	Dry
Matuka	*Porites lobata*	14	~3cm diam. X 9 cm length	Dry
Matuka	*Goniastria*	2	~3cm diam. X 9 cm length	Dry
Matuka	*Montipora*	2	~3cm diam. X 9 cm length	Dry
Moala	*Porites lobata*	19	~3cm diam. X 9 cm length	Dry
Moala	*Platygyra*	3	~3cm diam. X 9 cm length	Dry
Moala	*Pavona clavus*	2	~3cm diam. X 9 cm length	Dry
Moala	*Montipora*	2	~3cm diam. X 9 cm length	Dry
Moala	*Goniastria*	1	~3cm diam. X 9 cm length	Dry
Fulaga	*Porites lobata*	14	~3cm diam. X 9 cm length	Dry
Fulaga	*Montipora*	3	~3cm diam. X 9 cm length	Dry
Fulaga	*Platygyra*	4	~3cm diam. X 9 cm length	Dry
Fulaga	*Pavona clavus*	1	~3cm diam. X 9 cm length	Dry
Kabara	*Goniastria*	2	~3cm diam. X 9 cm length	Dry
Kabara	*Montipora*	2	~3cm diam. X 9 cm length	Dry
Kabara	*Porites lobata*	4	~3cm diam. X 9 cm length	Dry
Kabara	*Diploastrea*	3	~3cm diam. X 9 cm length	Dry
Vanua Vatu	*Porites lobata*	9	~3cm diam. X 9 cm length	Dry
Vanua Vatu	*Pavona clavus*	1	~3cm diam. X 9 cm length	Dry
Vanua Vatu	*Diploastrea*	3	~3cm diam. X 9 cm length	Dry
Nayan	*Porites lobata*	5	~3cm diam. X 9 cm length	Dry
Nayan	*Diploastrea*	4	~3cm diam. X 9 cm length	Dry
Tuvuca	*Porites lobata*	9	~3cm diam. X 9 cm length	Dry
Tuvuca	*Diploastrea*	5	~3cm diam. X 9 cm length	Dry
Cicia	*Porites lobata*	12	~3cm diam. X 9 cm length	Dry
Cicia	*Diploastrea*	8	~3cm diam. X 9 cm length	Dry
Mago	*Porites lobata*	19	~3cm diam. X 9 cm length	Dry
Mago	*Diploastrea*	2	~3cm diam. X 9 cm length	Dry
Mago	*Pavona clavus*	2	~3cm diam. X 9 cm length	Dry
Mago	*Montipora*	1	~3cm diam. X 9 cm length	Dry
Vanua Balavu	*Porites lobata*	62	~3cm diam. X 9 cm length	Dry
Vanua Balavu	*Platygyra*	2	~3cm diam. X 9 cm length	Dry
Vanua Balavu	*Diploastrea*	17	~3cm diam. X 9 cm length	Dry
Vanua Balavu	*Pavona clavus*	1	~3cm diam. X 9 cm length	Dry
Vanua Balavu	*Cyphastrea*	6	~3cm diam. X 9 cm length	Dry
Vanua Balavu	*Montipora*	1	~3cm diam. X 9 cm length	Dry
Total		273		

Table 8. Coral cores collected for calcification and growth studies.

Appendix I. Participants

Name	Institution	Function
Phil Renaud	Khaled bin Sultan Living Oceans Foundation	Executive Director
Andy Bruckner	Khaled bin Sultan Living Oceans Foundation	Chief Scientist
Amy Heemsoth	Khaled bin Sultan Living Oceans Foundation	Director of Education
Badi Samaniego	University of the Philippines KSLOF Fellow	Fish surveyor
Joao Monteiro	University of Azores, KSLOF Fellow	Coral fluorescence
Jeremy Kerr	Nova Southeastern University, KSLOF Fellow	Groundtruthing / habitat mapping
Anderson Mayfield	National Museum of Marine Biology and Aquarium of Taiwan, KSLOF Fellow	Coral genetics
Gwilym Rowlands	Nova Southeastern University National Coral Reef Institute	Groundtruthing / habitat mapping
Steve Saul	Nova Southeastern University National Coral Reef Institute	Groundtruthing / habitat mapping
Roko Sau Joesefa Cinavilakeba	Pacific Blue Foundation and Vice Chairman of the Lau Provincial Council	Traditional Leaders and community representative
Stacy Jupiter	Wildlife Conservation Society of Fiji	Local Scientist
Laitia Raloa	Lau Provincial Office	Protocol Officer
Ron Vave	University of the South Pacific	Scientific Diver
William Saladrau	Fiji Department of Fisheries	Scientific Diver
Ken Marks	Atlantic and Gulf Rapid Reef Assessment Program (AGRRA)	Photo transects
Alex Dempsey	Nova Southeastern University National Coral Reef Institute	Benthic surveyor
Dawn Bailey	Dive-In OCEAN foundation	Coral surveyor
Janet Eyre	Reef Environmental Education Foundation (REEF)	Fish surveyor
Derek Manzello	NOAA	Ocean acidification
Katie Hillyer	Victoria University, Wellington New Zealand	Benthic surveyor
Nick Cautin	Dive Safety Officer	Diving operations

Appendix II. Education Report

In June 2013, the Khaled bin Sultan Living Oceans Foundation conducted research in Fiji while on a month-long Global Reef Expedition. During that time, the Education Department also provided land-based education seminars throughout the Lau Province at primary and secondary schools as well as for the general public. Overall, the Foundation conducted 14 school and 8 village seminars reaching almost 1,500 people on ten different islands. This is the first time in Foundation's history that this much education has been provided in a single mission.

These educational efforts were conducted by in partnership with local Fijian representatives Roko Laitia Raloa, Protocol Officer at the Lau Provincial Council's Office; Roko Sau (Roko Josefa Cinavilakeba), High Chief and Representative of the Pacific Blue Foundation; and Ron Vave, Scientific Diver from the University of the South Pacific. Below is a general outline of curriculum presented.

GENERAL OUTLINE OF THE TOPICS DISCUSSED THROUGHOUT LAU PROVINCE:

I. About Living Oceans Foundation
II. Overview of the Global Reef Expedition
    a. Video about the ship
    b. Video showing SCUBA research
III. What is a coral?
    a. Relationship between coral, zooxanthallae, and mineral
IV. Benefits of coral reefs
V. Main threats to coral reefs in Fiji
VI. What can you do to help?

Additionally, the Executive Director, CAPT Phil Renaud, was able to provide educational seminars in Suva, Fiji. After these seminars, he was able to have further discussions with these stakeholders about the state of coral reefs in Fiji. Below is a general outline of the topics that Renaud discussed.

GENERAL OUTLINE OF TOPICS DISCUSSED IN SUVA, FIJI:

VII. About Living Oceans Foundation
VIII. Overview of the Global Reef Expedition
    a. Science objectives
        i. Surveys
        ii. Habitat mapping
IX. About coral reefs
    a. Importance
    b. Global threats
    c. Local threats
    d. Resilience

EDUCATION IN THE LAU PROVINCE

Island	Village	Activity Type	# Participants
Totoya	Tovu	Primary School seminar (Grades K-8)	• 4 adults • 2 teachers • 1 principal • 38 students
Matuku	Levukai	Village/school seminar (Grades K-5)	• 28 adults • 1 principal • 28 students
Moala	Naroi	Village seminar	• 99 adults
		Primary School seminar (Grades K-8)	• 4 teachers • 1 principal • 96 students
		Secondary School seminar (Grades 9-12)	• 12 teachers • 1 principal • 103 students
Fulaga	Muanaicake	Primary school seminar (Grades K-8)	• 6 adults • 3 teachers • 1 principal • 61 students
		Village seminar	• 36 adults
Kabara	Naikeleya	Primary school seminar (Grades K-5)	• 14 adults • 2 teachers • 1 principal • 24 students
		Village seminar	• 35 adults
Kabara	Tokalau	Primary school seminar (Grades K-8)	• 15 adults • 3 teachers • 1 principal • 50 students
Vanuavatu	Taira	Primary school seminar (Grades K-8)	• 3 adults • 2 teachers • 29 students
Nayau	Salia	Village seminar	• 13 children • 70 adults
Tuvuca	Tuvuca	Primary school seminar (Grades K-8)	• 4 teachers • 1 principal • 36 students
		Village seminar	• 56 adults
Cicia	Tarukua	Primary school seminar (Grades K-8)	• 4 teachers • 1 principal • 28 students
Cicia	Mabula	Primary school seminar (Grades K-8)	• 3 teachers • 1 principal • 101 students
		Secondary school seminar (Grades 9-12)	• 6 adults • 12 teachers • 1 principal • 145 students
Vanua Balavu	Adi Maopa	Primary School seminar (Grades K-8)	• 4 teachers • 1 principal • 67 students
Vanua Balavu	Mualevu	Secondary School seminar Grades (9-12)	• 12 teachers • 1 principal • 100 students
Vanua Balavu	Mavana	Village seminar	• 53 adults
Vanua Balavu	Malaka	Village seminar	• 37 adults • 3 children

BREAKDOWN OF EDUCATION IN LAU PROVINCE:

- 10 Islands
    - Totoya
    - Matuku
    - Moala
    - Fulaga
    - Kabara
    - Vanuavatu
    - Nayau
    - Tuvuca
    - Cicia
    - Vanua Balavu
- 15 Villages
    - 8 Village talks: 414 adults; 16 children
- 14 Schools; 906 Total students; 67 Teachers; 13 Principals; 48 other adults
    - 11 Primary schools; 558 Total students; 31 Teachers; 10 Principals
    - 3 Secondary schools; 348 Total students; 36 Teachers; 3 Principals

TOTAL # REACHED: **1,464**

EDUCATION IN SUVA, FIJI

Organization	# Participants
University of the South Pacific	50 students and faculty
Briefing to the Ministry of Fisheries	5 staff members of the Ministry of Fisheries
IUCN	25 Coral reef stakeholders from various organizations
TOTAL	**80**


Khaled bin Sultan
Living Oceans
Foundation