MITIARO NEARSHORE INVERTEBRATE & FINFISH ASSESSMENT

April-May 2018

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This report was funded under the ‘Ridge to Reef’ project and was implemented by Cook Islands Government (Ministry of Marine Resources).

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1. PROJECT BACKGROUND

Biodiversity of coastal and marine ecosystems in the Cook Islands is critical to the health and well-being of local communities, often for the provision of natural resources, food, shelter, medicine and cultural traditions. Island geography ranges from the high island of Rarotonga and raised coral atolls of Atiu, Mauke, Mangaia and Mitiaro with shallow lagoons and fringing reefs; to atolls such as Aitutaki and Manuae which are characterized by large, deep lagoons and minimal terrestrial areas encircled by coral reefs.

The use of marine resources in the Cook Islands is concentrated within the coastal zone. Over harvesting can occur and is typically limited to a few select species. This represents a critical need to first understand the biology and ecology behind these valuable resources.

Some inshore reef fisheries are in a degraded state of health due to over-fishing, poor management practices and a lack of knowledge or awareness of such issues. Compounding the need to secure biodiversity and food resources against poorly managed fisheries is the lack of opportunities to generate household income, which leads to increased dependence on subsistence fisheries that cannot be easily accommodated using either traditional or formal systems.

The South Pacific is highly vulnerable to climatic influences such as the El Niño and La Niña cycles due to the underlying geography of most Pacific Island nations. The worsening of extreme climatic events in recent years reinforces the need for a targeted approach to water, land, forest and coastal management. Available scenario modelling indicates that greenhouse gas emissions will cause a temperature rise that will adversely affect coral reefs and other coastal marine ecosystems and have significant impacts on the biodiversity. Increased seawater temperatures are likely to cause increased coral bleaching, while more extreme and frequent storm events will lead to storm surges, inundation and flooding. Bodies of freshwater in the Cook Islands are extremely limited, with no large lakes or rivers. Changes in sea temperatures and currents will likely shift the patterns of occurrence of tuna species, whales and possibly the migration patterns of sea turtles on a large scale. Climate change and disaster risks also threaten livelihoods, whether based on agriculture, fisheries, forestry, tourism or trade, and in some cases local populations living on atolls will be required to relocate due to the impacts of climate change and expected sea-level rise. It is likely that climate change and the expected increase in the frequency and intensity of weather-related events (combined with changing rainfall patterns, increased temperatures and coastal erosion) will challenge food security in the Cook Islands over the next few decades.

Effective management of coastal and marine resources is necessary to minimize natural and human-induced impacts on the environment. Management can be directed to meet specific objectives, at both national and community levels and is of the utmost importance for the conservation of protected, endangered or highly impacted species. However, the most important factor to consider is what level of management is appropriate for both the marine resources and the communities whom depend on them. In the Cook Islands, most inshore marine resources are managed through a traditional/cultural system: *rā'ui*. *Rā'ui* is a small-scale areas designated by traditional leaders in conjunction with local communities and managed with the assistance of government. Typically *rā'ui* sites are identified for the temporary protection of a particular resource (for example, trochus). Traditional leaders may request managers monitor and assess the status of the resource and inform when areas have harvestable stock.

1.1 Rationale

Overall, research and monitoring of important marine resources in the Cook Islands is limited and patchy. Efforts to monitor and manage biodiversity in the Cook Islands have made only limited progress to date. The following marine survey forms a comprehensive baseline assessment for Mitiaro. The primary objective for this assessment was to:

- Identify areas of high abundance and diversity
- Assess the distribution and abundance of species of interest
- Note differences, if any, between regulated, non-regulated and *rā'ui* areas
- Compare current populations to historical records

This assessment will form a consistent, updated point for reference for future surveys and monitoring programs, as well as inform management regarding the ecological status and stocks of important marine resources. Our work focuses on coastal and inshore zones.

1.2 Mitiaro Enua

Mitiaro is situated at 19º 51’6’S 157º 42’1’W. Together with Atiu to the west and Mauke and Mangaia to the south, these islands are commonly referred to as *Ngaputoru*. The *Ngaputoru* group has been dated to be around 12.3 million years old and undertook a period of tectonic uplift during the eruption of the capital island Rarotonga, approximately 230km away (National Environment Service, 2011). The formations of these raised coral atolls or *Makatea*, elevated late Pleistocene reef limestone on all three sister islands to heights of approximately 15 m to 72 m.

Mitiaro has a limited lagoon area and consists of a fringing coral reef with a total reef circumference of 19 km. Mitiaro reef flats are shallow and exposed at normal low tides. This exposure can stress corals, invertebrates and reef fish. Invertebrates that can survive the pressure of prolonged exposure to air are further subjected to harvest by local communities (George and Kea, 2014). The *ariri* (*Turbo setosus*) for example is one of the main invertebrate species considered a delicacy on the island and therefore subject to local harvest.

To date there has been limited amount of scientific research conducted on the island of Mitiaro. However, an initiative to provide baseline data on reef resources was carried out by the Ministry of Marine Resources (MMR) by Ponia *et al*. (1998). Subsequent finfish, invertebrate and coral reef surveys of both the reef and fore reef included Lyon (2002), Rongo *et al*. (2013) and MMR (2014).

There is one designated area for a *rā’ui* named Oponi Te Vai; two survey sites were conducted within the *rā’ui*. Beginning from the main harbour in town this extends northward and covers the area from the beach to the surf zone (Figure 1). The regulations that surround *rā’ui* are traditionally community policing. There are no other forms of marine management on the island.

2. METHODOLOGY

The survey of Mitiaro took place from 30th April to 5th May 2018 with a total of ten sites surveyed. For historical comparisons, inner reef sites of Okarava, Vai Nauri and Kovea, were three that were previously surveyed by Ponia *et al*. (1998). Over reef sites, Okarava and Kovea, were previously surveyed by Lyon (2002) and resurveyed by Rongo *et al*. (2013). The other seven sites were added to capture a representative sample of the island.

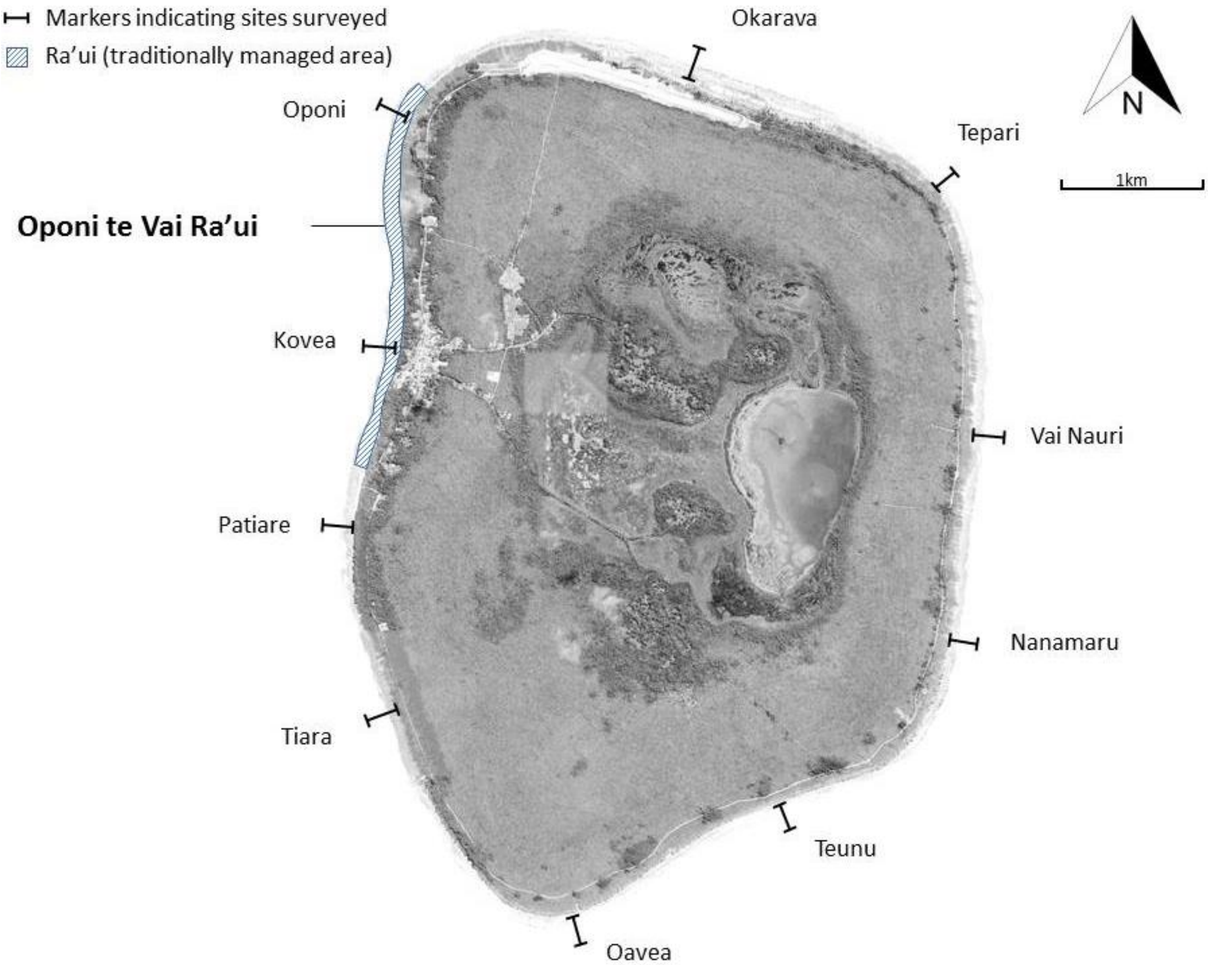

Figure 1. Mitiaro survey sites and one designated *rā'ui* area. Map source: Google DigitalGlobe.

2.1 Habitat zones

Within each site, habitats were identified as inner reef benthos (RBT), reef front (RFT) and over reef (ORT). Habitats were surveyed on the inner reef by walk sampling and if required, snorkelling, whilst the over reef habitat was conducted using SCUBA.

2.1.1. Inner reef habitat

For habitats RBT and RFT located on the inner reef, invertebrates were surveyed using the belt transect method. Four 40 m transects (replicates) were surveyed in each habitat zone. Finfish, coral and substrate data was not collected on the inner reef due to an insufficient depth of water for snorkel surveying and photoquadrat image collection.

2.1.2. Fore reef habitat

For the ORT habitat, SCUBA surveys for finfish and invertebrates were conducted in 10 m depth of water. Finfish data was collected along one transect (replicate) with 4 m width (2 m on each side of transect) and 50 m length. Invertebrates were surveyed using the same transect, with a 1 m width and 40 m length. Substrate data was collected along the same path, with a total of 10 x 1 m^2 photo quadrats gathered for substrate analysis.

2.2 Data Analysis

Data collection of all species included identification to the lowest possible taxonomic classification, counts, and measurements. Identification of all species of fish, invertebrates and corals were obtained from a number of resources including the Cook Islands Biodiversity website, Veron (2000), Randall (2005) and Allen *et al*. (2012).

2.2.1. Invertebrates and finfish

Microsoft Excel was used for data entries and for basic computations such as Pivot tables and Pivot charts for both invertebrates and fish. To compare invertebrate species densities and species richness between sites, the statistical package R was used to perform analysis of variance (ANOVA). Statistical analyses were not performed for finfish data, due to a lack of replication within each site. The standard error (SE) for the mean was also calculated and is used as the measure of variance.

2.2.2. Coral and substrate

DxO Viewpoint 3 software was used to straighten photoquadrats image perspective and CPCe 4.1 software was used to select random points of assessment (n = 16) and record substrate or coral species at each point.

3. RESULTS

3.1 Invertebrates

A total of 1,890 individuals were observed across 90 transects, representing a total of 20 taxa. There were 14 species of marine invertebrates recorded on the inner reef and 12 species recorded over the reef. The most frequently observed species was the *ungakoa* (*Dendropoma* spp.) where a total of 1,235 individuals were recorded across all transects. The *rori toto* (*Holothuria atra*) and *paua kura* (*Chama pacifica*) were also frequently observed with total individuals of 221 and 190, respectively.

3.1.1 Invertebrate densities

Average invertebrate density on the inner reef was greatest at Patiare (142 ± 24 ind./100 m^2) and least at Tepari (10 ± 6 ind./100 m^2) (Figure 2). Densities at Patiare were significantly greater than Kovea, Okarava, Oponi and Tepari (p = 0.002).

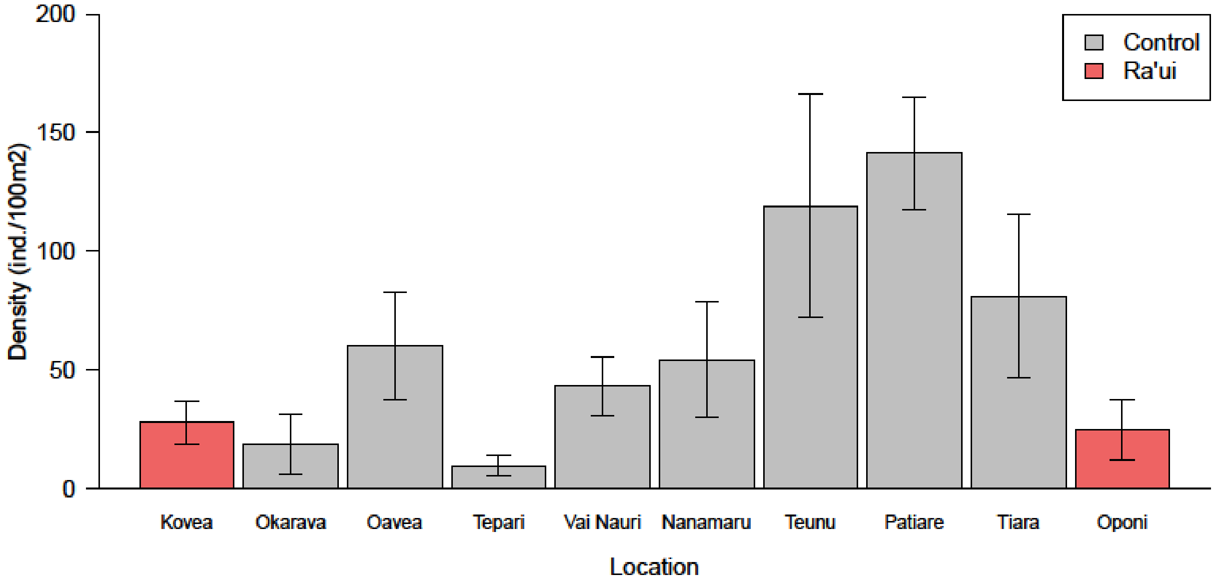

Figure 2. Invertebrate densities on the inner reef in control (grey) and *rāʼui* (red) sites.

Invertebrate densities over the reef were greatest at Okarava (20 ind./100 m^2). No invertebrates were recorded at Tepari and Patiare (Figure 3).

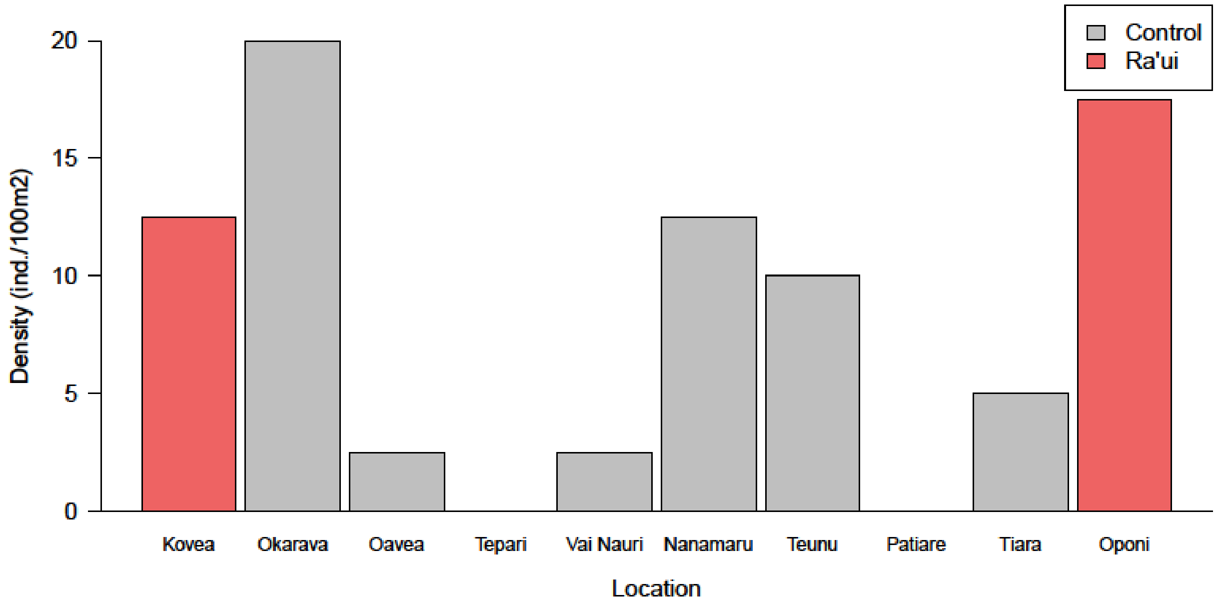

Figure 3. Invertebrate densities over the reef in control (grey) and *rā'ui* (red) sites.

Average *ungakoa* density on the inner reef was greatest at Teunu (111 ± 48 ind./100 m^2). *Ungakoa* were not recorded at Kovea (Figure 4). Densities at Teunu were significantly greater than Kovea and Tepari ($p = 0.029$).

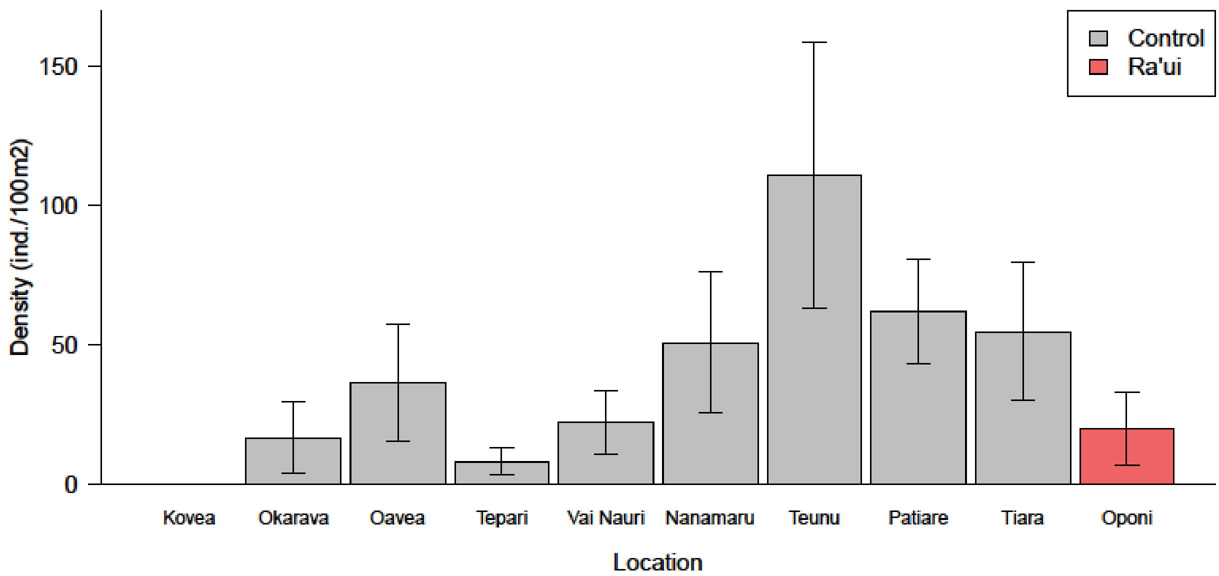

Figure 4. *Ungakoa* densities on the inner reef in control sites (grey) and *rā'ui* sites (red).

Average *rori toto* density on the inner reef was greatest at Patiare (40 ± 20 ind./100 m^2) and least at Tepari and Vai Nauri (1 ± 1 ind./100 m^2 and 1 ± 1 ind./100 m^2) (Figure 5). Densities at Patiare were significantly greater than all other sites ($p = 0.003$).

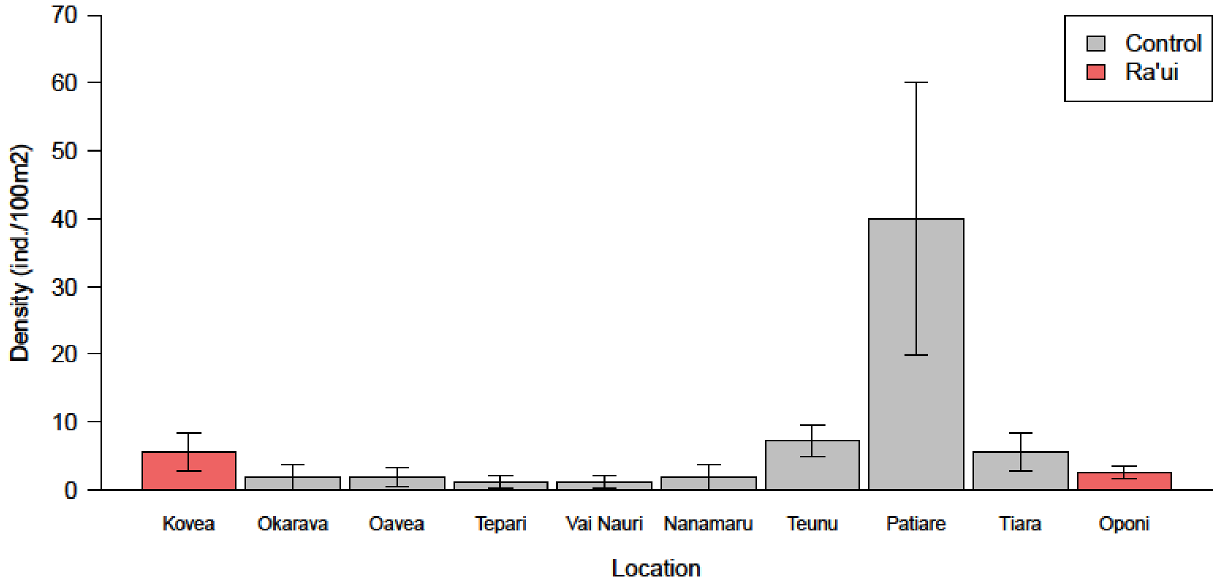

Figure 5. *Rori toto* densities on the inner reef in control sites (grey) and *rā'ui* sites (red).

Average *paua kura* density on the inner reef was greatest at Patiare (22 ± 14 ind./100 m^2). No *paua kura* were recorded at Okarava, Tepari, Nanamaru, Teunu, Tiara and Oponi (Figure 6). No significant differences were found between sites.

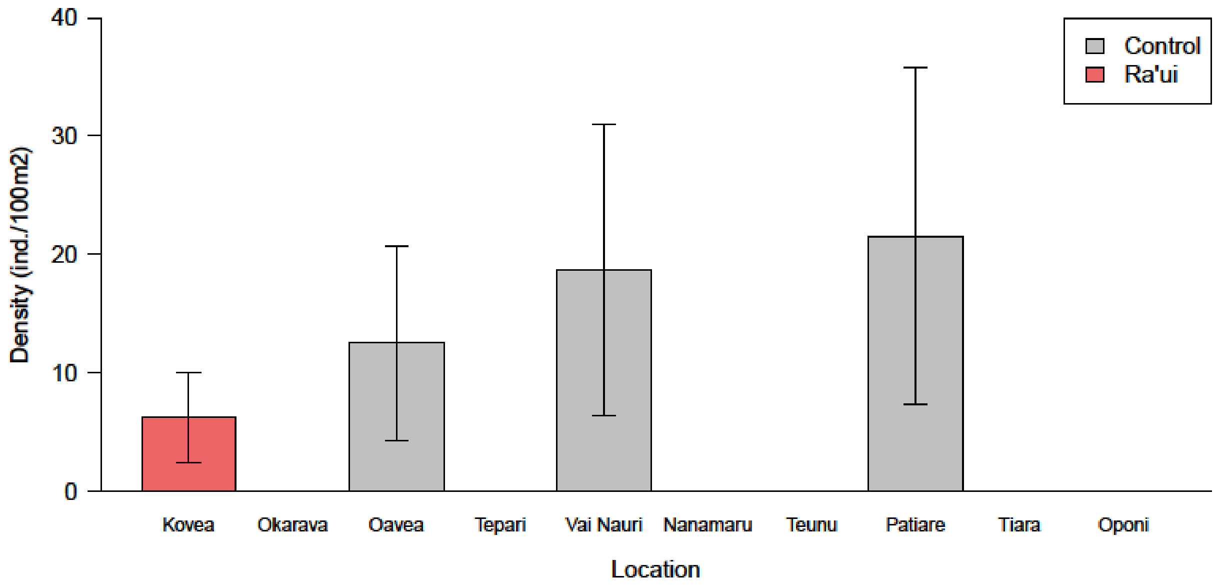

Figure 6. *Paua kura* densities on the inner reef in control sites (grey) and *rā'ui* sites (red).

Average *ariri* density on the inner reef was greatest at Oavea (8 ± 4 ind./100 m^2). *Ariri* were not recorded at Okarava, Tepari, Vai Nauri and Oponi (Figure 7). Densities at Oavea were significantly greater than Okarava, Tepari, Vai Nauri and Oponi ($p = 0.023$).

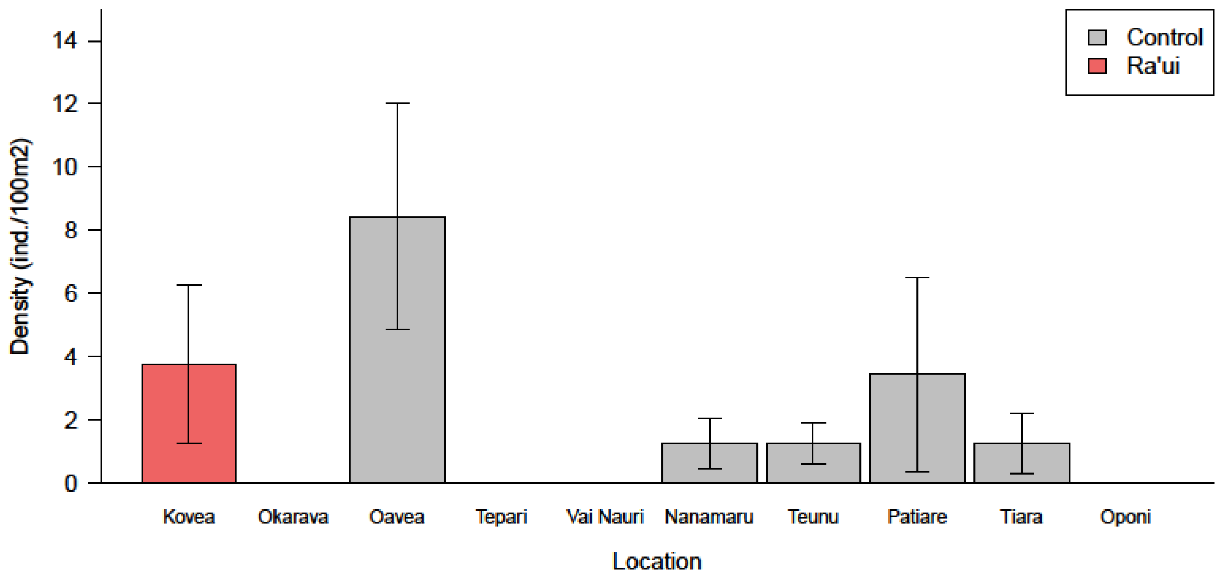

Figure 7. *Ariri* densities on the inner reef in control sites (grey) and *rā'ui* sites (red).

Average *paua* density on the inner reef was greatest at Kovea (0.3 ± 0.3 ind./100 m^2) and Tepari (0.3 ± 0.3 ind./100 m^2). *Paua* were not recorded at any other sites (Figure 8). No significant differences were found between sites.

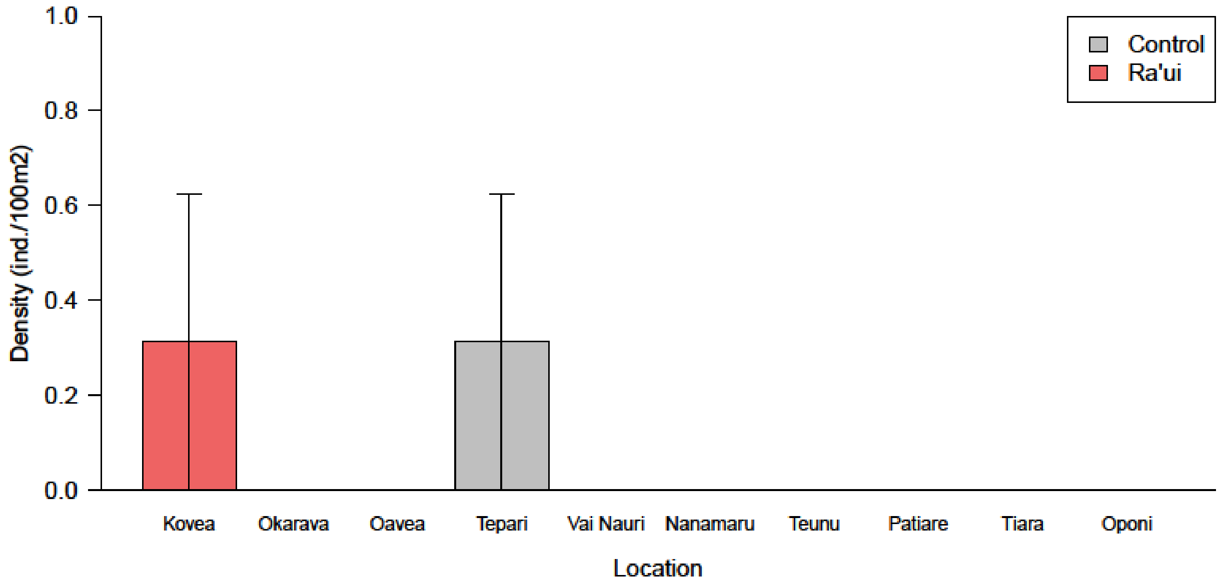

Figure 8. *Paua* densities on the inner reef in control sites (grey) and *rā'ui* sites (red).

3.1.2. Species richness

Average species richness on the inner reef was greatest at Patiare (3 ± 1 no. taxa/40 m^2) (Figure 9). Species richness at Patiare was significantly greater than Nanamaru, Okarava, Oponi and Tepari ($p < 0.001$). Species richness at Kovea was also significantly greater than Nanamaru, Okarava and Tepari ($p < 0.001$).

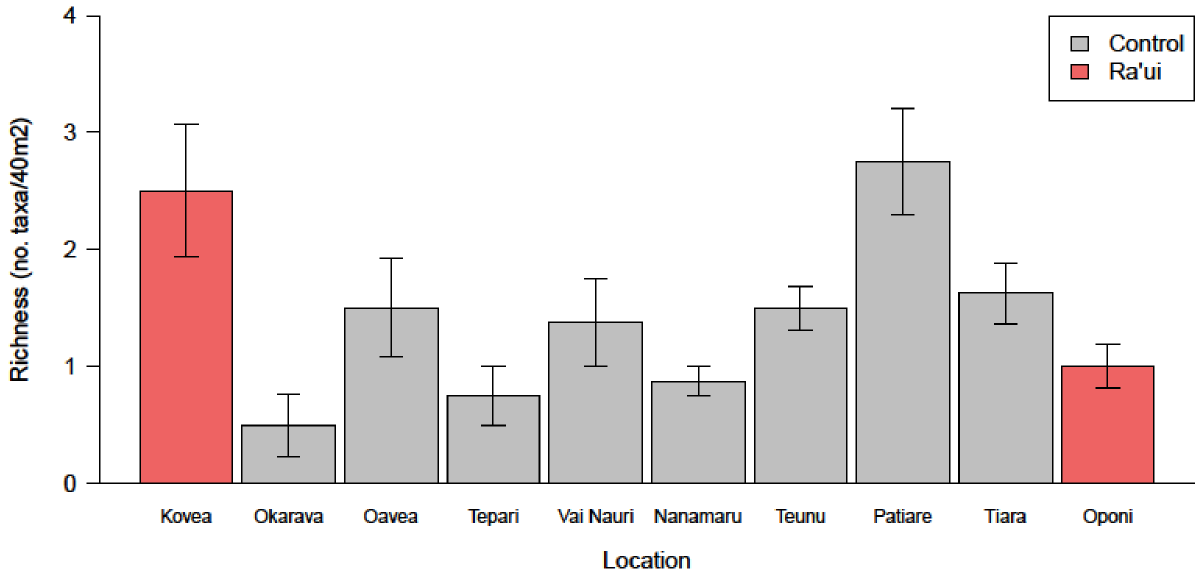

Figure 9. Invertebrate species richness on the inner reef in control (grey) and *rā'ui* (red) sites.

3.2 Finfish

A total of 2,558 fish was observed across 10 transects representing a total of 66 taxa. The most frequently observed species was *Chromis acares* where a total of 845 individuals were recorded across all transects. Olive anthias (*Pseudanthias olivaceus*) and *maito* (*Ctenochaetus striatus*) were also frequently observed with total individuals of 470 and 282, respectively.

3.2.1. Finfish density

Finfish density over the reef was greatest at Patiare (191 ind./100 m^2) and least at Oavea (67 ind./per 100 m^2) (Figure 10).

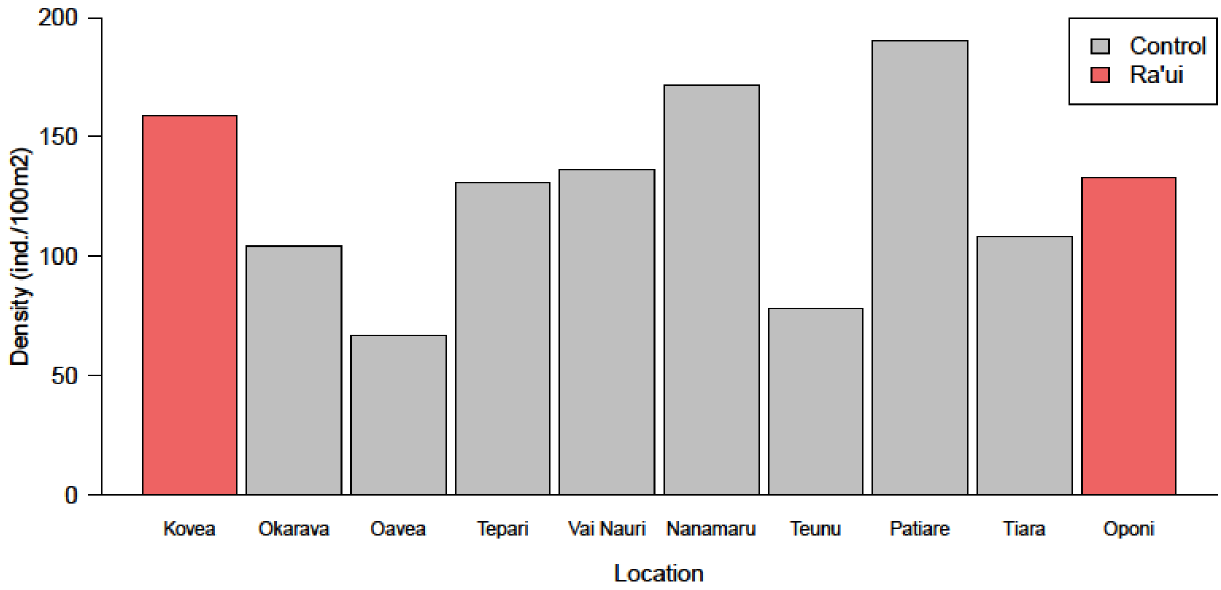

Figure 10. Finfish density over the reef in control (grey) and *rā'ui* (red) sites.

3.2.2. Species richness

Average species richness over the reef was greatest at Tepari (32 taxa/50 m^2) and least at Teunu (15 taxa/50 m^2) (Figure 12).

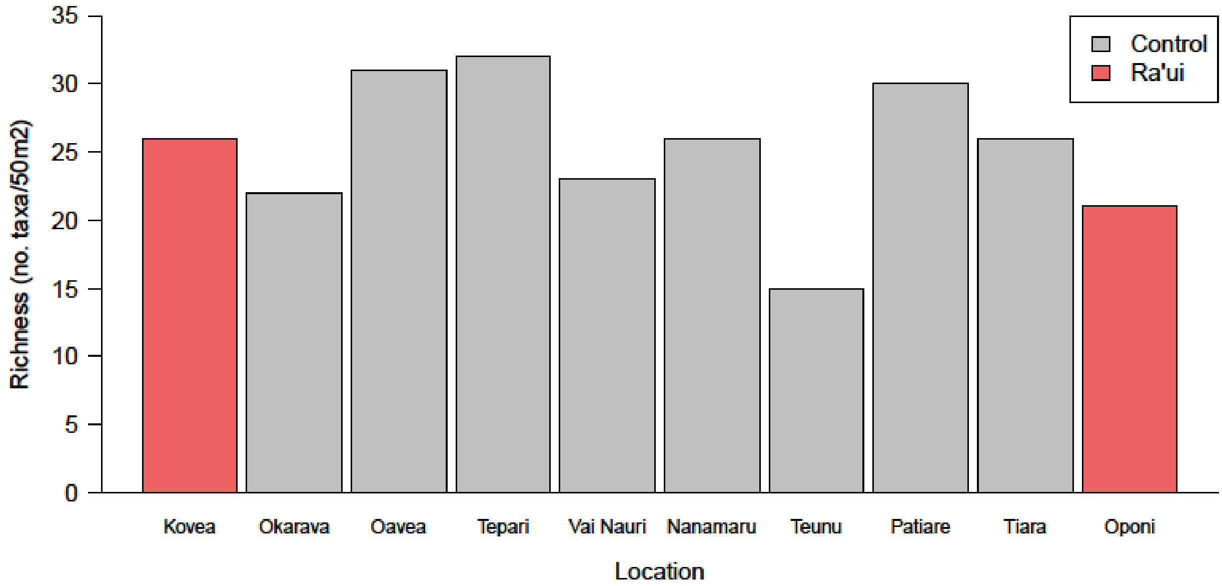

Figure 12. Finfish species richness over the reef in control (grey) and *rā'ui* (red) sites.

3.3 Coral and substrate

Over the reef, the total live coral cover was 27% (Figure 13). The average hard coral cover was greatest at Tiara (44 ± 6%) and least at Nanamaru (15 ± 4%). Hard substrate and macro algae accounted for the highest percentage cover over the reef with averages of (27 ± 5%) and (24 ± 4%), respectively.

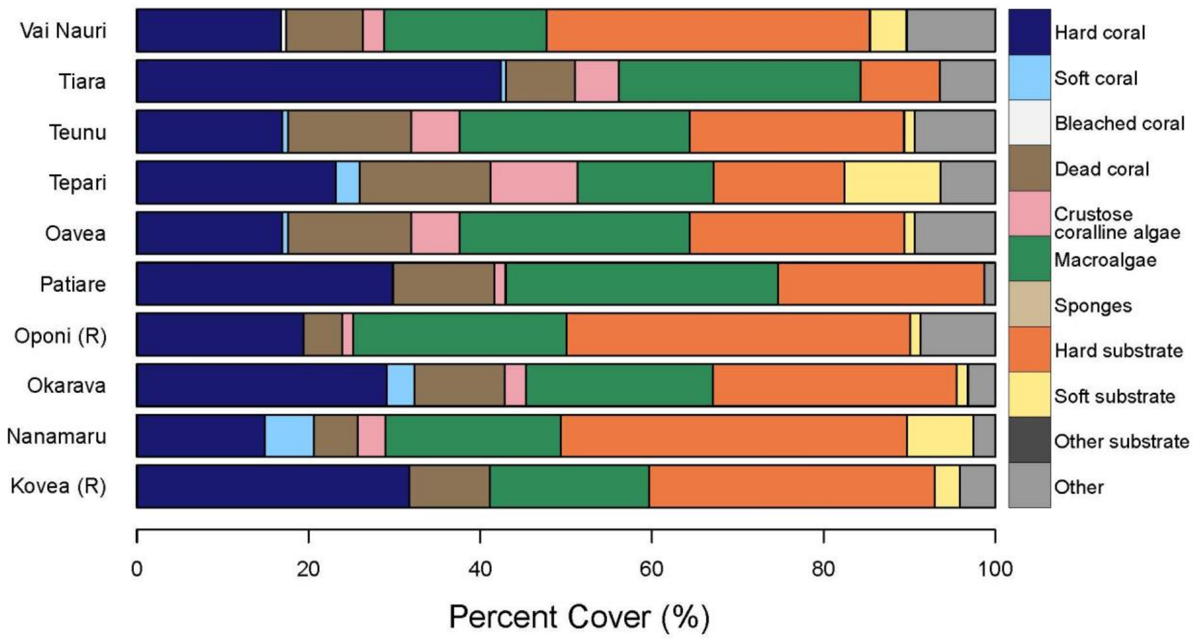

Figure 13. Substrate type and percentage cover from over the reef in control and *rā'ui* (R) sites.

3.3.1. Historical comparisons

In comparison with historical data from Rongo *et al*. (2013), Okarava showed a 5% increase in hard coral cover and Kovea, a 10% decrease (Figure 14). Okarava had no significant changes with an average of 29% in 2018, the same average found by Lyon in 2002. In contrast, Kovea showing a 13% increase in hard coral cover since 2002.

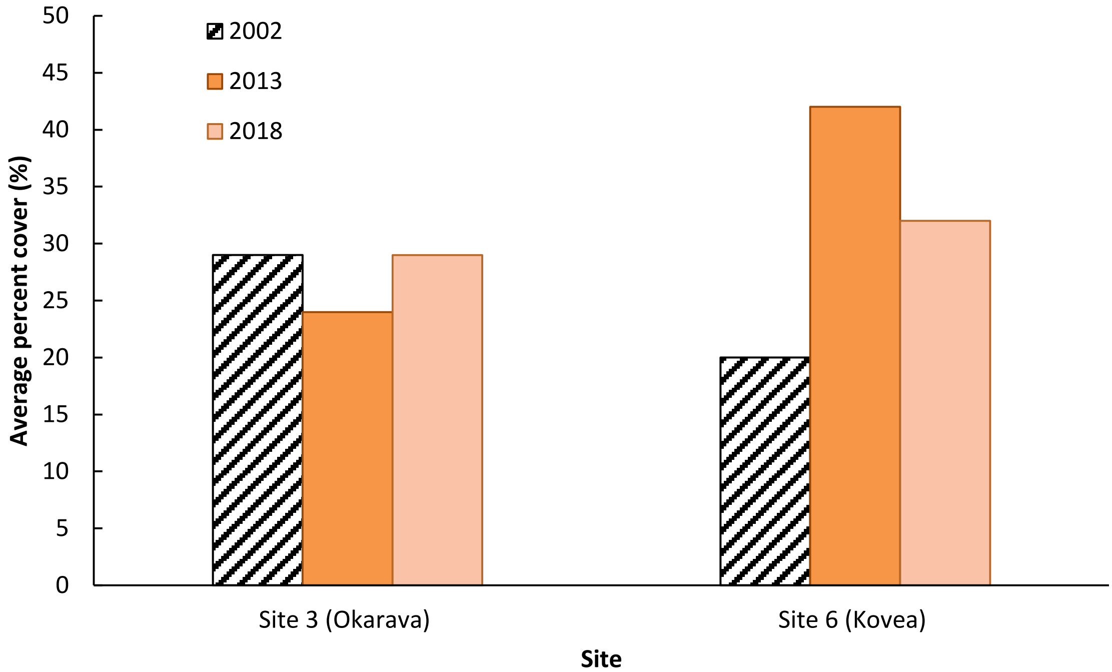

Figure 14. Comparisons of the average percentage hard coral cover from two ORT sites surveyed in 2002, 2013 and again revisited by MMR in 2018.

4. DISCUSSION AND BIOLOGICAL INFORMATION

The average invertebrate density on the inner reef was greatest at Patiare which was significantly greater than Kovea, Oponi, Okarava and Tepari (Figure 2). Additionally, the most frequently observed invertebrate was *ungakoa* with significantly greater densities found at Teunu than Kovea and Tepari (Figure 4). This shows that with the exception of Patiare, sites on the inner reef located on the south-west, southern and eastern sides are more abundant in invertebrate density than sites on the western and northern sides (Figure 1). The airport and the town of Takaue are located in the northern and western sides of Mitiaro, respectively. Furthermore, George and Kea (2014) postulate that reef gleaning is a common practice on Mitiaro mainly for *ariri*, however this also includes *paua kura* and *ungakoa*. The greatest density of *ariri* was at Oavea on the south side and *paua kura* at Patiare. Invertebrate densities appear more abundant in sites further away from the town and airport. This is consistent with the idea that reef walks will occur in areas closer to town and homes due to ease of access and gathering. This is evidence to suggest that reef gleaning may be reducing the density of invertebrates in sites closer to town for overall invertebrates, and namely *ungakoa*, *ariri* and *paua kura*.

Invertebrate densities were also significantly different between control and *rā'ui* sites on the inner reef. *Ungakoa* and *rori toto* densities at Patiare were significantly greater than both *rā'ui* sites, Kovea and Oponi (Figure 4, 5). George and Kea (2014) noted that *rā'ui* had been eroding for some time now and its communal protection used to be the pathway for conservation of marine species. Traditionally, *rā'ui* was a demarcated area marked off by a chief for a period of time only to be harvested at a later date. Hoffman (2002) stipulates that it was the customary right for all (not just the chief) to enforce the *rā'ui*, that this was essential for its continual success. Perhaps, over time with the changes of power from traditional chief to government rule, the respect for *rā'ui* eroded. A marine reserve that has legal implications and can be legally enforced may provide alternative benefits to maintaining invertebrate densities on the inner reef.

Over the reef average hard coral cover ranged from 15% to 44% and had an overall average of 25% (Figure 13). In comparison to Rongo *et al* (2013), Okarava showed a 5% increase equalling the same average cover of 29% by Lyon in 2002. Kovea showed a 10%

decrease in hard coral cover since 2013, though this was still greater than 19% in 2002. Recent climatic events occurred during this period. In 2016, a coral bleaching event was noted during a coral reef survey in Rarotonga where (ignoring recovery of bleached corals); 80% mortality was found (Rongo *et al*. 2017). The warm waters during this period may have had an adverse effect on the fore reef of Mitiaro. A large proportion of dead coral substrate (Figure 10) may be remnants of a bleaching event that also impacted not only Rarotonga but Mitiaro as well.

Sites over the reef with the highest coral cover were located on the west side, the leeward side of Mitiaro. In descending order from the highest coral cover; Tiara had an average of 44%, followed by Kovea 32%, Patiare 30% and Okarava 29% (Figure 15). With the exception of Okarava, high biodiversity on the leeward side provides good shelter from strong wave action, oceanic currents, and prevailing trade winds. This high diversity of corals is the greatest in Cook Island waters to date (Rongo *et al*. 2013). Private SCUBA charters may provide some benefit to the community and add to business ventures for locals.

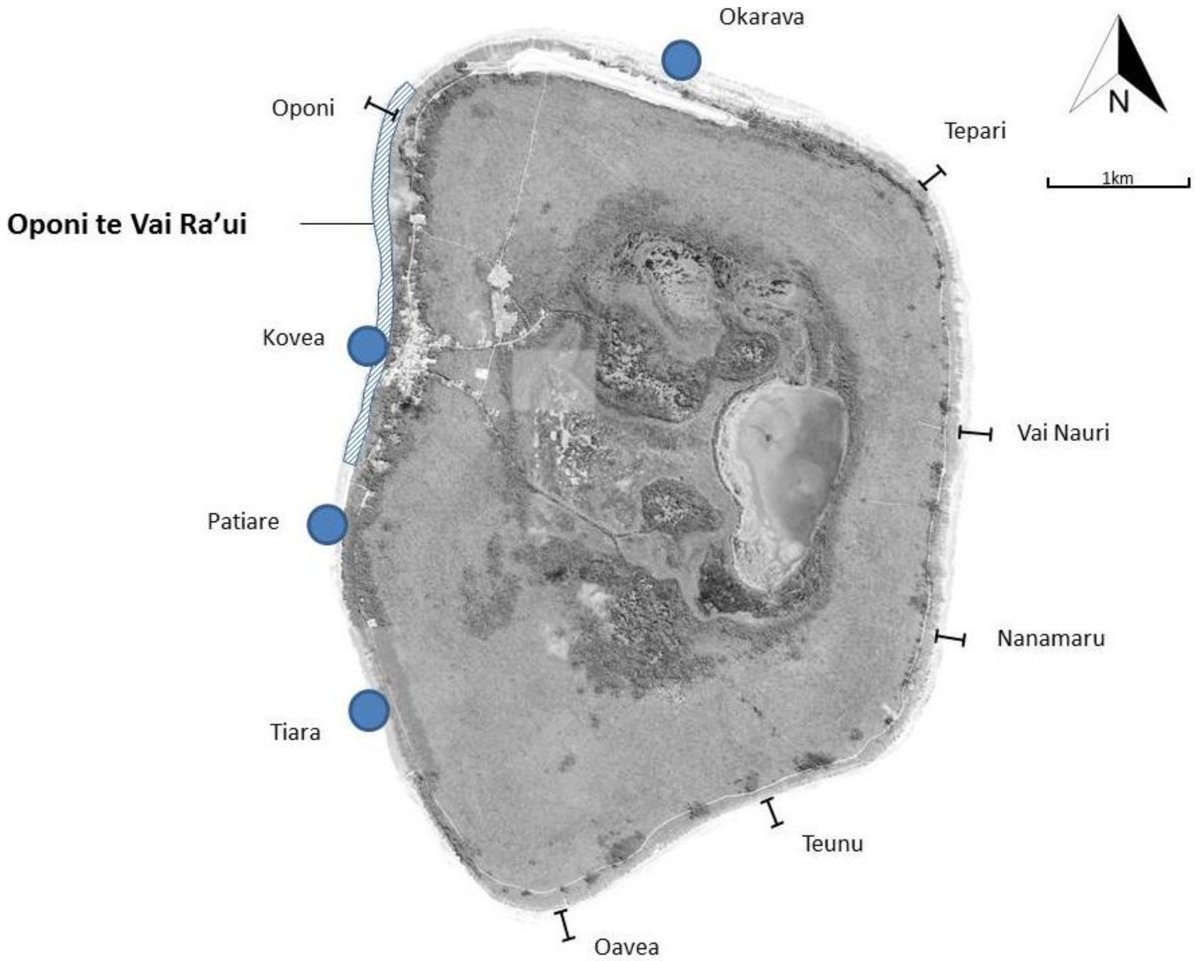

Figure 15. Blue circle indicates leeward sites with the highest coral cover.

5. RECOMMENDATIONS

Outlined below are suggested recommendations that should have little immediate impact in the quantity of species harvested, but should have long term positive benefits for subsistence fishers, ecosystem resilience and biodiversity conservation in Atiu and Takutea. These recommendations may be accepted or modified to suit the need of fishermen, communities and managers.

- All invertebrate species shall not be subject to any form of sale, whether local or commercial, and only be subject to subsistence fishing by the Mitiaro community.
- No *paua* harvests should occur in any part of the reef and *paua* be left alone for an extended amount of time. This is to allow stocks to replenish, giving smaller sizes time to grow to maturity in order to reproduce for future populations.
- It is recommended that no killing of grey reef sharks or any shark, to maintain the balance between predators and prey on the fore reef; ultimately, maintaining a healthy reef.
- The Mitiaro 2018 survey highlighted high coral biodiversity over the reef. It is recommended SCUBA diving charters be open to discussion as another avenue for a community private business. This is due to the high coral cover on the leeward side, the highest in the Cook Islands.
- It is recommended that an alternative to traditional management be installed such as a marine reserve. Marine reserves can have legal implications whilst traditional management of *rā'ui* can still be observed.

REFERENCES

Allen, G., Steene, R., Humann, P., & DeLoach, N. (2012). Reef fish: identification tropical Pacific. Singapore: New World Publication; ISBN 978-1-878-348-36-4.

George N., Kea T., 2014. The status of invertebrates resources at Manihiki and Rakahanga: September 2014. Ministry of Marine Resources. Rarotonga, Cook Islands.

Godoy, N., Gelcich, S., Vásquez, J. A., & Castilla, J. C. (2010). Spearfishing to depletion: evidence from temperate reef fishes in Chile. Ecological Applications, 20(6), 1504-1511.

Hoffmann, T. C. (2002). The reimplementation of the Rā'ui: Coral reef management in Rarotonga, Cook Islands. Coastal Management, 30(4), 401-418.

Lyon, S. (2002). Mitiaro baseline survey, Mitiaro harbour development project. For the Cook Islands National Environment Service, 15 pp.

National Environment Service. (2011). Cook Islands Second National Communication under the United Nations Framework Convention on Climate Change. Government of the Cook Islands. RepORTavailable at: http://www.environment.gov.ck/attachments/article/48/Second%20National%20Communication%20pages%201-30.pdf

Ponia et al. (1998) Mitiaro reef resources: baseline assessment. Cook Islands Ministry of Marine Resources, 22 pp.

Randall, J. E. (2005). Reef and shore fishes of the South Pacific: New Caledonia to Tahiti and the Pitcairn Islands (Vol. 1). Honolulu: University of Hawaii Press.

Rongo, T., Evans, J., Passfield, K., Cramp, J., Sudek, M., Tautu, B., McDonald, G., Rongo, T.C., & B. Hanchard. 2013. Cook Islands Marine Park: coral reef survey of Aitutaki, Manuae, Mitiaro, Takutea, and Atiu in the southern Cook Islands. Government of the Cook Islands. 64 pp.

Rongo, T., Kora, J., McDonald, G., Phillips, A., Smith, A. 2017. Rarotonga fore reef community survey 2016. Government of the Cook Islands. 41 pp.

Russ, G. R., & Alcala, A. C. (1989). Effects of intense fishing pressure on an assemblage of coral reef fishes. Marine Ecology Progress Series, 13-27.

Veron, J.E.N. (2000). Corals of the World, vol. 1–3. Australian Institute of Marine Science, Townsville, 404-405.