Reef Check Vanuatu Report July-August 2004

For the stakeholders of Efaté's coral reefs

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EXECUTIVE SUMMARY

OVERVIEW

An international team of marine scientists and Reef Check volunteer researchers from Townsville, Queensland visited the Shéfa Province of Vanuatu on a 21-day scientific expedition in 2004. The expedition was organised in response to a request from the Efaté Scuba Association and Vanuatu Department of Fisheries to help build local community capacity to monitor reef health and the effects of recent expansions in aquarium fish exports from the region. The region's marine aquarium trade holds the potential to provide a valuable and significant source of income to coastal communities, a key factor for sustainable economic growth.


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The expedition team conducted an assessment of coral reef health and the impacts of this industry on the reefs surrounding Efaté. The team also trained 11 local dive and marine protected area staff in Reef Check and aquarium fish survey methods and helped to set up a national Reef Check Trainer with the tools to continue with this project.

This expedition was the first of its kind for Reef Check Australia and succeeded in providing assistance to coral reef stakeholders in Vanuatu, in capacity building for coral reef monitoring activities, as well as providing an outstanding opportunity to its Australian volunteers to experience coral reef conservation and management issues in the South Pacific.

BUILDING NETWORKS

Through this expedition Reef Check Australia facilitated a relationship between government, local industry and communities from Australia and Vanuatu. Continued collaboration between the multiple stakeholders of Vanuatu's coral reef resources has been recognised as key to successful, sustainable management. Reef Check Australia aims to continue to facilitate and participate in such collaboration.

TRAINING, EDUCATION AND PUBLIC AWARENESS


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Building local capacity to monitor the status of Vanuatu's reef resources has been identified as a strategic goal of the Vanuatu Department of Fisheries. Engaging coral reef stakeholders to assist with reef management has been proven to increase the likelihood of success.


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Reef Check Australia's Training team ran a successful series of Reef Check and aquarium fish monitoring training workshops for Mele Bay and Nguna-Pele communities. After successfully completing and passing the courses, many of the new trainees accompanied the survey team on the expedition dives and gained extra field experience and training.

THE SURVEY

The Reef Check *Plus* protocol was used to survey coral communities, key macro-invertebrate populations, other human impacts and food fish populations and the MAQTRAC protocol was used to survey key aquarium fish. In addition, a rapid assessment technique was used to determine the tourism value of each site. Surveys were conducted at Mele Bay, Pele Island and Hat Island.

KEY FINDINGS

CORALS AND REEF CONDITION

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Extremely high percentages of coral cover of up to 70% were observed at Devil's Point in Mele Bay and 50% cover around the marine protected areas of Nguna-Pele Islands. These coral communities comprised of attractive, healthy plate and branching coral growth forms, representing high tourist value. There was little evidence of damage, with minor impacts from cyclones and small boat anchors.

AQUARIUM FISH

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A wide range of colourful fish was observed in this region, which is a key attraction for tourists, as well as important for the aquarium industry. A particularly high abundance of pygmy angelfish (*Centropyge* spp.), which are popular aquarium fish, were observed with a potential new species found by Dr Glenn Almany.

Densities of a number of species that are targeted by the aquarium collectors were found to be lower at one of the collection sites visited than at the protected site that was surveyed. Further studies are needed to determine if these findings are a cause of aquarium fish harvesting or due to natural differences in the abundance of such species across reefs. Such studies will also be essential to determine and maintain sustainable levels of extraction for this valuable industry.

COMMERCIALLY IMPORTANT MARINE SPECIES

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Key macro-invertebrate abundance was low at all sites visited with higher numbers of giant clam (*Tridacna* spp.), pencil urchins (*Heterocentrotus mammilatus*) and trochus (*Trochus niloticus*) where fishing pressure was reported as lower. Key food fish abundance was also low at all sites visited. These findings support anecdotal reports that artisanal fishing pressure is high in this region.

FUTURE DIRECTIONS

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The establishment of a network of marine protected areas within regions that are harvested is an effective instrument to protect habitats and stocks of fish and invertebrates from over-collection and to ensure these resources are available for future generations. Engaging the community in the monitoring and management of these reserves is key for their success, especially in areas where resources are limited and the success of the Nguna-Pele MPA should be showcased. Reef Check provides a tool for communities to demonstrate the effectiveness of their reserves, which ultimately builds support and stewardship of their resources.

The Vanuatu Department of Fisheries aim to educate and engage their local communities in the management of their coral reef resources. To assist in the realisation of these goals, Reef Check Australia aim to return to Vanuatu annually to continue to assist with:

- Running training workshops for community Reef Check and MAQTRAC teams;
- Establishment of permanent monitoring sites for community teams;
- Providing man power to assist with data collection activities;
- Facilitate networks with Australian institutions, e.g., at James Cook University who may be a valuable resource for future research in Vanuatu.

SUPPORT

Reef Check Australia's Vanuatu coral reef monitoring expedition proudly acknowledges funding and in-kind support from Reef Check, Reef Check Australia, Vanuatu Department of Fisheries, Efaté Scuba Operators Association, AusAid, Air Vanuatu, CRC Reef, Queensland Department of Primary Industries and Fisheries, James Cook University, Fulbright Program, National Science Foundation, United Nations Environment Program, United States Coral Reef Task Force and in particular, the Volunteer expedition team, who contributed personal funds as well as three weeks of their time to make the adventure possible.

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ACKNOWLEDGEMENTS

Many dedicated people worked tirelessly to put this expedition together. We'd like to thank the following people for their efforts:

- Efaté Scuba Association – in particular Peter Whitelaw from Sailaway Cruises
- Rodney Habla from Hideaway Island Resort
- The Hideaway dive team, Mike, Jerry, Jokka, Russell, Johnny
- Mike Lameier (Peace Corps)
- Chris Bartlett (Peace Corps)
- Taloa Village
- Nguna-Pele Marine Protected Area Staff (Nicholas Michael, Taura Jack and Fifi)
- Vanuatu Department of Fisheries
- Australian High Commission – Victoria Hillman

Reef Check Australia Team who helped with training workshops, data collection, data entry and analysis:

- Jos Hill
- Sam Birch
- Dr Glenn Almany
- Dean Miller
- Roz Martin
- Yacov Salomon
- Paul Benjamin
- Tim Donnelly
- Heath Stafford
- Sam Jones
- Jules Lawson

Reef Check Australia's Vanuatu coral reef monitoring expedition proudly acknowledges funding and in-kind support from Reef Check, Reef Check Australia, Vanuatu Department of Fisheries, Efaté Scuba Operators Association, AusAID, Air Vanuatu, CRC Reef, Queensland Department of Primary Industries and Fisheries, James Cook University, Fulbright Program, National Science Foundation, United Nations Environment Program, United States Coral Reef Task Force and in particular, the Volunteer expedition team, who contributed personal funds as well as three weeks of their time to make the adventure possible.

INTRODUCTION

This project was initiated by the **Efaté Scuba Association** in collaboration with the **Vanuatu Department of Fisheries** and local **Marine Protected Area Staff** in response to local concern regarding potential impacts from an expanding aquarium industry around Efaté.

The department of Fisheries currently lack resources for data collection to conduct comprehensive monitoring of the status of their coral reef resources. In light of an expanding aquarium collection industry in the region, it was recognised that the timely establishment of monitoring sites is a necessary measure to determine the extent of any collection impacts at harvested sites and to determine and maintain sustainable levels of extraction for this valuable industry.

The solution was to utilise a volunteer workforce to collect data that can be provided to the government for integration into their database systems. The Efaté Scuba Association joined forces with Reef Check Australia volunteers to establish a number of monitoring sites in the Efaté region and to run training workshops for local Reef Check teams.

Project Objectives

- ✓ Establish and conduct a baseline assessment of survey sites for long-term monitoring in the Efaté region. This study will build on a similar assessment of aquarium collection sites conducted during February 2004 (Sykes, 2004) and May 2004 by the Secretariat for the Pacific Community (SPC).
- ✓ Provide equipment and training for a number of local divers and snorkellers to permit regular monitoring for the management of reef systems and fish populations;
- ✓ Provide data to the Vanuatu Department of Fisheries to be integrated into their local database for use in long-term management of the marine resources in Efaté;
- ✓ Provide a project report to the Department of Fisheries, AusAID and the Efaté Scuba Association;
- ✓ Provide recommendations for ongoing monitoring of established sites and additional sites;
- ✓ Provide recommendations towards the future development of a Vanuatu Fisheries Management Plan;
- ✓ Participate in awareness building for local indigenous land and sea custodians about the health and value of their marine resources and, the financial and environmental benefits of implementing a sustainable natural resource management plan;
- ✓ Provide support for the local Nguna-Pele MPAs and the MPA teams, which builds on existing work being done in this area, and to acknowledge recent achievements of these teams.

The purpose of this report is to describe the objectives and achievements of the expedition, present the data collected and to make recommendations to future monitoring in the Efaté region and for the pending Aquarium Fishery Management Plan.

The Marine Aquarium Trade

The marine aquarium trade is a growing industry that can offer a livelihood for many thousands of fishers in coastal communities around the world and importantly, in areas where there are few alternatives. This industry, therefore, represents a valuable source of income for exporting countries.

Environmental concerns resulting from this industry include habitat destruction from use of destructive collection methods, which results in unnecessary and often irreversible environmental damage to coral reefs. Over-exploitation of target species and secondary effects of this on reef communities is also a potentially serious impact, which can have a detrimental effect on coral reef health. Other potential problems include poor handling practices, which can contribute to marine fish deaths, incurring financial losses on marine ornamental retailers who purchase the fish. Responsible management of these fisheries is needed to ensure their sustainable use and conservation for future generations (MAC 2001; Wood 2001; Sadovy and Vincent 2002).

Aquarium Industry in Vanuatu

The aquarium trade in the Pacific is increasing but is restricted by air-transport infrastructure. Improved and expanded air services and transport infrastructure in the Pacific has enabled increased participation in this trade (Baquero 1999). The aquarium fish trade in Vanuatu was first established in the 1990s with two small-scale, locally owned companies. This industry is based in Port Vila, Efaté where there is an international airport. In 2003, one of the smaller companies was purchased by a foreign operator, which supplies a larger distribution centre in the U.S.A. The year 2003 marked a significant increase in aquarium exports (fish, invertebrates and live rock) as this company expanded (personal communication, Vanuatu Department of Fisheries, 2004).

Aquarium fish are characteristically small reef fish species such as the coral beauty angelfish (*Centropyge bispinosa)*. In Vanuatu such fish are collected using scuba. Aquarium collectors are known to dive in excess of 40 m for certain species of fish. The most common fish exported from Efaté are the pygmy angelfish, which live in the top 30 m of the coral reef. These include the flame angel (*Centropyge loricula),* coral beauty (*C. bispinosa),* lemonpeel *(C. flavissimus),* and bicolour (*C. bicolour)*. However, deeper species are also collected because they attract a high export price. These include the fairy wrasse (*Cirrhilabrus* spp.) and flasher wrasse (*Parachelinus* sp.), which are found around the 50 m depth. There are up to 3 shipments per week each containing approximately 5-700 animals (personal communication, aquarium tradesman).

Collection methods deployed

The aquarium divers use either scuba or hookah air supplies depending upon the depth of the site, physical conditions on the day, and the local density of target animals. Non-destructive 'invisible' monofilament nets are used for collection. The travel time to the holding facility in Port Vila does not exceed 3 hours from the collection sites and mortality is expected to be low. In preparation for export, the fish are placed in small plastic bags that are half filled with water and oxygen.

What is sustainable harvesting?

Sustainable harvesting is defined as the replenishment of stocks at the same or greater rate as they are collected (Wood 2001). Monitoring of stocks and catch statistics is necessary to determine sustainable levels for harvesting. Stable correlations between catch effort and the number of fish caught, as well as stable underwater observations of population abundance indicate sustainable harvesting levels.

Unfortunately, the number of fish that can be sustainably removed from one reef will not necessarily be the same for another reef because of the variability in abundance of particular species at particular locations. Therefore, stocks of ornamental species need to be monitored and managed on a country-by-country and reef-by-reef basis (Wood 2001). There is a need for more research on the ecological effects of collection of fish for the aquarium trade (Wabnitz et al. 2003), but until we expand our knowledge and in light of limited understanding of these effects, a precautionary approach to the management of this industry, in terms of setting cautious fish catch limits, is necessary to ensure benefits from marine resources can be sustained into the long-term (see IUCN 2003).

Why is over-harvesting a problem?

A major concern with over-harvesting of ornamental fish is that populations may be unable or slow to recover to their former (or a healthy level) of abundance. Where the abundance of fish falls below a critical level (called the sustainable reproductive threshold), finding spawning mates can be difficult and populations may be very slow to recover or, in extreme cases, risk local extinction (Sadovy and Vincent, 2002). Very little is known of the life history or reproductive capacity of many reef fish species. Experiences from other Indo-Pacific regions indicate over-fishing of reef fish species can take decades to recover to original numbers (Sadovy and Vincent, 2002) rendering them unusable to other user groups resulting in a net loss to the local economy and jobs. In addition to losing the target fish populations, changes in species abundance can lead to ecological changes in reef communities which can result in an overall less-productive system (Sadovy and Vincent 2002; Jackson et al 2001).

Preferentially harvesting juveniles, as is common with the aquarium trade, can potentially reduce the risk of over-harvesting by leaving breeding adults on the reefs, however, where juveniles are consistently heavily harvested, adult populations are likely to decline as only a limited number of young will grow to reach adult size and replenish the adult stock (Wood 2001; Wabnitz et al. 2003).

Local land management

Vanuatu has a custom land tenure system. Those wishing to use a resource must lease use rights from its owners for a monthly fee that is determined by these owners. Commercial fishing industries, therefore, negotiate to collect at specific sites and arrange to pay a monthly fee. Within communities that little utilise the marine resources, there is limited awareness of their value and the potential ecological impacts of extensive removal of particular fish species. As the species targeted by the aquarium trade are primarily not those used for food, this industry provides additional and easy income to landowners.

In order to ensure this industry is managed in a sustainable manner, a fishery management plan is currently under development by the Vanuatu Department of Fisheries and the South Pacific Commission (personal communication, Vanuatu Department of Fisheries, 2004).

Collection locations

During 2003-3 fish have been collected from reefs around Pango Point, in Mele Bay and further around Devil's Point and around the Southern coast of Hat Island. The fish are transported by boat to Port Vila; however, on some occasions transport over land by truck has been used to maximise collection activities at profitable sites.

Due to the range of species targeted by the collectors, a diversity of habitats must be used to locate these species, meaning that no one type of habitat is used specifically. However, the bulk of export fish leaving Vanuatu are commonly found on reef crests and outer reef slopes.

Resource use conflicts

Multiple-use conflicts between the tourism and aquarium industry have arisen where collection has been reported to occur at preferred tourist sites. Tourists want, and expect to see colourful fish on coral reefs and reef tour operators fear over-fishing of colourful fish at their dive and snorkel sites will degrade the tourism potential of these sites.

METHODS

Survey methods

The standard Reef Check methods were used for fish, substrate and inverts with slight modifications to the species lists. The aquarium fish were surveyed using the MAQTRAC fish protocol, again with slight modifications to the species list. The MAQTRAC survey protocol was designed by Reef Check for use in monitoring the effects of the aquarium trade on coral reefs. The MAQTRAC fish survey methods are essentially the same as the Reef Check methods. In order that data sets can be integrated, the same methods and target aquarium fish species were used for this study that were used in the February 2004 project (Sykes 2004).

Both Reef Check and MAQTRAC methods are transect-based where one full survey consists of 4 x 20 m long transects that are separated from one another by a minimum of 5 m (figure 1). These transects are conducted at two depths between 2-6 m and 6-12 m. In this study we surveyed at 5 m and 10 m depths at mean tide height.

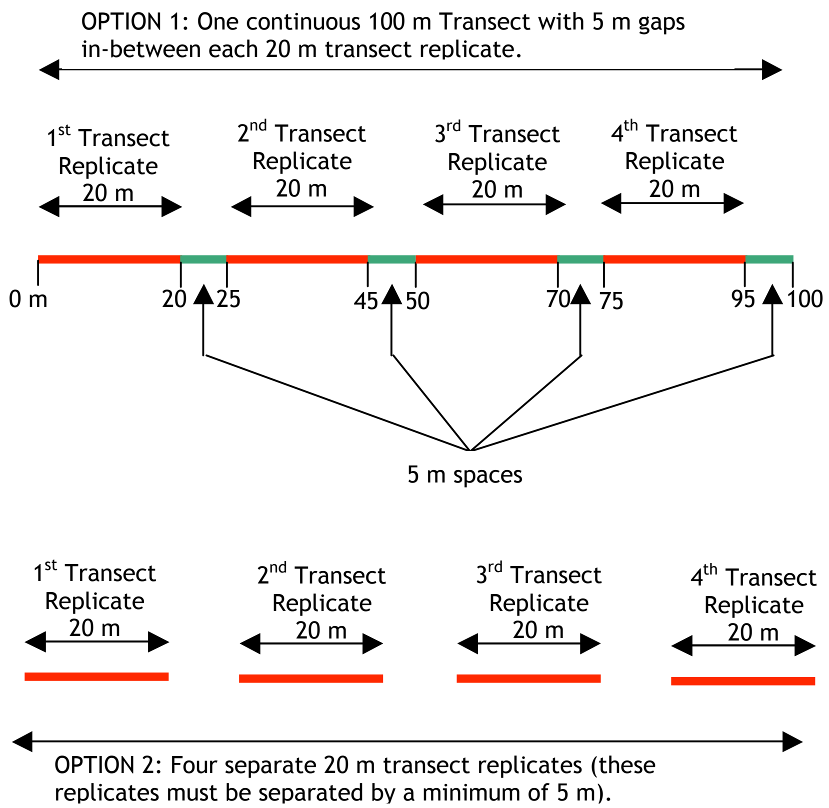


Figure 1: The transect.

Site descriptions

The Site form in Appendix 1 outlines the information collected at each site. This information was incorporated into the site descriptions table in Appendix 2.

Fish

The fish surveys were conducted first to minimise disturbance. One dive buddy conducted the Reef Check food fish survey while laying out the transect tape and the other buddy conducted the MAQTRAC aquarium fish survey. The standard Reef Check/MAQTRAC 5 m wide and 5 m high belt transect was used. Divers swam at a constant speed and spent approximately 10 minutes to search each 20 m belt transect.

The species list used for the MAQTRAC survey were those selected for the region during the February 2004 survey (Sykes 2004) and represented a selection of those used for the more intensive surveys conducted by the SPC team during May 2004. These represented those fish that were significant in the local aquarium trade and therefore indicators of collection pressure. Of these species some represented those found in restricted habitats, local endemics or variants and those important to the ecosystem. See Appendix 1 for a list of all fish surveyed.

Coral and substrate

The Reef Check "point sampling" method was used with a 0.5 m interval. To remove bias, a weighted line was used to determine the point that was directly below the line. The substrate categories and codes used by Reef Check are detailed in Appendix 1.

Invertebrates and impacts

The standard Reef Check 5 m wide belt transect was used to search for target invertebrates and impacts. A U-shaped search pattern was used to ensure the whole 5 m belt was surveyed. The indicators selected are listed in Appendix 1.

These methods are also described at www.reefcheck.org or in Hill and Wilkinson (2004).

Survey design

The aims of this expedition were to establish sites for long-term monitoring and collect baseline data from these survey sites. We decided that the survey sites selected should represent both areas that were used by aquarium collectors and those that were not. Resources and logistical limitations severely restricted the number and location of sites that could be surveyed on this expedition and these limitations detailed in Appendix 3.

<u>Study 1: Impact study</u>

A 'baseline pilot impact study' was conducted at a single reef area where aquarium fish collection took place and at a single reef area where collection did not take place. The reef areas selected had similar habitats in order that some comparisons between these areas could be made.

Within the impact and control sites, 2 locations were established in which 5 Reef Check transect sites were surveyed. We refer to one full Reef Check survey (4 x 20 m transects at both depths) as a transect 'site'. Therefore, at each location a total of 20 x 20 m transect replicates were surveyed at 5 m and 10 m depths (figure 2).

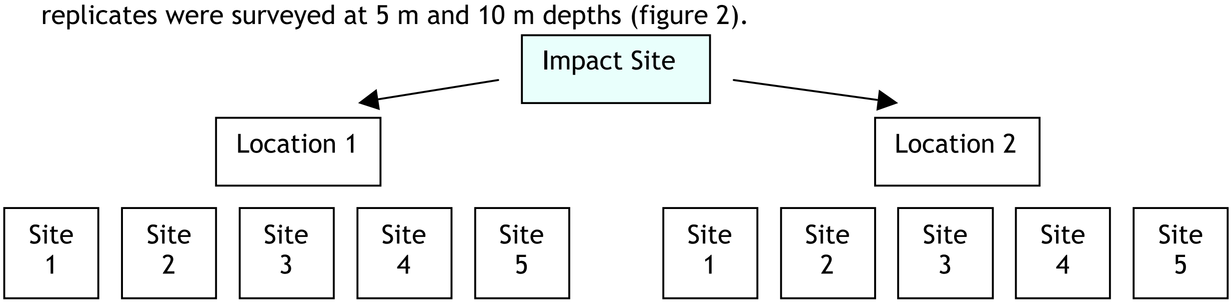


Figure 2: Survey design that was replicated at both impact and control sites.

The habitat of both the control and impact sites was spur and groove fringing reef. Sandy gullies were not surveyed. Where a gully interrupted a 20 m transect replicate, the point at which the gully began was recorded, the gully skipped and the survey continued on the next reef spur at the target depth. This protocol ensured the survey was conducted at a constant depth and within the reef habitat itself. We recommend subsequent surveys of this area follow this protocol where sand patches are ignored in order that percent coral cover data can be compared.

Study 2: Rapid assessment

A rapid assessment was conducted at Hat Island to obtain a snapshot of the reef health. At the East Mooring a single shallow Reef Check survey was conducted (4 x 20 m replicates at 5 m depth). At the NW side of Hat Island, 1 full Reef check survey for substrate was conducted (at 5 m and 10 m depth), 1 invertebrate survey at 5 m depth, and 20 x 20 m replicates for the aquarium fish survey.

Analysis

Mean percentage cover of benthic communities and mean abundance of fish and mobile invertebrates are presented in this report. Minimal analyses were done on these data because surveys were intended to provide baseline data that can be integrated with data sets from similar surveys conducted during 2004 and with which longer-term comparisons between subsequent datasets (from these and additional sites) can be made.

At this stage we recommend that catch statistics be made available in order that more detailed interpretations of the patterns of abundance we observed at our two study sites can be made. Our colleagues at James Cook University are interested to assist with this project.

For a robust spatial comparison of coral reef resources at collection and non-collection sites, we recommend additional surveys be conducted at additional sites and data sets combined from existing surveys.

Site selection criteria

The survey sites were selected according to the following criteria:

- Accessibility;
- Suitability of habitat for 40 x 20 m transects (1 km of reef of the same habitat required);
- Significance to local communities and tourism industry;
- Use by the aquarium industry.

Sites

See figure 3 to locate the following sites and figure 4 for photographs of these sites. A more detailed description of these sites is provided in Appendix 2.

Impact study sites

1. Devil's Point
2. Nguna-Pele Island, Location 1: Laonamoa and Location 2: Worearu.

Rapid Assessment sites

3. East Coast of Hat Island
4. NW Hat Island

All information on sites was obtained from local residents in Efaté using the Reef Check site form (see Appendix 2).

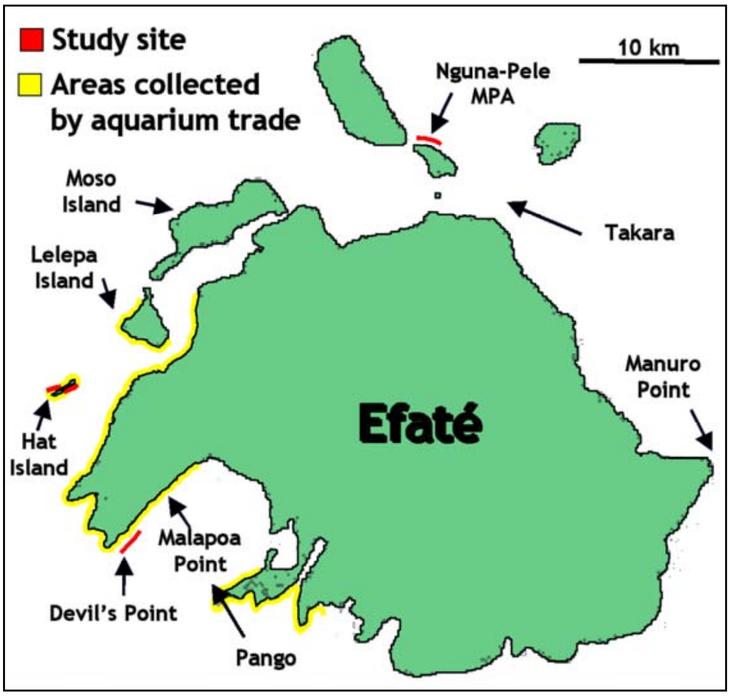


Figure 3: Aquarium collection and survey sites around Efaté.

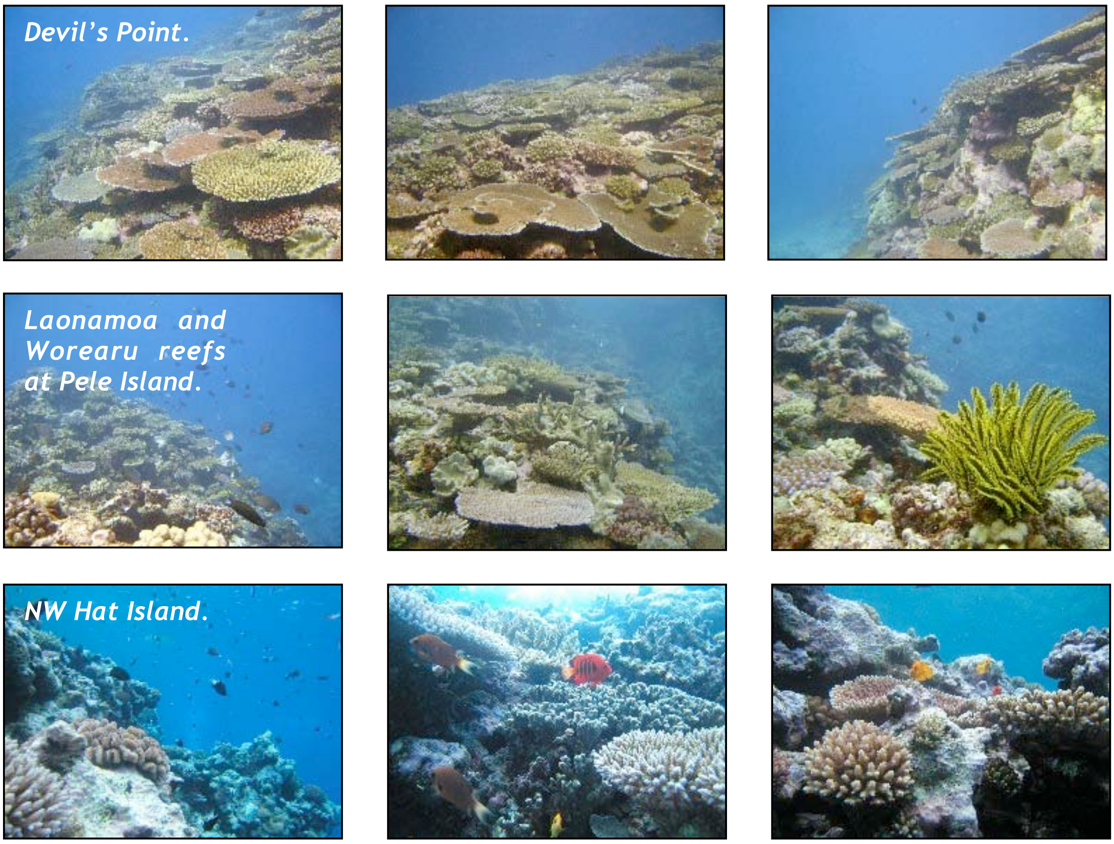


Figure 4: Photos of the survey sites.

RESULTS

IMPACT STUDY

Substrate

The substrate habitats were comparable between locations within the impact and control sites as well as between the impact and control sites. The main substrate types were hard coral and rock. Hard coral cover was high at 68-70% at 5 m and 56-63% at 10 m at Devil's Point. This was lower at Laonamao and Worearu with 44% at 5 m and 40-49 at 10 m depth. Plate, branching and submassive hard coral lifeforms dominated both depths at Devil's Point and a similar pattern at Laonamao and Worearu, although branching coral was more abundant there. Most rock was covered with turf algae or coralline algae, with the latter being most abundant at all sites and locations.

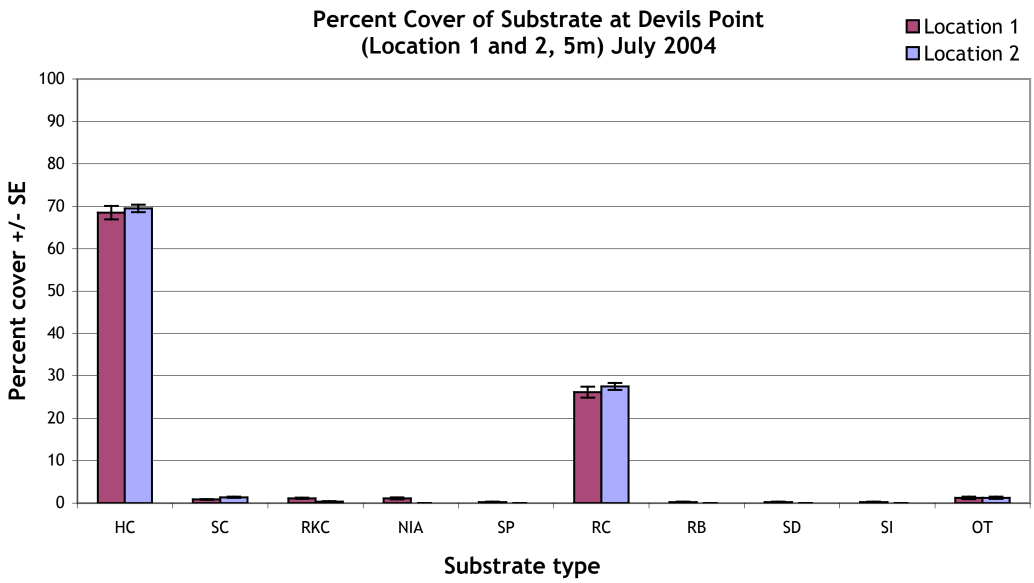


Figure 5: Substrate cover at Devil's Point (5 m).

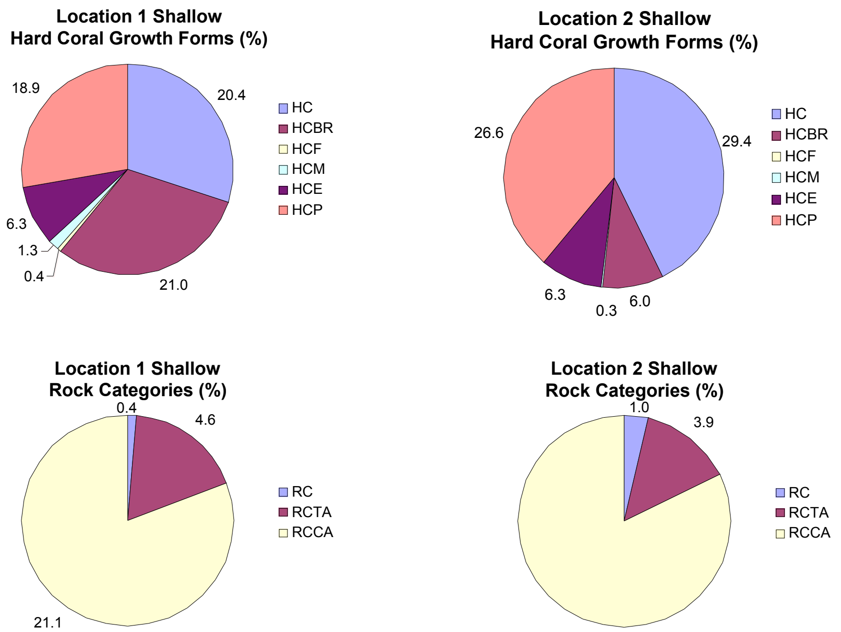


Figure 6: Hard coral lifeforms and rock categories at Devil's Point (5 m).

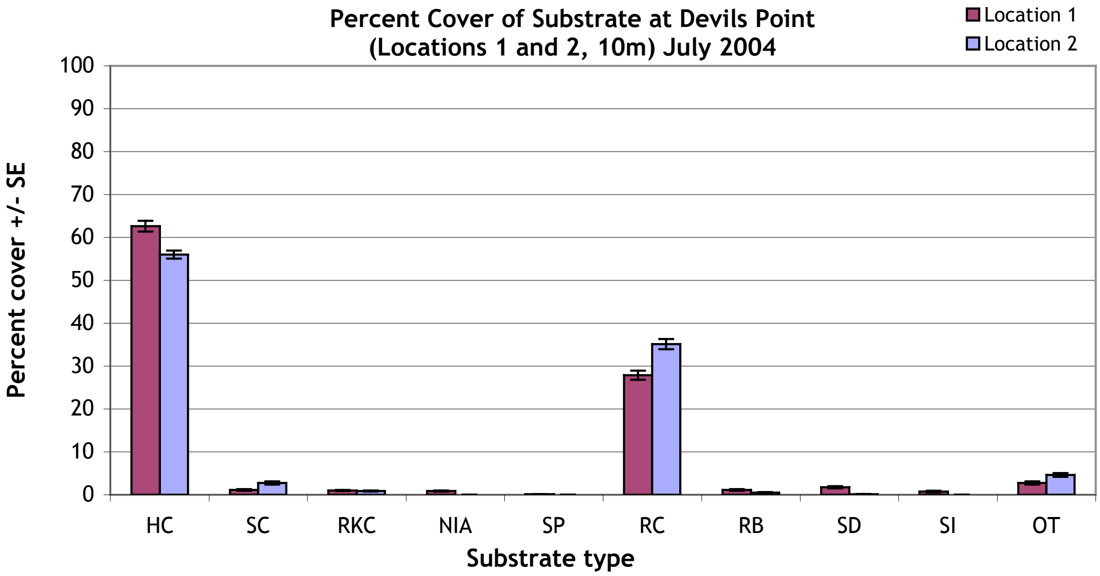


Figure 7: Substrate cover at Devil's Point (10 m).

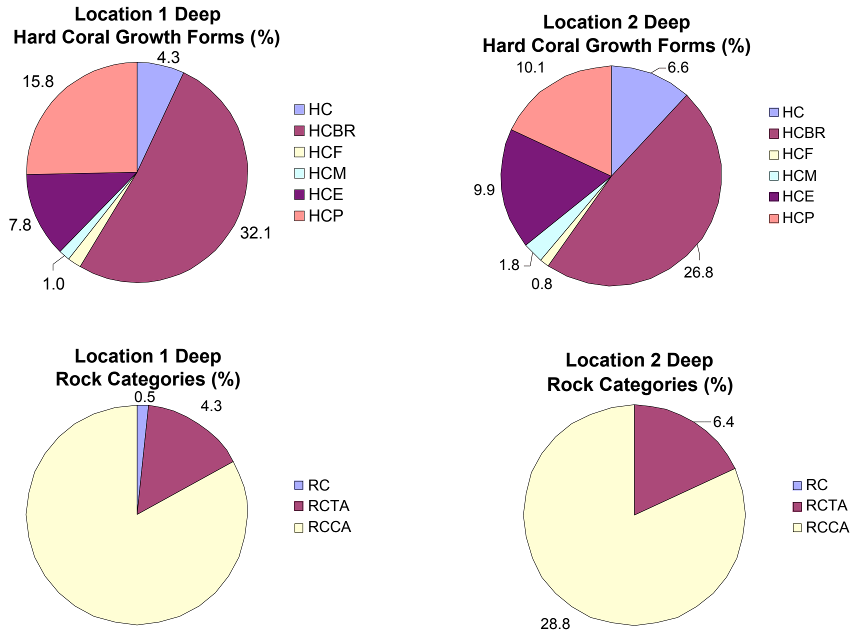


Figure 8: Hard coral lifeforms and rock categories at Devil's Point (10 m).

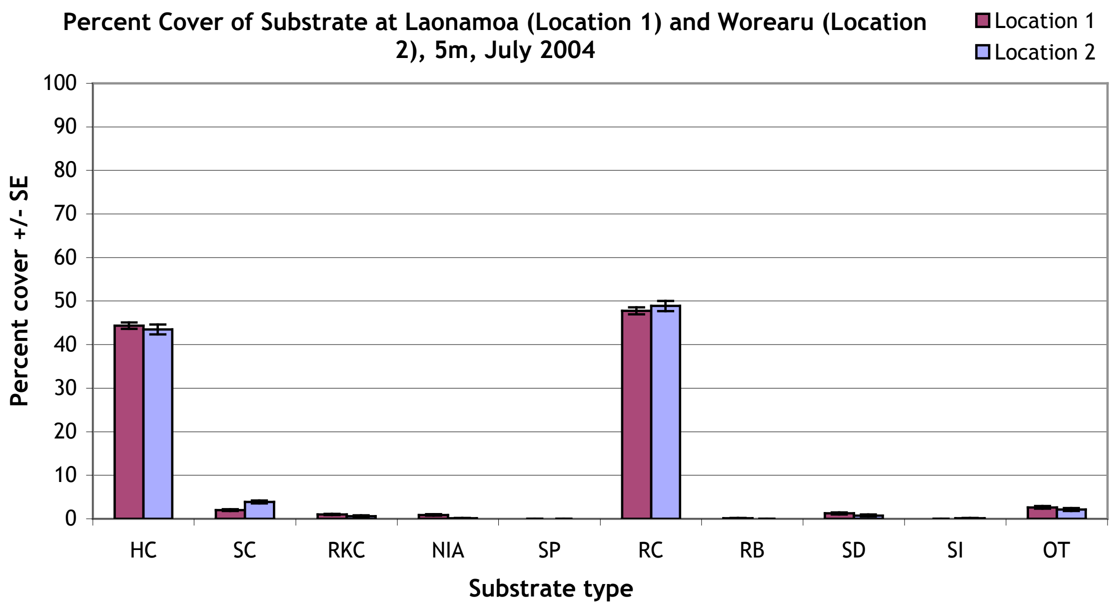


Figure 9: Substrate cover at Laonamoa and Worearu (5 m).

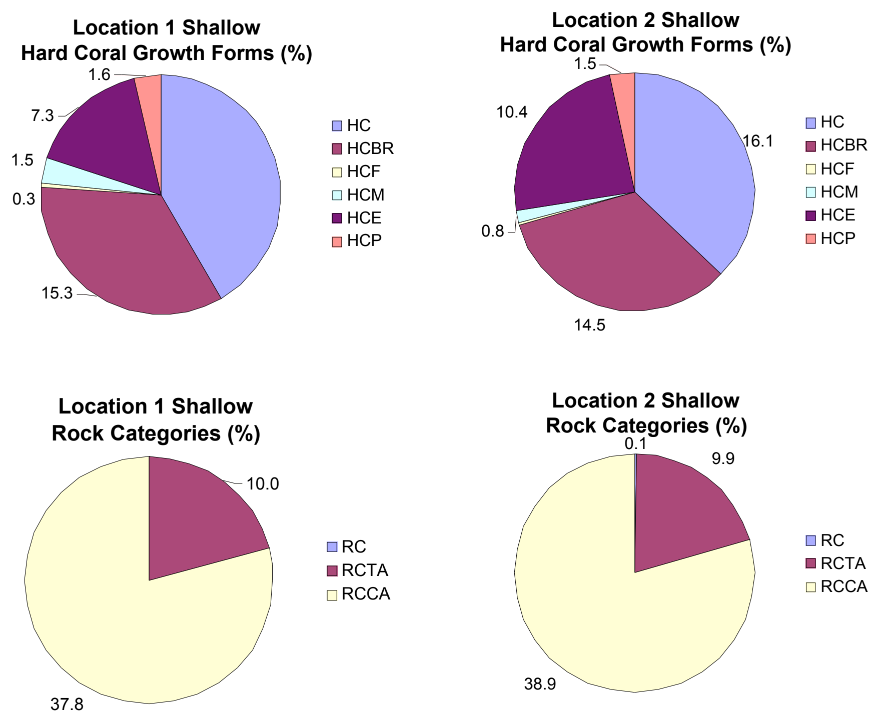


Figure 10: Hard coral lifeforms and rock categories at Laonamoa and Worearu (5 m).

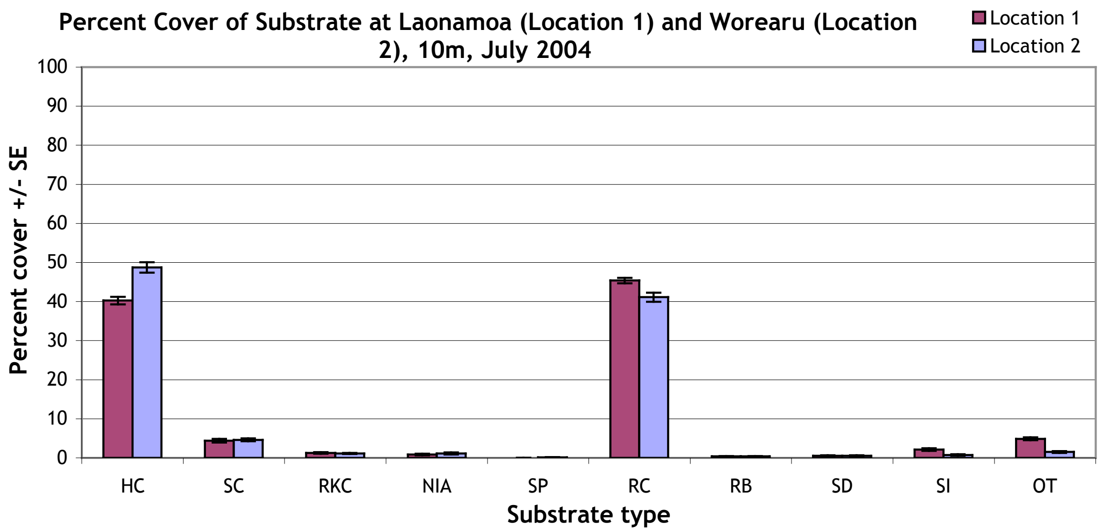


Figure 11: Substrate cover at Laonamoa and Worearu (10 m).

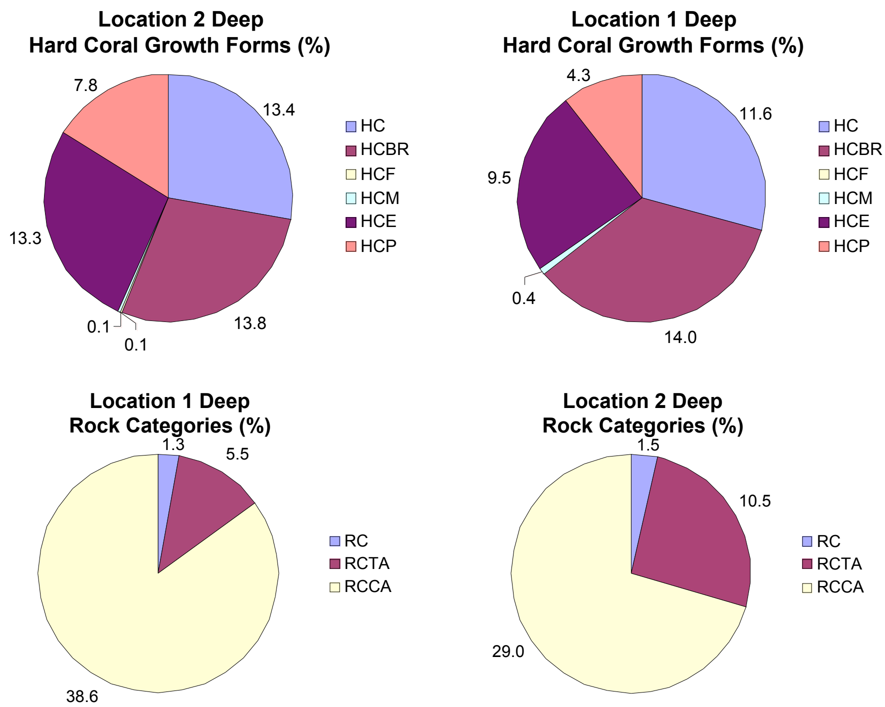


Figure 12: Hard coral lifeforms and rock categories at Laonamoa and Worearu (10 m).

Aquarium Fish

The abundance of aquarium fish was similar between the locations within the impact and control sites illustrating consistency within impacts and controls, however there were significant differences between the control and impact sites.

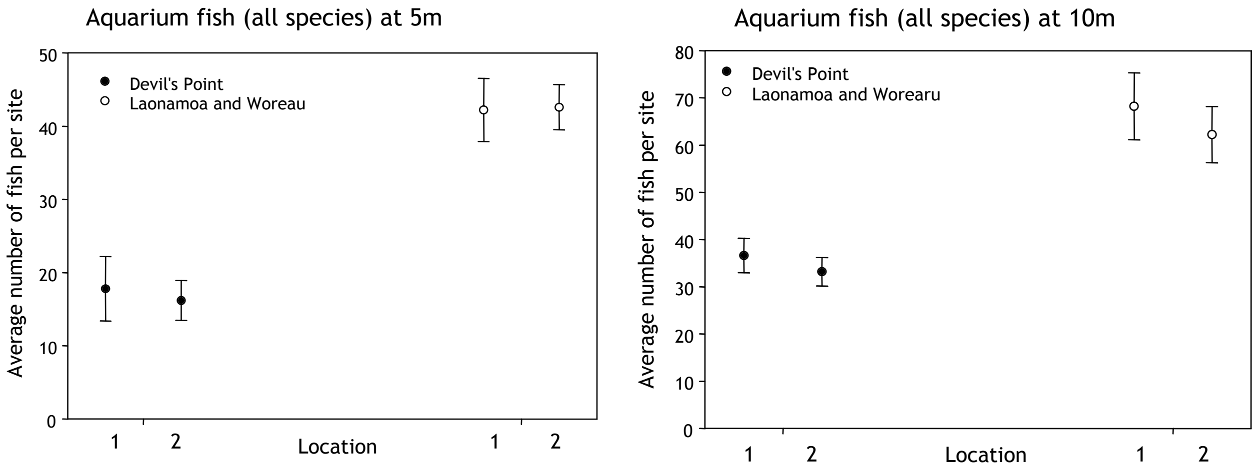
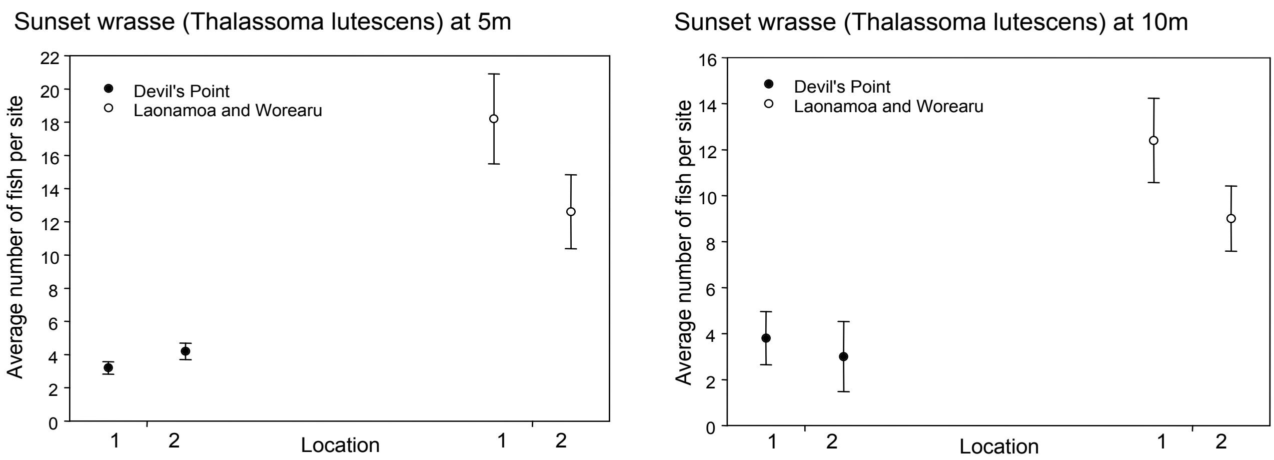


Figure 13. Average total aquarium fish observed per site (4 x 20 m transects) at Devil's Point and Pele Island (Laonamoa and Woreau) at 5 and 10 m depth.

The following fish species represented 50-70% of the total number of individuals surveyed at both the control and impact sites, were conspicuous members of the reef community and represented those present at the holding facility for the aquarium traders in Port Vila. Figure 14 illustrates a marked difference in fish abundance at the control locations compared with the impact locations.



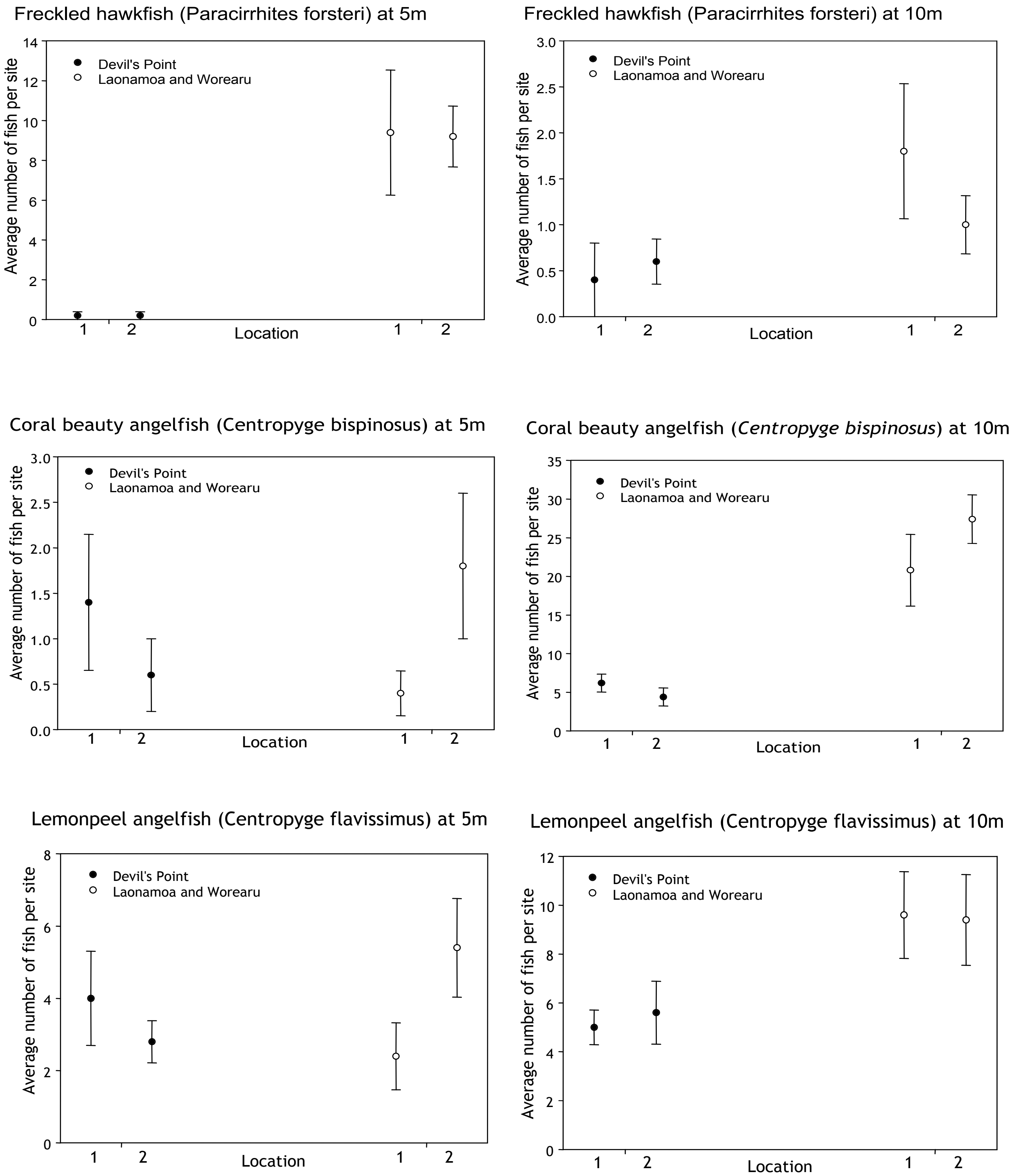


Figure 14: Abundance of Thalassoma lutescens, Paracirrhites forsteri, Centropyge bispinosus and observed per site at Devil's Point and Pele Island (Laonamoa and Woreau) at 5 and 10 m depth.

See Appendix 1 for a summary of all aquarium fish.

Reef Check indicator Fish

Many of the food fish were absent at Devil's Point.

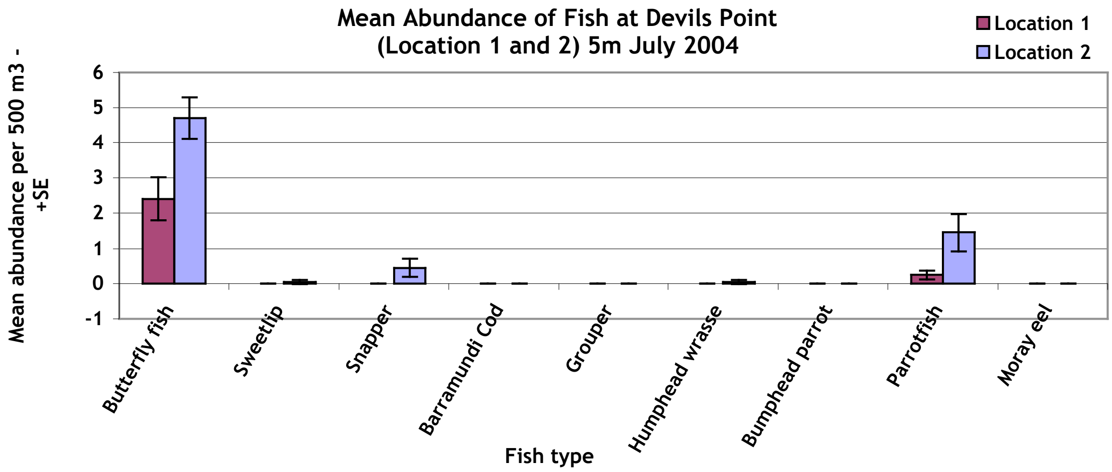


Figure 15: Average Reef Check fish per 20 m transect at Devil's Point. 5 m depth.

The most abundant fish type at location 1 was butterfly fish followed by parrotfish, humphead wrasse and sweetlips. Barramundi cod, snapper, grouper, bumphead parrotfish and morey eel were not observed. A similar trend was observed at location 2 where fish were slightly more abundant.

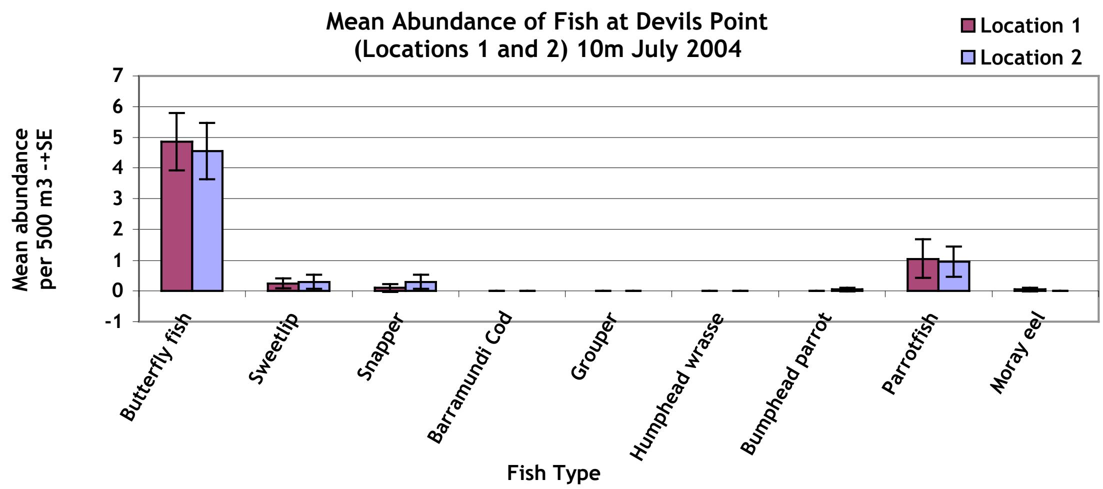


Figure 16: Average Reef Check fish per 20 m transect at Devil's Point. 10 m depth.

Location 1 10m: The most abundant fish type at location 1 was butterfly fish followed by parrotfish, sweetlips, snapper and morey eels. Barramundi cod, grouper and bumphead parrotfish were not observed. A similar trend was followed at location 2.

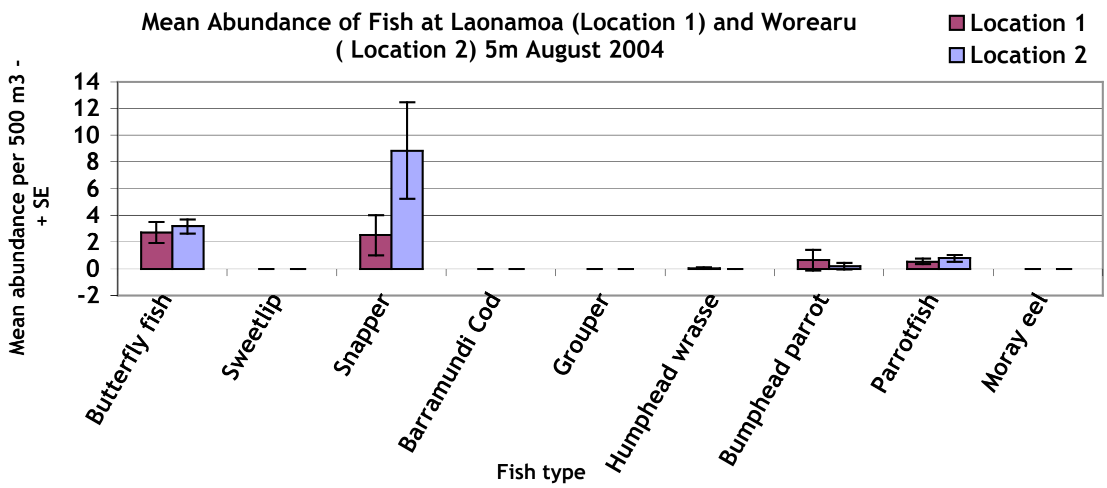


Figure 17: Average Reef Check fish per 20 m transect at Laonamoa and Worearu (Pele Island) 5 m depth.

Butterflyfish and snapper were the most abundant fish type at both location 1 and 2, with few bumphead and other parrotfish. Snapper were more abundant at location 2 than location 1. sweetlips, barramundi cod, grouper, humphead wrasse and morey eels were not observed.

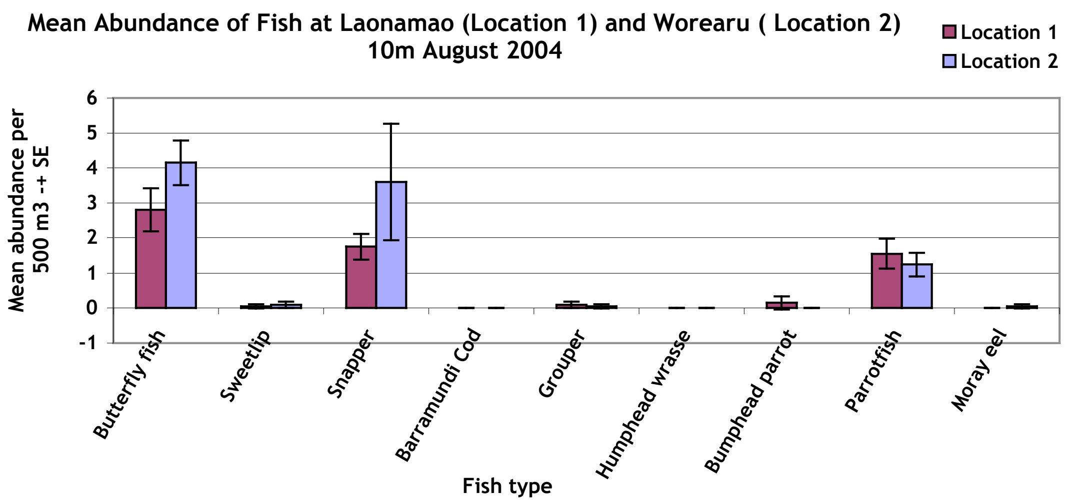


Figure 18: Average Reef Check fish per 20 m transect at Laonamao and Worearu (Pele Island) at 10 m depth.

Similar trends were seen at 10 m than at 5 m with parrotfish being more abundant as well as few sightings of grouper, sweetlips and morey eels. Butterflyfish and snapper were more abundant at 10 m than 5 m.

Key Macro-Invertebrates

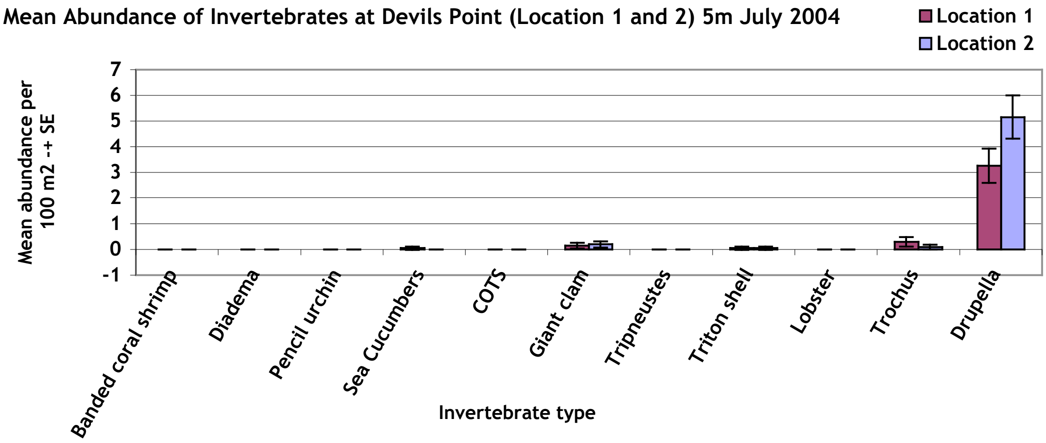


Figure 19: Average key macro-invertebrates per 20 m transect at Devil's Point (5 m depth).

The most abundant invertebrates at 5 m, location 1 were *Drupella* spp. followed by trochus, giant clam, sea cucumbers and triton shells, banded coral shrimp, *Diadema*, pencil urchin, crown-of-thorns starfish (COTS), *Tipneustes* and lobster were not observed at location one. A similar pattern was observed at location 2 but only *Drupella* spp., giant clams, triton shells and trochus were observed.

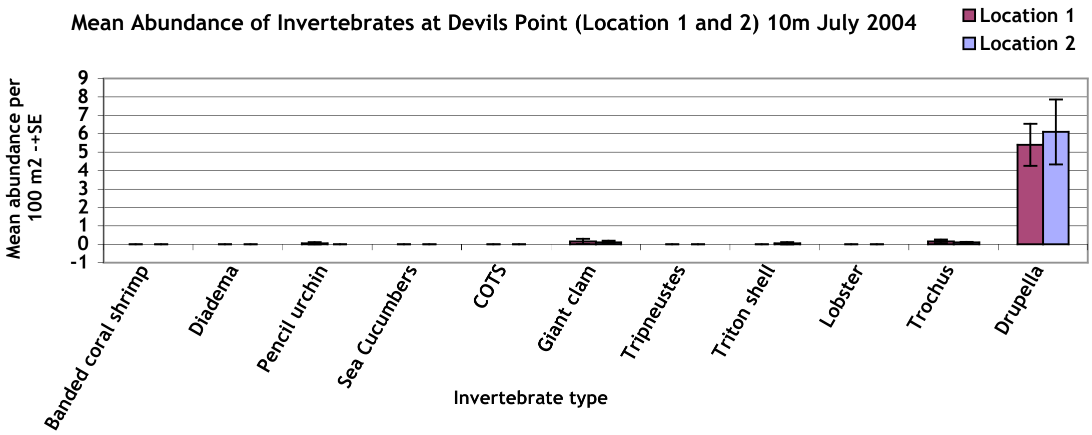


Figure 20: Average key macro-invertebrates per 20 m transect at Devil's Point (10 m depth).

The most abundant invertebrates at 10 m, location 1, were *Drupella* spp. followed by trochus, giant clams and pencil urchins. Banded coral shrimp, *Diadema*, COTS, *Tipneustes*, triton shells and lobster were not observed at location one. Only *Drupella* spp., trochus and giant clams were observed at location 2 with levels of abundance in that order.

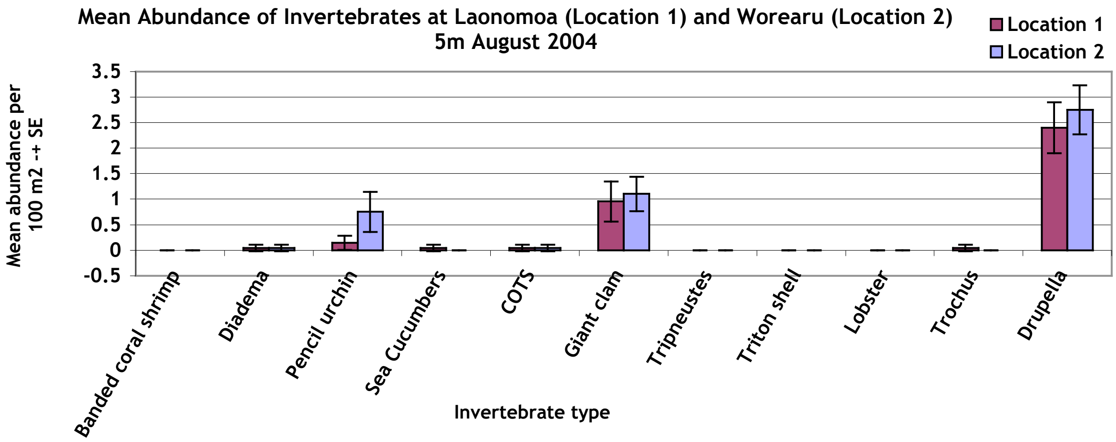


Figure 21: Average key macro-invertebrates per 20 m transect at Laonomoa and Worearu (Pele Island) (5 m depth).

The most abundant invertebrates at both Laonomoa and Worearu were *Drupella*, giant clams and pencil urchins in that order of abundance. *Diadema* and COTS were observed in low numbers at both locations with sea cucumbers and trochus only observed at Laonomoa.

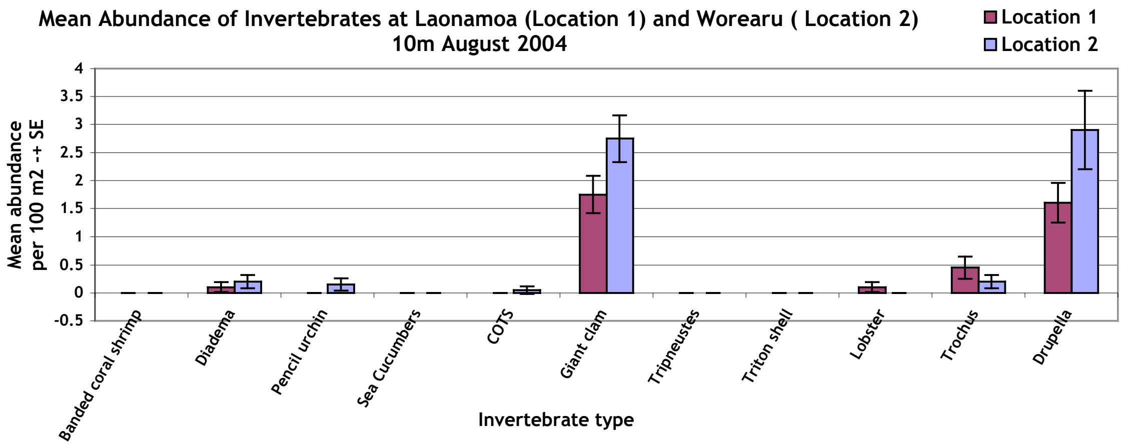
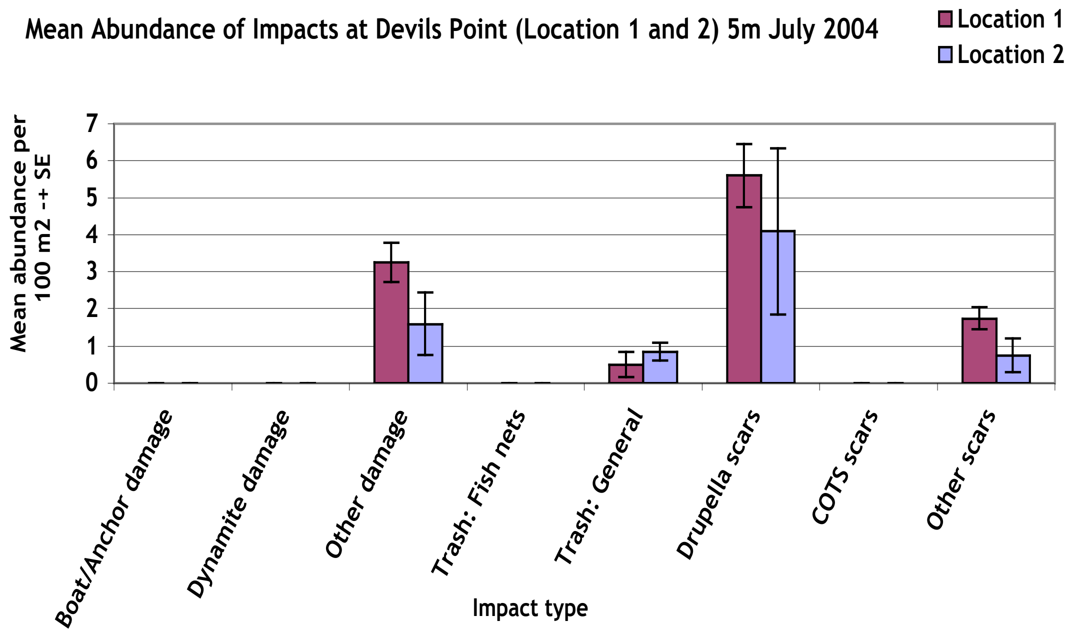


Figure 22: Average key macro-invertebrates per 20 m transect at Laonomoa and Worearu (Pele Island) (10 m depth).

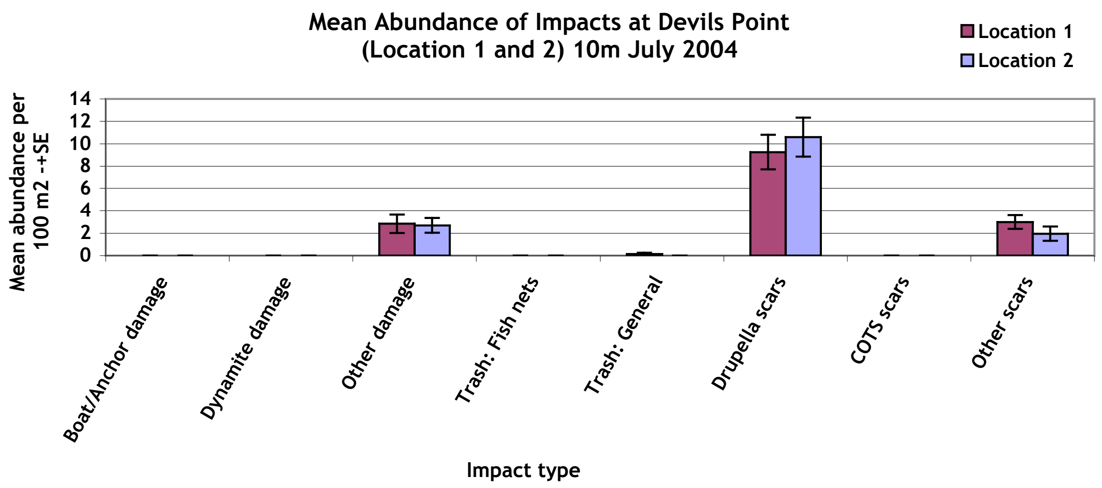
The most abundant invertebrates at both Laonomoa and Worrearu were *Drupella* spp. and giant clams with both these invertebrate types being more abundant at Worearu. Trochus and *Diadema* were also observed at both locations in small numbers. Lobster was observed at Laonamoa and pencil urchins and COTS were observed at Worearu.

Impacts

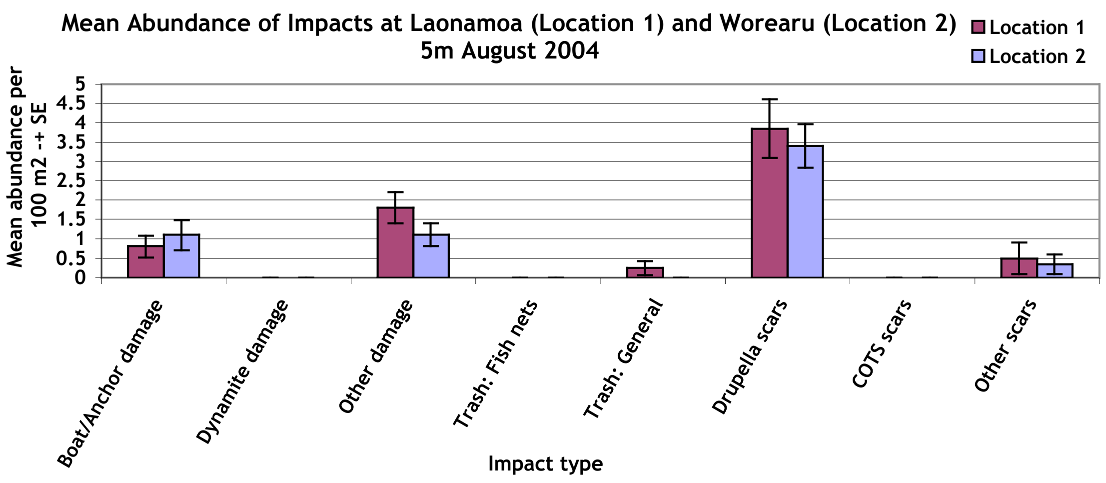
a


Mean Abundance of Impacts at Devils Point (Location 1 and 2) 5m July 2004
Location 1
Location 2
Mean abundance per 100 m2 -+ SE
Boat/Anchor damage
Dynamite damage
Other damage
Trash: Fish nets
Trash: General
Drupella scars
COTS scars
Other scars
Impact type

b


Mean Abundance of Impacts at Devils Point (Location 1 and 2) 10m July 2004
Location 1
Location 2
Mean abundance per 100 m2 -+SE
Boat/Anchor damage
Dynamite damage
Other damage
Trash: Fish nets
Trash: General
Drupella scars
COTS scars
Other scars
Impact type

c


Mean Abundance of Impacts at Laonamoa (Location 1) and Worearu (Location 2) 5m August 2004
Location 1
Location 2
Mean abundance per 100 m2 -+ SE
Boat/Anchor damage
Dynamite damage
Other damage
Trash: Fish nets
Trash: General
Drupella scars
COTS scars
Other scars
Impact type

d

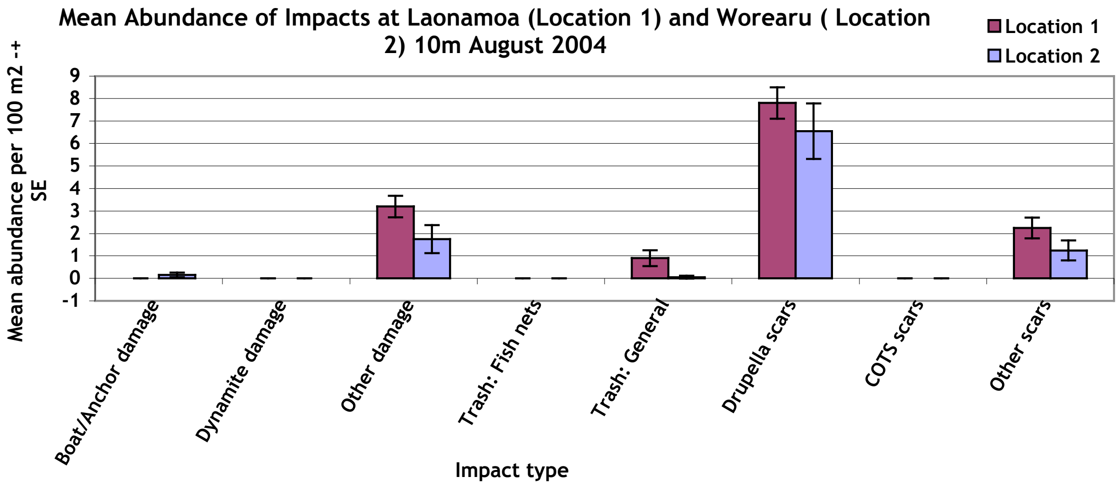


Figure 23 a-d: Average impacts per 20 m transect at Devil's Point and Laonamoa and Worearu (Pele Island) (5 m and 10 m depth).

At all locations and sites a similar pattern was observed with Drupella spp. scars being most abundant impacts with unidentified damage and scars, and some trash was also observed at the 5 m depths.

RESULTS - HAT ISLAND RAPID ASSESSMENT

Substrate

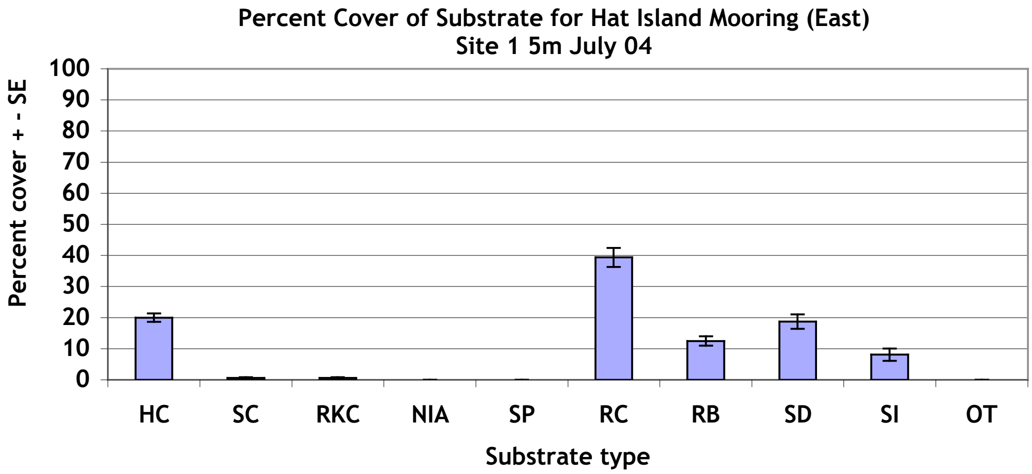


Figure 24: Substrate cover at Hat Island Mooring (East) (5 m).

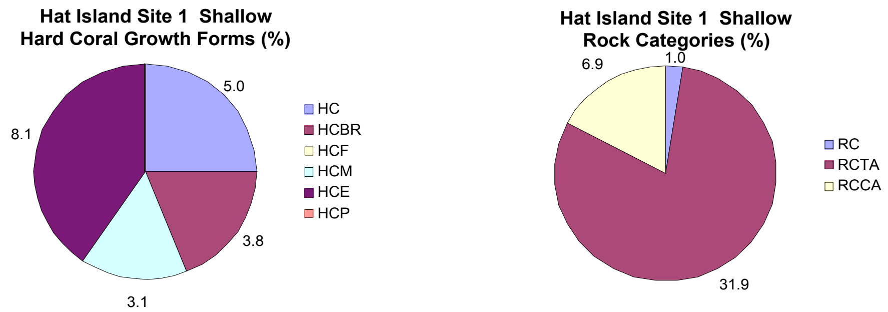


Figure 25: Hard coral lifeforms and rock categories at Hat Island Mooring (East) (5 m).

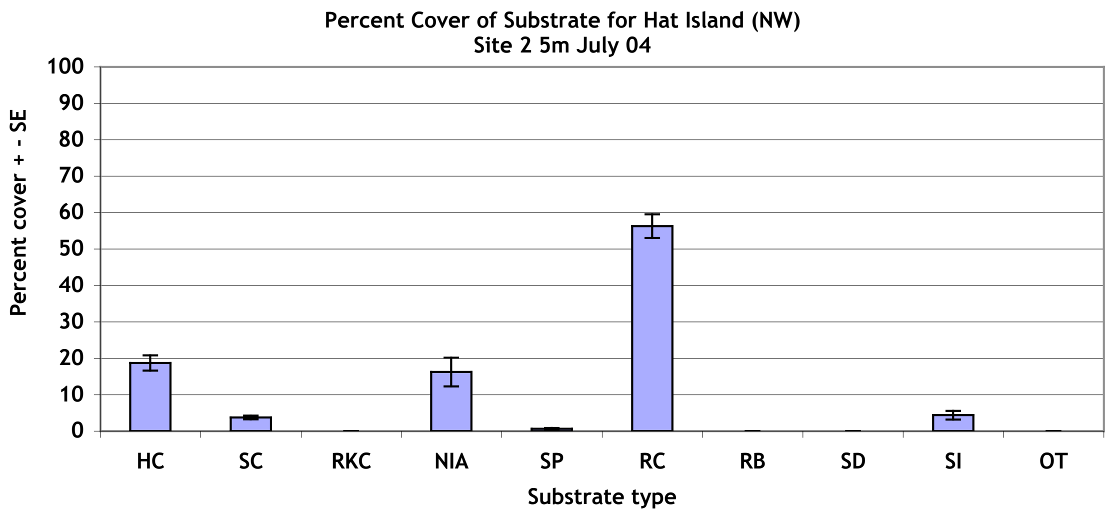


Figure 26: Substrate cover at NW Hat Island (5 m).

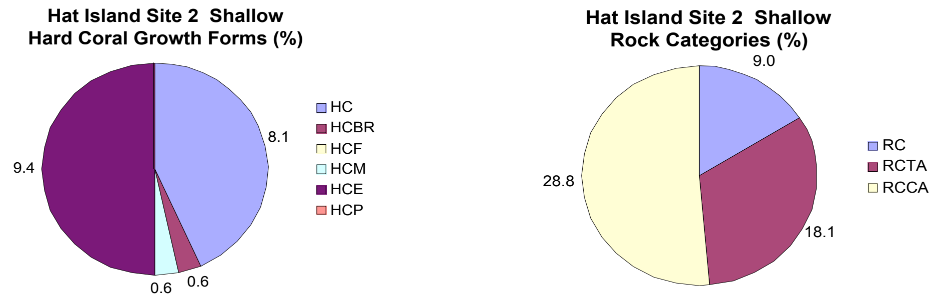


Figure 27: Hard coral lifeforms and rock categories NW Hat Island (5 m).

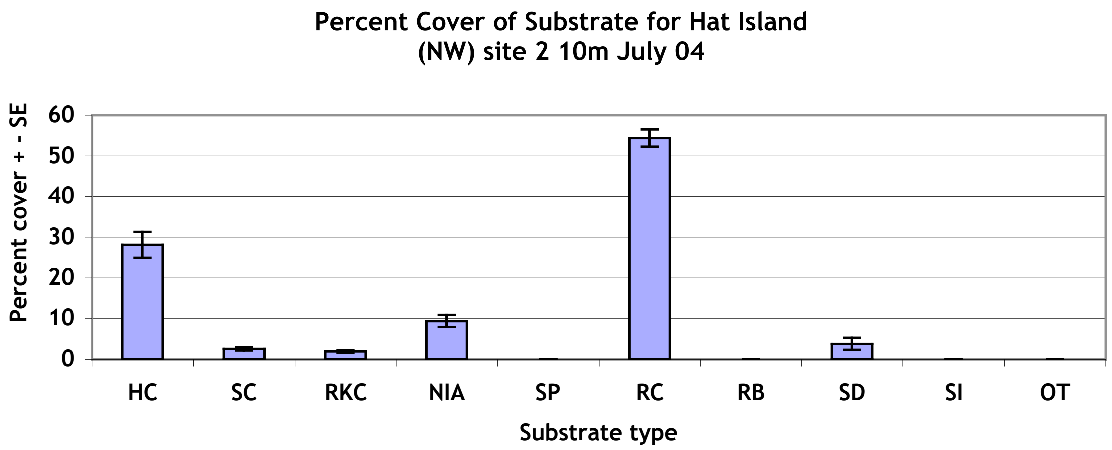


Figure 28: Substrate cover at NW Hat Island (10 m).

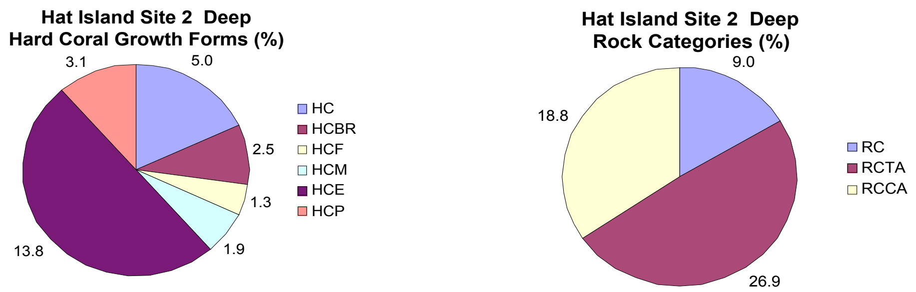


Figure 29: Hard coral lifeforms and rock categories NW Hat Island (10 m).

Hard coral cover was much lower and more robust lifeforms on Hat Island than at the control and impact sites.

Aquarium fish

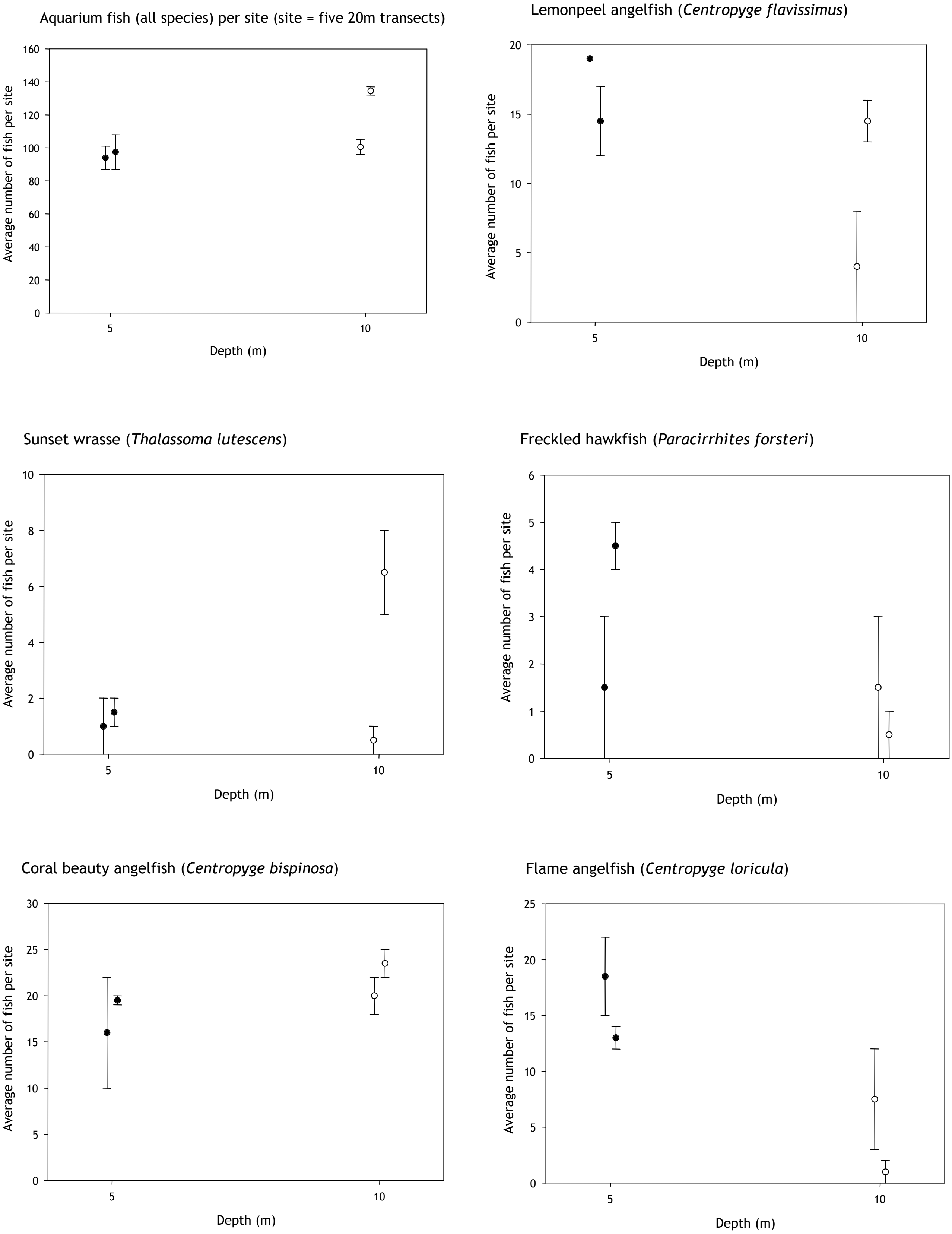


Figure 30: Mean abundance of aquarium fish at NW Hat Island per site at 5 and 10 m depth.

The total aquarium fish observed is high compared to numbers observed at Devil's Point or Pele Island. Similar numbers were observed at both depths, with abundance higher at location 2, 10 m. See Appendix 1 for a summary of all aquarium fish.

Reef Check fish

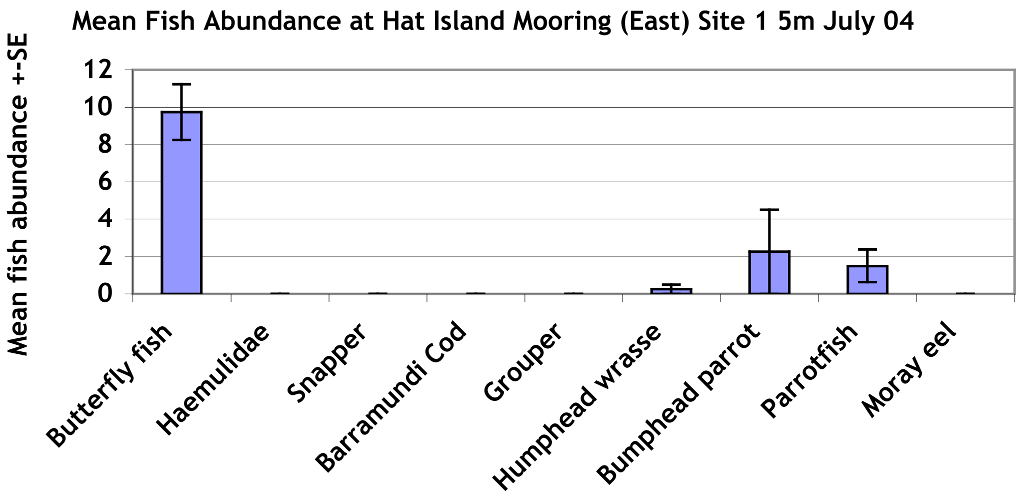


Figure 31: Average Reef Check fish per 20 m transect at Hat Island Mooring (East). 5 m depth.

Butterfly fish were the most abundant of the Reef Check target fish observed at the East Coast of Hat Island. Low numbers of bumphead parrotfish, other parrotfish and humphead wrasses were also observed.

Key Macro-Invertebrates

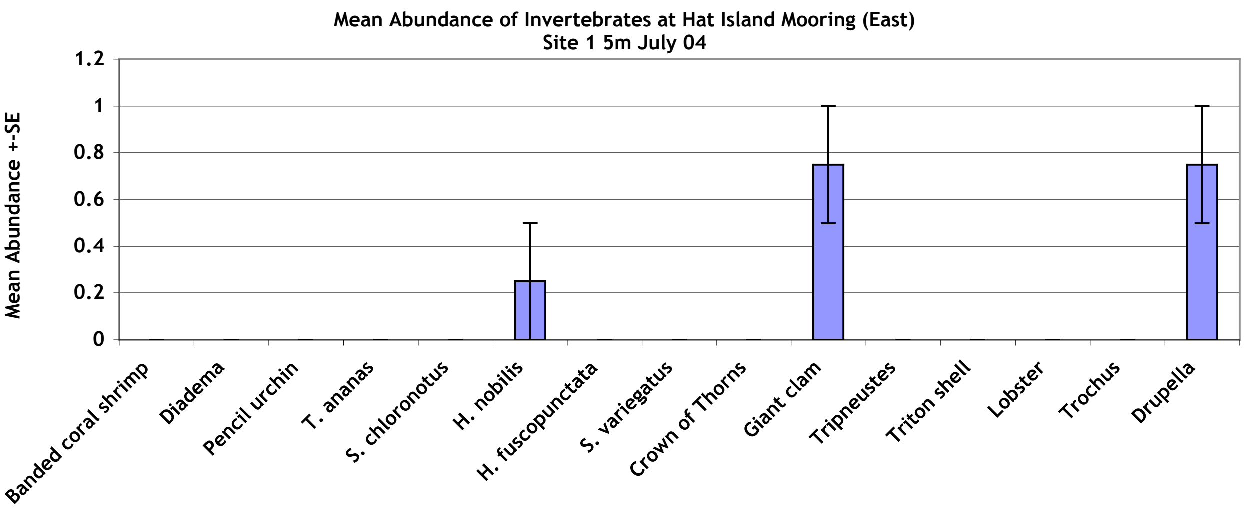


Figure 32: Average key macro-invertebrates per 20 m transect at Hat Island Mooring (East) (5 m depth).

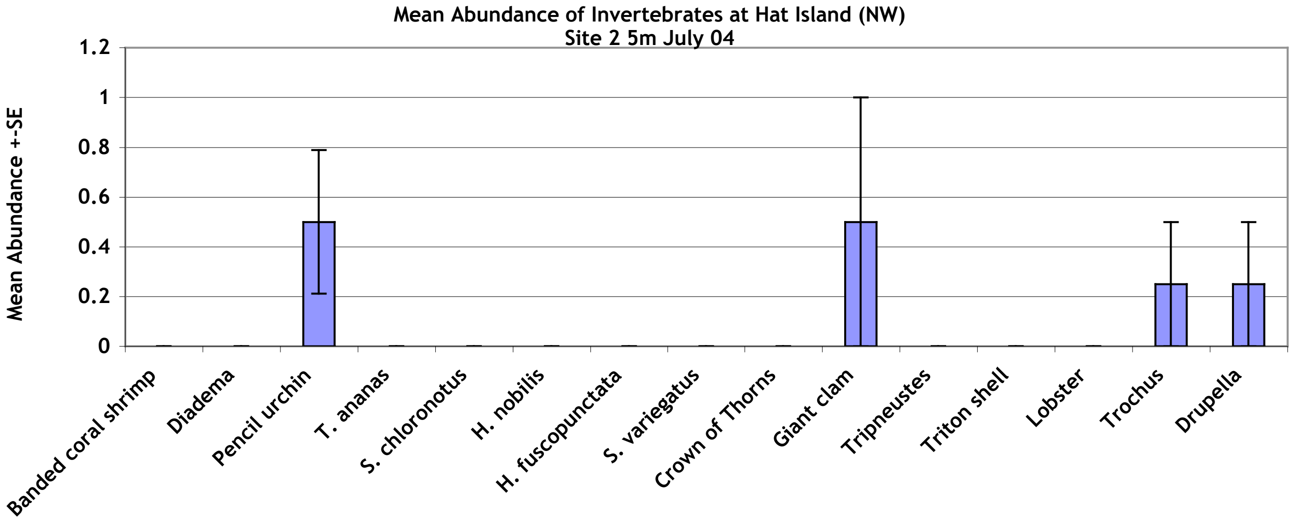


Figure 33: Average key macro-invertebrates per 20 m transect at NW Hat Island (5 m depth).

Impacts

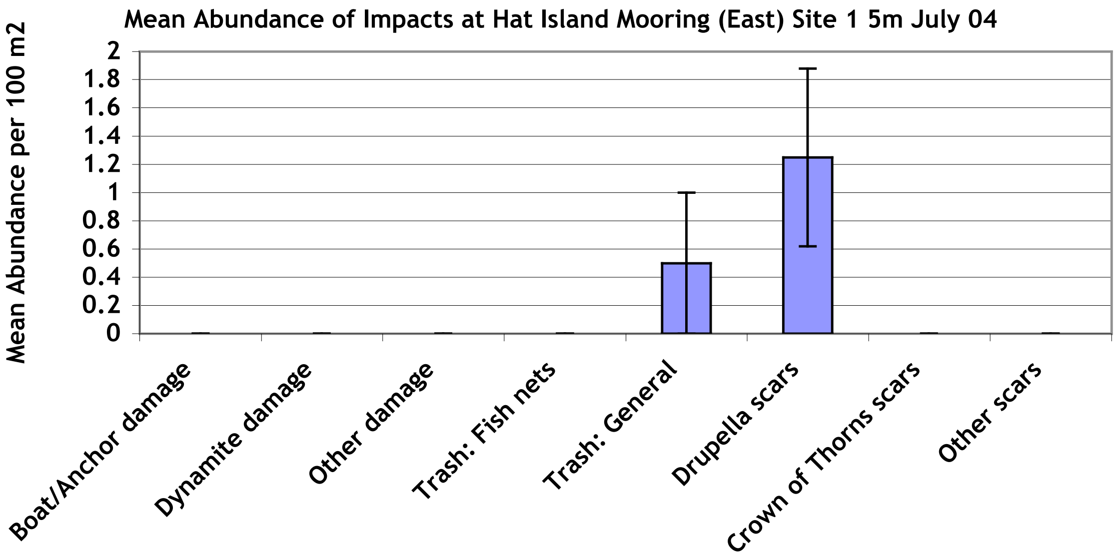


Figure 34: Average impacts per 20 m transect at Hat Island Mooring (East) (5 m depth).

The most common impact on the East side of Hat Island was *Drupella* spp. scars and trash. No other impacts were observed.

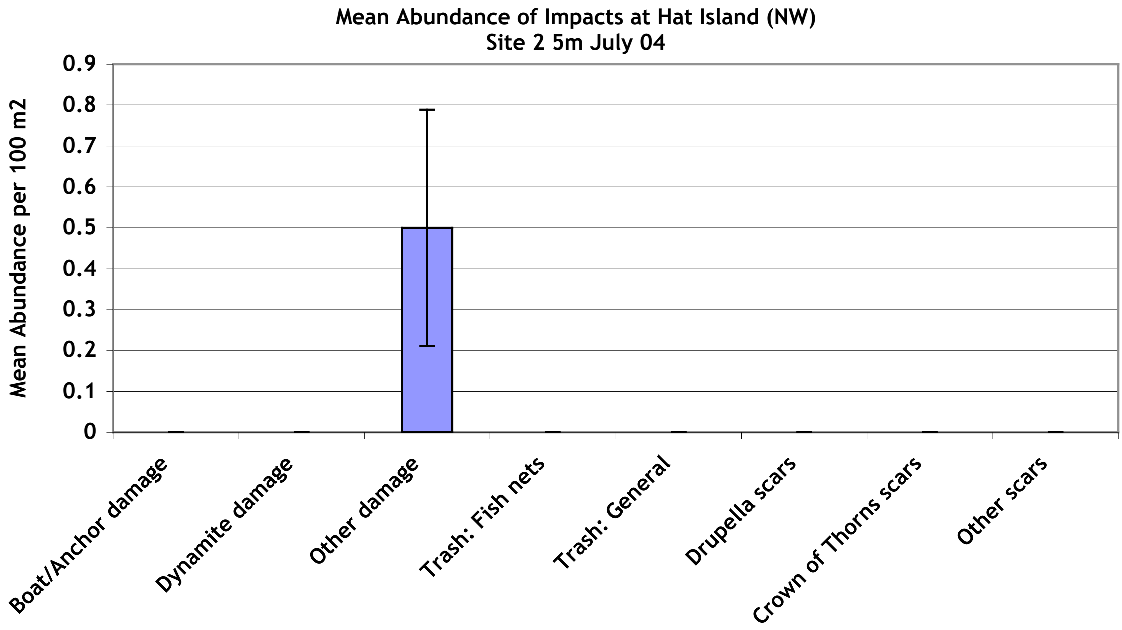


Figure 35: Average impacts per 20 m transect at NW Hat Island (5 m depth).

The only impacts observed at the NW side of Hat Island was unidentified damage to coral.

DISCUSSION

In this section we discuss the preliminary analysis of the results, the implications of overfishing and provide recommendations for the management of the fishery to include future monitoring activities.

It is important to interpret the data from this study with care because due to logistical constraints we were only able to survey a single collection and non-collection site within similar habitats. The main purpose of the expedition being to establish baseline sites for longer-term community monitoring. The logistical constraints of this study are discussed in Appendix 3. We recommend further sites be established as soon as possible in order to develop a robust impact monitoring system for the region. The site we established to date represent an excellent snapshot at the coral reef resources around Efaté and an excellent baseline from which to compare future survey results as well as with data collected in the previous study by Sykes (2004) and the SPC in May 2004.

Pilot baseline impact study

The coral reef habitats of both the locations within the impact (Devil's Point aquarium collection site) and control sites (Laonamoa and Worearu at Pele Island) were similar in the coral and substrate composition. With both Devil's Point and Pele Island displaying complex coral lifeforms (plate and branching hard coral), which is characteristic of habitat for small reef fish species. The coral appeared healthy with no damage observed illustrating that appropriate, environmentally-friendly, non-destructive fishing methods have been used by the aquarium collectors.

General impacts were low. Coral-eating crown-of-thorns starfish have been reported as increasing at various locations around Vanuatu (Sulu et al, 2002 and personal communication, Hideaway Island Dive Resort, 2004), but they were not abundant at the sites visited in this study, which suggest that COTS outbreaks are a localised issue. Low numbers of coral-eating *Drupella* spp. snails were observed at all sites with little impact on coral cover. The higher incidence of anchor damage around Pele Island than Devil's Point is likely from small boat use where local fishermen frequent the reef.

Aquarium fish

Reef Check surveys were conducted between 5 and 12 m depth, which limited the suit of species surveyed to those that occur within this depth range. Therefore we cannot make conclusions about those species that are more common at depth, such as the flasher and fairy wrasse (*Cirrhilabrus* spp and *Parachelinus* sp.). Higher coral cover was observed at the impact site, indicating more available habitat for small reef fish. However, significant differences between the abundance of small reef fish at the impact and control sites were observed for the lime or sunset wrasse (*Thalassoma lutescens)*, freckled hawkfish (*Paracirrhites forsteri)*, coral beauty angelfish (*Centropyge bispinosus)* and lemonpeel angelfish (*C. flavissimus)*, with nearly double the number of fish observed within the control site at both depths surveyed. It is unclear whether these differences reflect habitat differences or fishing pressure. A major limitation to drawing conclusions regarding the cause of the differences seen was that only a single collection and non-collection area could be surveyed. We recommend correlating the data provided from this expedition with catch statistics to allow a more detailed analysis of our data to interpret the patterns of abundance we observed at our study sites. In addition, these data should be analysed with other data sets collected during 2004 to obtain a wider picture of the status of the resources.

C. loricula, along with the species for which the abundance differences were observed, were all observed at Sustainable Reef Supplies (SRS) aquarium facility in high numbers and at varying stages of life histories with the majority being juveniles. The question is whether the lower abundance of this group of species at the depths surveyed at Devil's Point rather than at Pele Island is due to habitat differences of impacts from fishing pressure.

With regards to the selectivity of the harvesting, where juveniles are consistently preferentially harvested at a high rate, adult populations may decline as only a limited number of young grow to a reproductive age (Wood 2001; Wabnitz et al. 2003). We recommend this factor be taken into account when determining sustainable levels of harvesting for this industry.

The flame angelfish *(Centropyge loricula)* is highly sought after in the aquarium trade in Vanuatu and represents the highest percentage of collected species and percentage of sales (personal communication, Vanuatu aquarium tradesman, 2004). There were few *C. loricula* at both impact and control sites. The habitat of Devil's Point and Pele Island may not have been ideal for these two species, hence their absence. Again, the analysis of these data with catch statistics would help determine if this trend was due to natural habitat differences or a cause for concern. Nevertheless, *C. loricula* and the popular blue tang (*Paracanthurus hepatus)* are known to have patchy distributions around Efaté as they are limited to specific habitats, and may be at more risk of over-harvesting than other species (Roberts and Hawkins 1999; Wabnitz et al. 2003).

A major concern with over-harvesting of ornamental fish, and the significance of this baseline survey, is that populations may be unable or take decades to recover to their former (or a healthy level) of abundance rendering them unusable to other user groups resulting in a net loss to the local economy and jobs. In addition to losing the target fish populations, changes in species abundance can lead to ecological changes in reef communities which can result in an overall less-productive system (Sadovy and Vincent 2002; Jackson et al 2001). Therefore, the steps taken by the Vanuatu Department of Fisheries and the community stakeholders to develop marine resource monitoring and management plans for this region demonstrate the commitment towards sustainable management of this industry. The development and maintenance of these plans therefore merit significant support from funding agencies to ensure these efforts are successful in meeting their objectives.

Food and Curio

The major food fish families and species observed appeared low in abundance at both Devil's Point as well as Pele Island. Artisanal fishing is known to occur at both these sites and may have impacted on these populations. Economically important invertebrate populations were also low at both locations, however, the higher abundance of giant clams, trochus and pencil urchins at Pele Island may suggest lower fishing pressure for food and curio. This may be linked to the lack of commercial fishing at Pele Island.

The establishment of marine protected areas (MPAs) as fishery management tools would benefit both the aquarium fishery as well as other commercial and subsistence fisheries. Community-run MPAs are an ideal tool for cost-effective management of fisheries. The protection of areas of reef around collection sites can act as an insurance against over-harvesting by providing a refuge for breeding populations (Rogers 2001, Russ 1996, 2002, Mclanahan 2001). Reef fish populations have recovered very quickly in marine protected areas (MPAs) established on heavily impacted reefs in the Philippines (Sadovy and Vincent 2002; Wilkinson et al. 2003). To be effective, these MPAs would need to include a diversity of habitats to ensure inclusion of all target species. The designation of no-take areas to help conserve stocks of ornamental species can also be used as control sites for industry monitoring as a means to determine the status of reef populations and to identify potential effects of over-harvesting (Wood 2001).

To ensure support and compliance, stakeholders need to be involved in the designation and governance of marine protected areas. Involvement of community stakeholders in monitoring the status of coral health, fish and invertebrate populations both inside and outside MPAs can be a powerful tool to both convince these stakeholders of the benefits when they can see them themselves and to empower these communities to manage their own resources. The success of the community-run Nguna-Pele MPA indicates the potential of this tool for fishery management in Vanuatu and has been showcased as an example of a successful community MPA by the Global Coral Reef Monitoring Network (see Wilkinson 2004). This is a significant achievement for the resource stakeholders in Vanuatu and demonstrate the potential for success of this tool in the region making the support of such projects in Vanuatu a sound investment for donor agencies. We recommend the recipe for the success of this MPA be celebrated and communicated to other villages through collaborative village workshops or other appropriate means. This approach has proven successful in the Philippines (See 'The role of monitoring in the effective management of Apo Island Marine Reserve, Philippines in: Wilkinson et al 2003)

Rapid Assessment - Hat Island

The information collected at Hat Island provides a baseline with which future surveys can be compared. Therefore, results are only briefly discussed here.

The reef habitat at both locations on Hat Island was different to that at Devil's Point and Pele Island so the data were not directly comparable and fish and invertebrate populations were expected to be different. Hard coral cover was much lower and more robust lifeforms were present than at the other sites visited. It might be expected that fewer reef fish would be present than where coral cover is higher and more complex in structure, as found at Pele Island and Devil's Point. Cyclone damage of the coral did not appear extensive with some rubble observed at the East Coast Mooring.

The abundance of aquarium fish was similar at both depths, and much higher than at Devil's Point and Pele Island. The flame angelfish (*C. loricula*) were more common at Hat Island than either Pele Island or Devil's Point. This difference in abundance may be affected by habitat type in a manner that is not directly obvious from the data collected from this survey.

Higher abundances of these food fish species on Hat Island than at Devil's Point or Pele Island may be an indication of lower artisanal fishing pressure. Few macro-invertebrates were observed but many pencil urchins were seen on the reef flat rather than on the surveys.

The only impacts were unidentified coral damage that may have been caused by small boat anchors, and cyclone damage.

We recommend comparing the data sets from the Sykes (2004) study with those of this survey to ascertain any patterns in abundance of the target species.

Tourism conflicts

Conflict between the aquarium trade and dive tourism industries is a common problem because the aquarium collectors remove colourful reef fish that tourists pay tourist operators to see (Wabnitz et al. 2003). However, both industries stand to benefit the economy with an enormous expansion and economic potential in reef tourism in recent years (Wood 2001). The South Pacific Tourism Organisation has recently published that Vanuatu is one of the major dive destination in the South Pacific. This industry, however, represents only 1.7% of the global market, therefore there is huge potential for industry development. The report highlights that divers generally have a high level of expenditure compared to other markets and are attracted to the pristine marine environment (SPTO 2004). The challenge for managers, therefore, is to maintain these industries side by side.

Spatial zonation of tourism and fisheries through use of MPAs may allow their existence together in Efaté. The establishment of marine protected area with tourist access fees at tourist sites may provide a mechanism for local community economic gain from reef use regardless of whether it is aquarium fishing or tourism.

CONCLUSIONS AND RECOMMENDATIONS

The aquarium trade offers obvious benefits to the local economy of Vanuatu. Due to spatial variations in the abundance of reef fish and invertebrate populations, stocks need to be monitored on a reef-by-reef basis (Wood 2001). The data collected in this study will serve as a baseline for these sites but additional sites and analyses of monitoring data along with fish catch data need be done to further understand the patterns of abundance of target fish and invertebrates. See the next section for more detailed recommendations for continued monitoring.

It is important to take a precautionary approach to the management of this industry, in terms of setting cautious fish catch limits, to ensure benefits from marine resources can be sustained into the long-term (see IUCN 2003). The Marine Aquarium Council provide management guidelines and industry benefits for members. We recommend these guidelines be utilised to assist in the development of sustainable industry standards for the aquarium trade and resource monitoring should form a component of industry management. See Appendix 4.

Recommendations for monitoring

In order to determine the effects of the aquarium (or any other fishing) collection, we recommend the following:

1. Baseline surveys of new collection sites
We recommend that all new collection sites be surveyed prior to the start of any collection activities. In order to obtain an estimate of natural variation in fish populations, we recommend up to 3 fish surveys be conducted as a baseline. Due to the cultural and economic importance of Hat Island, we recommend regular monitoring of key sites around the island to ensure reef characteristics are maintained at the current status, which has inspired its submission for World Heritage listing.

2. Long-term monitoring of collection and non-collection sites
We recommend that all collection sites be monitored seasonally (if possible) to determine the effects of harvesting on target fish and invertebrate populations and coral health. Non-collection sites of comparable habitats and preferably in close proximity to collection sites should also be monitored to determine if any changes in reef populations noted at collection sites are mirrored at non-collection sites. See Tissot and Hallacher (2003). For ideas on how often to do the monitoring and equipment required see Hill and Wilkinson (2004).

3. Setting up the monitoring sites
A number of collection sites have been identified by Sykes (2004) in addition to those presented in this report. Additional non-collection sites need be established also. Currently, no sites are marked with permanent markers. We recommend that this be done in order to make it easy for data collectors to find sites without the need for a marine scientist to go through the site selection process at each survey interval. Sites can be marked with metal stakes with start and end points marked with a sub-surface marker buoy. Sub-surface buoys can be identified by snorkelling over the known GPS point, but are more stable in areas subject to cyclone damage and less likely to be removed by fishermen. See Hill and Wilkinson (2004) for more information on how to mark permanent transects.

We recommend seeking further AusAID or Packard Foundation support to establish monitoring sites.

4. Who should do the monitoring?

Lack of resources for monitoring is a major limiting factor for the Vanuatu Department of Fisheries. It is encouraging that there is enormous enthusiasm within the Efaté Scuba Association to collaborate with the Vanuatu Department of Fisheries in coral reef monitoring. This enthusiasm should be sustained to monitor areas around tourist sites and to support community-managed areas as has already happened with Nguna-Pele. However, the incentives for involvement of these stakeholders need to be identified and managed to ensure the support and enthusiasm of these groups is maintained. It might not be appropriate to request tourist operators to monitor collection sites, where conflict arises between these two industries and benefits of use from these sites are received by the aquarium industry and not the tourism industry. A requirement for the aquarium industry to monitor resources as a condition of their permit is a cost-effective solution. Should outside assistance be required for data collection activities, volunteers from Reef Check Australia could be contracted to assist, which provides another role for AusAID or Packard Foundation support.

We recommend third party scientists should be involved in monitoring activities where possible to ensure data are accurate.

5. Where should the data go?

We recommend the Vanuatu Department of Fisheries coordinate the collection, analysis and reporting of monitoring data. From the field, data will need to be collected and sent to a central coordinator and the results fed back into the community in order that participants can see the effectiveness of their own management actions. On a larger scale in Vanuatu, the resource monitors from the Non-Government Organisation, Won Small Bag, may provide the ideal framework around Vanuatu through which to liaise with those in charge of community MPAs and the collection of monitoring data and distribution of monitoring results (Personal Communication, Mike Lameier, 2004).

6. Training

Non-professional monitors will require regular re-training and overview workshops to ensure that standards are maintained and the data are precise. These workshops will also function to maintain motivation and recruit more data collectors. We recommend that annual workshops be held for all monitors, with external assistance from Reef Check where required. We recommend seeking AusAID or Packard Foundation funding to ensure an annual visit from a Reef Check Trainer to provide assistance to Vanuatu trainers and workshop organisers. Peace Corps volunteers would be ideal to continue with this project.

7. Socioeconomic monitoring

We recommend socio-economic monitoring of coral reef stakeholders be conducted at least in the development of management plans. See Bunce et al (2000) and Bunce and Pomeroy (2003).

FUTURE ASSISTANCE

The collaboration of Reef Check Australia volunteers and the community stakeholders in Vanuatu worked well on this expedition. The communities benefited from multiple training workshops, and from the provision of training and monitoring materials. While organizations, such as, SPC are better suited to assist with detailed resource assessments and the development and implementation of management plans, Reef Check Australia may continue to assist with the following:

- Running training workshops for community Reef Check and MAQTRAC teams;
- Establishment of permanent monitoring sites for community teams;
- Man power to assist with data collection activities;
- Our contacts at James Cook University in Australia may also be a valuable resource for future research in Vanuatu.

APPENDIX 1

Coral and substrate codes

Basic Reef Check Substrate Codes	**Reason**	**Reef Check Australia *Plus* Codes**	**Reason**
HC - hard coral (includes blue coral, fire coral and organ pipe coral)	The major building component of the reef.	HC - all other hard coral lifeforms	Coral lifeforms provide information on the structure of the reef
		HCB – bleached hard coral	
		HCBR – branching hard coral	
		HCF – foliose hard coral	
		HCM – massive hard coral	
		HCE – encrusting hard coral	
		HCP - plate hard coral	
SC - soft coral	Non-reef builder	SC – ornamental soft coral	Provides more information on what soft coral families are present
		SCL – leathery soft coral	
		SCZ - zoanthids	
SP - Sponge	Indicator of sewage pollution if abundant	SP – non-encrusting sponges	SPE is normally the type to blame for proliferation and competition with HC
		SPE – encrusting sponge	
OT – other		OT - other	
NIA – nutrient indicator algae	Nutrient pollution	NIA - nutrient indicator algae	Nutrient pollution
RC - rock	Bare surface on which young coral can settle	RC – rock	Additional information on the reef makeup
		RCTA – turf algae	
		RCCA – coralline algae	
RKC – recently killed coral	Indicator of recent disturbance	RKC - recently killed coral	Indication of recent disturbance
		RKCNIA - recently killed coral covered with nutrient indicator algae	Indication of recent disturbance and quick colonisation by algae – potentially influenced by high nutrients or a lack of herbivores
		RKCTA – recently killed coral covered with turf algae	Indication of recent disturbance and quick colonisation by turf algae
SI – silt	Indication of sedimentation	SI - silt	
SD – sand		SD – sand	
RB - rubble	Indication of dynamite damage or storm damage.	RB - rubble	

Invertebrate and fish list

Table 1: Indicator invertebrate and fish organisms

Indicators	**Overfishing**	**Dynamite Fishing**	**Cyanide Fishing**	**Curio Collection**	**Aquarium Fish Collecting**	**Pollution e.g. fertilizer or sewage**	**Coral damage**
Invertebrates							
Banded coral shrimp (Stenopus hispidus)					X		
Crown of Thorns starfish (Acanthaster planci)						X?*	X
Lobster	X						
Long-spined black sea urchins (Diadema spp.)							
Giant clams (Tridacna spp.)	X			X			
Pencil urchin				X			
Sea cucumber (Thelenota ananas, Stichopus chloronotus)	X						
Triton (Charonia spp.)	X			X			
Drupella spp. snails							X
Tripneustes urchins	X					X	
Trochus	X			X			
Fish							
Butterfly fish (Chaetodon spp.)	X		X		X		
**Grouper (>30 cm) (Serranidae)	X	X	X				
Barramundi cod (Cromileptes altivelis)	X	X	X		X		
Snapper (Lutjanidae)	X	X					
**Humphead wrasse (Cheilinus undulates)	X	X	X		X		
Parrotfish (>20cm) (Scaridae)	X	X	X		X		
Bumphead parrot (Bolbometopon muricatum)	X	X	X		X		
Sweetlips (Haemulidae)	X	X	X		X		
Moray eel (Muraenidae)	X				X		

*There may be a link between crown-of-thorns starfish outbreaks and nutrient pollution (CRC Reef, 2004)
**Note that all grouper > 30 cm and sized to the nearest 10 cm are counted. Maori wrasse and bumphead parrotfish that are off the transect area recorded because the transect length is insufficient to capture true populations of these large fish which have a large range.

Impact list

Impact
Coral damage: boat/anchor
Coral damage: dynamite
Coral damage: other
Trash: fish nets
Trash: general
Bleaching (% of coral population)
Bleaching (% of colony)
Disease (% presence of disease of coral population)
Drupella spp. scars
Crown-of-thorns starfish
Other scars

Aquarium fish list

This list is a modification of that used by MAQTRAC in 2003. Species found below 12 m were removed from the list due to the depth limit of data collection. Species in blue were those most abundant at the aquarium facility.

Common Name	Scientific Name	Reason
Angel, lemonpeel	*Centropyge flavissima*	High collection rate
Angel, bicolour	*C. bicolor*	High collection rate
Angel, coral beauty	*C. bispinosa*	High collection rate
Angel, flame	*C. loricula*	High collection rate
Angel, Herald's	*C. heraldii*	High collection rate
Angel, smoky	*C. flavissima hybrid?*	Unusual, locally common hybrid or new species
Anthias, purple queen	*Pseudanthias tuka*	High collection rate
Anthias, tiger tuka	*P. lori*	Encountered irregularly
Basslet, dottyback male	*Cypho purpurascens*	High collection rate
Basslet, dottyback female	"	High collection rate
Butterfly, dot-and-dash	*Chaetodon pelewensis*	High collection rate
Butterfly, longnose	*Forcipeger flavissimus*	High collection rate
Butterfly, Merten's	*Chaetodon mertensii*	High collection rate
Cardinal, blueye	*Apogon compressus*	High collection rate
Clown, bluestripe/orangefin	*Amphiprion chrysopterus*	Restricted habitat
Clown, Clark's	*A. clarkii*	Restricted habitat
Clown, pink skunk	*A. perideraion*	Restricted habitat
Clown, Tomato	*A. melanopus*	Restricted habitat
Damsel, humbug	*Dascyllus aruanus*	High collection rate
Damsel, threespot	*D. trimaculatus*	Restricted habitat
Damsel, neon/electric	*Pomacentrus coelestis*	High collection rate
Damsel, fusilier	*Lepidozygus tapeinosoma*	High collection rate
Damsel, green chromis	*Chromis viridis*	High collection rate
Damsel, Stark's	*Chrysiptera starckii*	High collection rate
Filefish, Flame	*Pervagor melanocephalus*	High collection rate
Dartfish, bar/zebra	*Ptereleotris zebra*	High collection rate

Goby, sleeper/bar	*Valencienna strigata*	High collection rate
Hawk, flame	*Neocirrhites armatus*	Restricted habitat
Hawk, freckled	*Paracirrhites forsteri*	Restricted habitat
Hogfish, coral/axilspot	*Bodianus axillaris*	High collection rate
Lion, volitans/red	*Pterois volitans*	High collection rate
Moorish idol	*Zanclus cornutus*	High collection rate
Puffer, blue-dot	*Canthigaster soalndri*	High collection rate
Puffer, valentini	*C. valentini*	High collection rate
Tang, blue	*Paracanthurus hepatus*	High collection rate
Tang, mimic	*Acanthurus pyroferus*	High collection rate
Tang, Sailfin	*Zebrasoma veliferum*	High collection rate
Tang, Tomini	*Ctenochaetus tominiensis*	High collection rate
Trigger, Picasso	*Rhinecanthus aculeatus*	High collection rate
Wrasse, bicolor cleaner	*Labroides bicolor*	High collection rate
Wrasse, canary	*Halichoeres chrysus*	High collection rate
Wrasse, flasher	*Parachelinus sp.*	High collection rate
Wrasse, lime/sunset	*Thalassoma lutescens*	High collection rate
Wrasse, red coris	*Coris gaimard*	High collection rate

Site information

Site name:________________________________

BASIC INFORMATION

Country:______________________		State/Province:____________	City/town:__________________	
Date: ________________	Time:	Start of survey: ____________	End of survey: ________________	
Latitude (deg. min. sec):	___________________________	Longitude (deg. min. sec) :	___________________________	
Distance	from shore: ________m	from nearest river: _____km		
River mouth width:	________ <10m	_______ 11-50m	______ 51-100m	____101-500m
Dist. to nearest population center:	_________ km	Population size: ____x1000		
Weather:	_____ sunny	_______ cloudy	_______raining	
Visibility:	_________m			
Why is this site selected:	________________________	Is this best site in the area?	_____Yes _____No	

IMPACTS:

Is this site:	Always sheltered:________	Sometimes sheltered: ______	Exposed:__________	
Major coral damaging storms	Yes:_______	No:_______	When was last storm: _________	
Overall Anthropogenic impact	None: _____	Low: _______	Med: _______	High: ____
Is siltation a problem	Never	Occasionally: _______	Often: ______	Always: ____
Dynamite fishing	None: _____	Low: _______	Med: _______	Heavy: ____
Poison Fishing	None: _____	Low: _______	Med: _______	High: ____
Aquarium Fishing	None: _____	Low: _______	Med: _______	High: ____
Harvest Inverts for Food	None: _____	Low: _______	Med: _______	High: ____
Harvest Inverts for curio sales	None: _____	Low: _______	Med: _______	High: ____
Tourist Diving/snorkeling:	None: _____	Low: _______	Med: _______	High: ____
Sewage Pollution	None: _____	Low: _______	Med: _______	High: ____
Industrial pollution	None: _____	Low: _______	Med: _______	High: ____
Commercial fishing	None: _____	Low: _______	Med: _______	High: ____
Fish for the live food fish restaurant trade	None: _____	Low: _______	Med: ____	High: ____
Artisinal/recreational	None: _____	Low: _______	Med: ____	High: ____
How many yachts are typically present within 1km of this site :	None: _____	Few (1-2): ____	Med (3-5): ____	Many (>5): ____

Other impacts: ____

PROTECTION:

Any Protection (legal or other) at this site?	Yes:______	No: _________	if yes, answer questions below
Is protection enforced	Yes (full enforcement):______	No:_________	

APPENDIX 2

Site descriptions

	Devil's Point	**Pele Island: Laonamoa and Worearu**	***Hat Island. Location 1 (E. Coast mooring)***	***Hat Island Location 2 (NW coast of S)***
Latitude Longitude	17° 43' 03" South 168° 12' 45" East	*17° 20' 09.4" South* *168° 24' 38.4" East*	*17° 38' 21.6" South* *168° 09' 29.2" East*	*17° 38' 28.5" South* *168° 08' 46.6" East*
Exposed	Yes	Yes	Yes	Yes
Proximity to human populations	Close to Port Vila and small communities.	200 m from small coastal communities - some wholly, some partially dependant upon resources.		
Land-based pollution	Potential for some sewage pollution from Port Vila, but the bay is well-flushed.	No		
Cyclone impacts	Caused some siltation during 2002.	Low impact in 2002 and 2004	Impact in 2002 and low in 2004	
Protection	No	Community MPAs in the area. These sites are fished by local communities only.	No. But a submission has been placed for World Heritage listing due to its cultural significance and outstanding marine resources. It is rated as an important place for tourism.	
Tourism	Low from Hideaway Island	Low	High	Low but in close proximity to dive and snorkel sites.
Blast fishing	Past	No		
Cyanide fishing	Past	No		
Commercial fishing	Low	No	Low - foreign trawlers have been sighted	
Aquarium fishing	Yes. Since 2003 to present. *C. locicula*	No	Yes. Occasionally according to dive tourism operators.	Yes. Towards the Southern end of the island. *C. loricula* is an

	and *C. bispinosa* are the main species collected.			important target species.
Artisanal fishing	High	Medium	Low	
Coral reef habitat	Spur and groove fringing reef.	Spur and groove fringing reef.	Back reef, gentle sandy slope, interspersed with coral bommies. To either side of the gentle slopes are fringing reef flats and steep slopes that drop down to 20 m depth into a sandy slope.	Steep oceanic fringing reef wall that drops down to 40 m depth with moderate, robust coral cover
Why was the site selected?	Impact site.	Nguna-Pele was the control sites and the only known area where aquarium collection had not taken place that we could access with small outboards. Nguna-Pele was the nearest control area of similar habitat to Devil's Point because of the reach of the aquarium collectors up the West coast of Efaté.		These sites were selected for a rapid assessment due to the importance of Hat Island to both the aquarium fish trade and dive tourism operators.

APPENDIX 3

Logistical constraints

There were a number of logistical constraints that limited the extent and location of surveys conducted on this expedition.

While other expedition goals were met in training, provision of equipment and awareness-raising, fewer strategically-selected sites were surveyed than had originally been planned. The initial plan was to conduct a baseline assessment of a number of sites that include both collection and non-collection sites around the Southwest of Efaté to include Hat, Lelepa and Moso Islands and sites around Nguna-Pele and for greater inclusion of the tourist operators in the data collection activities. This greater inclusion would have increased the capacity of the team to survey more sites as well as leave an increased capacity for community monitoring behind in Vanuatu.

The dive operators that were to be involved included Sailaway Cruises, Tranquility and Silent World. Involvement of these operators was to enable access to many sites around Efaté with the team living aboard these vessels. Damages to Silent World's boat during the cyclone of February 2004 rendered this boat unusable while Tranquility was charted by the Survivor team. Survivor was based in the Moso-Lelepa Island area and access to these islands was prohibited. Finally, Sailaway Cruises' boat was damaged 2 days prior to the arrival of the team. The loss of these vessels vastly reduced the sites that could be accessed. Last minute changes to the plan had to be made and the Reef Check Australia team ended up based at Hideaway Island Resort under the generosity of Rodney Habla for the first 2 weeks where only access to Devil's Point was possible, and on Nguna Island for the final week of the expedition. Unfortunately the key fishery officer, Kalo Pakoa, was overseas at the time and decisions on suitable sites was left to the discretion of the team and Peace Corps volunteer Mike Lameier. Under the circumstances the team pulled together in a remarkable manner however we recommend a closer working relationship with the Department of Fisheries for future community monitoring activities.

The 'control' non-collection sites at Pele Island were a fair distance from the 'impact' collection site of Devil's Point meaning that the habitats, although similar, could not be considered the same, which makes drawing conclusions to the patterns of abundance of aquarium fish difficult. A paired impact/control site was not available due to a lack of adjacent impact and control sites existing in the same coral reef habitat. Due to the logistical constraints discussed, resources and time were not sufficient to conduct a robust impact study that consisted of multiple impact and control sites. Nevertheless, the surveys conducted will serve well as baselines for future work in this area.

A schooner was chartered to access Hat Island during the expedition in order that some baseline surveys could be conducted. It was felt that it was important to survey Hat Island due to its cultural significance. In addition, a survey had been conducted 6 months prior using the same protocol and it was felt valuable to re-survey this site. The February 2004 location was:
Latitude: 17° 38' 49" South
Longitude: 168° 08' 44" East
We could not return to the exact same location due to poor weather conditions that restricted access to where the reef was slightly more protected. However, the previous study only included 4 x 20 m transects, which was deemed insufficient to draw conclusions regarding reef populations (Sykes, 2004).

APPENDIX 4

Management of aquarium collection

The aim of this section is to provide ideas and recommendations that will help managers ensure resources are used in an equitable and sustainable manner that will benefit the local economy for generations to come (Bryant et al. 1998). These management recommendations focus on the marine aquarium trade. However, many of these suggestions may be relevant for other fisheries, such as key-macro invertebrates and food fish populations that were observed to be low in this study.

We recommend that a collection area management plan be put in place according to the principles of ecosystem management in order to ensure ecosystem integrity and the sustainable use of the marine aquarium fishery. Registration and licensing within all sectors of the industry, together with introduction of mandatory minimum standards and appropriate training and inspection schemes help to retain control on how operations are carried out (Wood 2001). The Marine Aquarium Council (MAC) has been established to help manage the trade where the traders are empowered to ensure they harvest in a sustainable manner. MAC-certified collection areas must be governed by a collection area management plan that follow particular principles and consist of particular components.

MAC Management principles:

- The collection and fishing of target marine aquarium organisms are undertaken according to the principles of sustainable use;
- Destructive collection and fishing practices are prohibited;
- Collection and fishing activities within the collection area support the conservation of biological diversity in the collection area;
- basic principles of environmental management and ecosystem management are applied in the collection area; and
- Collection and fishing are undertaken in a planned and organised manner.

MAC components of a collection area management plan

- Geographical boundaries of the collection area;
- Ownership and political boundaries of the collection area;
- Identification and listing of all stakeholders relevant to the collection area;
- Basic annual catch data for the marine aquarium organisms collected or fished in the collection area;
- Collection and fishing history of the collection area;
- Listing of significant organisms not collected or fished in the collection area.

MAC-certified marine ornamentals must be harvested from a certified collection area and pass from one certified operation to another. The certification requires that standards of sustainability and fish handling are maintained from 'reef to retail' (MAC 2001).

There are a number of management tools that can be utilised to control collection. Those that are likely to be successful are those that can be implemented with available resources. These include:

- Industry standards;
- Monitoring catch per unit effort (CPUE);
- Monitoring fish populations;
- Quotas;
- Protected species;
- Industry permits;
- Marine protected areas;
- Education programs.

Industry standards

MAC certification as described above.

Monitoring catch per unit effort

Monitoring of fish CPUE at collection sites is a useful indicator of over-fishing and can be calculated from information that can be provided by the aquarium collectors from collection dive logs (Wood 2001; Wabnitz et al. 2003). Collection logs for SRS already exist and are used to determine export figures for this industry. Useful data for each species collected include:

- Site – (GPS coordinates or determine location name or description);
- Number of fish caught;
- Size of fish (juveniles or adults);
- Length of dive;
- Methods used;
- Depth at which fish are caught.

To determine exactly what information is necessary to calculate CPUE it may be necessary to first determine how the divers conduct their collection dives. If divers go specifically in search of particular fish on some dives and do general searches on others then it may be necessary to determine how much time per dive is used in search of particular species in order to monitor CPUE for each species.

Monitoring fish populations

Monitoring fish populations can help in the following ways:

- Impact studies: Monitoring fish populations at collection and control sites can provide information on the natural variability of the fish populations and determine if significant reductions do occur at collection sites. Adaptive management strategies to respond to changes in CPUE and target fish abundance can be used to ensure pre-determined levels of harvesting pressure are not exceeded.

- Baseline information: Baseline monitoring of future collection sites prior to harvesting activities will provide information on target fish abundance and its variability in time. These baselines can be used to determine if harvesting pressure is too high.

- Recovery information: Where sites are deemed to have been over-harvested, monitoring the recovery will provide information on the recovery potential of these reefs, which could be useful in helping to determine sustainable levels of harvesting pressure.

Quotas

Species by species export quotas are a useful way to implement a quota system. Limiting the number of particular species that can be collected from a particular site during a particular time frame to a sustainable level is an obvious solution but comes with a number of problems. Firstly, we lack the knowledge of what a sustainable harvesting rate is for most species, therefore the quota system should remain flexible should monitoring data suggest over-harvesting of particular species is occurring. Recruitment can also vary substantially both spatially and temporarily, so the carrying capacity of a population will vary from site to site. (Doherty 1991; Sale 1991; Wabnitz et al. 2003). Crude estimates of maximum sustainable yield may be calculated according to those in place in neighbouring countries. However, due to reef-by-reef variations, monitoring is necessary to determine how appropriate these yield quotas are.

Protected species

It may be necessary to prohibit the collection of species that have a poor history of survivorship in aquaria. The bicolour angelfish (*C. bicolour*) and Moorish Idol (*Zanclus cornutus*) were observed at all locations in low abundance and are targeted by collectors. These fish have been reported to have a poor record of survival in captivity, as few individuals are able to acclimatise to captivity. Some scientists have recommended a total ban on the collection of these species due to their unsuitability for aquaria (Wabnitz et al. 2003). In addition, certain species of fishes, such as the ornate butterflyfish (*Chaetodon ornatissimus*) feed only on live coral and almost inevitably starve in captivity (Pyle 1993). This species was observed at the aquarium holding facility in Port Vila. Total bans on the collection and export of species identified as unsuitable for the aquarium trade may be useful.

Industry permits

Permits can assist in regulating the collecting effort by restricting the number of collectors. However, as with quotas, detailed information on the target species life history, recruitment characteristics and the extent of exploitation are still required (Wood 2001).

Marine protected areas

Marine ornamental fish tend to have limited home range size and high levels of habitat specificity (Sadovy and Vincent 2002). The protection of areas of reef around collection sites can act as an insurance against over-harvesting by providing a refuge for breeding populations. Because most fish species have a dispersive larval phase that last from days to weeks, such protected sites can act as sources of juveniles that disperse to collected area, as well as a source for adults that emigrate from protected areas to surrounding regions (Rogers 2001, Russ 1996, 2002, Mclanahan 2001). Reef fish populations have recovered very quickly in marine protected areas (MPAs) established on heavily impacted reefs in the Philippines (Sadovy and Vincent 2002; Wilkinson et al. 2003). To be effective, these MPAs would need to include a diversity of habitats to ensure inclusion of all target species.

The designation of no-take areas to help conserve stocks of ornamental species can also be used as control sites for industry monitoring as a means to determine the status of reef populations and to identify potential effects of over-harvesting (Wood 2001).

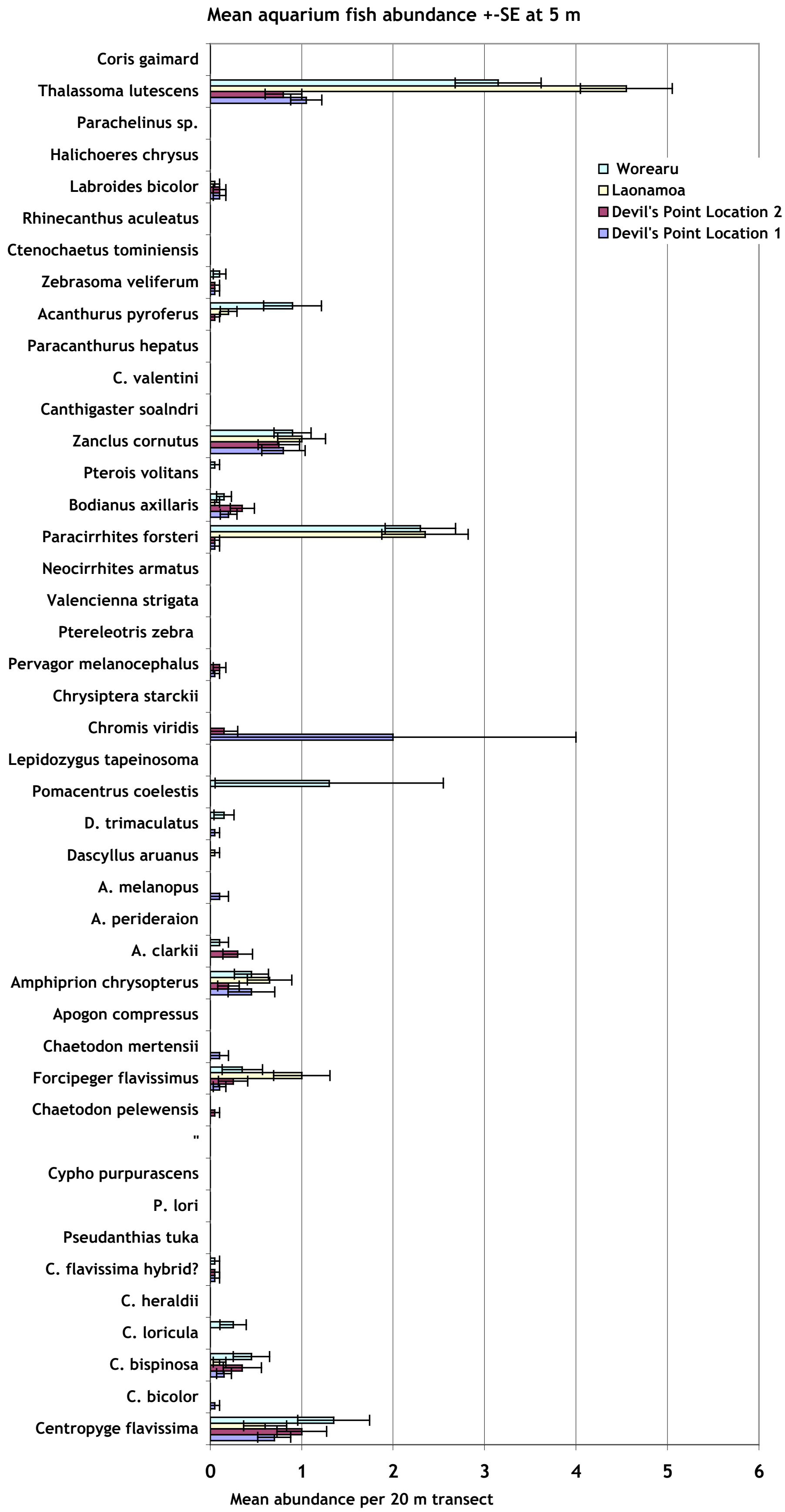
Stakeholders need to be involved in the designation of protected areas, which may be full no-take zones or just protected from aquarium collection. The most effective means of enforcing this is to engage local communities, who may benefit by means of the fees paid to use their resources. Empowering communities to manage their own reefs has resulted in successful programs around the Indo-Pacific where the communities are provided with the results and can see how their management actions affect their reef (Wilkinson et al. 2003). Reef Check provides an ideal monitoring protocol for community monitoring because it is simple and some advice and support is provided from the Headquarters in LA. This system may work well in Vanuatu where the sense of resource ownership is already present. The designation of community MPAs may be appropriate for areas where food fishing pressure is also high (Wabnitz et al. 2003). The Nguna-Pele MPA presents a good example of a successful community MPA in the region. Nguna-Pele communities benefit from increased revenue from tourism and compliance is ensured through community support of the area.

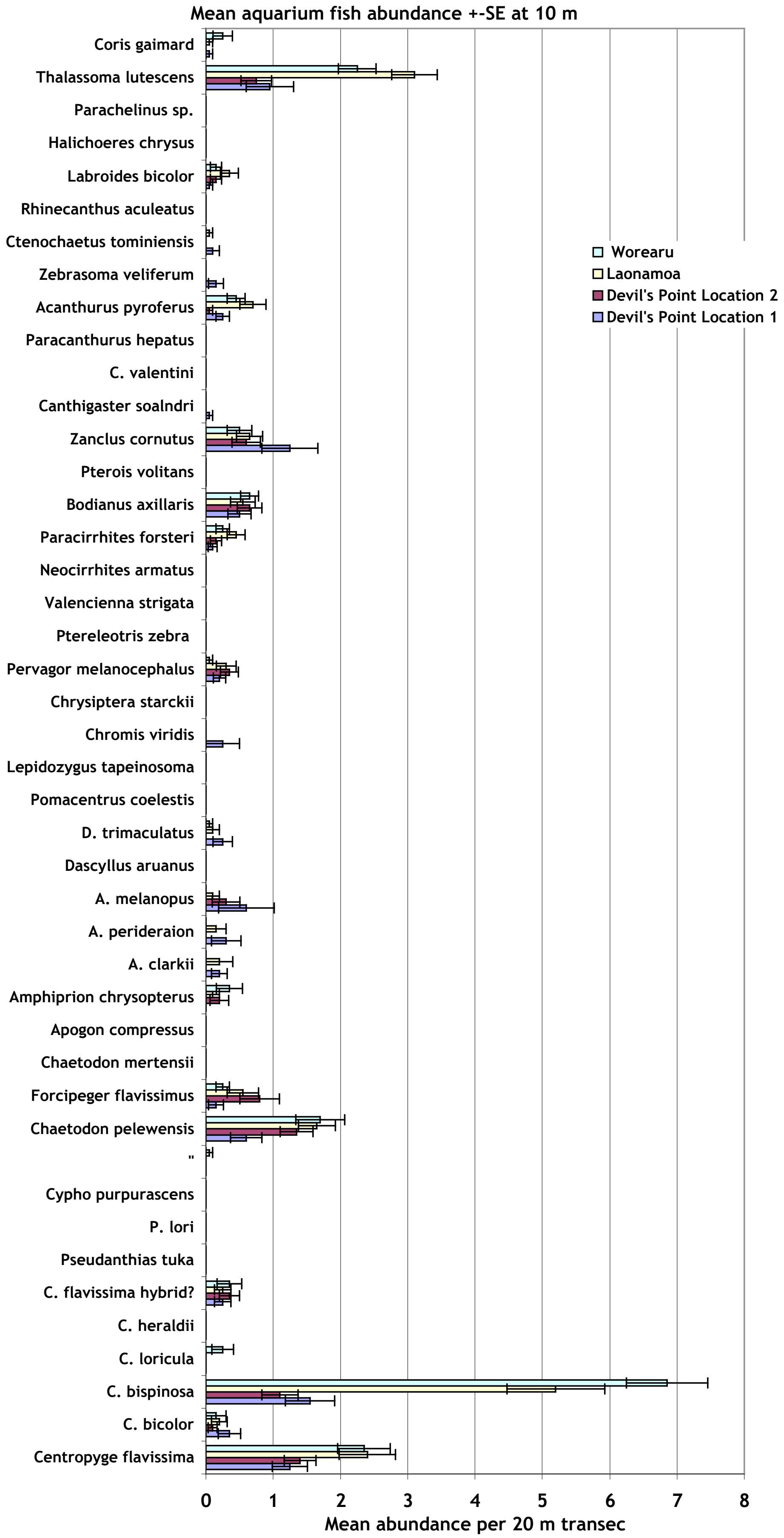
Education programs

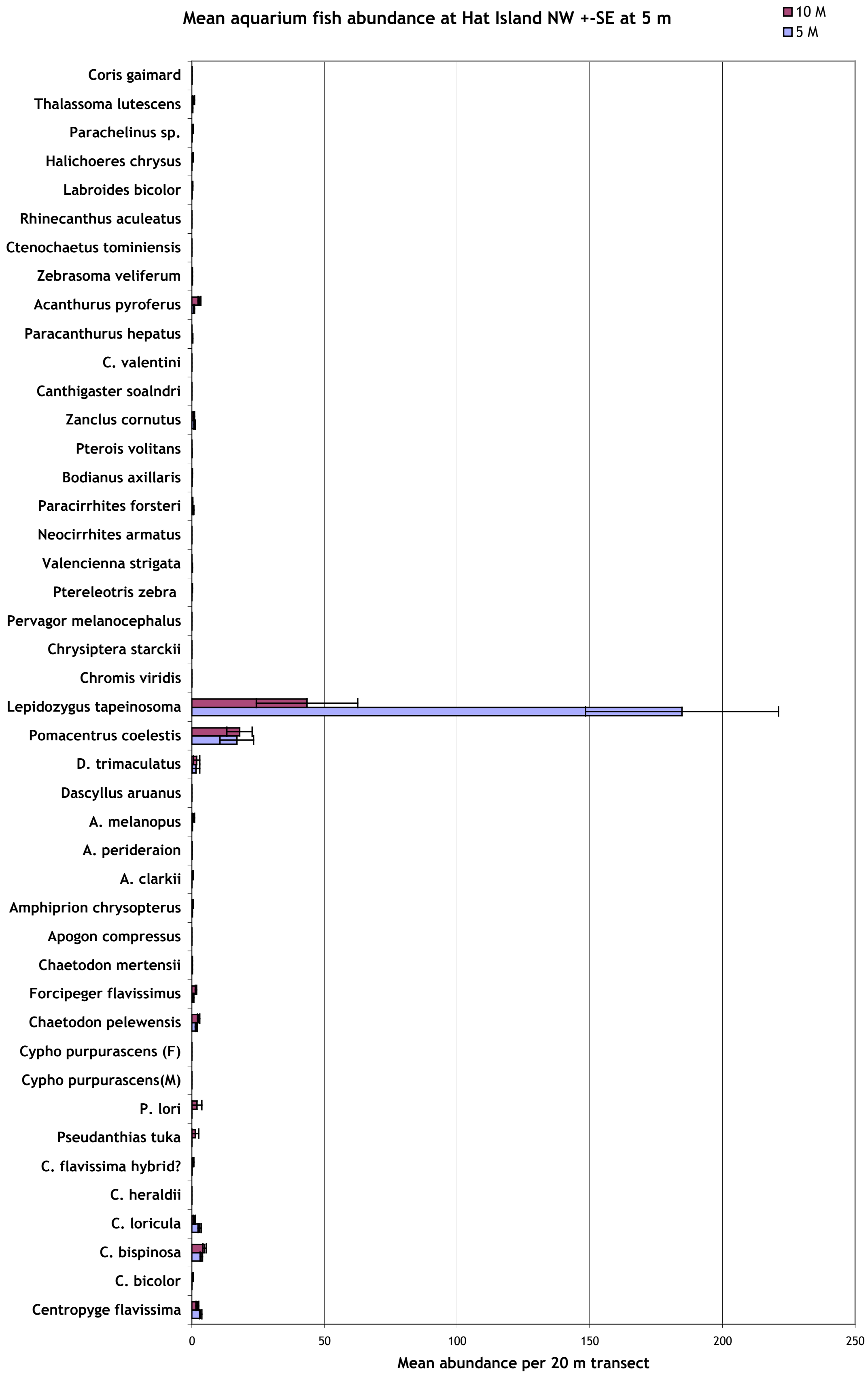
The production of educational materials that support training in this trade could be a useful tool to encourage better standards and promote public awareness of conservation and management issues associated with the marine aquarium trade (Wood 2001). In order to ensure local benefits from fishing industries it is important that local land owners understand the value of the marine resources at their doorstep and negotiate a fair price for fishing rights.

APPENDIX 5

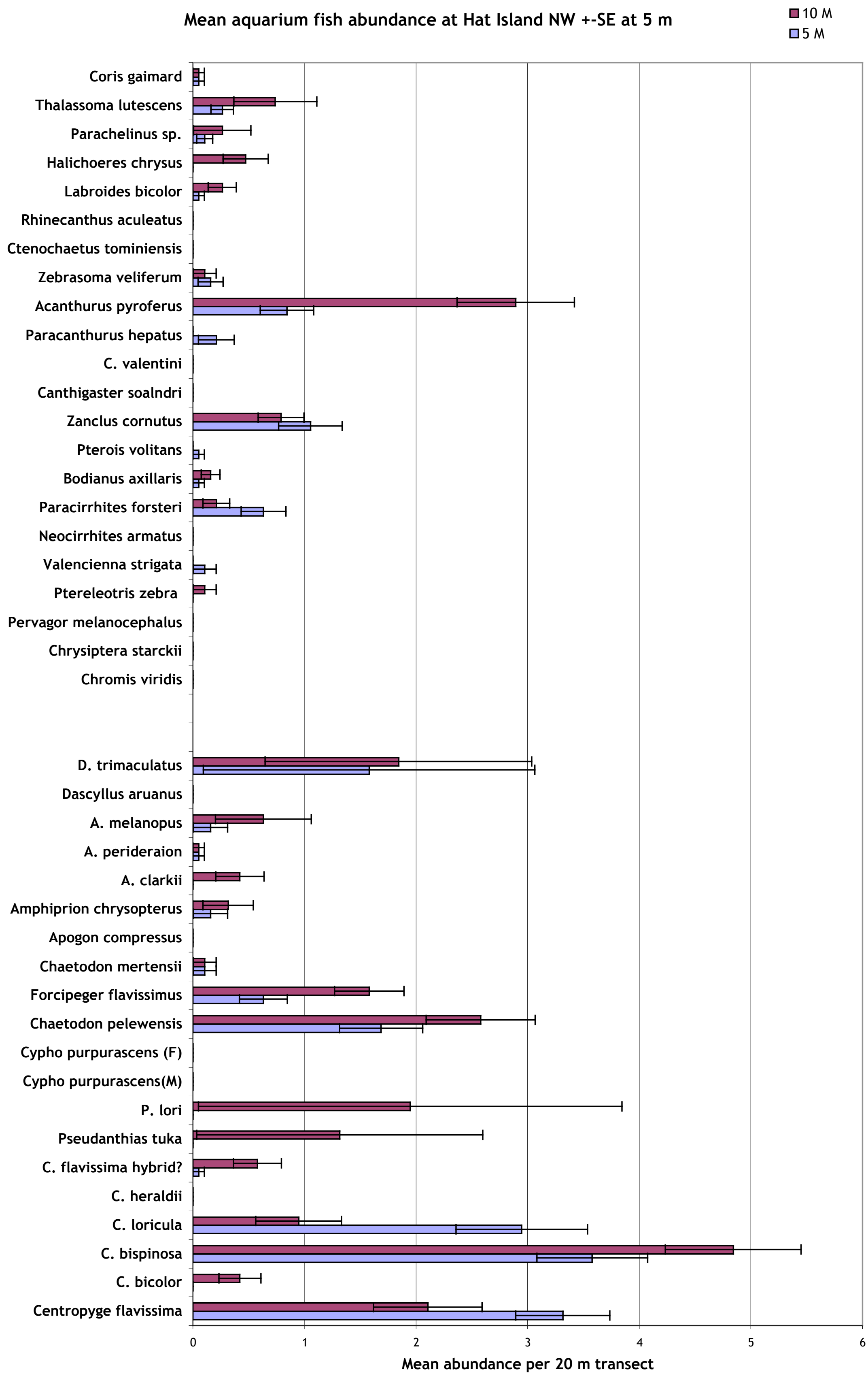
Mean abundance of all aquarium fish from all sites surveyed.




Mean aquarium fish abundance +-SE at 10 m
Coris gaimard
Thalassoma lutescens
Parachelinus sp.
Halichoeres chrysus
Labroides bicolor
Rhinecanthus aculeatus
Ctenochaetus tominiensis
Zebrasoma veliferum
Acanthurus pyroferus
Paracanthurus hepatus
C. valentini
Canthigaster soalndri
Zanclus cornutus
Pterois volitans
Bodianus axillaris
Paracirrhites forsteri
Neocirrhites armatus
Valencienna strigata
Ptereleotris zebra
Pervagor melanocephalus
Chrysiptera starckii
Chromis viridis
Lepidozygus tapeinosoma
Pomacentrus coelestis
D. trimaculatus
Dascyllus aruanus
A. melanopus
A. perideraion
A. clarkii
Amphiprion chrysopterus
Apogon compressus
Chaetodon mertensii
Forcipeger flavissimus
Chaetodon pelewensis
"
Cypho purpurascens
P. lori
Pseudanthias tuka
C. flavissima hybrid?
C. heraldii
C. loricula
C. bispinosa
C. bicolor
Centropyge flavissima
Worearu
Laonamoa
Devil's Point Location 2
Devil's Point Location 1
0
1
2
3
4
5
6
7
8
Mean abundance per 20 m transec


Mean aquarium fish abundance at Hat Island NW +-SE at 5 m
10 M
5 M
Coris gaimard
Thalassoma lutescens
Parachelinus sp.
Halichoeres chrysus
Labroides bicolor
Rhinecanthus aculeatus
Ctenochaetus tominiensis
Zebrasoma veliferum
Acanthurus pyroferus
Paracanthurus hepatus
C. valentini
Canthigaster soalndri
Zanclus cornutus
Pterois volitans
Bodianus axillaris
Paracirrhites forsteri
Neocirrhites armatus
Valencienna strigata
Ptereleotris zebra
Pervagor melanocephalus
Chrysiptera starckii
Chromis viridis
Lepidozygus tapeinosoma
Pomacentrus coelestis
D. trimaculatus
Dascyllus aruanus
A. melanopus
A. perideraion
A. clarkii
Amphiprion chrysopterus
Apogon compressus
Chaetodon mertensii
Forcipeger flavissimus
Chaetodon pelewensis
Cypho purpurascens (F)
Cypho purpurascens(M)
P. lori
Pseudanthias tuka
C. flavissima hybrid?
C. heraldii
C. loricula
C. bispinosa
C. bicolor
Centropyge flavissima
0
50
100
150
200
250
Mean abundance per 20 m transect

This graph does not show the Chromis viridis *or* Lepidozygus tapeinosoma.



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