REPORT

CORAL REEF BIODIVERSITY COMMUNITY-BASED ASSESSMENT AND CONSERVATION PLANNING IN THE MARSHALL ISLANDS: BASELINE SURVEYS, CAPACITY BUILDING AND NATURAL PROTECTION AND MANAGEMENT OF CORAL REEFS OF THE ATOLL OF RONGELAP.

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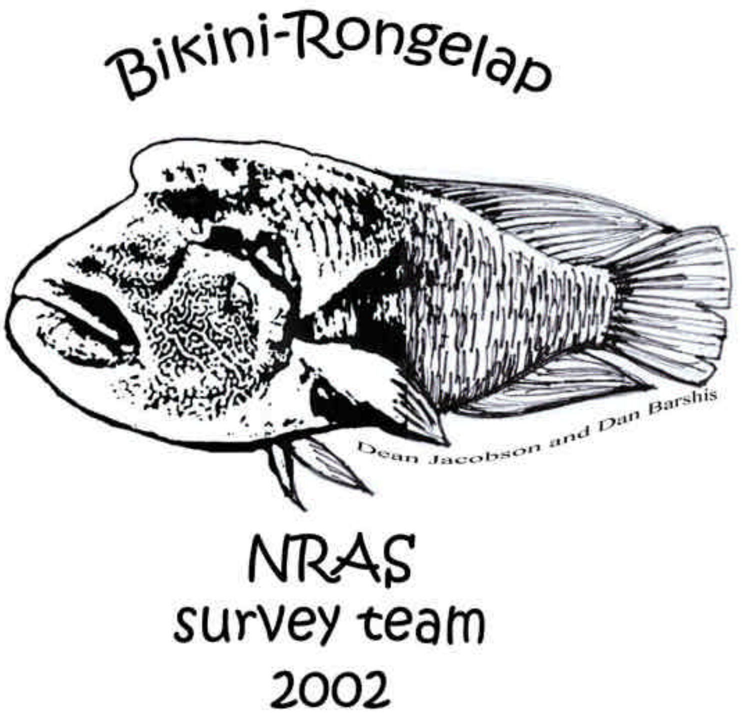

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Abstract

The project was undertaken to assess the reef health, status, fisheries potential, conservation value and biodiversity of two atolls in the Marshall Islands: Rongelap and Bikini. The data produced represent a first comprehensive reference of reef status at national and international level and are used to recommend national marine conservation plans for Rongelap and Bikini. This report focuses on Rongelap Atoll. There is much interest from the local Government for the management of marine resources and the plans to re-inhabit the islands are imminent. The work carried out on the expedition in Rongelap was for the Rongelap Atoll Local Government (RALGov) to assess their marine resources, on which to base new eco-tourism and sport diving and fishing ventures.

The project was also successful in training local people to practices of reef assessment and monitoring techniques for establishing marine protected areas (MPAs). The trained people have the skills, knowledge and interest necessary to continue this work in the future. The project is also promoting reef conservation among the population through newspaper and journal articles and presentations.

During this project, a multidisciplinary team of scientists and trained volunteers carried out surveys on the coral reef ecosystem. The surveys included several levels of detail, ranging from species level biodiversity surveys to volunteer-based reef status surveys. The team assessed for each site (a) the species diversity for fishes and corals, (b) quantitative ecological information including abundance and biomass of fishes, coral cover and substratum, and algae cover and diversity, and (c) community-level reef status information collected by the Reef Check method. In addition, the team set up and conducted a detailed survey of two permanent transects for future monitoring.

The project team surveyed 12 sites around Rongelap Island from shore and a further 2 sites on other islands west of Rongelap Island. The results show that this area could be divided into 5 biogeographical zones, encompassing lagoon sites, outer reef sites and passes. The outer reef zone showed the highest coral cover and species richness. A high proportion of food fishes was also found in these zones, although a different suite of fish species was abundant and large inside the lagoon. High fish biomass, high percentages of coral cover and a total species number of 361 fishes and 170 corals indicated that the reefs around Rongelap Island are outstandingly pristine and healthy. Considering the small size of the area surveyed, it is exemplary that the reef supported more than two thirds of all fishes known from the Marshall Islands.

This report gives recommendations and scientific background to support the establishment of new MPAs and community-based management practices. Once these MPAs are approved, they will represent the first example of coral reef conservation in the RMI. This work has also been the first example of collaborative monitoring between the government, individuals and local NGOs and represented the first effort towards the participation into a regional network of research, monitoring and management of reefs and their resources.

Acknowledgements

There are different agencies and people that we wish to thank for permitting this work to be accomplished. Without their help and support this research could not have been possible:

Mayor James Matayoshi, for having asked CMI and their associated people for technical help for this research and for having demonstrated faith in our work and supporting us with housing, transportation, fuel, tanks and a fantastic team of local supporters.

Senator Abbacca Maddison to be so supportive on Rongelap and to faciliate our introduction ot the community.

John Fysh for helping with the painstaking work of organizing trips and accommodation for 14 scientists during the period of relocation celebration.

Kenneth Kramer from Pacific International Incorporation for lending us the use of his boat for a day.

Alice Leeney for helping preparing field equipment and supervising the shipment of our gear to the remote island of Rongelap.

Dr. Carden Wallace at the Museum of North Queensland for her help with identification of *Acroproa* corals.

Dr. Douglas Fenner at the Australian Institute of Marine Science for the help in coral identification.

Dr. John Randall for help in fish identfication.

Adella Edwards, cartographer at the James Cook University, for her assistance in preparing maps.

This work could not have been possible without the financial support of grant agencies and local organizations:
Marshall Islands Marine Resources Authority, Rongelap Atoll Local Government (RALGov), Marshall Energy Company, Marine Resources Pacific Consortium, US-Department of Interior, Whitley Institute, Reef Check.

Photo by Robert Fournier

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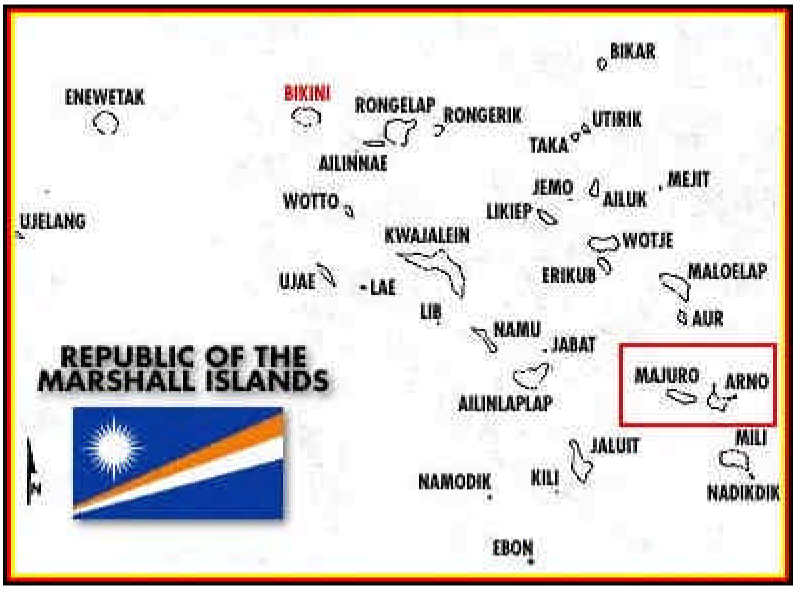
1. Introduction

The Republic of the Marshall Islands (RMI, 168 00 E, 9 00 N) encompasses 29 atolls and 5 islands (Figure 1). The atolls of the RMI encompass over 1,200 low coral limestone and sand islands, with the highest point of approximately 10 m above sea level (CIA, 2001). RMI comprises more than one-tenth of the world's atolls (Micronesia, 2002) and ranks eleventh globally regarding coral reef area (Spalding et al., 2001). With the exception of the two north-western atolls, Enewetak and Ujelang, the Marshall Islands are arranged in two island chains running roughly NNW to SSE: the western Ralik Chain and the eastern Ratak Chain. Both the atoll of Rongelap and the atoll of Bikini are in the Ralik chain.

Figure 1. Map of the Republic of the Marshall Islands (Micronesia, 2002).



The RMI has an unusual history due to the nuclear weapons testing by the USA. The tests were conducted for sixty-seven nuclear bombs between the years of 1947 and 1962 on the atolls of Bikini and Enewetok, with many more atolls affected (CIA, 2001, Niedenthal 2001, Micronesia, 2002).

1.1 Marine resources and management

The RMI is a country with very diverse and unique natural resources (Fosberg, 1990) which are very nearly totally marine (RMIBiodiversityProject, 2000), The Marshall Islands have an ancient tradition of sustainable use of marine resources controlled by social rules (Weissler, 2001). The natural environment has been well tendered with these customary practices. However, these values have been lost to modern life styles acquired through the presence of western immigrants and, more recently, investors from Western and Asian countries. As a consequence, the natural resources are being depleted and degraded (Weissler, 2001). Sedimentation, pollution from big oil stocking tankers and foreign fishing vessels, dredging, and overexploitation of the marine biological resources for the live fish industry and corals for aquarium trade, and extraction for local use (clams and turtles) are a list of many threats to coral reefs and the coastal environment. Problems of over-fishing are becoming increasingly evident to fishermen in the outer islands, as in Likiep and Jaluit (SP, pers. comm.). Moreover, population numbers are increasing rapidly (1.5 % annual rate of increase), amplifying the threats to reefs with waste and sewage disposal. The fisheries management has changed dramatically over the years. In the past it was managed by traditional means, directed by chiefs in the form of 'Mo' areas. 'Mo's' or taboo areas were set apart as reserves for harvesting food, while conserving a food resource, as a way of living in harmony with the environment (RMIBiodiversityProject, 2000). This tradition has been lost but recently local people started asking the support of the national agencies – such as the Environmental Protection Agency and the Marshall Islands Marine Resource Authority – in order to regulate harvesting of resources in their atolls through re-introduction of the traditional fishing restriction zones. The Marshallese people believe the reactivation of a 'mo' would ensure natural resources not to be depleted while at the same time would create a necessary sanctuary to safe guard areas for future generations (RMIBiodiversityProject, 2000).

Also, at a central government level there is increasing interest in sustainable use and restoration of depleted resources. A "Biodiversity Strategy and Action Plan" was issued in 2000 by the Marshall Islands to plan for the conservation of RMI biodiversity and for the sustainable use of its biological resources through (a) activation of conservation sites, (b) education and capacity building for local people to gain the knowledge and skills for conservation of the natural resources; and (c) research to gain a better understanding of the marine ecosystems. Similarly, the recently issued document "Strategic Development Plan, Vision 2018" (RMI, 2001) is based on the recommendations made by the Second National Economic and Social Summit held in March and April of 2001, and states a strong need for natural — especially marine — conservation clearly. The document specifically indicates the need to establish marine reserves to enhance (a) fisheries, (b) tourism, and (c) local awareness. RMI is also party to the international environmental agreements on Biodiversity, Climate Change, Desertification, Law of the Sea, Ozone layer protection and Ship pollution and has also signed but not yet ratified to Climate Change-Kyoto Protocol (CIA, 2001). As part of the RMI's obligations to the international environmental agreements, Acts have been drawn up to govern the law. Some of these Acts are summarized in Table 1.

Table 1. RMI legal instruments relevant to the marine environment, stating their outcome and objectives.

Act	Outcome	Objectives
National Environmental Protection Act, 1984	Established the RMI Environment Protection Authority (EPA) as an independent statutory authority.	-regulating individual and communal activities to ensure maintenance of safe, healthy and aesthetically pleasing surroundings. -prevent env. Degradation. -monitoring of human impacts on natural resources. -preserving historical, cultural and natural aspects of the nation's heritage.
Coast Conservation Act, 1988	Calls for planning, monitoring and controlling the	-survey the resources and uses of the coastal zone.

	development of the coastal zone. The Act also directs RMI EPA and provides for the establishment of an EIA program	-prepare a coastal zone management plan to regulate and control development activities in the CZ. -develop and implement plans for coastal resource conservation.
Marshall Islands Marine Resource Authority Act (MIMRA), 1988	Established MIMRA to coordinate and regulate the exploration, exploitation and management of biological and physical resources.	-prohibiting destructive fishing techniques such as the use of dynamite or chemicals. -define standards for fishing equipment. -prohibits foreign fishing vessels from fishing within the EEZ without appropriate licensing
Marine Resources (Trochus) Act, 1983	Regulates the harvesting of *Trochus*.	- establish a licensing and permitting system and define a harvest season.
Marine Resource Act, TTPI Code	Originates from preceding Trust Territory Code.	-prohibits the killing of turtles on land and the collection of eggs -sets minimum ocean-capture size limits and establishes seasonal capture quotas. -limits for the harvesting of cultivated sponges and black-lip pearl oysters.
Endangered Species Act, TTPI Code, 1975	Protects certain Sp. Deemed to be endangered. The endangered sp. List of the Trust Territory was adopted.	-prohibits harvesting, possessing, selling or exporting any threatened or endangered plant or animal sp.
Marshall Islands Marine Resource Authority Act (MIMRA), 1997	Long-term conservation and sustainable use of fishery resources	Fisheries conservation, management and development.

Source: (adapted and summarized from Crawford, 1993).

Highlighted in the table is the MIMRA Act of 1997; it is under this Act MIMRA is enabled to take measures for the management of fish in the fishery waters based on the precautionary principle. The 1997 Act enables MIMRA to have open and closed fishing seasons, restrictions on fish size and equipment used. MIMRA can protect nesting and breeding areas, while most importantly they can declare any specified area as a protected area and establish reserve areas. The authority can take measures for management and development of fisheries within the internal waters and inside 5 miles of the baseline from which the territorial sea of any atoll is measured. A local government council may take measures for the management and development of local fisheries to the same limits in accordance with the MIMRA Act, 1997, including the establishment of marine protected areas with approval from the authority. The local government of Rongelap Atoll (RALGov) is empowered by the MIMRA 1997 Act to establish marine protected areas (MPAs). The establishment of MPAs is therefore a local government objective and a national government priority.

1. 2 Background

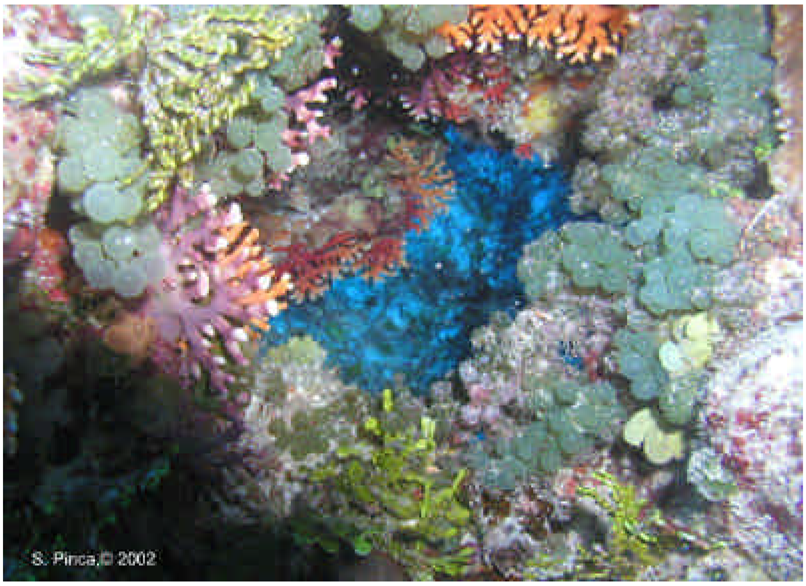
The target locations for the study were the two atolls of Rongelap and Bikini, located in the far North of the western Ralik Chain. Rongelap Atoll, 125 miles south-east of Bikini, has been un-inhabited for 5 decades. The population has been forced to abandon their island following the explosion of the H-bomb 'Bravo' whose fall-out hit Rongelap in 1954 (Micronesia, 2002). An unexpected change in wind direction at the time of the blast left Rongelap in the path of deadly clouds of radioactive ash. The US claimed that Rongelap was safe and took no responsibility for any relocation of the people from the atoll at the time. It was later proven by a US Congressional Committee that there had been warnings of a change in wind direction the day before the test, and also warnings that if the testing went ahead Rongelap would be affected. The US eventually had to accept responsibility and in 1995 the US established a trust fund for the Rongelapese people. Part of this US established trust fund is being spent on infrastructure on the islands of Rongelap Atoll as a precursor to re-inhabitation.

Figure 2. Aerial photograph of Rongelap atoll.

Since 1954 the inhabitants have been moving in exile from atoll to atoll in search of a temporary home. The people of Rongelap were moved to Mejatto, an island on Kwajalein Atoll, in 1985 by Greenpeace, while the US still claimed the island was safe. Since 1985 Rongelap Atoll has been uninhabited, the reefs and lagoons un-fished, until 1998, when the resettlement program was put into effect with Phase 1 of the repatriation. Rongelapese are preparing to once again inhabit their native islands and are at present working for a reestablishment of a community.

Rongelap local government (RALGOV) has formally requested the assistance of the College of the Marshall Islands (CMI) Marine Science (MSP) team to undertake the study in order to collect baseline information on the status of reef of the island that is soon to host about seven hundred new inhabitants. As consequence of the historical events, Rongelap has effectively been protected from exploitation for over 50 years. On a global scale, it might be one of the few untouched reefs remaining. However, the government and the people themselves need to organize a plan for the attentive exploitation of the natural resources that will take place when the imminent relocation starts. The baseline assessment and the relative recommendations will help in such a task.

Moreover, the proximity of Bikini and Rongelap could lead to an expansion of the existing tourist operation on Bikini. Divers and sport fishermen could visit the two atolls and practice different activities. Such an opportunity could become advantageous for both atolls and could be used for employment and development prospects for the relocating inhabitants on both atolls.



2. Methods

This project entailed three phases, leading to a local institutionalization of a marine conservation program in the long term. Phase one: training and education of local volunteer monitors. Phase two: field work: surveys in the two atolls, with participation of both specialists and local volunteers. Phase three: data processing, results issuing and preparation of recommendations for guidance rules for the establishment of MPAs in RMI.

Phase 1. The first, educational, phase took place during the two weeks preceding the field work. Marshallese students and volunteers were trained in marine resource assessment methods, identification of marine organisms and data management. The following activities took place in Majuro atoll:

- Classroom teaching of students in species identification and survey design,
- Practical training in survey operations
- Practical teaching in diving-for-science procedures, safety and dive planning
- Information of the public about the project and the marine environment through newspaper articles

The second part of the education/awareness phase goes on in Majuro as after-field activity, through participation to conferences, presentations, newspaper articles and lectures. This phase is valuable in order to inform the Marshallese public — young students, fishermen and regional governments — about the importance of coral reef ecosystems and their conservation.

Phase 2. This was the survey part of the project to check on the status of marine resources in line with the local government's requirements and wishes. This reef assessment phase was conducted by experts and previously and newly trained local students. The *training-by-doing* aspect of this phase was done conforming to the need expressed by the government to train Marshallese people to the assessment of local marine biodiversity. The program collected three levels of data with varying quality, reliability and utility: A. Biodiversity Information, B. Reef Status data and Monitoring baseline, C. Community and volunteer data (Table 3). The field work involved several stages of survey activities. The external specialists and assistants entered the project at this point.

Detailed survey of target sites. The following survey techniques were applied at the identified target sites:

- Coral and fish biodiversity: presence/absence and semi-qualitative abundance in timed swims (two fish experts)
- Algae diversity and abundance: points records for algal coverage with algae quadrats (25 x 25 cm, 4 replicate per transect, 4 x 3 replicates per site)
- Line intercept transects for substrate, coral and algae: percent cover on a 50 m line (3 replicates per site, three different depths) and reef health transects: counts of *Acanthaster planci* (coral eating crown-of-thorn starfish), dead and bleached coral
- Line transects for invertebrates: counts of target species of invertebrates on a 50 m x 5 m corridor (3 replicates per site, three different depths)
- Line transects for fish (size and abundance): fish counts and size estimation of commercially and ecologically important species, on a 50 x 5 m corridor m (3 replicates per site, three different depths)
- Reef Check: global volunteer reef health assessment scheme (www.reefcheck.org)
- Permanent transect installation for repetitive monitoring programs and long time data acquisition, such as coral recruitment, effects of re-location, fishing and diving activities, and climatic effects such as coral bleaching.

The survey methods were based on standard methodologies used in coral reef science (English et al., 1997, for ecological and monitoring surveys, Werner and Allen, 1998, for biodiversity assessments, Pinca, 2001, for the previous study in RMI), and Reef Check for the community monitoring (www.reefcheck.org). Surveys were depth stratified at deep (18 m), medium (12 m) and shallow (5 m) depth. Very shallow areas or lagoons were assessed only for coral and fish biodiversity. Data were entered *in situ* and analysed in Majuro. For substrate categories, coral life forms and target genera and species for: corals fish, seaweeds, invertebrates, see Appendix I.

Phase 3. Data processing, results issuing and preparation of recommendations took place in Majuro, Australia, and the UK, between September and November 2002. Each scientist participated to the elaboration and preparation of the report. The results are being published as well as used to prepare recommendations for the location and managing design for new MPAs in the two atolls. Public presentations, lectures, articles and displays are being held in the town of Majuro and will be presented at international conferences. The first conference to be attended by Silvia Pinca will be the Second International Tropical Marine Ecosystems Management Symposium (ITMEMS2) in Manila between March 25th-29th 2003. A special session in Micronesia coral reef management will be held by Dr. Pinca.

2.1 Site selection

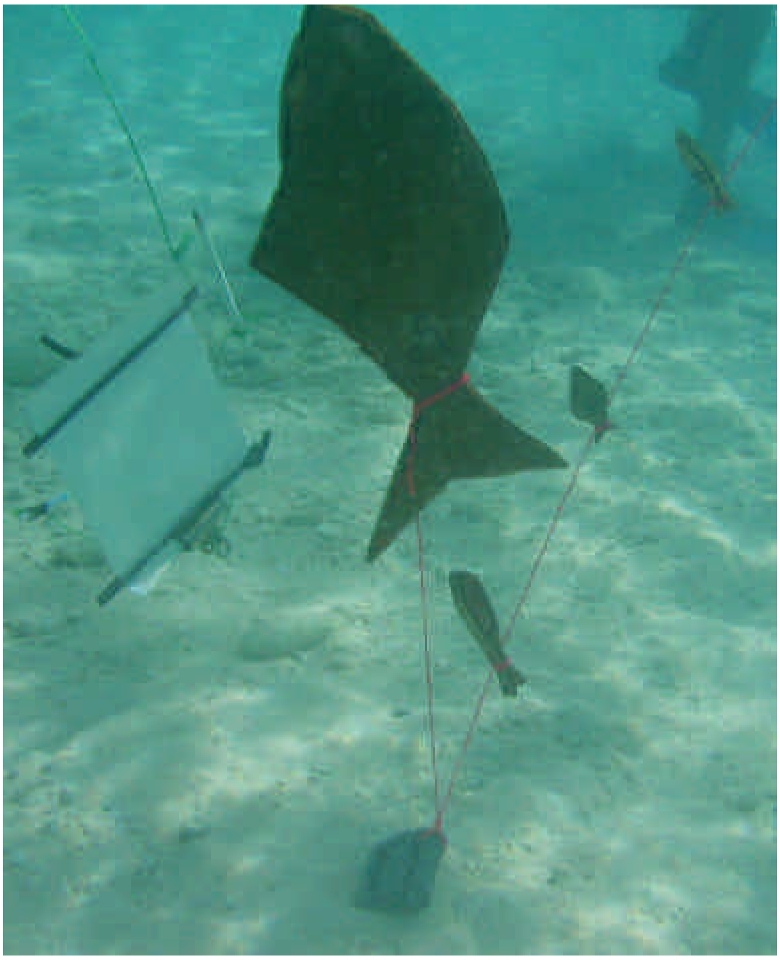
For logistical reasons, the sites in Rongelap Atoll were limited to the main island of Rongelap-Rongelap (Rongelap main island) and to two sites at the south side of the atoll: on the ocean side of the islands of Arubaru and Eniroruuri. On Rongelap-Rongelap balance was given to sites located on the lagoon and the ocean side.

2.2. Training

The participants in the NRAS team followed a program of training and validation appropriate to the undertaking of marine surveys. The training was organized for scientists, experienced volunteers and Marshallese students on marine science courses. The team familiarized and revised their knowledge on fish families and target fish species, coral forms and target coral species, target species of seaweeds and target invertebrate species. The target species were chosen from information on past studies done in the RMI by members of the NRAS team and published literature on the Marshall Islands (Pinca, 2001). The validation was done through a series of identification tests on the computer and in the water, combined with test surveys where buddy scuba divers recorded the same information and then the results were compared. In order to participate on the surveys, the divers had to pass the calibrated tests. Results had to be within 10% of difference between the two divers, to assure good data quality and comparability between team members.

Underwater fish size estimation was aided by a ruler with centimetres tags marked on the recording slate. To learn this size estimation underwater with the natural magnification, trails with wooden fish where prepared and suspended underwater. They had to be sized in a test (Photograph 1).

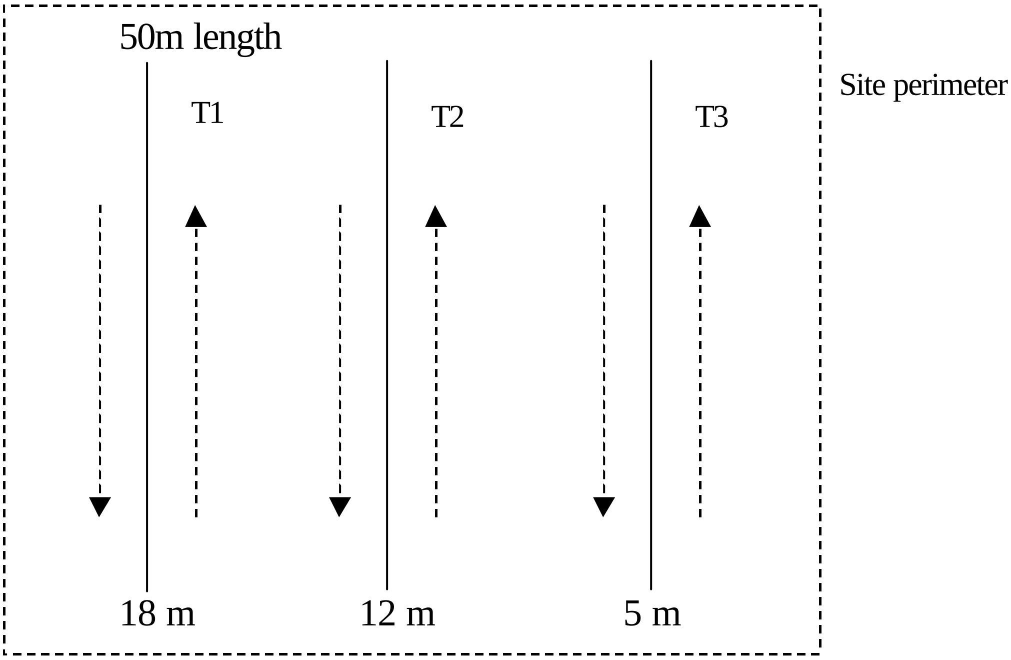
Photograph 1. Wooden fish prepared for a test on fish size estimation underwater.



2.3 Transect Surveys

The NRAS surveys included recording the fish, coral, invertebrate and seaweed data on a series of 3 transects; 2 divers were working on each of the three transects that were located at predetermined depths. The diagram in Figure 3 below shows the layout of transects at one site, with the site perimeter indicating the coverage of information gathered from one site. The transect method was chosen to represent the characteristics of the whole site, over a range of depths (between 5 to 20 m) to give a wide enough coverage on different zones on the reef (Figure 3). Each diver would swim the transect four times, accomplishing different duties at a time.

Figure 3. Layout of three transects at each survey site (Transect 1, 2, and 3 are T1, T2, and T3).



A 50 meter tape measure was laid to allow quantitative analysis and used as a marker so the same transect would be covered on return swims from one end of the transect to the other. 18 meters was the maximum depth for the deep transect, allowing enough time for the pair of scuba divers to complete the work without going in to decompression time. On each transect at each site two scuba divers were collecting the information. Each diver had two jobs, accomplished on a transect swim at a time.

"Fish" Surveyor (Diver to pass over site first):	*"Coral" surveyor:*
Records large fish	Lays the 50m tape
Records smaller fish	Records the corals or substrate every 50cm
Records 4 quadrates of seaweed target genera and percentage coverage (at the markers of 10, 20, 30, 40 m on the tape)	Records the number of target invertebrates
Helps buddy roll up the tape measure	Reels up the 50m measuring tape

2.3.1 Fish data

Fish counts were undertaken by 1 scuba diver, swimming along the 50 m length measuring tape. On the first swim, the diver recorded fish of size C class (over 20 cm in size) and on a second transect swim fish of size A (< 10 cm) and B class (6-10 cm). The fish surveyor swam along the designated depth contour recording fish while the buddy laid the tape measure behind. Fish surveyors recorded all target fish, within an estimated box of 5 meters, 2.5 m to either side of the tape, 5 m above and 5 m forwards (Figure 4). The target fish were recorded at family and species level for the fish families shown in the table in Appendix 2. The fish species recorded where estimated into three size classes: A 6-10cm, B 10-20cm, C >20cm. The meandering swimming pattern allowed to record the smaller species and the sedentary species.

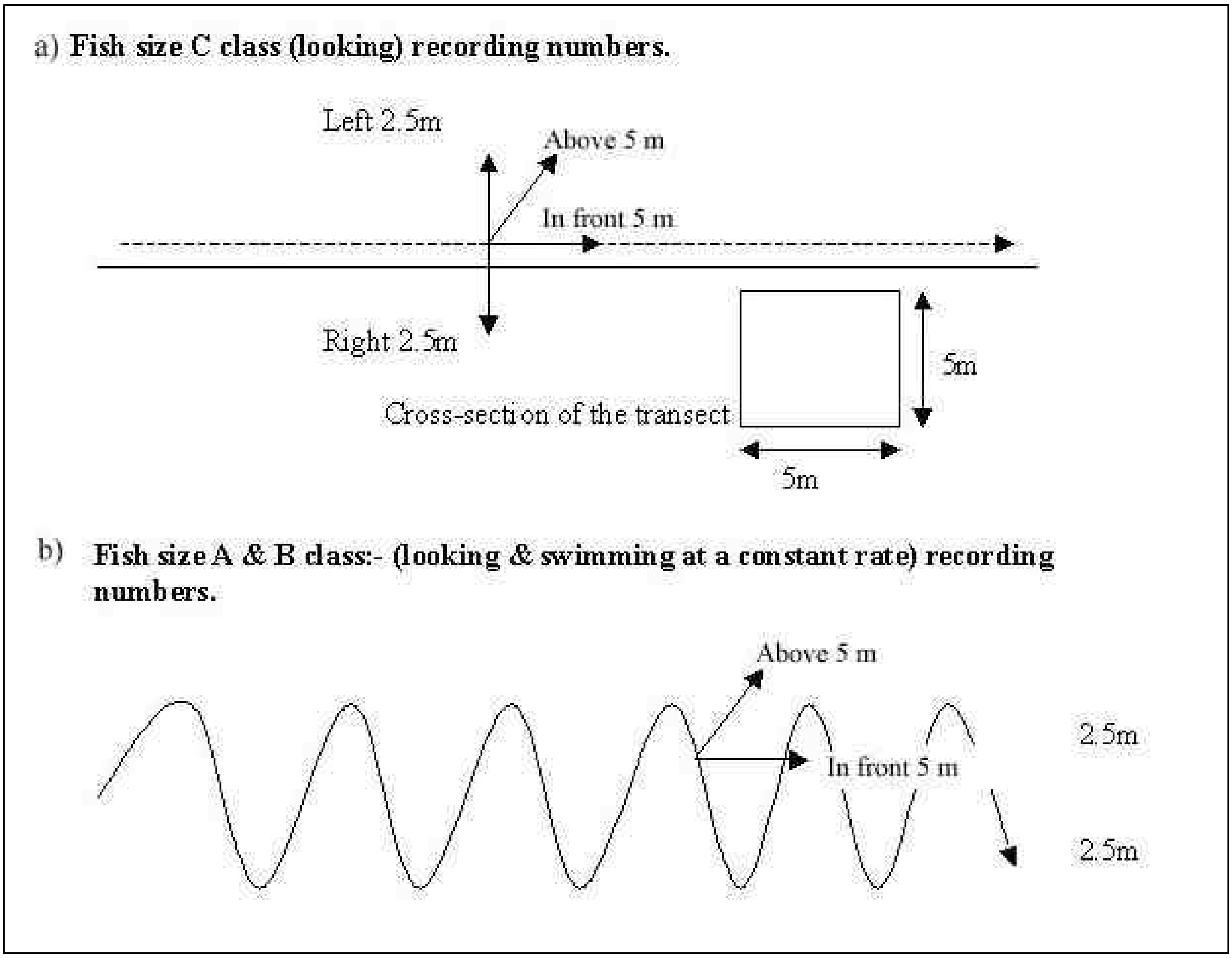
The fish size classes allow the minimum average fish biomass to be calculated, according to the formula:

$$W=a*L^b$$

Where W is weight in grams, *L* the Length in cm, and *a* and *b* are coefficients.

The biomass data could also be used as a baseline for future monitoring programs. Fish individuals which were 'observed twice' on a transect i.e. fish, which crossed in front of the diver once and shortly afterwards a similar fish (or the exactly same fish) was encountered again, were counted as separate individuals unless the observer saw them turning around and hence could be sure it is the same fish.

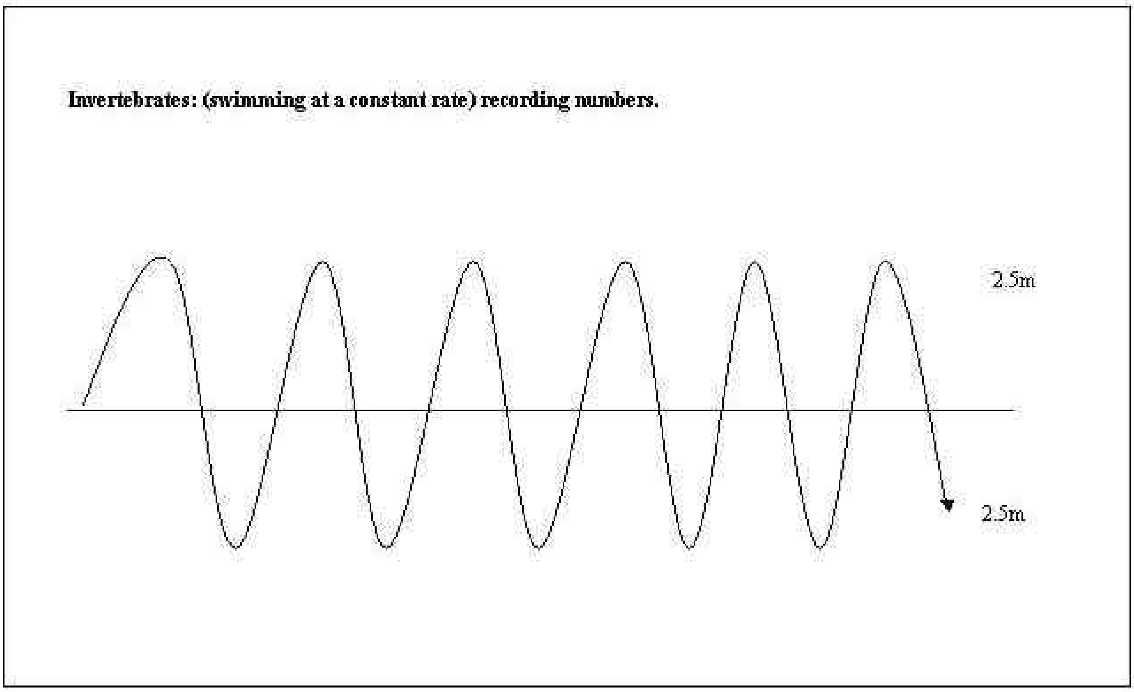
Figure 4. Patterns of swimming and observation radius for (a) large fishes and (b) small fishes.



2.3.2 Invertebrate data collection

The invertebrate data were collected by one scuba diver meandering across the 50 m measuring tape looking to a distance of 2.5 m either side of the tape (Figure 5), counting the target species (listed in Appendix 3). The purpose of criss-crossing the transect was to record the smaller species and the sedentary species.

Figure 5. Patterns of swimming and observation radius for target invertebrates.



2.3.3 Benthic Line Intercept Transect (LIT)

LITs were carried out according to AIMS-ASEAN methodology with minor adjustments. Recorders noted all features at two levels, AIMS-ASEAM life-forms and target coral genera or species (see Appendix 1). The coral data was collected by a diver, swimming along the length of the 50 m measuring tape and recording the substrate below the tape at every 50 cm.

2.3.4 Seaweed data collection

A quadrat of 25 cm x 25 cm dimension was placed next to the transect at the 10 m, 20 m, 30 m, and 40 m marks. Density or percentage coverage was estimated inside the quadrats and averaged for each depth. Target genera and larger groups were identified (Appendix 4). Samples of seaweeds were taken for preservation (pressing of dry samples) and cataloguing at the library of the College of the Marshall Islands.

2.4.1 Fish Diversity

Fish species richness was assessed by Maria Beger, using timed swims for 60 to 90 minutes at each survey site. All sites were sampled at least once; two sites had multiple samples. Underwater observations were recorded onto a plastic sheet on a slate. The most commonly seen species were pre-printed on the recording sheet and ticked when seen, other species were noted separately on the same sheet. Fish species were only recorded when their identification was absolutely positive. A small percentage of fishes could not be identified to species level because of constraints in visibility, cryptic behavior and too great a distance from the observer. To supplement the visual census, on some occasions samples were obtained by capturing the fish using the ichthyocide clove oil, which stuns small fish. This technique was used for smaller or cryptic fishes that are difficult to visually identify *in situ.* Underwater photos also aided with identification in a few cases.

All fish species were given a semi-quantitative rating, following the DAFOR scale (Table 2). These ratings were given considering their relative abundance, i.e. fish species that usually occur in large aggregations were rated at the higher end of the scale.

Table 2. Semi-quantitative abundance rating for coral reef fishes.

Rating	Abundance
0	None
1	Rare, 1 individual seen
2	Occasional, 2 to 6 individuals seen
3	Frequent, 7 to 50 individuals seen
4	Abundant, 30 to 200 individuals seen
5	Dominant, more than 200 individuals AND they form a major part of the overall fish biomass

The timed swim method involved a rapid descent to 25 to 30 m, with the deepest dive being 52 m on one occasion. Then the observer ascended slowly, swimming in a meandering fashion, and spent a considerable time of the dive in the surge zone. The observer included all major habitat types present at the site in the survey. Biological and topographical habitat types were also recorded semi-quantitatively (for Habitat types see Appendix 9).

The data were analyzed using multivariate clustering to demonstrate zonation of fish communities on Rongelap atoll and, in more detail, of Rongelap island. Using the Coral Fish Diversity Index (CFDI) (Allen, 2002), an estimate of total expected coral reef fish fauna was calculated. The reserve prioritization program WORLDMAP (Williams, 2000) was used to illustrate conservation priorities on Rongelap-Rongelap form the point of view of fish species diversity.

2.4.2 Coral Diversity

Corals were surveyed by Zoe Richards during 16 scuba dives to a maximum depth of 52m (average depth 30 m – exposed wall, 15 m – lagoon). Each of the 14 sites was sampled once apart from R1 and R10 at which additional dives were conducted to establish permanent monitoring transects.

Coral species richness was assessed using timed swims for 60 mins at each survey site. The timed swim method involved a direct descent to 30 m, followed by a slow ascent, swimming in a zigzag path to the shallow parts of the reef where a large proportion of time was spent surveying the reef crest. All records were based on visual identifications made underwater, except where skeletal detail was required for species determination. In the latter case, reference specimens were collected and studied at the Museum of Tropical Queensland by the Zoe Richards and Dr Carden Wallace (*Acropora*), and Dr Douglas Fenner (non-*Acropora*). Voucher specimens have been deposited in the Museum of Tropical Queensland (Townsville, Australia) and are available for viewing upon request. References for species identifications were Wallace, 1999; Veron, 2000; Hoeksema and Best, 1991; Wells, 1954; Nemenzo, 1976.

Coral species were given a semi-quantitative abundance rating following the DAFOR scale (0 = none; 1 = Rare, 1 colony; 2 = Occasional, 2-6 colonies; 3 = Frequent, 7 – 30 colonies; 4 = Abundant, 30 – 200 colonies; 5 = Dominant, more than 200 colonies and form a major component of the overall coral biomass). An estimate of percentage cover of coral was given for each site along with recording the three most dominant species.

Data was analyzed using multivariate clustering to demonstrate the zonation of coral communities on Rongelap atoll, and in more detail, Rongelap-Rongelap island. The reserve prioritization program WORLDMAP (Williams, 2000) was used to illustrate conservation priorities on Rongelap atoll with respect to coral species diversity.

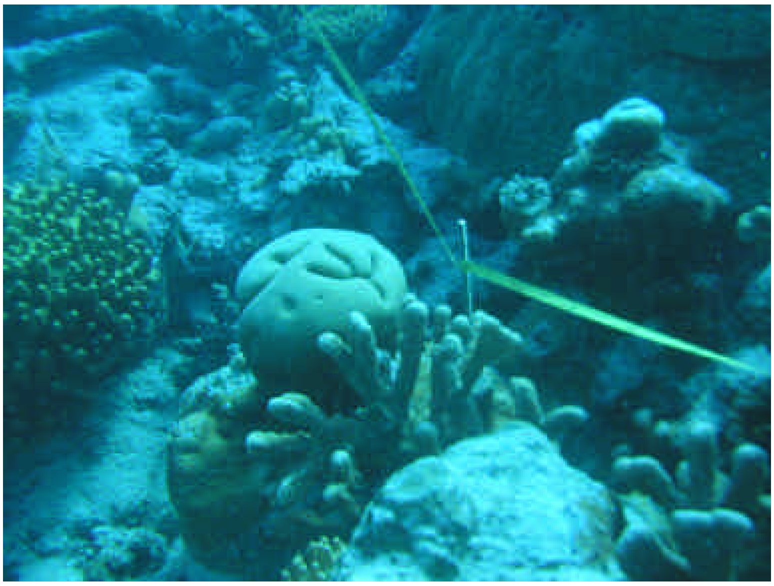
2.5 Physical information and profiles

Physical profile transect were accomplished with the all team collaborating. Three transects perpendicular to the shore were deployed. Two divers were working on each transect, using a 10 m line. One dive buddy pair worked on each of the three transects. Diver 1 (D1) for each dive buddy team was leading, holding one end of a 10 m rope to measure the length of the transect. D1 also took a depth reading every 10 m and estimated horizontal visibility. Diver 2 followed at intervals while recording substrate type and coverage (following substrate categories detailed in Appendix 1) and health of the reef for each segment. A fourth team was swimming instead parallel to the shore at 20, 15, 10 and 5 m, covering 20 m at each depth, and describing substrate and main physical features (presence of gullies, boulders etc.). Following the dive, the team completed a site assessment form entering information on GPS reading and location description.

2.6 Permanent transects

Two permanent transects (see an example in Photograph 2) were deployed for future references and monitoring. One transect was laid at 8-10 m off Jaboan point and one was laid on the wall, on the east side of Rongelap-Rongelap, at a depth of 12 m. At each site, eleven metal pins were deployed and hammered inside the bedrock, at 5 m apart between each other, along a 50 m line. Underwater epoxy was used to glue the points inside the rock.

Photograph 2: Example of a pin on permanent transect PT1.



2.7 Photographic documentation

At each site a professional photographer (Robert Fournier) was in charge of taking underwater pictures of individual fishes or corals for identification and documentation purposes, using a professional underwater camera (Nikonos 4 ®). A digital underwater camera (Olympus Camedia ® 4.1, with Ikelite ® housing) was deployed to take general pictures of habitat and individual species and to document the status of the permanent transects by S. Pinca, and in some occasion by other participants. For the first week of surveys in Rongelap, an underwater videocamera was deployed by Craig Musburger for taking videos of general habitat conditions and fish swimming behavior for later identification purposes.

2.8 Summary of methods

In summary, a variety of survey methods were applied in order to obtain a comprehensive picture of every aspect of coral reef ecology and status. To provide the reader with a quick reference of the methods used, Table 3 gives a comprehensive summary of all methods.

Table 3. A summary of all survey methodologies applied during NRAS. Levels refer to biological detail as follows: A-species level identification, B-ecological/monitoring data, and C-community-level data.

Name	Data collected	Method	Level
Coral and fish biodiversity	Record presence – absence (corals) and semi-qualitative abundance and sizes (fish) for all species	Timed swims by experts	A
Algae coverage and diversity	Point records for algal coverage and diversity at three depths	Algae 4 x 3 quadrats (25 x 25 cm)	A
Algae coverage and abundance	Line intercept transects, percent coverage at three depths	3 x 50 m line	A, B
Line intercept transects for coral and benthos	Records of distance since interception, percent cover at three depths	3 x 50 m line, life form level of identification, substrate types	B
Line transects for invertebrates	Counts of invertebrates	3 x 50 m line, 5m wide, target species identification	B
Line transects for fish (size and abundance)	Fish counts, target species, size estimation, biomass (English et al. 1997).	3 x 50 line, 5 m wide, species id, counts and length – biomass conversion	B
Reef health transects	Counts of *Acanthaster planci*, (Crown- of- thorns starfish), *Drupella sp.* (coral eating snail), dead coral and bleached coral	3 x 50 m line	B
Reef Check	Global volunteer reef health assessment scheme (www.reefcheck.org)	Low detail assessment, ideal for community participation and training.	C
Permanent transect	Installation of permanent transects for temporal monitoring	50 m long, every 5 m a pin; map substrate, corals, fish, algae	A, B

3. Results

3.1 Summary of achievements

In total, fourteen science divers were involved in the study of the health and biodiversity of coral reefs in Rongelap. The collected information will be issued to local governments and international organisations that study the status of coral reefs around the world. The survey team compiled a range of different data at 14 sites at Rongelap Atoll (Table 4). 12 of these sites were based on Rongelap-Rongelap island (Figure 6). In total 434 dives were conducted to accomplish this survey.

Table 4. Surveys accomplished at 14 survey sites at the southern Rongelap Atoll

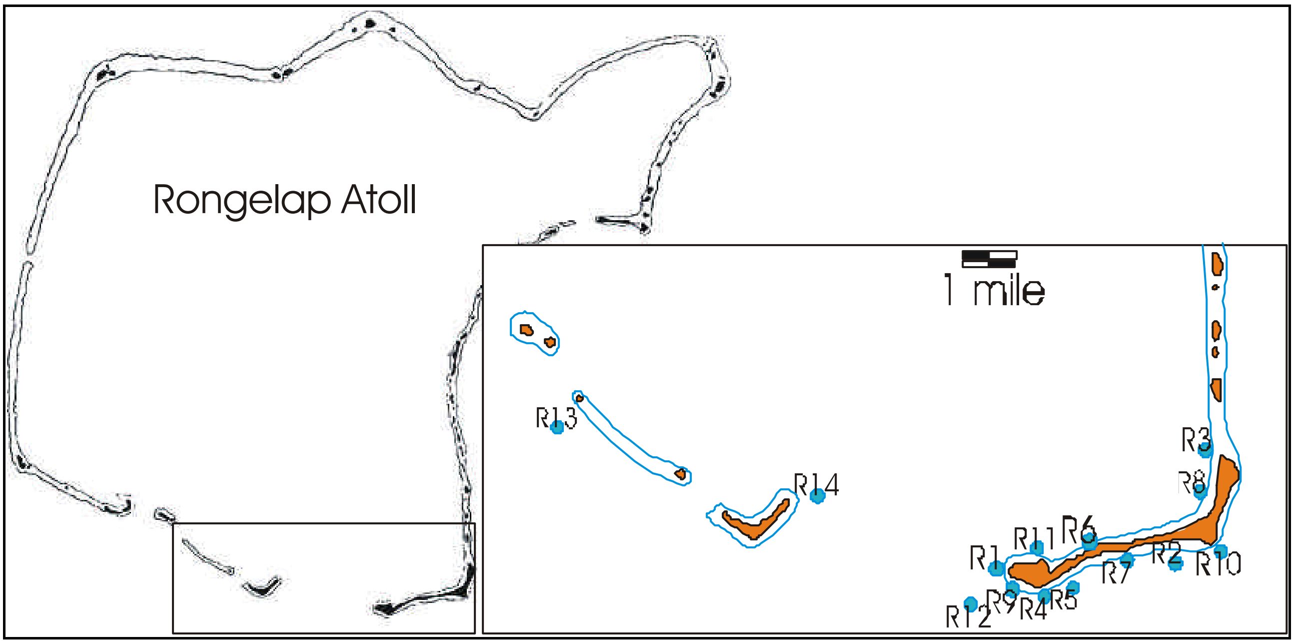
Survey	Effort
50m fish census: biomass and abundance of beta-diversity	3 depths
50m benthic census: substratum, corals and soft corals	3 depths
50m algae survey: biodiversity and %cover in quadrats	3 depths
Fish biodiversity	1 person
Coral biodiversity and collection	2 persons
Photography	1 person
Digital Photography	1 person
GPS (Global Positioning System) co-ordinates	1 person

The team selected two sites which were outstanding in their biological diversity, and that represent typical habitats found in the area. These sites were surveyed as above, but additionally there were repeated biodiversity surveys, a deep survey to include deep dwelling organisms, and the establishment of a permanent transect. The permanent transects are based at 11 meters of depth at PT 2 (R10) and at 7 meters at PT1 (R1). They consist of 11 pins cemented into the reef matrix along a 50 m transect; the pins are used to enable relocation of the transect, since, in order to avoid adverse impacts on the reef condition and development on the permanent transect, the tape itself was not placed permanently and needs to be re-laid at the next visit. Pins are located at either end and in 5 m steps along the transect. The permanent transects enable temporal monitoring of the reef. At Jaboan point (Site R1), the team conducted a Reef Check© survey. Reef Check is an internationally acclaimed and established method of assessing and comparing reef health on a global scale (ReefCheck, 2002). The location was recorded by Global Positioning System (GPS), using the "Degree Minute.decimal-minute " setting and WGS 84 projection (Table 5).

Table 5. GPS co-ordinates of survey sites on Rongelap atoll.

Site name	Latitude	Longitude
R1	N 11 09.20707	E 166 50.18976
R2	N 11 09.39472	E 166 53.14641
R3	N 11 10.74334	E 166 53.74411
R4	N 11 09.10086	E 166 50.32076
R5	N 11 08.93800	E 166 50.58275
R6	N 11 09.46714	E 166 52.00121
R7	N 11 09.43624	E 166 52.92400
R8	N 11 10.43048	E 166 53.75506
R9	N 11 09.12210	E 166 50.25059
R10	N 11 09.30557	E 166 53.40841
R11	N 11 09.23958	E 166 50.62749
R12	N 11 09.16394	E 166 50.21003
R13	N 11 11.49714	E 166 43.42705
R14	N 11 10.09542	E 166 46.79730
PT1	N 11 09.23154	E 166 50.12474
PT2	N 11 09.30557	E 166 53.40841
Reef Check	N 11 09.20707	E 166 50.18976

Figure 6. Map of Rongelap atoll (after Spennemann, 1998) and detail of survey sites in southern Rongelap.



3.2 Ecological data

We present here an ecological analysis of the set of data, separated by categories of target objects and organisms (substrate, target corals, seaweeds, fish). We used simple statistical descriptors (mean and standard deviation) for this analysis and we concentrated on the differences among zones and regions with different location and topographical characteristics: depth layers, lagoon versus ocean, geographical location around the island and the Southern side of the atoll (Table 6).

Table 6. Matrix of ecological analysis to facilitate quick referencing.

Categories analysed	Section No.		
	Depth	Lagoon vs Ocean	Bio-geographic zones
Substratum	3.2.1.1	3.2.1.2	3.2.1.3
Coral targets	3.2.2.1	3.2.2.2	3.2.2.3
Fish targets	3.2.3.1	3.2.3.2	3.2.3.3
Algae	3.2.4.1	3.2.4.2	3.2.4.3

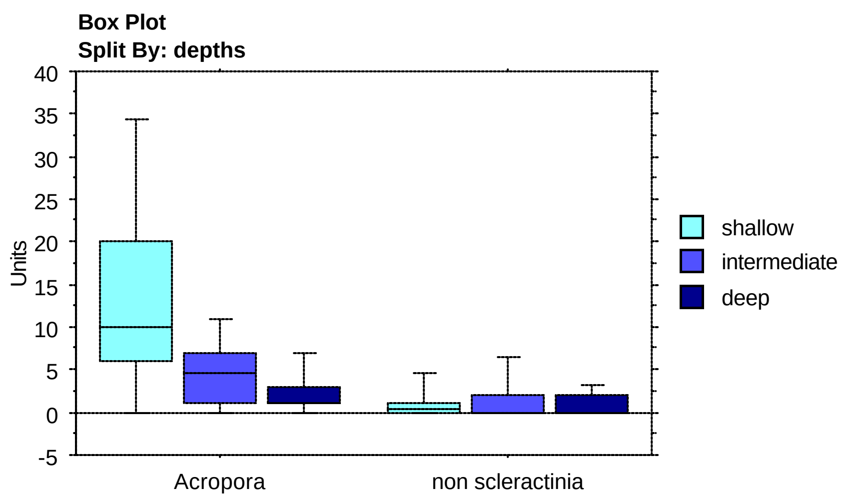
3.2.1 Substrate

We analyzed differences in distribution of the categories of substrate recorded. The comparisons of average values analyzed were studied for 3 depth layers, ocean versus lagoon sites, and 5 geographical locations. For depth and locations we used the Kruskal-Wallis test for multiple comparisons for non-parametric data (Zar, 1999) and for ocean *vs* lagoon we used a *t*-test. Differences to be considered meaningful were only those that gave a statistically significant level of probability equal or $p < 0.05$.

3.2.1.1 Depth

We analyzed the depth preference of different categories of corals recorded, such as the zooxanthelleate hard corals (scleractinia) and other reef-building corals such as blue and fire corals. Both *Acropora* ($p_{\text{Anova}} = 0.008$) and non scleractinia corals ($p_{\text{Anova}} = 0.05$) showed sharp differences of coverage with the depth. *Acropora* corals are more abundant at shallower depths (>10m) while non scleractinia (blue and fire corals) are more important at deeper layers (Figure 7).

Figure 7. Differences among the three depth layers for *Acropora* and non scleractinia corals.



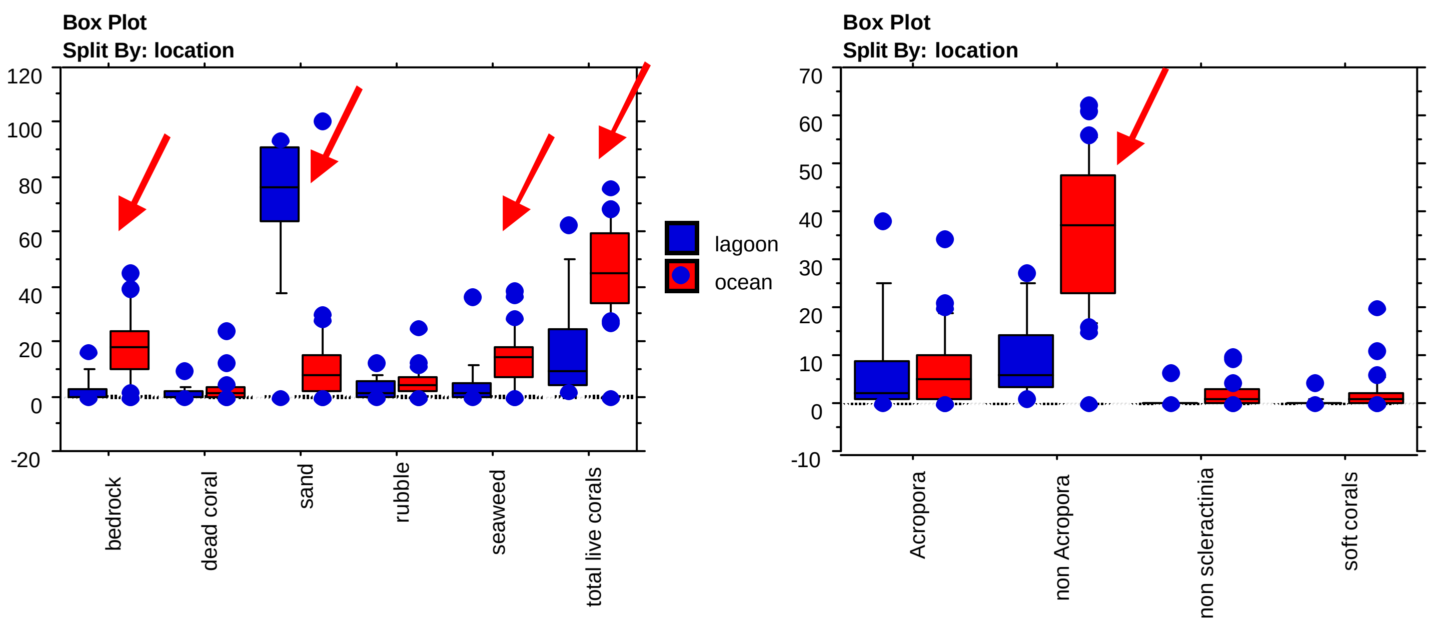
3.2.1.2 Lagoon vs Ocean

The substrate of lagoon and ocean sites was very different. Most of the components of what covers the ocean floor (substrate categories) show very different proportions of coverage at the two different locations: bedrock, live coral - among these, non-*Acropora* coral and non *scelaractinia* corals (fire, lace and blue coral) - as well as seaweeds are more abundant at the ocean location. Sand –as expected – shows higher coverage at the lagoon sites. Results are summarized in Table 7 and Figure 8. Dead coral, rubble, *Acropora* and soft corals were not significantly different at the two locations.

Table 7. Difference of substrate coverage between ocean (O) and lagoon (L) sites. P is the probability value associated with the statistical test (*t*-test). Categories with significant results are marked in bold.

Category	Significant/ Non significant	Higher in L or O	P value
Bedrock	**S**	**O**	**<.0001**
Dead coral	NS	-	.38
Sand	**S**	**L**	**<.0001**
Rubble	NS	-	.18
Live coral	**S**	**O**	**<.0001**
Acropora	NS	-	.95
Non *Acropora*	**S**	**O**	**<.0001**
Non scleractinia	**S**	**O**	**.04**
Seaweeds	**S**	**O**	**.005**
Soft	NS	-	.37

Figure 8. Differences in substrate coverage between ocean and lagoon sites. Arrows indicate significant results (p < 0.05).



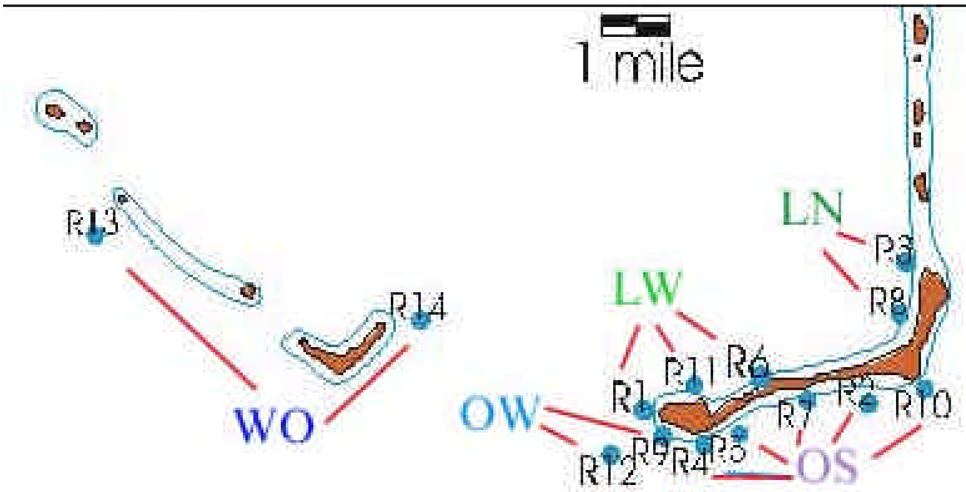
3.2.1.3 Geographical locations

We analyzed the differences in percentage coverage of the same substrate categories among preselected geographical zones around southern Rongelap atoll. Locations were classified as lagoon and ocean sites, and sites containing both ocean and lagoon habitats, as observed in Jaboan. The different regions were chosen by their differences in exposure, location in relation to passes and topography (see Figure 9).

Table 8. Sites grouped by bio-geographical zone. L = lagoon, O = ocean, J= Jaboan.

Site name	Lagoon/ocean	Geographical zone
R1	L (J)	Lagoon W
R2	O	Ocean S
R3	L	Lagoon N
R4	O	Ocean S
R5	O	Ocean S
R6	L	Lagoon W
R7	O	Ocean S
R8	L	Lagoon N
R9	O (J)	Ocean W
R10	O	Ocean S
R11	L	Lagoon W
R12	O (J)	Ocean W
R13	O	W Ocean (pass)
R14	O	W Ocean (pass)

Figure 9. Map of the pre-selected bio-regions, chosen as function of the sites exposure and topography.



Bedrock, rubble, sand, total live corals, non *Acropora*, non scleractinia and seaweeds show sharp differences in their relative coverage. The differences were evaluated using the Kruskal-Wallis test (Table 9) for multiple comparisons of average values.

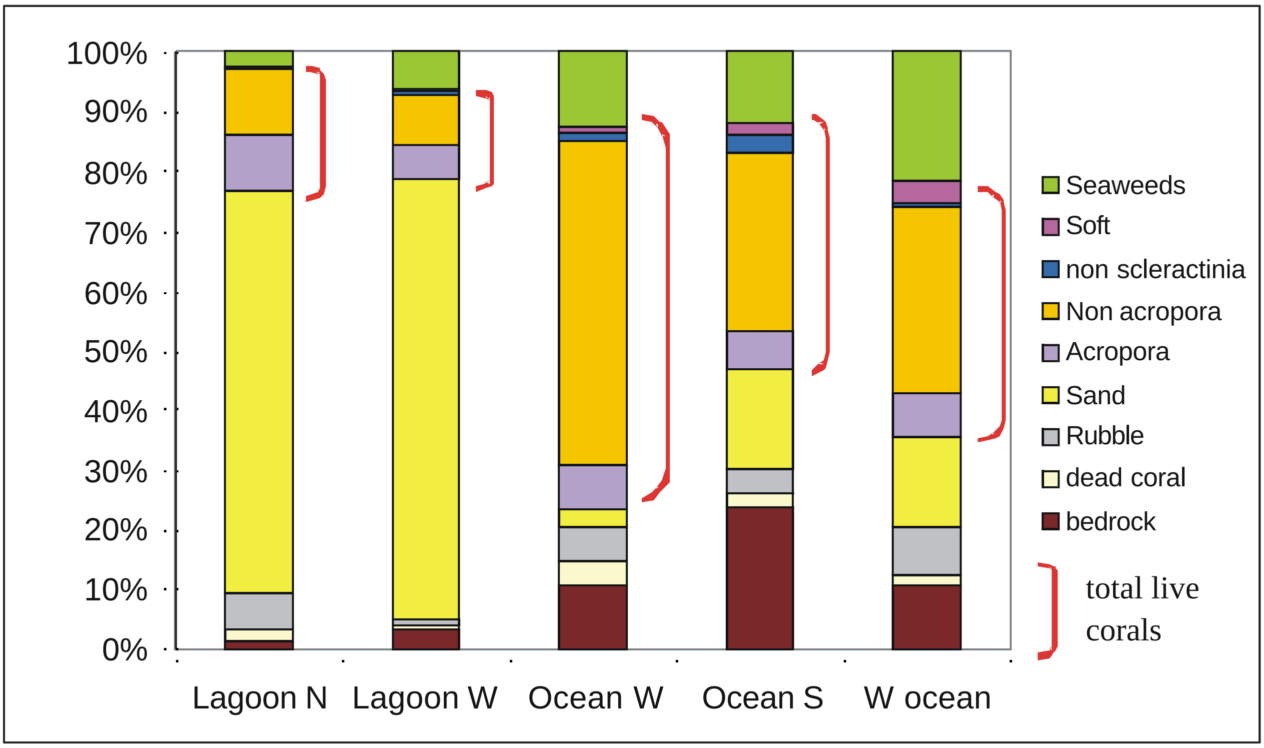
Table 9. Summary of differences of substrate coverage among substrata in five biogeographical locations. Values of p for each independent test are given. (L = lagoon; O = Ocean). Bold characters indicate statistically significant results (p<0.05).

	Dead coral	Bed-rock	Rubble	Sand	Sea-weeds	Total live corals	*Acropora*	Non *Acropora*	non scleractinia	Soft
K-W p	0.3	**0.0002**	**0.04**	**0.0003**	**0.005**	**0.0004**	0.31	**< 0.0001**	**0.006**	0.30

The proportions of substrata varied for different bio-geographical zones (Figure 10). Sites at Jaboan point were an exception as they contained both lagoon and ocean features in one location. They were included with the Ocean West and Lagoon West zones.

Sand is the typical substrate of lagoon areas, while bedrock and live corals are the typical substrate of ocean sites. Non *Acropora* is characteristic of ocean areas, while *Acropora* does not present preferences, different species being adapted to either ocean or lagoon location. Ocean West zone supports the highest proportional coverage of non *Acropora* corals. In the zone Ocean South, off the Southern side of Rongelap-Rongelap island, and West Ocean – West off the South pass – we recorded more bedrock and sand compared to the Ocean West zone. This is probably related to higher exposure compared to the West Ocean (at the tip of the island and on East side of the pass). Seaweeds were of very low abundance at the northern lagoon locations.

Figure 10. Relative percentage of substrate coverage among 5 bio-geographical zones.



3.2.2 Coral target species

In the previous section we analyzed substrata coverage, which included coral target species in the total live coral cover. We here look more closely at patterns within the target coral assemblages. We selected 17 most abundant (highest record at a site > 10 %) or most recurrent (present at least at 5 sites) species or genera of coral (Appendix 1) and analyzed their distribution at the three depth layers, at the two locations lagoon and ocean, and among the six different geographical areas.

3.2.2.1 Depth

There was no significant preference of corals for certain depths from our data. All genera and species were distributed relatively homogenously across depths. Only *Acropora palifera/cuneata* has sharp depth preference and it is most abundant at the shallower layer (>10m; p k-w = 0.02, Figure 11).

Figure 11. Depth preference in *Acropora palifera/cuneata* (Cricketbat coral).

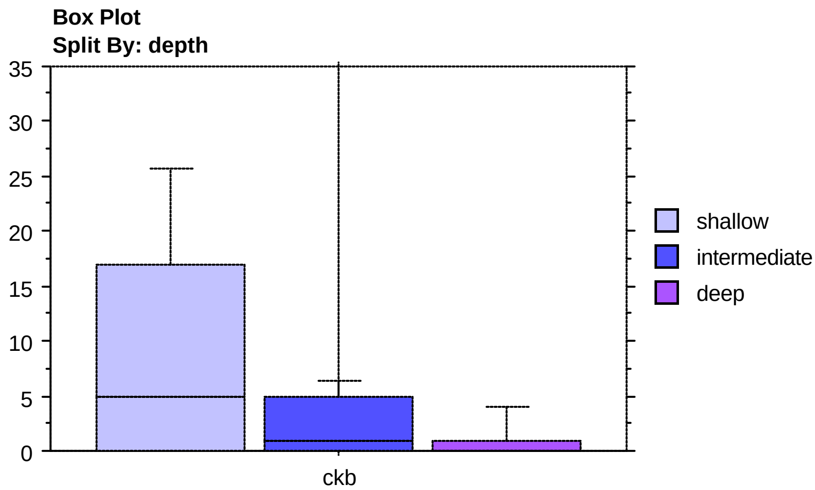


Table 10. Selected target coral species and genera for comparisons of coverage, based on abundance (highest record at one site > 10 %) and recurrence (present at least at 5 sites). Bold corals had presence > 15 and total abundance > 5%, used in the regional differences analysis.

Species or genus	Common name	Abbreviation	No. of sites present	Max coverage (%)
Acropora palifera/ cuneata	**Cricketbat coral**	**Ckb**	**22**	**32**
Porites lobata/austrlaliensis…	**Lobe coral**	**Lob**	**34**	**32**
Seriatopora hystrix	**Thorn coral**	**Th**	**22**	**22**
Porites cylindrica	**Gingerroot coral**	**Gr**	**19**	**18**
Montipora spp.	**Sand paper coral**	**Sdp**	**22**	**16**
Pocillopora verrucosa	**Medium Broccoli coral**	**Mbc**	**15**	**10**
Pocillopora damicornis	Broccoli coral	Bc	12	9
Stylophora pistillata	Finger coral	Fn	11	8
A. subglabra/echinata/speciosa	Bottlebrush *Acropora*	BB	6	8
Favites spp.	**Crater coral sharing**	**Cs**	**20**	**7**
Favia spp.	**Crater coral with valleys**	*Cv*	**15**	**5**
Astreopora	**Volcano coral**	**Vo**	**26**	**6**
Heliopora coerulea	Blue coral	Bl	14	6
Pocillopora eyduoxi/…	Large Broccoli coral	Lbc	10	5
Leptastrea spp.	**Angular crater coral**	**Ac**	**14**	**5**
Oulophyllia spp.	Large brain coral	Lbr	11	3
Ctenactis echinata, Herpolita limax	Long mushroom	Lmu	11	2

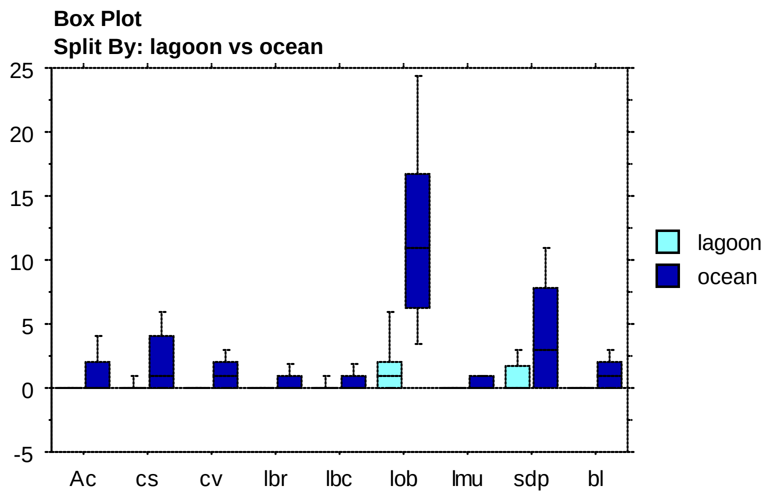
3.2.2.2 Ocean vs lagoon

Depending on habitat and physical conditions, differences in the coral communities in lagoon and ocean sites should be expected. The lagoon waters are shallower, and more turbid, and support mainly small patch-reefs on sandy substratum. Ocean waters are very clear, allowing light to penetrate deeper. Significant differences between these two locations were shown for *Leptastrea*, *Favites*, *Favia*, *Oulophyllia*, *Pocillopora eyduoxi*, *Porites* massive, C. *echinata*/*H. limax*, *Monitopora* and *Helipora coerulea* (in bold in Table 11). All of these corals are significantly more abundant at the ocean sites. The differences between these corals were often due to a lack of species or genera at sites inside the lagoon (Figure 12). This could be a function of the relative scarcity of patch-reefs which makes encountering them on a 50 m transect difficult. More likely, however, these species/ genera were less common or lacked on the small patch-reefs.

Table 11. Difference of abundance between lagoon and the ocean sites, analyzed by t-tests for the 17 most recurrent species and genera.

Species or genus	P t-test	Lagoon Mean	Lagoon Standard deviation	Ocean Mean	Ocean Standard deviation
A. palifera/cuneata (ckb)	0.2	2.2	8.2	5.2	6.4
Porites lobata/austrlaliensis **(lob)**	**<0.0001**	**1.6**	**2.4**	**12.3**	**7.8**
Seriatopora hystrix (th)	0.6	2.2	5.6	1.6	2.7
Porites cylindrica (gr)	0.15	1.2	2.8	3.3	5.1
Montipora spp. **(sdp)**	**0.02**	**1.0**	**1.7**	**4.1**	**4.7**
Pocillopora damicornis (bc)	0.09	0.07	0.3	0.9	1.8
Pocillopora verrucosa (mbc)	0.09	0.5	1.8	1.8	2.5
Stylophora pistillata (fn)	0.12	0.13	0.4	0.9	1.8
(bb) (bottlebrush Acropora)	0.4	0.2	0.6	0.6	1.7
Favites spp. **(cs)**	**0.003**	**0.2**	**0.4**	**2.1**	**2.3**
Favia spp. **(cv)**	**0.002**	**0.07**	**0.3**	**1.3**	**0.3**
Astreopora (vo)	0.3	0.9	1.6	1.5	1.4
Heliopora caerulea **(bl)**	**0.005**	**0**	**0**	**1.2**	**1.5**
Pocillopora eyduoxi/… **(lbc)**	**0.2**	**0.13**	**0.4**	**0.6**	**1.2**
Leptastrea spp. **(Ac)**	**0.01**	**0.07**	**0.3**	**1.3**	**1.7**
Oulophyllia spp. **(lbr)**	**0.01**	**0**	**0**	**0.6**	**0.8**
Ctenactis echinata, H. limax **(lmu)**	**0.04**	**0.07**	**0.3**	**0.4**	**0.57**

Figure 12. Differences of coverage between ocean and lagoon sites for selected species.



3.2.2.3 Geographical zones

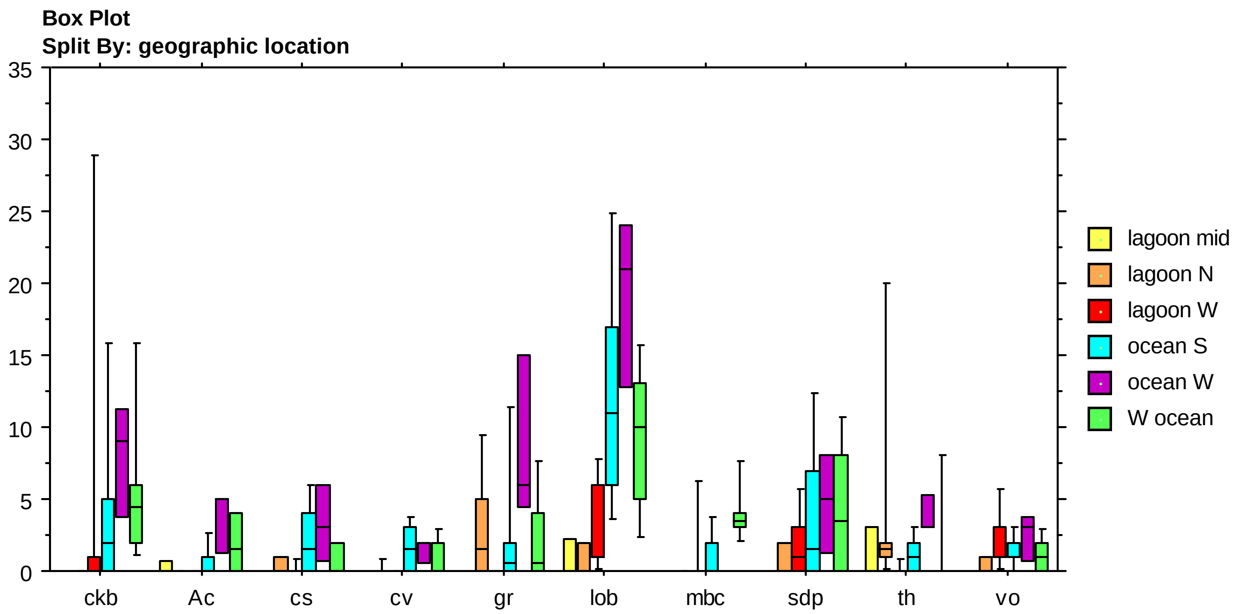
Among the 17 selected target species we specifically analyzed the ones that have presence > 15 and total abundance > 5% for differences among bio-geographical zones (compare Table 10), corals in bold). The selected corals showed some variation among the zones. We applied the Kruskal-Wallis test for multiple comparisons to illustrate the differentiations (Table 12).

Almost all the selected categories had preferential geographical locations, where they were more abundant than anywhere else. Only *Leptastrea*, *Montipora* and *Astreopora* were not significantly different among the regions. *Acropora palifera/cuneata*, (ckb), *Favites* (cs), *P. cylindrica* (gr), *Porites massive* (lob) and *Seriatopora hystrix* (th) showed higher abundance at the ocean west locations (OW) – off the Western tip of Rongelap-Rongelap. The genus *Favia* (cv) was more abundant at the Southern ocean (SO) locations and *Pocillopora verrucosa*(mbc) at the outer pass location (West ocean, WO, Figure 13).

Table 12. Difference of selected coral target species/genera among the zones. (P_{K-W} = probability value, P< 0.05 = significant).

Species or genus	Common name	Abbr.	P_{K-W}
A. palifera/cuneata	**Cricket-bat coral**	**Ckb**	**0.006**
Leptastrea spp.	Angular crater coral	Ac	*0.06- ns*
Favites spp.	**Crater coral sharing**	**Cs**	**0.004**
Favia spp.	**Crater coral with valleys**	*Cv*	**0.01**
Porites cylindrica	**Gingerroot coral**	**Gr**	**0.0002**
Porites lobata/australiensis…	**Lobe coral**	**Lob**	**0.0001**
Pocillopora verrucosa	**Medium Broccoli coral**	**Mbc**	**0.002**
Montipora spp.	Sand paper coral	Sdp	*0.24 – ns*
Seriatopora hystrix	**Thorn coral**	**Th**	**0.03**
Astreopora spp.	Volcano coral	Vo	*0.27- ns*

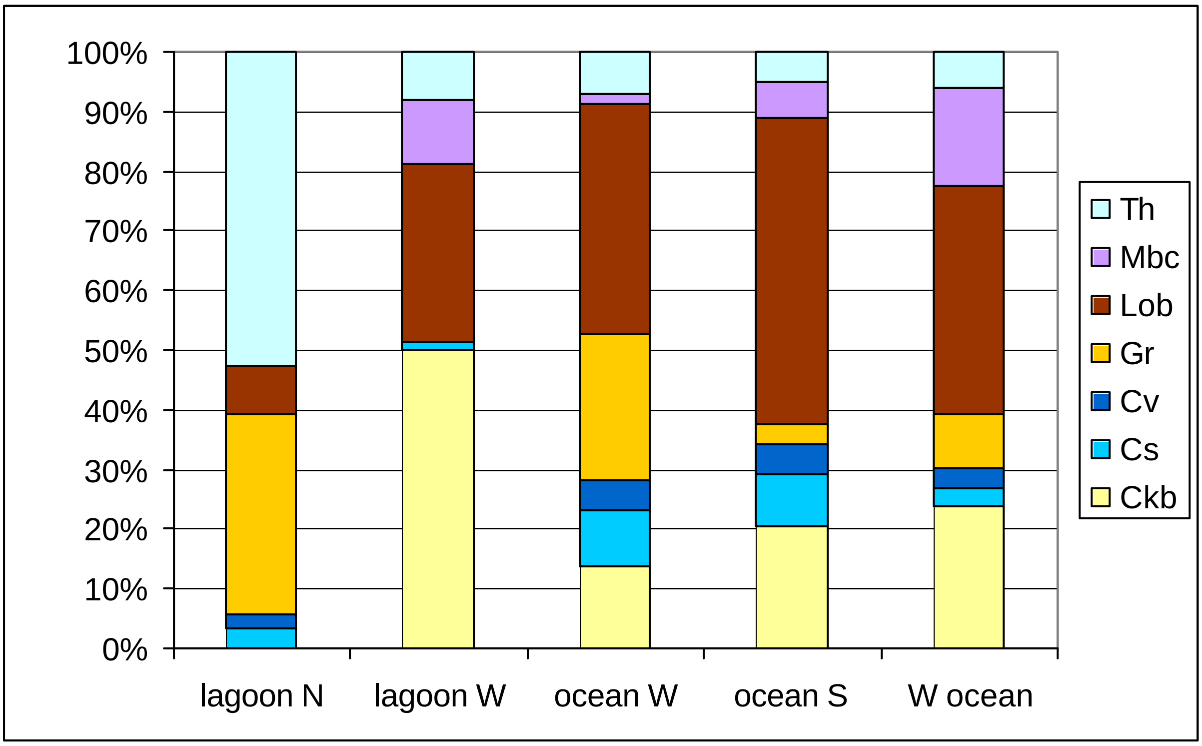
Figure 13. Difference of distribution of 10 selected coral species/genera among five bio-geographical zones.



We used these differences to describe the composition of each geographical zone by composition of most abundant and recurrent species and taxa (Figure 14).

The region at the North side of the island, on the lagoon side, is mostly composed by *P. cylindrica* (gr) and *S. hystrix* (th). The Western side of the island, on the lagoon side, is instead mostly composed by *A. palifera/cuneata*, especially around Jaboan Point, and *P. lobata/austr...*
All ocean regions had high coverage of both *P. lobata* and *A. palifera/cuneata*, but the Ocean West area (ocean side of Jaboan point) supported a higher coverage of *P. cylindrica* and less *Pocillopora verrucosa* compared to the other two regions on the ocean side. The region off the Southern pass (W ocean) showed higher coverage of *P. verrucosa* and less *Favia* and *Favites*.

Figure 14. Composition of each geographic zone by the selected coral species.



3.2.3 Fishes

The fishes counted to the level of species or genera along the transects were grouped by families. The most abundant and recurrent ones were analysed for comparison of their total abundance at the different sites (Table 13). The totally most abundant family were the Pomacentridae (Damselfishes). The second most abundant fish family is the Apogonidae (Cardinalfish) (Figure 15).

Table 13. Fish families that are most abundant (> 100). In bold the ones with strong ecological significance or commercial value.

English common name	Latin name	Total abundance	Total abundance / m^3
Damselfishes	Pomacentridae	6,478	0.126
Cardinalfishes	Apogonidae	1,787	0.035
Groupers	**Serranidae**	**847**	**0.017**
Surgeonfishes	**Acanthuridae**	**831**	**0.016**
Wrasses	**Labridae**	**619**	**0.012**
Mackerels	**Scombridae**	**536**	**0.010**
Parrotfishes	**Scaridae**	**410**	**0.008**
Fusiliers	**Caesionidae**	**320**	**0.006**
Butterflyfishes	**Chaetodontidae**	**255**	**0.005**
Jacks	**Carangidae**	**204**	**0.004**
Snappers	**Lutjanidae**	**199**	**0.004**

Figure 15 shows the relative abundance of the all fish including cardinalfish and damselfish, clumping together the rest of the families. The high predominance of these two families in terms of numbers is clear in this graph. Figure 16 shows the percentage of total abundance of the major fish families (excluding Damselfish and Cardinalfish, that are the most abundant ones but have almost no commercial significance). Surgeonfish (Acanthuridae), Groupers (Serranidae), Makerels (Scombridae) (including some reef visiting tunas) and Parrotfish (Scaridae) were the most important in terms of abundance. However, the high abundance of Makerels was due to one observation at R13, off the Southern pass.

Figure 15. Relative abundance of the all fish including cardinalfish and damselfish, clumping together the rest of the families. This graph shows the high predominance of these two families in terms of numbers.

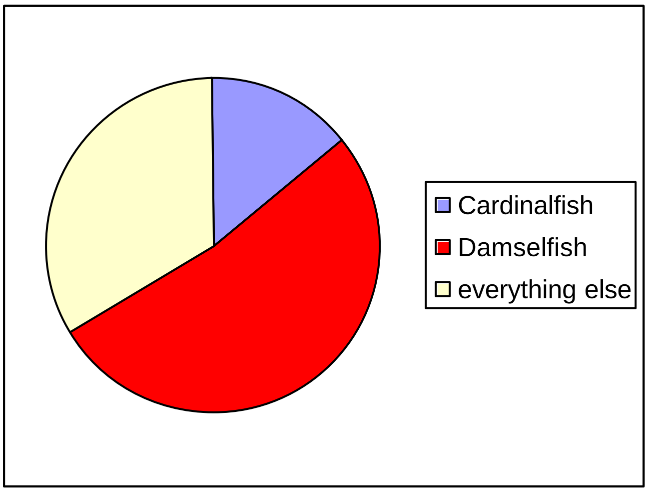
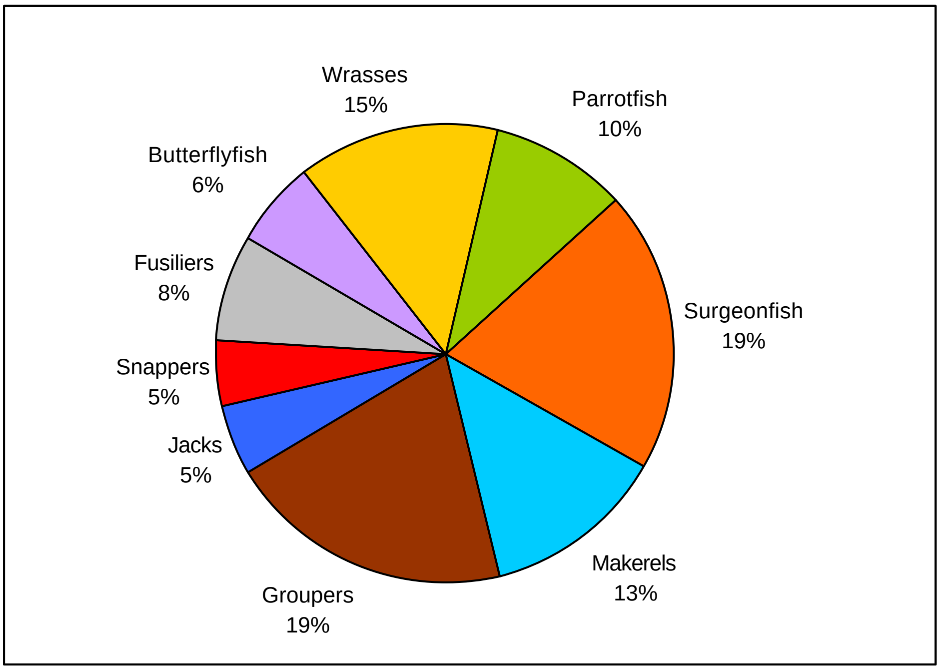


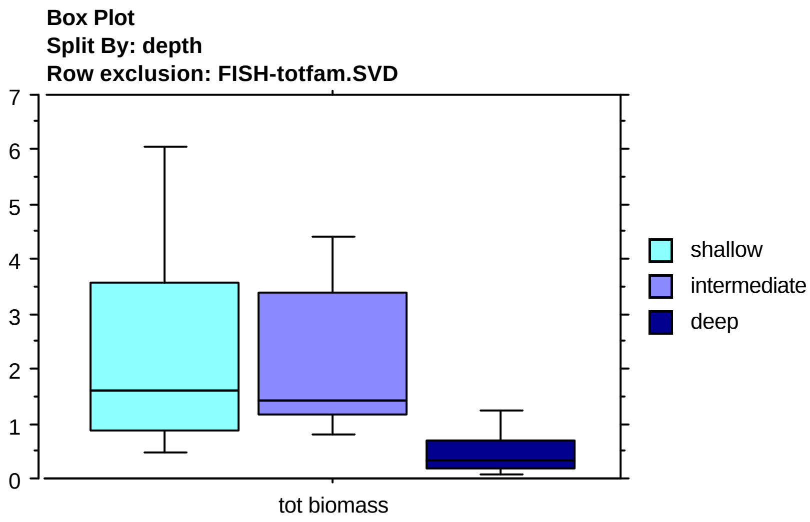
Figure 16. Relative abundance of the most important fish families in percent.



3.2.2.4 Depth

None of the fish families showed preference of depth in the depth range adopted in the surveys. However, biomass was significantly higher (P_{K-W} = 0.0009) at the first two layers (between 5 and 15 m, approximately), meaning that larger sizes of fish were found at this depth (Figure 17).

Figure 17. Distribution of total fish biomass at the three layers (p_{K-W} = .0009).



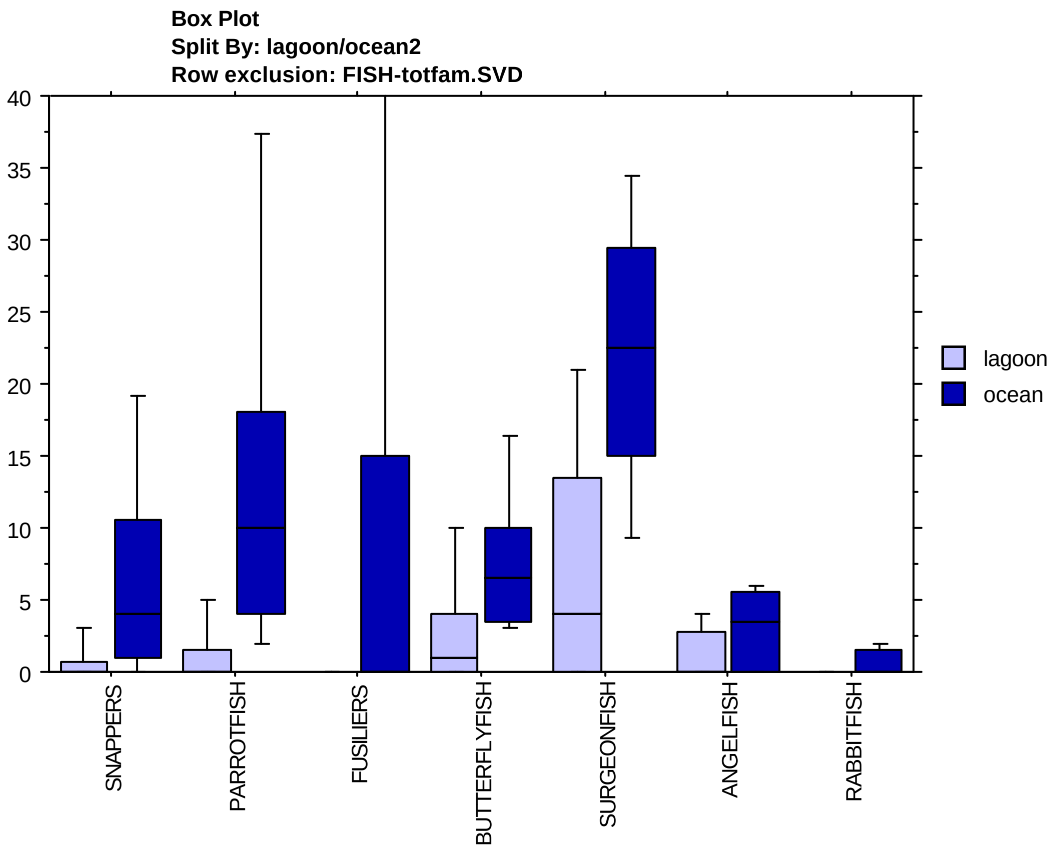
3.2.2.5 Ocean vs lagoon

Snappers, Parrotfishes, Fusiliers, Butterflyfishes, Surgeonfishes, Angelfishes (total abundance <100, in italics in Table 14), Rabbitfish (total abundance < 25, in italics in Table 14), showed significant differences in between the two zones. All of these fish families were more abundant in the ocean side (Figure 18). Angelfishes and Rabbitfishes were included in this analysis, although their abundance is less than 100 total counts, because they displayed a significant difference between the two habitats.

Table 14. Abundance of fish families showing difference of distribution between lagoon and ocean sites.

Family	$p_{t\text{-test}}$	Lagoon		Ocean	
		Mean	St Dev	Mean	St Dev
Surgeonfishes	0.01	8.9	13.6	27.4	24.6
Parrotfishes	0.05	2.3	6.4	19.1	32.4
Fusiliers	0.05	0	0	12.6	23.6
Butterflyfishes	0.05	3.8	7.0	7.7	5.2
Snappers	0.02	0.78	1.5	7.0	9.5
Angelfishes	0.02	3.8	7.0	7.7	5.2
Rabbitfishes	0.04	0	27.4	0.8	1.4

Figure 18. Distribution of total abundance in lagoon and ocean sites for the most abundant families. Numbers are average values.



3.2.2.6 Geographical zones

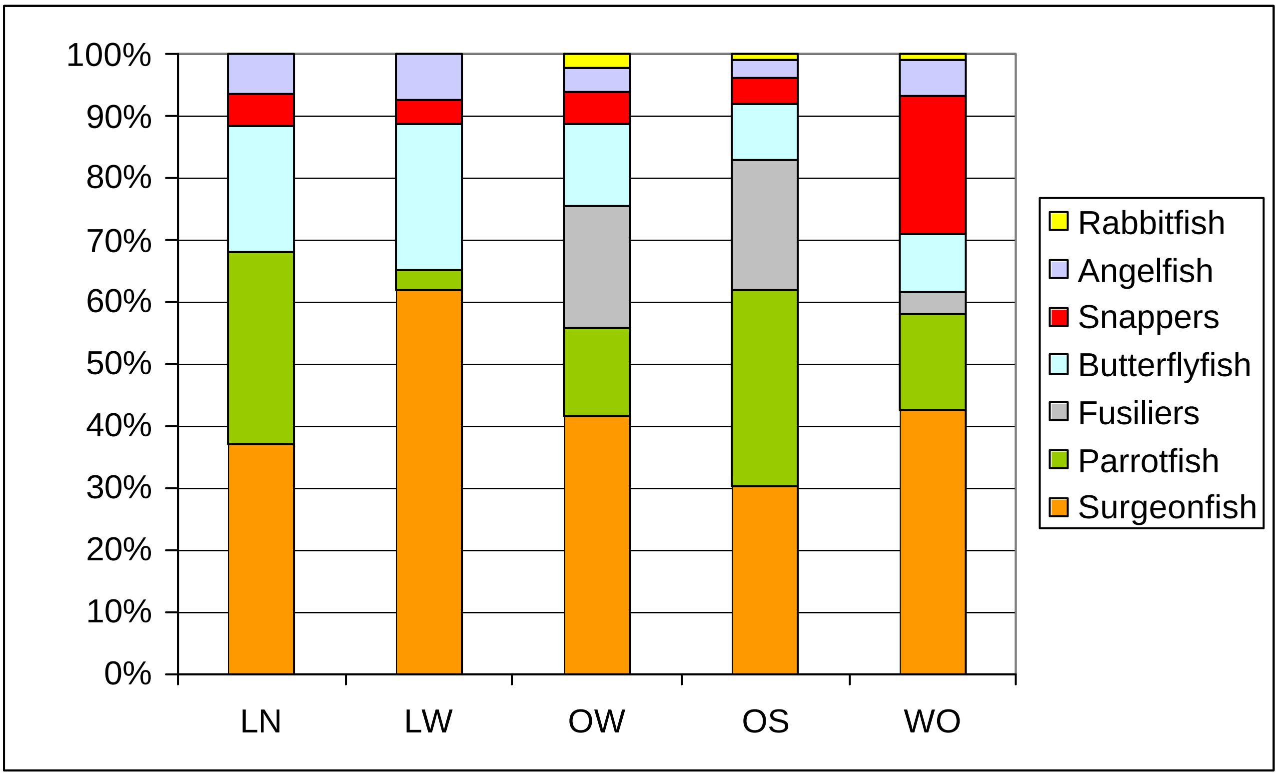
Varied fish assemblages were expected in the five distinct regions, as there were both differences in habitat and coral communities. The Kruskal-Wallis multi-comparison test to analyze difference in distribution among the five geographic zones resulted positive for 6 families (Table 15). This means that fish communities differed between the locations.

Table 15. Distribution of fishes among five zones, PKW<0.05 = significant.

Latin name	English common name	P_{KW}
Acanthuridae	Surgeonfish	0.004
Scaridae	Parrotfish	0.001
Chaetodontidae	Butterflyfishes	0.03
Lutjanidae	Snappers	0.0003
Pomacanthidae	Angelfish	0.01
Serranidae	Emperors	0.001

Each bio-geographical zone showed a distinct species composition (Figure 19). Surgeonfishes had a very irregular distribution, and they were found in large abundance in both lagoon and ocean sites. Lagoon regions had proportionally more butterflyfishes than the ocean regions. Rabbitfishes lacked in the lagoon areas, however they were seen on fish diversity surveys, which covered a larger area. The Northern lagoon zone contained a relatively abundant parrotfishes assemblage. Amongst the ocean areas, West Ocean (off the Southern pass) had the least relative abundance of Fusiliers and more Snappers. The Ocean South area held a comparatively higher number of Parrotfish than the other ocean areas.

Figure 19. Average abundance distribution of fish families among the five zones.

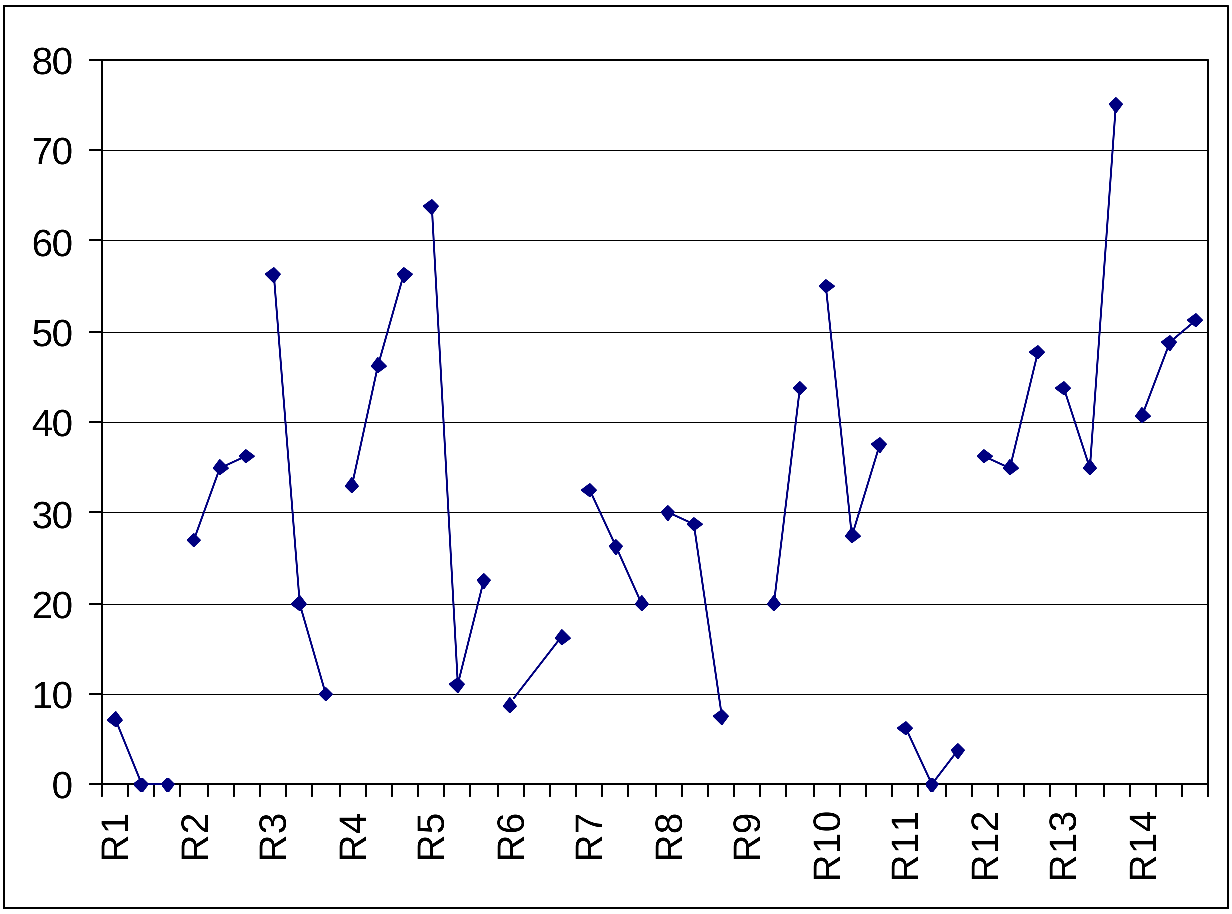


3.2.4 Seaweeds

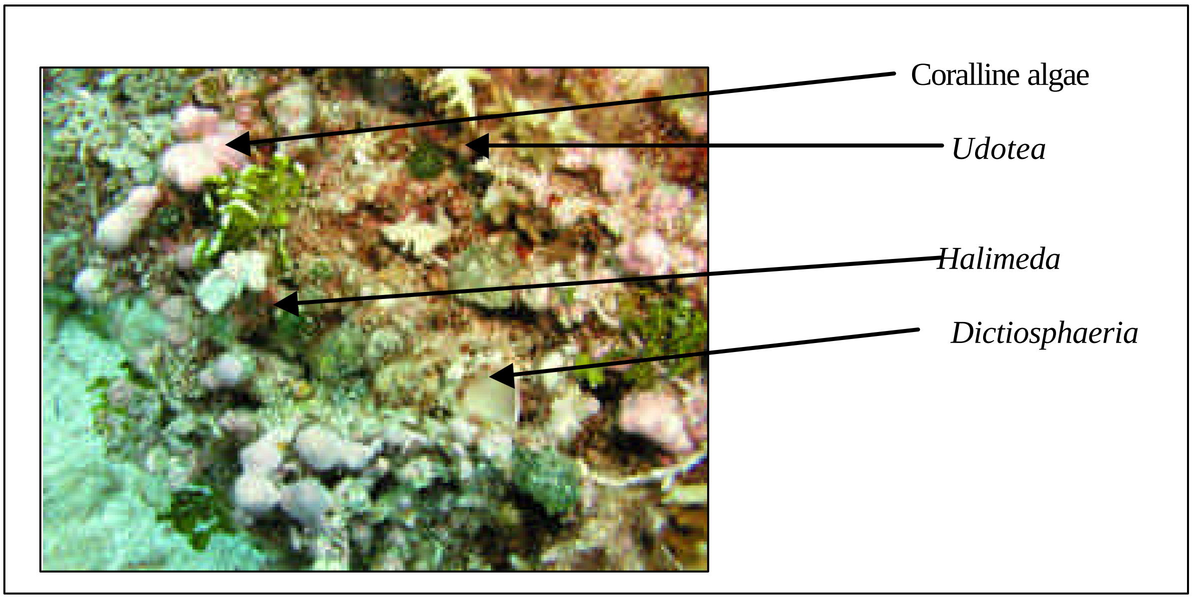
The total coverage of seaweeds varied between 0% and 75%. Ocean sites appeared in certain areas to be fairly covered by algae, but not to the point of overgrowing the corals (Figure 20). The most common seaweeds (in terms of presence and abundance) were *Micriodyction*, *Halimeda*, *Udotea/Avrainvillea* group, red coralline algae, and blue-green algae.

Macroalgae communities on rock substratum were very diverse (Photograph 3). Most overhangs and caves were dominated over by several species of *Halimeda*. *Microdyction* competes with *Halimeda*, but these two main seaweeds cover different depth layers, with *Microdyction* usually deeper than *Halimeda*. *Halimeda* is a genus that is able to invade any habitat, from sand flats, to caves, bedrock, dead coral, overhangs, and at any depth (Photograph 4).

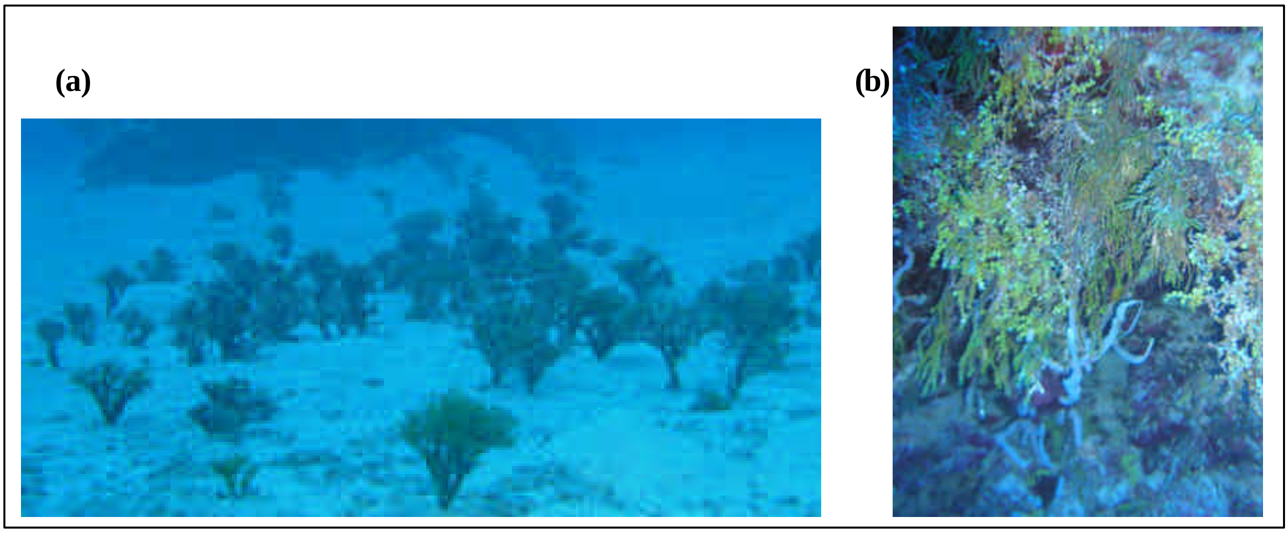
Figure 20. Seaweed cover (in %) at all sites, missing values for sites R6 and R9. Lines connect three transects in each site. R6 and R9 miss data from one transect.



Photograph 3. Algae assemblage with a high diversity of coralline algae and fleshy algae.



Photograph 4. *Halimeda* (a) on sand, and (b) in overhang on reef wall.



Algae data were collected by target species/genera list. We selected algae present at more than 10 sites for the subsequent analysis (Table 16).

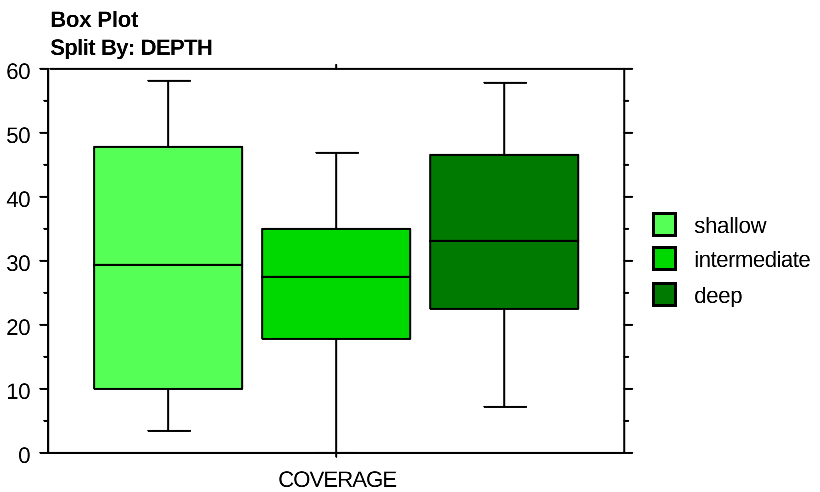
Table 16. Frequency of seaweeds in quadrats at all sites. In bold are algae present at more than 10 sites.

Latin name	Common name	Number of counts
Microdyction	**gauze seaweed**	**51**
Halimeda	**sand seaweed**	**111**
Udotea/Avrainvillea	**fan seaweed**	**41**
Lithophyllum	**coralline pink**	**20**
***Phormidium* sp**	**purple hairy**	**41**
Dictyosphaeria cavernosa	large bubble	1
Dictyosphaeria verslusii	small bubble	1
Venticaria ventricosa	sinking dark marble	1
Caulerpa serrulata	saw-blade	7
Caulerpa racemosa	sea grape	5
Caulerpa sertularioides	feather	1
Caulerpa	little daisy	1
Codium spp.	green velvet	2
Neomeris annulata	green finger	1
Enteromorpha cf	green filamentous	2
Jania spp.	purple spikes	1
Asparagopsis spp.	red fringy	1
Oscillatoria sp.	Red mat	2

3.2.4.1 Depth

The coverage of seaweeds does not change substantially among the three depth layers (Figure 21). This indicates a homogeneous distribution of macroalgae across the depths. However, it is likely that algae communities would change if deeper depths were included. The very clear waters around Rongelap- Rongelap island probably meant that the expected community shift could not yet be detected at 18 m depths.

Figure 21. Variation of seaweeds coverage among the three depths, in % coverage.



3.2.4.2 Ocean vs Lagoon

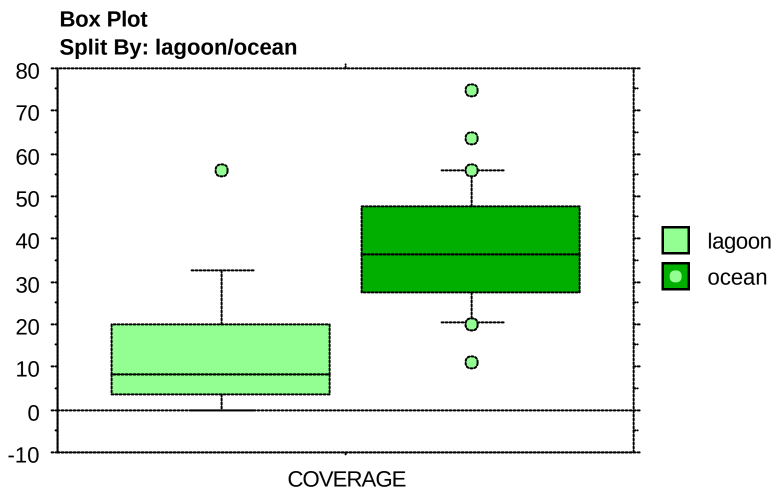
Both coverage and number of identified species were significantly more abundant at the ocean sites, as shown in Figure 22. In the lagoon, they were found on sandy substrate as well as boulders and bommies.

Figure 22. Statistical characteristics of algae coverage in lagoon and ocean sites, (a) mean algae coverage and probability value associated to *t*-test (P), (b) difference in algae coverage.

a)

P < .0003	lagoon	ocean
Mean	13.9	38.7
Std. Deviation	15.6	14.5

b)



3.2.4.3 Geographical zones

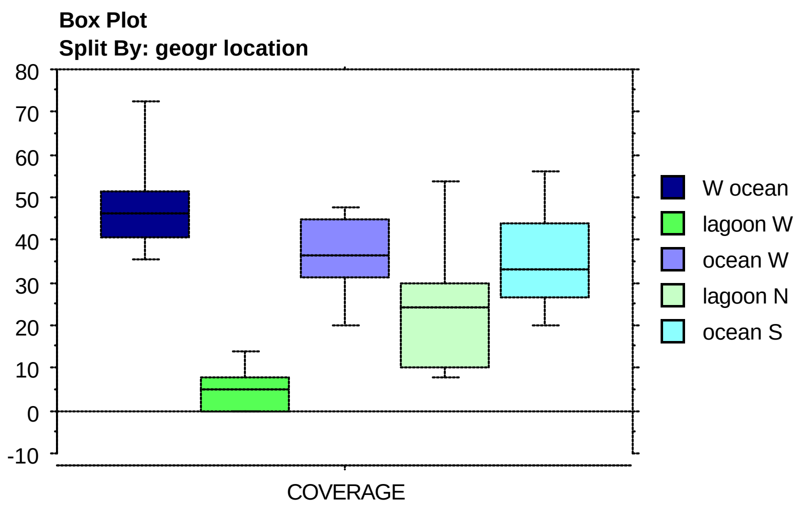
When studying the coverage of total seaweeds among the five geographical zones, we discovered sharp differences in the algal communities and coverage (Figure 23 and

Table 17). Value of *p* for the Kruskal-Wallis test of multiple comparison = 0.0002. Total coverage was highest at the West Ocean sites (west off of Southern pass), and lowest at the lagoon west sites.

Table 17. Values of mean and standard deviation for total coverage of seaweeds in percent (StDev= standard deviation, P_{KW} = probability value associated with the Kruskal-Wallis test of differences among groups average values). P = 0.0002.

Geographical area	Coverage (%)	
Lagoon N	Mean	25.4
	StDev	17.7
Lagoon W	Mean	5.3
	StDev	5.6
Ocean W	Mean	36.6
	StDev	10.7
Ocean S	Mean	35.3
	StDev	14.6
W Ocean	Mean	49.1
	StDev	13.9

Figure 23. Difference of algae coverage among the five bio-geographic zones.

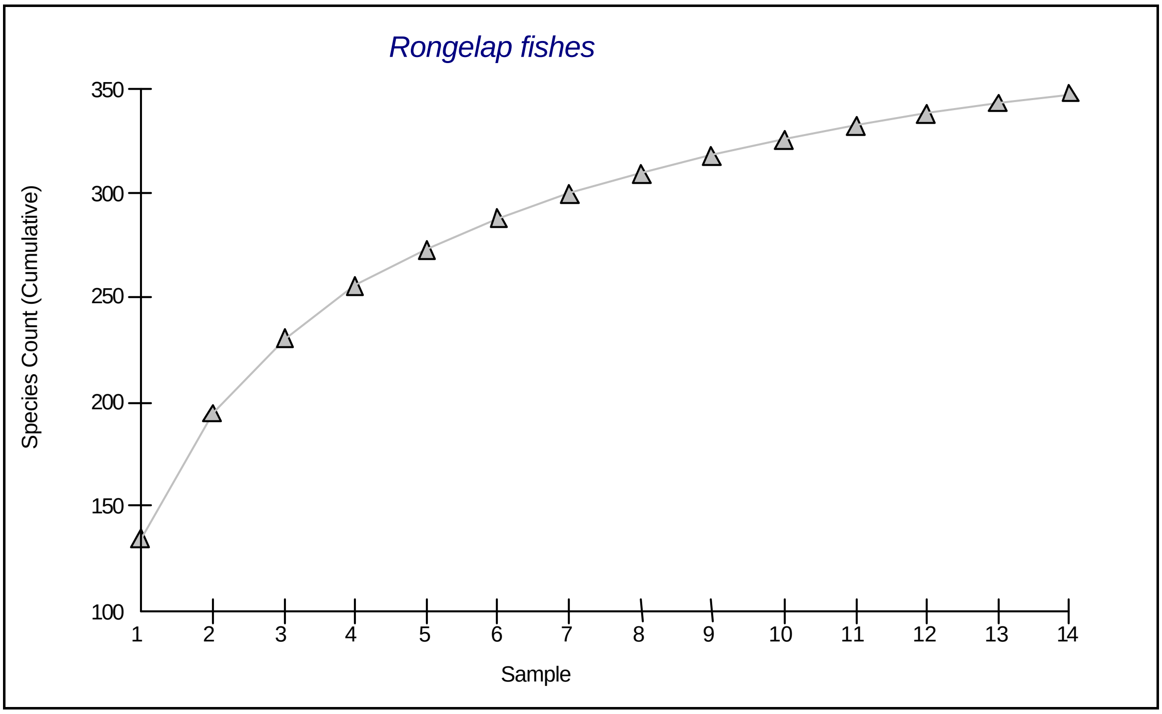


3.3 Diversity data

3.3.1 Fish diversity

A total of 361 fish species were recorded from Rongelap atoll. They were observed on dives at 14 sites, additional dives and snorkels undertaken in the area. Fishes observed on the 14 sites exclusively amount to 339 species. With higher sampling effort a much higher total species number can be expected. Randall and Randall (1987) report 817 reef, shore and epipelagic fishes from the Marshall Islands, Allen (2002) refer to a total of 795 reef fishes for the Marshall Islands overall. The species accumulation curve from this survey suggests that a high number of additional species can be expected if the area is increased and more dives are carried out (**Figure 24**). Assuming that each dive adds a few new species to the accumulated total number, after around 50 to 60 dives a plateau is reached for a small regional setting such as an embayment, atoll or group of islands. At the plateau, only 1 to 2 species are added per dive (Fenner, pers.comm., Beger, unpublished data). At Rongelap we were still adding 10 to 15 species per dive. In order to compile a comprehensive fish species list for the entire Rongelap atoll, a wider range of sites must be sampled. Considering the small size of Rongelap Rongelap, however, it is indicative of the health and pristine condition of these reefs that we recorded more than half of the fishes known from the Marshall Islands.

Figure 24. Species-area accumulation curve for fishes of Rongelap atoll for 14 sites, data from single dives only.



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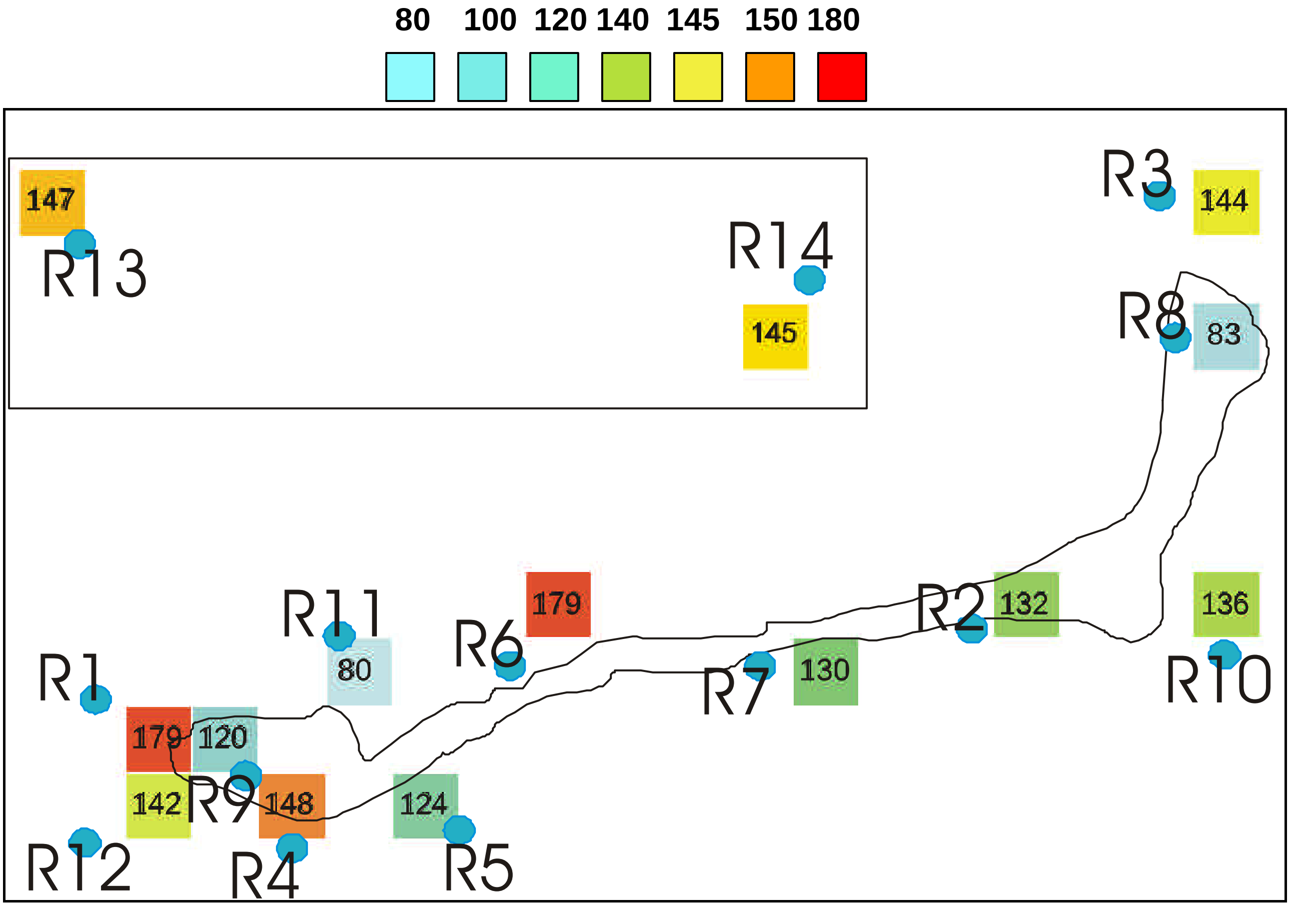
Amongst the sampled sites on Rongelap island and the southern atoll, species numbers per site varied greatly (Figure 25). The number of fish species at each site varied from 80 to 179, with an average of 135 species (28.5 Standard Deviation). The highest fish species counts with 179 species per site were reported at R1 in the pass at Jaboan and R6, a lagoon site. Lagoon sites vary greatly in their fish biodiversity, depending on the numbers, size and variety of coral mounds scattered on the sandy substratum. The outer wall sites on the oceanward side of the island supported a relatively uniform fish biodiversity. The tip of the island (R1 in Jaboan) supported a particularly high variety of fishes, because its variety of habitats includes both exposed wall and lagoonal features.

Figure 25. Fish species richness at sites on Rongelap Rongelap and southern islands (inset, for exact location compare Figure 6), numbers in colored squared represent total fish species richness on a color scale (red – richest, blue – poorest sites).



3.3.1.1 Community structure of fishes

The fish fauna of Rongelap atoll was mainly composed of species associated with coral reefs. The moray eel family (Muraenidae) was expected to be one of the most speciose groups (compare Randall and Randall, 1987). However on this project not many species were detected owing to their cryptic habits. They are best sampled using strong liquid ichthyocides such as rotenone, which were avoided on this trip to minimize impacts. Although the goby family (Gobidae) ranked highly amongst the families, it was not adequately sampled owing to their crypticism and small size. One of the shortcomings of the visual census methodology used on this survey is that it often fails to detect cryptic and nocturnal species. These species live in crevasses and caves, are extremely small, have a camouflaged color pattern or hide during the day.

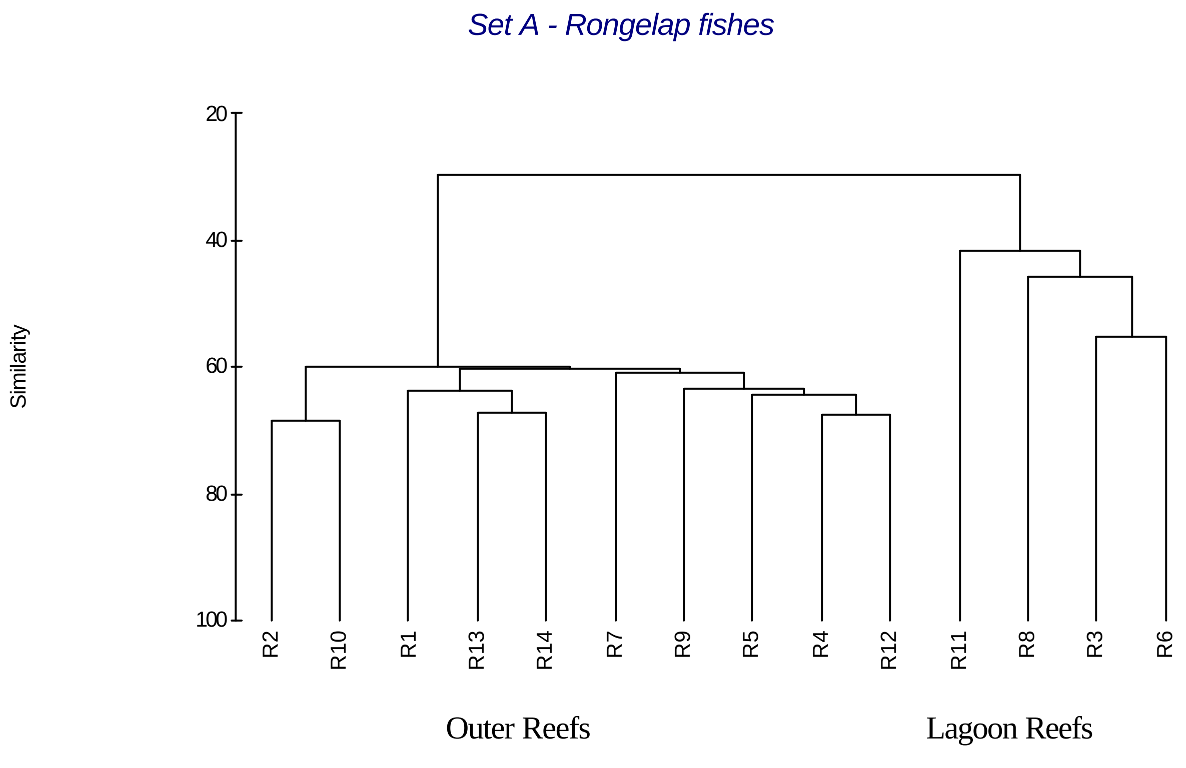
As mentioned above, we aimed to distribute sampling sites evenly between the sheltered lagoonal reef and the exposed outer walls. Fish communities are distinctly different at these parts of the atoll. The steep outer drop-offs harbor several epi-pelagic species such as Bluefin Jacks (*Caranx melampygus*) and Rainbow Runners (*Elagatis bipinnulata*). Several fishes only occur at the deeper section of the wall below 30 m of depth, such as Helfrich's Dartfish (*Nemateleotris helfrichi*) and Starck's Tilefish (*Hoplolatilus starki*). Other specialists are associated with the outer reef surge and are only found in the exposed shallows. Such species included, but were not limited to, the

Achilles Tang (*Acanthurus achilles*), the Whitespotted Surgeonfish (*A. guttatus*), mixed roaming schools of parrotfish (*Chlorusus frontalis, Scarus altipinnis, Cetoscarus bicolor*), and the Midget Chromis (*Chromis acares*).

The sheltered lagoon habitats supported different fish species, which were surprisingly diverse and abundant. Most fishes were found associated with patch reefs on the sandy substratum. Large schools of herbivorous fish were observed roaming between these coral bommies, usually these schools included surgeonfish and parrotfish. An abundant variety of groupers was found near and on the patch reefs. They were significantly more diverse in the lagoon sites than the outer sites. The most abundant species were the Highfin Grouper (*Epinephelus maculates*) and the Speckled Grouper (*Epinephelus cyanopodus*). A number of specialist species was reported from the sheltered shallow zone that only experiences mild surge. The most prominent species observed were sergeant damselfishes (*Abudefduf sordidus*) and the Grey Demoisielle (*Chrysiptera glauca*).

A cluster analysis based on Bray-Curtis similarity was used to determine community patterns in the fishes. The resulting dendrogram illustrates the distinctive separation of lagoon and outer reef habitats, which clustered with 42 percent and 60 percent similarity respectively (Figure 26).

Figure 26. Dendrogram of Bray-Curtis similarity illustrating distinct fish communities for lagoon and outer reefs.



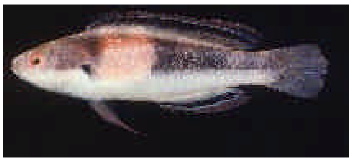
3.3.1.2 Endemism and Rarity

Considering the ability of marine fish larvae to disperse in the water column and travel with ocean currents, there are few endemic species on coral reefs compared to terrestrial environments. However, the Marshall Islands are relatively isolated in the Central Pacific, with the northern atolls being particularly remote. Huge distances to possible sources of larvae with few in between as stepping stones for species dispersal, a prevailing north-easterly wind and current and large distances between atolls have facilitated the development of several unique species of fish endemic to the Marshall Islands or the northern central Pacific. Endemic species are fished that only occur in a restricted geographical range.

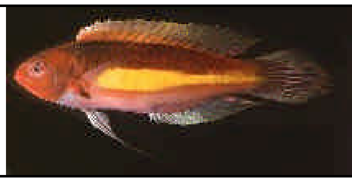
The following endemic species were observed:

Cirrhilabrus rhomboidalis (Randall) – This small wrasse is only known from the Marshall Islands, with specimen collected from Kwajalein. It only occurs below 40m (120ft) on outer reef slopes, and aggregates in groups above the substratum (picture from Fishbase, (2002).

Cirrhilabrus balteatus (Randall) – This small wrasse occurs in medium sized aggregations at a depth range from 10 to 25m on the outer exposed reef slopes, but also around larger patchreefs inside the lagoon. It is endemic to the Marshall Islands (picture from Fishbase, 2002).

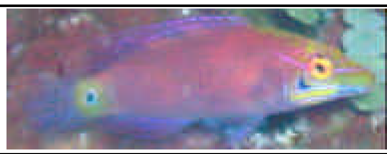


Cirrhilabrus luteovittatus (Randall) – This small wrasse occurs in medium sized aggregations at a depth range from 10 to 25m on the outer exposed reef slopes. It is only found in the Marshall Islands, Phonpei and the Caroline Islands (picture from Fishbase, 2002).



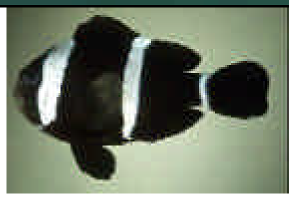
Cirrhilabrus sp. (possibly *katherinae*) – This small wrasse occurred on the outer drop-off on Rongelap Rongelap, and the southern islands (site R13). After consultation with John E. Randall from a picture we believe that the wrasse observed is either a new species, or a species not previously recorded from the Marshall Islands (*C. katherinae*).

Pseudocheilinus ocellaris (Randall) – This bright coloured wrasse is only found below 25m of depth under ledges and overhangs. It is wary and often difficult to see. It was only recently described from the Northern Marshall Islands (Randall 1999).



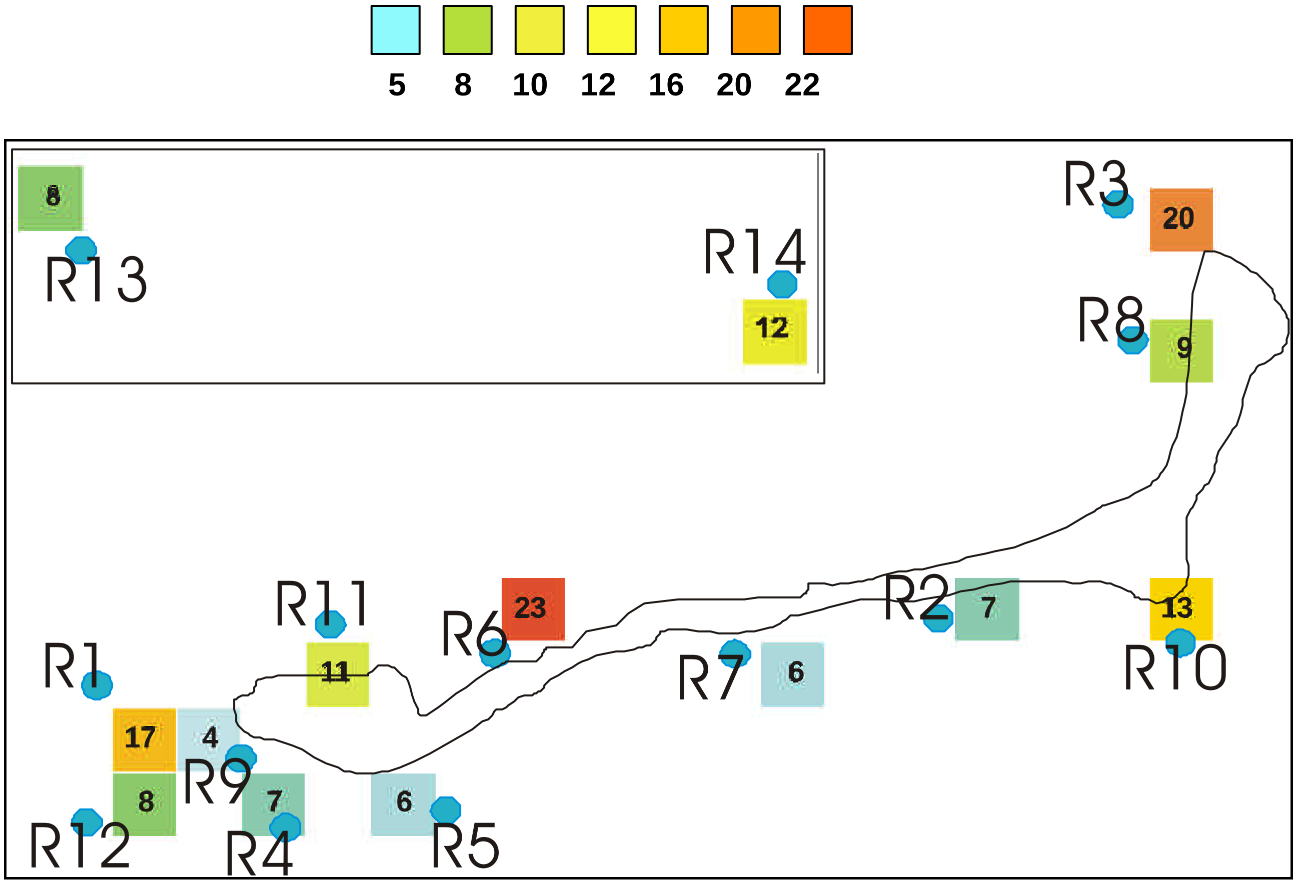
Pomachromis exilis (Allen and Emery) – The slender reef damsel is a shallow reef restricted range damselfish, which is only recorded from the Marshall Islands and the Caroline Islands (picture from Fishbase, 2002).

Amphiprion tricinctus (Schultz and Welander) – The three-banded clownfish is endemic to the Marshall Islands. It is relatively common around Rongelap and occurs associated with the anemone *Stichodactyla mertensi* (black fish) and *Heteractis aurora* (orange fish) (Fishbase 2002).



Rare species are fishes that only occur in relatively few spots on a reef, or are so cryptic that it is difficult to assess the probability of their presence at a given site. For coral reef ecosystems, there is little information on rarity and how to manage rare species. Recommendations on the conservation of rare fish species highlight the need to establish marine protected area networks incorporating the appropriate habitats (Jones et al., 2002). To demonstrate the potential locations of rare species on Rongelap atoll, we plotted the abundance of fishes that only occur once or twice throughout the whole dataset (14 sites, Figure 27). The hotspots for rare species richness do only partially overlap with total species richness.

Figure 27. Richness of rare fish species with the threshold of T=2 at 14 sites on Rongelap Atoll. The map shows how many rare fishes were reported from each site, numbers in colored squared represent rare fish species richness on a color scale (red – richest, blue – poorest sites)



3.3.1.3 Coral Fish Diversity Index (CFDI)

A leading expert in Indo-Pacific reef fish diversity recently devised a convenient method for assessing expected species richness in a site, a restricted geographic area or a region (Werner and Allen, 1998). Six relatively conspicuous and easy to identify fish families are chosen to calculate the Coral Fish Diversity Index: butterflyfishes (Chaetodontidae), angelfishes (Pomacanthidae), damselfishes (Pomacentridae), wrasses (Labridae), parrotfishes (Scaridae), and surgeonfishes (Acanthuridae). The number of species in these groups is added and inserted in a regression formula for restricted localities less than 2,000 km^2,

$$\text{Total expected fish species richness} = 3.39(\text{CFDI}) - 20.595 \quad (1)$$

that calculates the total expected species richness (Allen, 2002). The fish fauna in Rongelap atoll has a Coral Fish Diversity Index of CFDI= 172 (Table 18). The formula predicts a total expected species number of 562 fish species at Rongelap-Rongelap and the southern part of the atoll. This method enabled us to estimate fish species richness despite the low number of sites and the likelihood that rare or cryptic species were overlooked. It is likely that this number would increase with increasing reef area visited.

Table 18. Number of species from six target fish families at Rongelap atoll

Fish families	Number of Species
Butterflyfishes (Chaetodontidae)	24
Angelfishes (Pomacanthidae)	10
Damselfishes (Pomacentridae)	39
Wrasses (Labridae)	57
Parrotfishes (Scaridae)	16
Surgeonfishes (Acanthuridae)	26
Total CFDI	**172**

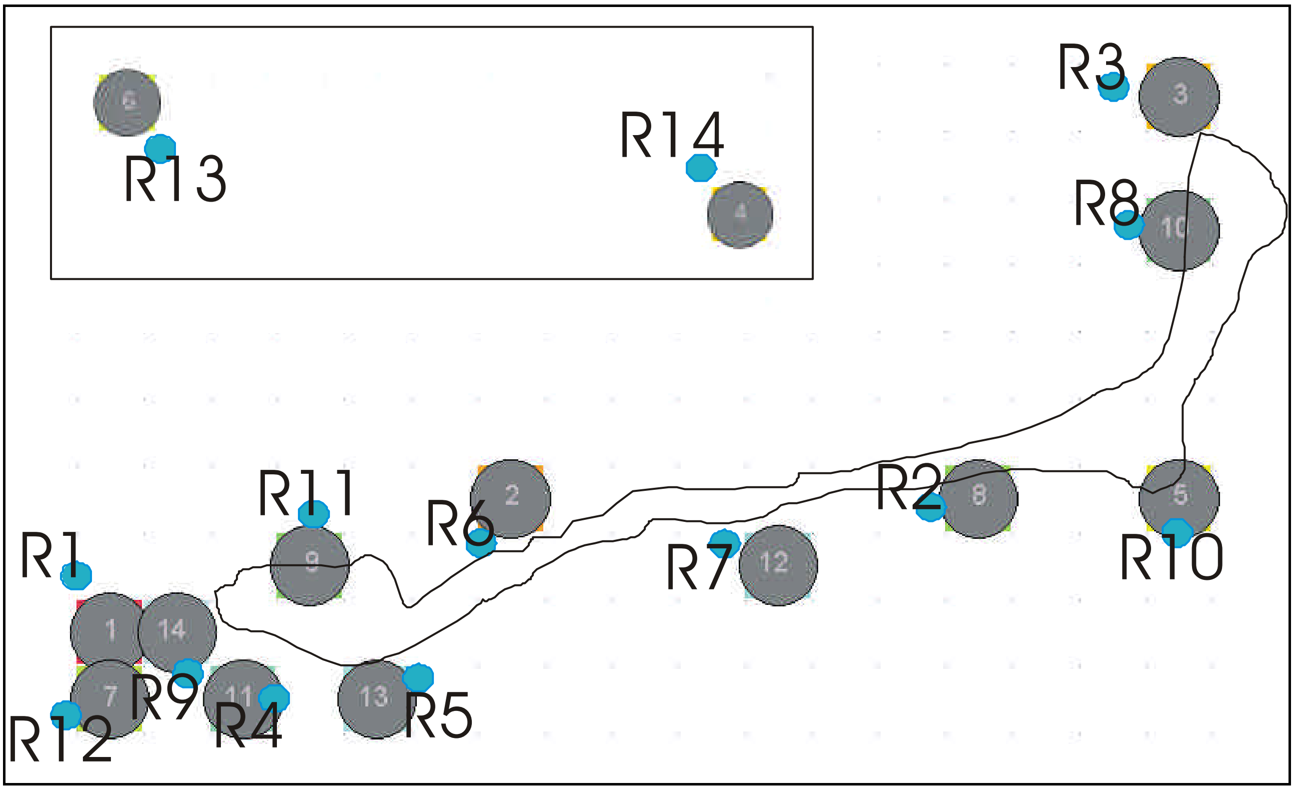
Allen (2002) refers to a CFDI of 221 in the RMI, derived from Randall and Randall (1987). This estimates a total of 822 reef fishes for the whole of the Marshall Islands (using a formula for large regions). Considering the small size of the island, our data captured a large proportion of these fishes, indicating the exceptional status of Rongelap reefs.

3.3.1.4 Marine reserves: Facilitating reef biodiversity conservation

Marine protected areas are a widely recognized means for both fisheries management and the conservation of biodiversity (Roberts et al., 2001, Roberts et al., 2002). It is still a young and little practiced approach to prioritize potential reserve sites by considering the conservation of marine biodiversity. However, procedures based on *complementarity*, where sites are selected to complement each other with respect to the species included in a reserve network, were shown to be most efficient (Beger et al., in press, Leslie et al., in press). We used the complementarity reserve prioritization method to highlight priority sites for coral reef fish conservation on Rongelap island (Figure 28). This illustrates that while the ocean sites support on average a higher number of fishes and more abundant species, the lagoon habitat forms an important ecosystem supporting many rare, habitat specific and cryptic species. In the reserve prioritization for fishes, the first site selected (R1) – a lagoon site- was one of the two sites with the highest species numbers. The second ranked site (R6) was a lagoon site with a highly diverse but distinct fish assemblage. The third site (R3) was also a lagoon site, which contained many rare species (threshold rarity, T=2). This indicates that the importance of lagoonal sites should not be underestimated.

While selection procedures based on diversity are effective for including a large proportion of fishes in a reserve network, there are significant limitations to these approaches. They do not take into account the likely persistence of species in protected areas. A species is considered represented when there is only one or a few individuals in a reserve, which is not likely to represent a viable population. They also do not consider socio-economic factors, fisheries and ownership of adjacent land.

Figure 28. Priority sites for the conservation of fish species richness



3.3.2 Coral diversity

The principle aim of the coral survey was to provide an inventory of coral species and compare the relative coral abundance and diversity at different sites with the view of selecting marine protected areas. The primary group of corals surveyed were the zooxanthellate scleractinian corals (those containing single-cell algae which contribute to building the reef). Also included were a small number of zooxanthellate non-scleractinian corals which also produce large skeletons which contribute to the reef {e.g. *Millepora* , fire coral; and *Heliopora*, blue coral), and a small number of azooxanthellate corals (*Balanophyllia* and *Stylaster*) which also produce calcium carbonate skeletons and contribute to reef building.

The results of this survey allow a comparison of the faunal richness of Rongelap atoll with other parts of the Pacific and S.E. Asia. However the list of corals presented is probably an underestimation, due to the limited number of sites sampled.

A total of 170 coral species were recorded from surveys of Rongelap atoll. Only 34 corals were previously recorded from Rongelap atoll (Wells, 1954). These results compare well to previous coral surveys in the Marshall Islands. Maragos (1994) found 269 species on a survey of several atolls in the northern Marshall Islands. A recent survey of the neighbouring atoll of Alinginae yielded 192 species (Maragos, pers.comm.). Rongelap atoll is the third largest atoll in the world. Reef survey sites were generally of two distinct types: exposed walls and lagoonal sites. Wall habitats comprised of a narrow fringing reef (up to 50 m wide) and reef crest interspersed with deep channels leading to a steep wall drop-off. Lagoon sites were composed of small patch reefs and bommie developments amongst sand. Further site information is provided elsewhere in this report.

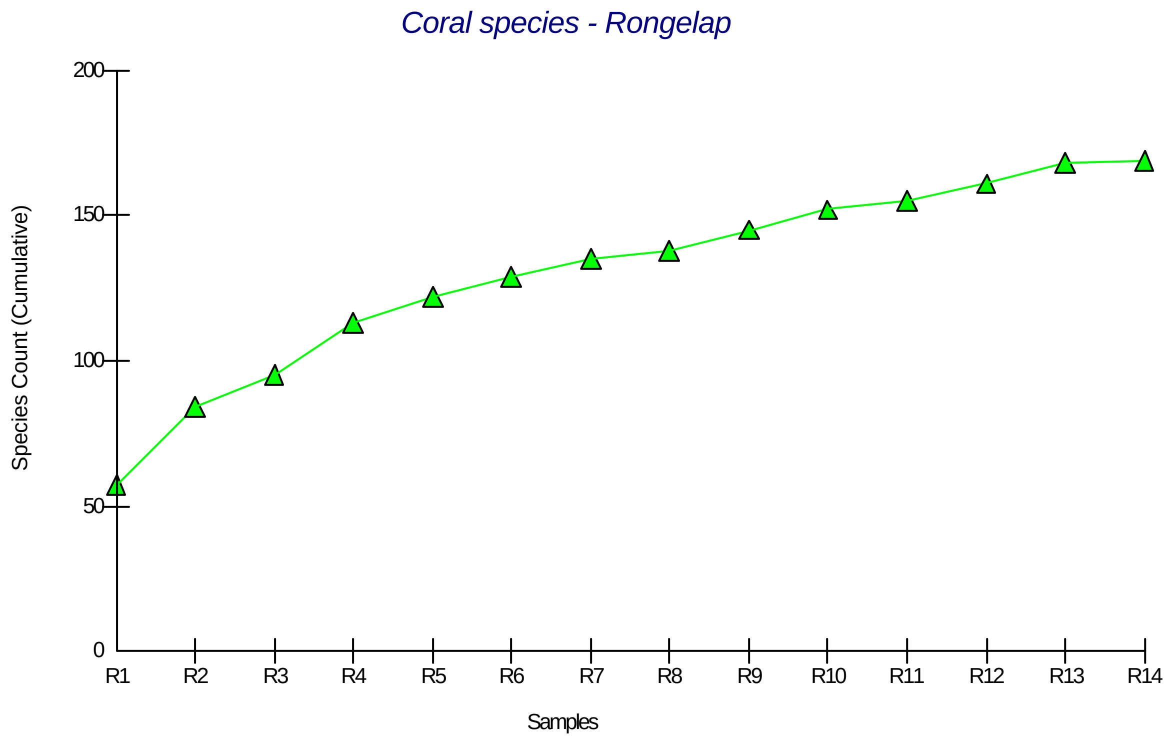
3.3.2.1 Coral Diversity

The coral fauna consisted mainly of Scleractinia. *Acropora* is the most speciose genus (Table 19) followed by *Montipora*. The total coral species richness for Rongelap atoll surpasses previous records (Wells, 1956), yet is still considered to be an underestimation of the actual total coral diversity of the entire atoll. The species accumulation curve (Figure 29) suggests that higher diversity would be expected if the sampling intensity were increased. Thus the entire atoll must be sampled in order to gain a comprehensive species list for Rongelap. Given the limited part of Rongelap atoll that was sampled in this study, the coral diversity is high with respect to the Marshall Islands as a whole which are estimated to have approximately 250 species of coral (Veron and Fenner, 2000), and Bikini atoll, which was surveyed as part of this project and where 198 species of coral were recorded (Richards, personal communication). It is suggested that reefs of Rongelap atoll are very healthy and some of the most pristine atoll reefs in the world.

Table 19. Genera with the greatest number of species.

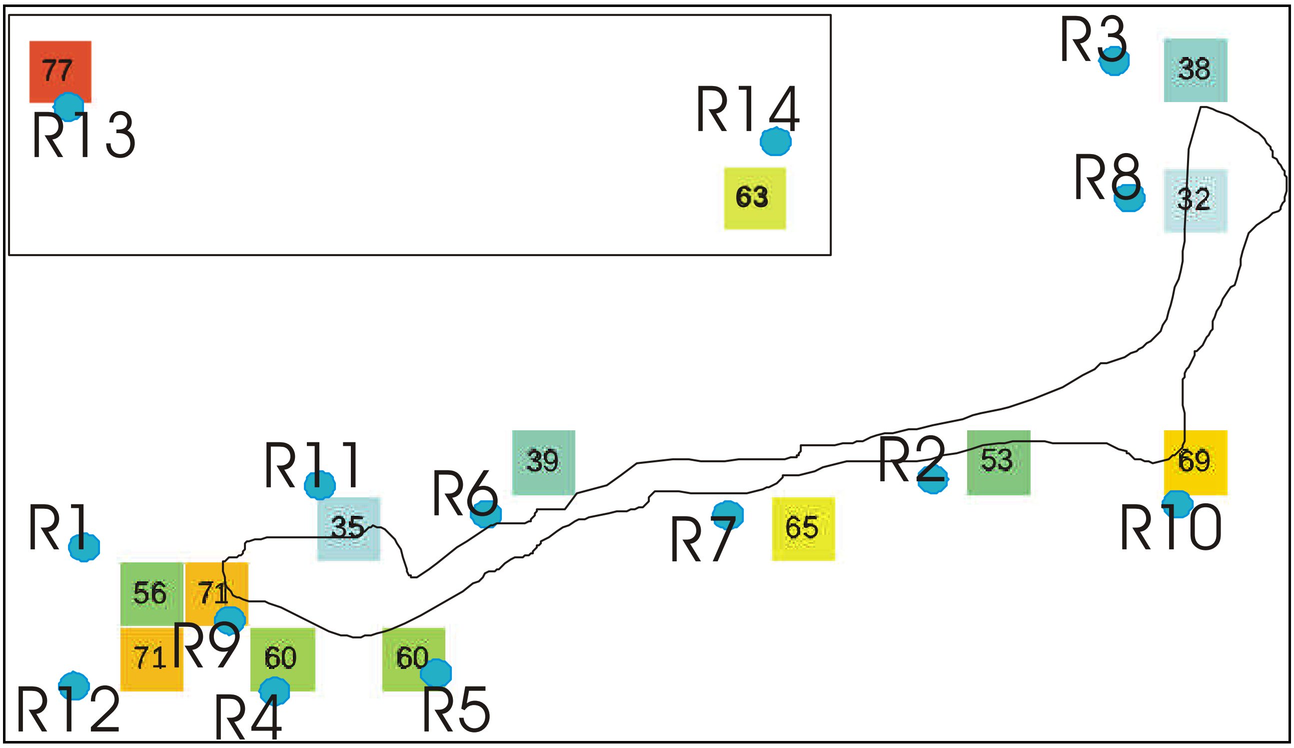
RANK	*GENUS*	*NO. SPP.*
1	Acropora	44
2	Montipora	21
3	Favities	7
3	Favia	7
3	Fungia	7
3	Porites	7
4	Psammocora	6
5	Pocillopora	5
6	Pavona	4
6	Hydnophora	4

Figure 29. Species-area accumulation curve for corals of Rongelap atoll for 14 sites.



Species numbers per site varied greatly with wall sites having consistently higher diversity than lagoonal sites (Figure 30). The southern island of Eniroruuri had the highest coral diversity with 77 species per site. The exposed wall at Jaboan pass has the highest diversity on Rongelap island (70 species). There is a distinct increase in coral species numbers around biogeographical features such as exposed points, where it is considered some accumulation of larvae may occur in the lee of currents.

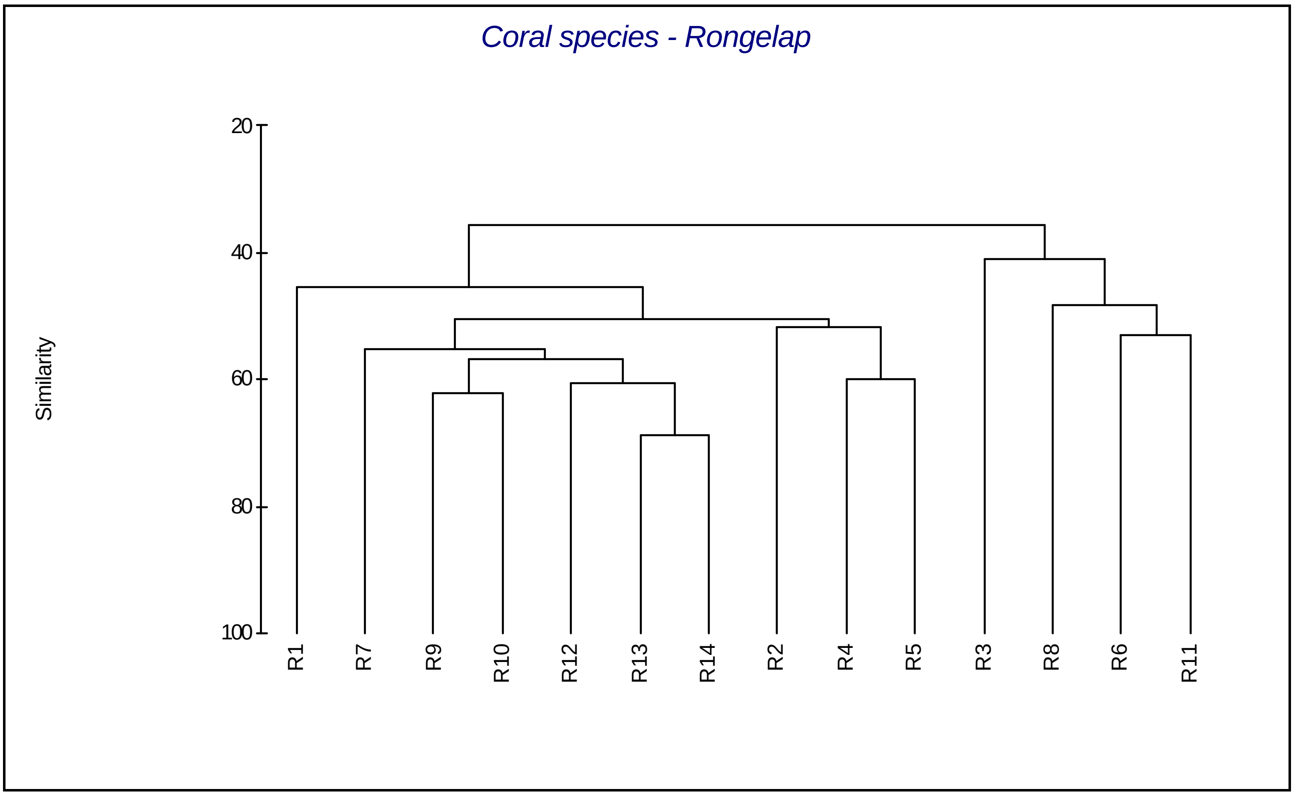
Figure 30. Coral species richness at sites on Rongelap Rongelap island and southern islands.



3.3.2.2 Coral community structure

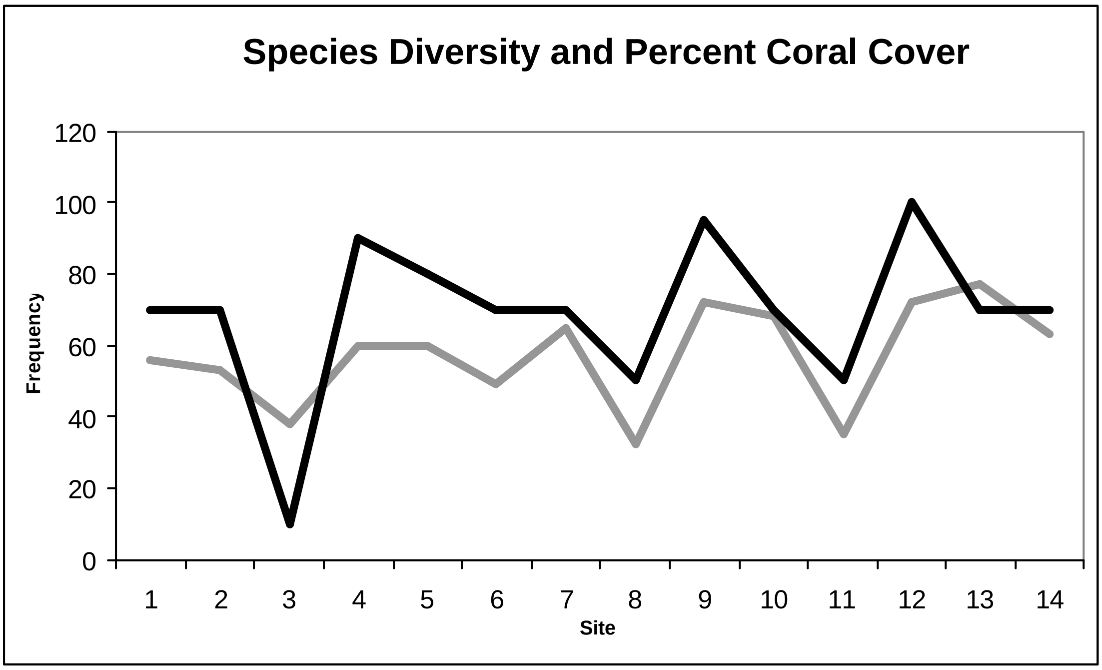
A cluster analysis based on Bray-Curtis similarity was used to determine community patterns in the corals. The resulting dendogram illustrates the distinctive separation of lagoon and outer reef habitats (Figure 31). Lagoonal sites (sites R3, R8, R6, R11) clustered together in a distinct separation from wall sites. The corals of Jaboan Pass (site R1) are placed apart from other wall sites, and the coral composition may indicate Jaboan Pass represents transitional habitat between wall and lagoonal locations. There is high similarity between the three high diversity of exposed wall sites (R12, R13, R14), which are adjacent to deep water passes and exposed to high water movement.

Figure 31. Dendogram of Bray-Curtis similarity showing distinct coral communities for lagoon (R3, R8, R6, R11) and oceanic wall reefs (R7, R9, R10, R12, R13, R14; R1 = Jaboan Pass).



11 out of 13 sites at Rongelap atoll had over 70% live coral cover (Figure 32). A higher coral cover correlated to a high coral diversity at most sites. Coral cover was only 10% on bommies at the northern tip of Rongelap island, but the species diversity was quite high compared with other lagoon sites. This result may be a reflection of the very shallow nature and high energy regime of this site, meaning that only very small isolated coral bommies persist.

Figure 32. Species diversity (gray) overlaid with percent cover (black), showing a correlation between diversity and percent coral cover at most sites in Rongelap Island.

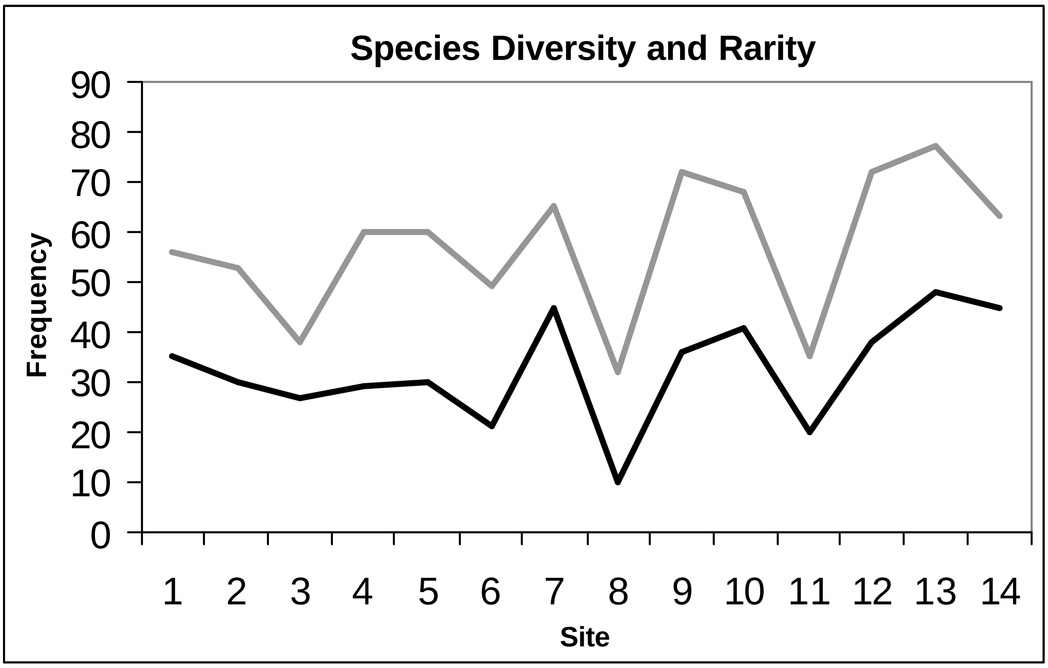


3.3.2.3 Endemism and Rarity

No coral species recorded were endemic to the Marshall Islands. Seven major range extensions were recorded in this study and many of these species were recorded from the Central Pacific Ocean for the first time. Further 9 minor range extensions were recorded for species that have not been recorded in the Marshall Islands before. Most of the species labelled “sp” are likely to be undescribed; these species require further study.

The sampling undertaken was insufficient to draw conclusions about the abundance and range of species recorded. However, the following analysis of rarity may provide insight into rarity patterns at Rongelap island. There are two key elements of rarity: geographic range and abundance. 20% of coral species at Rongelap atoll were locally rare in both the geographic and abundance senses. 56 % of coral species within coral communities at Rongelap atoll had a low relative abundance and occurred only once. A greater number of geographically rare species is not usually explained by the presence of greater diversity (Fenner, 2002, Jones et al., 2002). Results of this study do indicate however that the number of species with a rare relative abundance was closely related to the presence of greater diversity (Figure 33). This indicates that the community assemblage must be diverse to accommodate species with low abundances. 25 % of corals species at Rongelap atoll are site-restricted or geographically rare as they were recorded from one site only. It is expected that with further sampling this percentage will be reduced as a more comprehensive estimate of the abundance and range of these species will be revealed.

Figure 33. Plot of species richness (gray) versus rarity (black) at Rongelap atoll, showing the number of rare species (relative abundance) was related to overall diversity.



New Records for the Marshall Islands:

The following species were recorded from the Marshall Islands for the first time:

Acanthastrea brevis — This submassive coral was occassionally observed at lagoon and wall sites around Rongelap Rongelap but was not observed at the southern islands. Observed to growing as relatively small colonies, the very tall septal teeth of this species made it very conspicuous. This species is considered uncommon and was previously recorded from SE Asia, the West Indian Ocean and Red Sea. A voucher specimen of this species was collected and is housed at the Museum of Tropical Queensland.

Coscinarea monile — This encrusting coral has free margins and was observed at both lagoonal and wall sites at Rongelap Rongelap island. It was not observed at the southern islands. Colonies have a smooth surface due to the even and finely serrated septa. All colonies were a uniform brown color. This species is common in the western Indian Ocean but is considered uncommon in S.E. Asia. It has not previously been recorded from the Pacific Ocean. A voucher specimen of this species was collected and is housed at the Museum of Tropical Queensland.

Seriatopora dentritica — This compact bushy coral closely resembles *Seriatopora hystrix* but it has much thinner and more delicate branches. The fine branches have corallites that are aligned in rows down the branch. An adult colony of this species was observed only once at one wall location but was clearly distinguished from the *S. hystrix* which was growing nearby. This species is usually uncommon and has only been recorded from S.E. Asia, it has never been recorded from the Central Pacific.

Montastrea salebrosa — This coral normally grows as massive spherical colonies but at Rongelap island it was encrusting with free margins. Single colonies were observed from two exposed wall sites. This species has very circular corallites which are packed close together. The exert polyps (some more exert than others) which face different directions, and extensive extratentacular budding distinguish this species in the field. This species is considered rare and previously known only from SE Asia, the GBR and parts of the Western Pacific. A voucher specimen was collected and is housed at the Museum of Tropical Queensland.

Acropra loisetteae — This species has usually has an open branching growth form, but at the one lagoonal site on Rongelap island it had more of an arborescent table growth form. The thin curved branches with few radial corallites distinguish this species. It has not been recorded often in the literature so there is little known of its variability. It grows in lagoonal situations and often with other branching species. At Rongelap island it was brown in color with dark blue tips. This rare species has previously only been recorded from Malaysia and Western Australia. A voucher specimen of was collected and is housed at the Museum of Tropical Queensland.

Acropora nana — This corymbose species has very slender upright and non-tapering branches. It has evenly sized tubular radial corallites which are pressed against the branch, calice openings are round to oval with an upwardly extending lower wall. It was recorded from SE Asia, Australia, PNG, Fiji, Samoa and the Society Islands. Previous records from Northern Hemisphere Pacific Ocean localities were doubtful and this is the first verified identification from this region. The growth form of this species made it obvious in the field. It was located quite commonly in shallow reef edge locations along the exposed walls of Rongelap island and southern island sites. A voucher specimen was collected and is housed at the Museum of Tropical Queensland.

Acropora speciosa — This species grows as a side attached thin plate with fusing horizontal branches which give off tapering vertical branches. There are few radial corallites apart from around the base of branchlets. This species was recorded in small numbers from both lagoonal and wall habitats at Rongelap island. Within the lagoon it occurred at the base of walls on patch reefs. The tapering branchlets with narrow axial corallites distinguished this species in the field. Previously this species had been recorded from SE Asia, PNG, GBR and Fiji. Records of this species from Pacific Ocean localities in the Northern Hemisphere were doubtful and this is the first verified identification from this region.

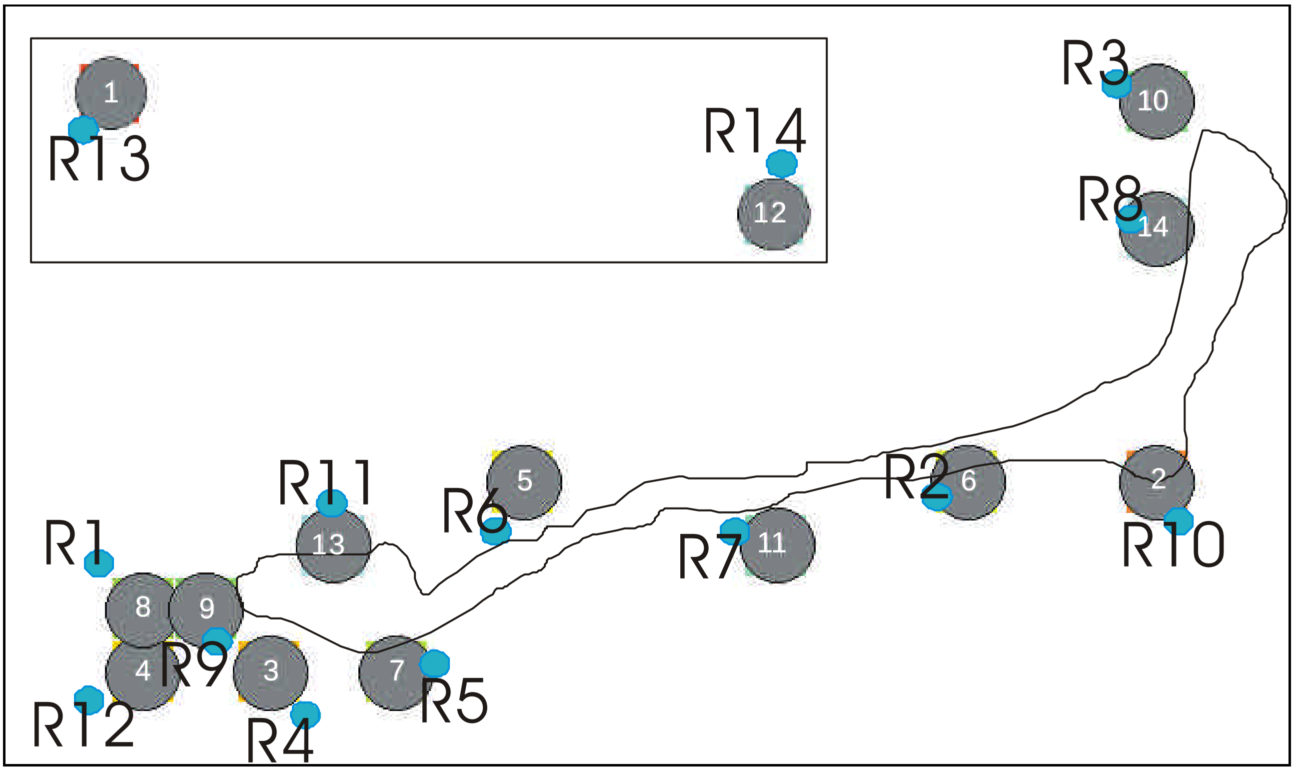
3.3.2.4 Coral Biodiversity Conservation

Increased human impacts have caused "massive and accelerating decreases in abundance of coral reef species and have caused global changes in reef ecosystems over the last two centuries" (Hughes et al., 2002). As a result, frequency and severity of coral bleaching and disease have also increased. Rongelap atoll is in the unique situation of being both a very remote atoll, and having very little recent fishing pressure or pollution. Stress responses such as coral bleaching or other disturbances were not observed in this study and have never been recorded at Rongelap atoll. Coral bleaching- even if very rare in the RMI- was however recorded in Majuro for the first time in the past ten years, in 2002 (ReefBase, 2002). Thus the oceanic reefs of Rongelap atoll have inadvertently been protected and are today some of the best representatives of oceanic reefs.

Although pristine today, the oceanic reefs of Rongelap atoll are highly vulnerable to future overexploitation if the resource base is not protected. Marine reserves have been shown as the most effective method of protecting reefs and their services in the long term.

We used the complementary reserve prioritization method to highlight priority sites for coral conservation at Rongelap atoll (Figure 34). This method focused on those sites with high coral diversity and species, which are site-restricted (occurring at one site only). It is proposed that the south wall site at Eniroruuri Island (R13) would be the priority site for coral species conservation amongst those sampled at Rongelap atoll. This site had the highest coral species diversity.
On Rongelap island, the oceanic wall site R10 was the priority site for coral conservation. This site had relatively high diversity and a large number of site-restricted species. Occurring adjacent to the airport terminal, this site was very accessible for shore-diving and had a relatively safe entry/exit point compared with other wall sites. A permanent transect was established here. Sites R4 and R12 are on the exposed wall side of Jaboan Pass are the next two priority sites. With high diversity and coral cover, these sites may be both a source and a sink for coral larvae. Many species of coral were recorded from these sites only.

Figure 34. Priority sites for the conservation of coral species richness.



3.4 Permanent transects

Two permanent transects were pinned down at two representative sites for future references and monitoring activities. One site is located on the windward site of the atoll, R10, and it has been chosen as good location for a permanent transect for its accessibility and for the high level of quality of reef and general fauna.
The other site, R1, is located at the Jaboan point, and it is been selected for a recommendation for a conservation management. The presence of the permanent transect will help monitor the location.

TOPOGRAPHICAL DESCRIPTION OF THE TWO SITES

Two detailed physical profiles were done at the two permanent transect sites (R1 and R10). Information on the topography of the ocean floor and on the substrate coverage was collected and analyzed. The following figures describe these data.

At R10 the profile was done along three transects perpendicular to the shoreline. One of the transects was inside a deep groove and two were on either side of it. The groove profile is much flatter and longer than the two other parallel to it, indicating a cut into the slope, a feature that is typical of windward ocean-side of atolls, as described by Emery *et al*. (1954).

As it can be noted from the Figure 35, the three profiles are quite different in their proportion of substrate kinds. Along the second profile inside the groove (Figure 36) live coral is more abundant at deeper strata; live coral is then substituted by dead coral, rubble and sand at shallower depths. The bottom of grooves is usually covered by sand and rubble, due to the high current and the eroding activity of waves. The other two transects present a high relative coverage of coral. Seaweeds are generally proportionally more important at depths > 5m.

At R1 four different profiles were accomplished, three perpendicular to the shore (Figure 37) and one parallel to it at 4 different depths.
Along the first transect the proportion of live coral is low at depths shallower than 10 m. This transect was close to a groove and the substrate most representative of this feature is a sand-rubble bottom, as it is obvious in Figure 38. Overall, the proportion of live coral is higher along these transects than at R10. This is a further indication of the particular health and richness of this site at Jaboan point.

Figure 35: Profiles of bottom topography at three neighboring locations at site R10**.**

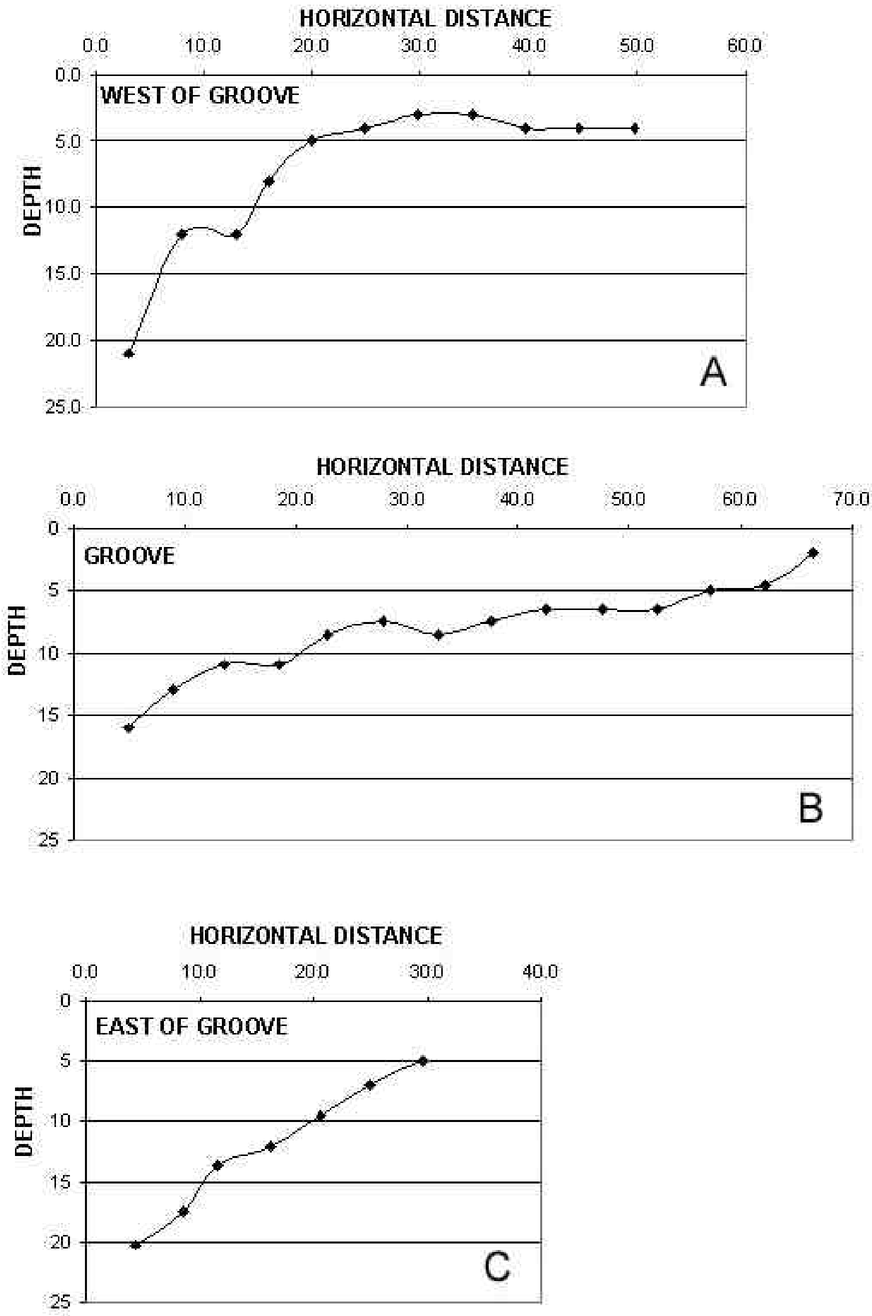


Figure 36: Percentage coverage of the three profiles at site R10.

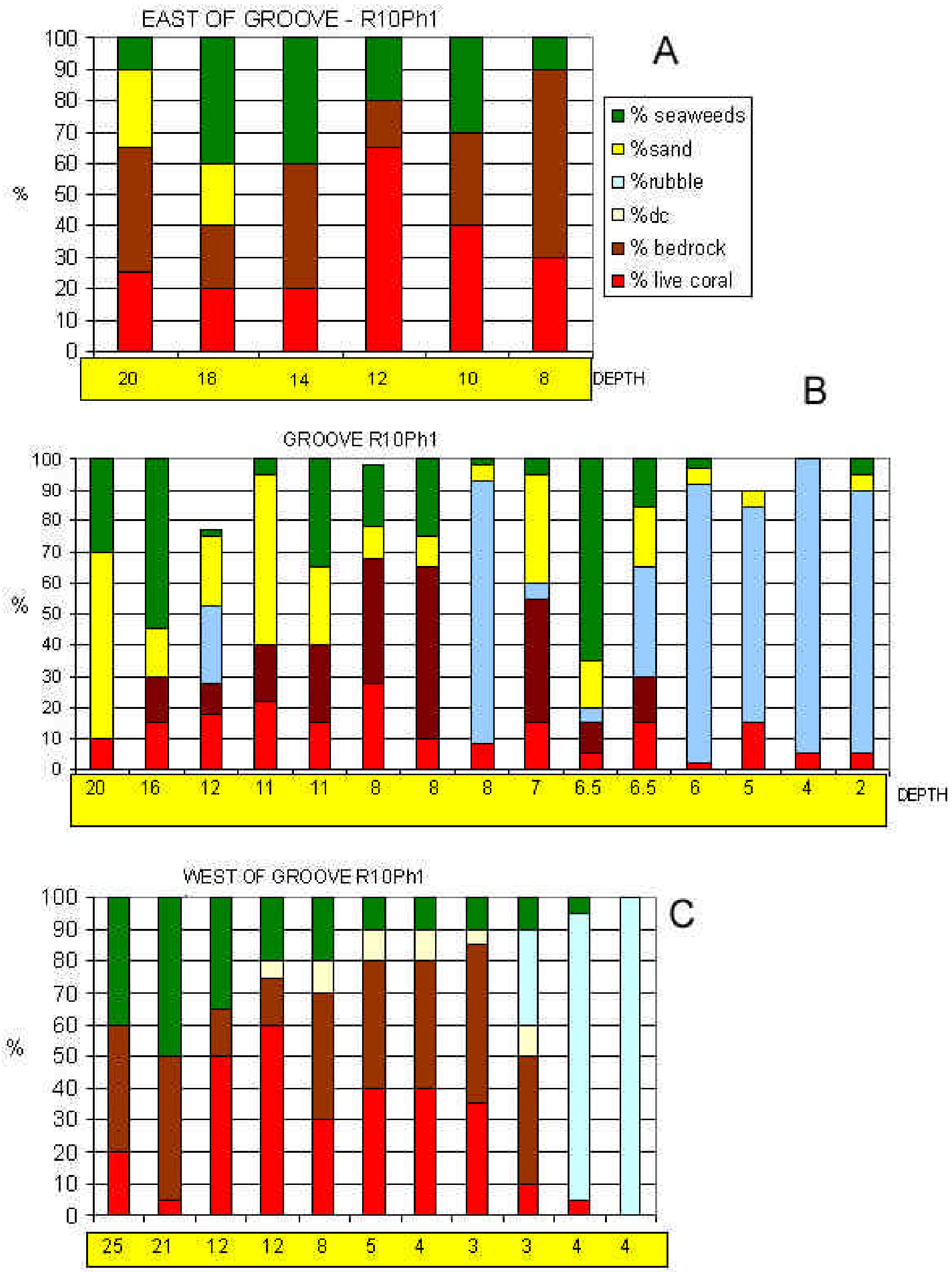


Figure 37: Profiles of bottom topography at three neighboring locations at site R1.

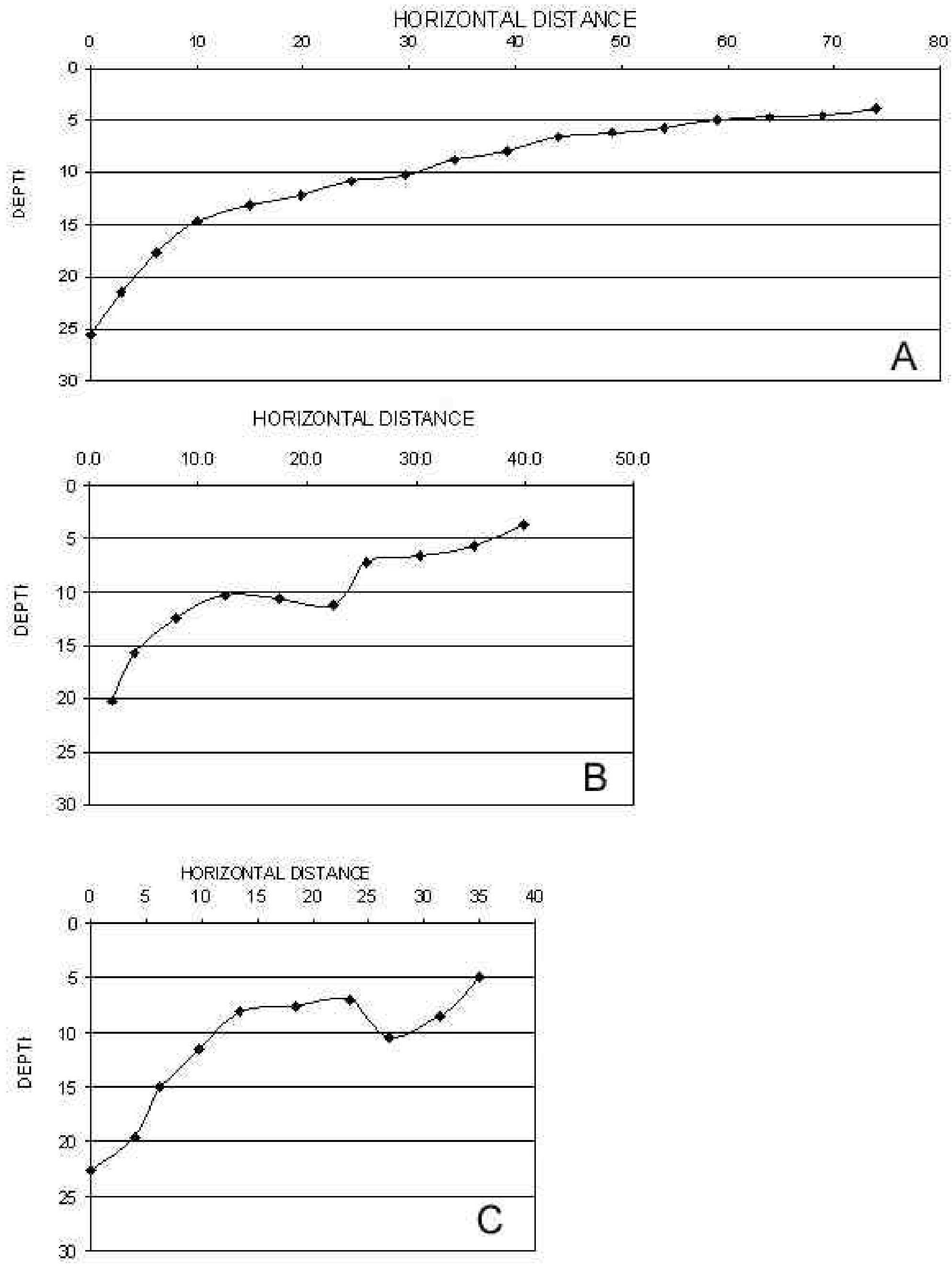
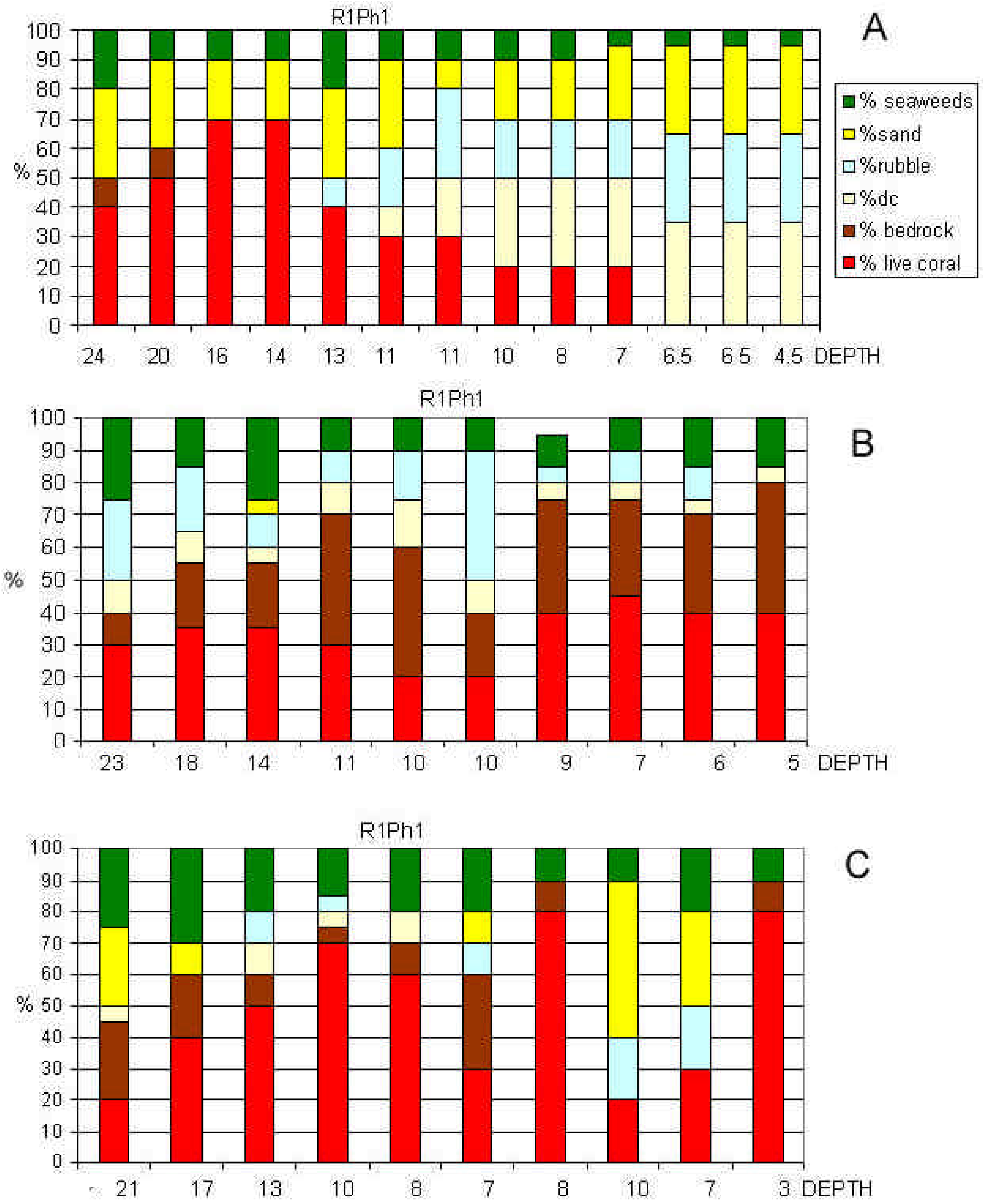


Figure 38: Percentage coverage of the three profiles at site R1.



4. Results and Discussion

In order to summarize the results section and to highlight the most important results, we provided a list of findings below (Table 1). For each previous chapter we summarize the main results.

Table 20. Major findings of the NRAS 2002 project on Rongelap Atoll.

	Result
Substrate	Hard oral cover was higher at shallower sites, averaging 39% of total substrate.
	Ocean had higher coral cover than the lagoon, particularly non-*Acropora*.
	Lagoon had higher sand cover than the ocean.
	Substrate proportions varied with bio-geographical zone.
	More rock was recorded on exposed sites.
Coral Targets	All species were evenly distributed by depth, only *Acropora palifera/ cuneta* preferred shallower depths.
	Higher coral cover was recorded on ocean sites.
	Many coral species were lacking or in low numbers in the lagoon.
	Most corals were relatively homogenously distributed between zones, but subject to the above point.
Fish Targets	The most abundant family was the damselfishes.
	Shallower reefs contained a higher fish biomass than deeper reefs.
	There was no depth differentiation by families.
	Fishes were more abundant on the ocean side.
	Fishes were heterogeneously distributed across bio-geographical zones.
Seaweeds	Algae cover did not change with depth.
	Ocean sites contained algae in higher abundances and more frequently.
	The southwestern sheltered zones had a higher algae cover than other zones.
	There were fewer algae in the western part of the lagoon.

Fish Diversity	361 fish species were recorded on Rongelap Island.
	Sites with high species richness did not contain many rare species.
	Lagoon sites ranked very high as fish conservation priorities, containing rare and distinctly different species compared to ocean sites.
	Both a lagoon and an ocean site should be considered for conservation
Coral Diversity	The survey raised the known coral species of Rongelap Atoll from 34 to 170.
	16 range extensions were recorded, with many of these species recorded in the Pacific Ocean for the first time.
	Most sites had high coral cover, diversity and new recruits.
	Oceanic wall reef sites were the most species rich.

The NRAS team found a distinct zonation between the outer fringing and lagoonal patch reefs of Rongelap Island. Coral reef zonation is a well-known characteristic of coral reefs (Alevizon et al., 1985, Acosta and Robertson, 2002). Different habitats and associations of species present in different areas of the island and depth zones resulted from the effect of wave action, exposure, topography and light conditions (Dunning et al., 1992).

This zonation was represented by a variety of habitats present at Rongelap Island, with the strongest differences apparent between lagoon and ocean side. On the lagoon the lesser water circulation, the higher protection from the wind compared to the ocean side and the different current patterns provid a calmer habitat. Here sand accumulates and corals usually do not construct barriers of reef, but patches or mounts of reef accretion. However, still inside the lagoon there are differences of coral associations and ecological communities due to the difference in wind impact and current circulation that control sedimentation, light and temperature. These are major physical parameters that control coral growth and community relations. The sharper differences were usually found between windward and leeward side.

Similarly, on the ocean side we expected and found visible differences in both a geological and biological structure of the reef between the windward and leeward side. Coral communities are often influenced by exposure, including impacts from waves, currents, winds and storms, but also sedimentation. These expectations were met at Rongelap Island. Windward reefs present usually more marked zonation, with boulders and a rubble zone on the reef flat, and spurs and grooves on the slope. There is usually more silting in the deeper part of the slope. Leeward reefs do not present boulders and rubble zone, nor spurs and grooves. The reef slope drop more gently in these protected areas, whereas exposed reefs usually had a very steep dropoff.

<u>*Ocean regions*</u>: Wall habitats that were studied comprised a narrow fringing reef (up to 50 m wide) and reef crest interspersed with deep channels leading to a steep wall drop-off. The western side of the South pass regions contains the highest total coral coverage. The Western tip of Rongelap-Rongelap is represented by high coverage of *Acropora palifera/cuneata, Favites, P. cylindrica, Porites austr.- and Seriatopora hystrix*. The outer wall sites on the oceanward side of the island

supports a relatively uniform fish biodiversity. The tip of the island (R1 in Jaboan) supports a particularly high variety of fishes, because its variety of habitats include both exposed wall and lagoonal features. The highest fish species counts with 179 species per site were reported here.

Lagoon regions: Lagoon sites are composed of small patch reefs and bommie developments amongst sand. The sheltered lagoon habitats support different fish species, which were surprisingly diverse and abundant. Most fishes were found associated with patch reefs on the sandy substratum. Large schools of herbivorous fish were observed roaming between these coral bommies, usually these schools included surgeonfish and parrotfish. An abundant variety of groupers was found near and on the patch reefs. They were significantly more diverse in the lagoon sites than the outer sites. This indicates that the importance of lagoonal sites should not be underestimated for future conservation measures.

Corals:

A total of 170 coral species were recorded from surveys of Rongelap atoll, 136 more than previously reported. Seven major range extensions were recorded in this study and several of these species were recorded from the Central Pacific Ocean for the first time. *Acropora* was the most speciose genus followed by *Montipora*. Both coral coverage and number of identified species were significantly more abundant at the ocean sites. In the lagoon, they were found on sandy substrate as well as boulders and bommies.

We recorded a high coral cover and beta-diversity throughout the survey sites, combined with good fish biomass values.

Our coral diversity records indicate a high diversity of corals, and also a high likelihood that new species may still be discovered there. Considering the small size of Rongelap Rongelap, this relatively high number was indicative of the health and pristine condition of these reefs. The total coral species richness for Rongelap atoll surpasses previous records yet is still considered to be an underestimation of the actual total coral diversity of the entire atoll. .

Based on the current availability of data, we would propose that the south wall site at Eniroruuri Island (R13) would be the priority site for coral species conservation amongst those sampled at Rongelap atoll. This site had the highest coral species diversity. On Rongelap Island, the oceanic wall site R10 was the priority site for coral conservation. This site had relatively high diversity and a large number of site-restricted species. Site R1, or the tip of Jaboan point, is suggested for conservation for both values of biodiversity, and for management reasons.

Fishes:

Fish biomass was significantly higher between 5 and 15 m, approximately, where the larger fish were found. Snappers, Parrotfishes, Fusiliers, Butterflyfishes, Surgeonfishes, Angelfishes, Rabbitfish prefered the ocean sites.

We recorded more than half of the fishes known from the Marshall Islands, including several endemic species only known from the Northern Marshall Islands.

In summary, the entire atoll must be sampled in order to gain a comprehensive species list for Rongelap for both corals and fish.

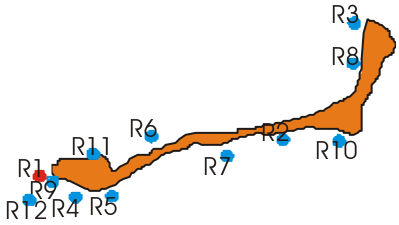
We suggest that reefs of Rongelap Island were very healthy and were some of the most pristine atoll reefs in the world.

Although pristine today, the oceanic reefs of Rongelap atoll are highly vulnerable to future overexploitation if the resource base is not protected. Marine reserves have been shown as the most effective method of protecting reefs and their services in the long term.

5. Site Descriptions

The following tables and figures summarize the description of habitat and species richness for each of the site samples in Rongelap.

R1: Jaboan on SW tip of Rongelap Island



Coordinates: N 11° 09.20707' E 166° 50.18976'

Conservation value: very high

Fish species: 176 **Coral species: 51**

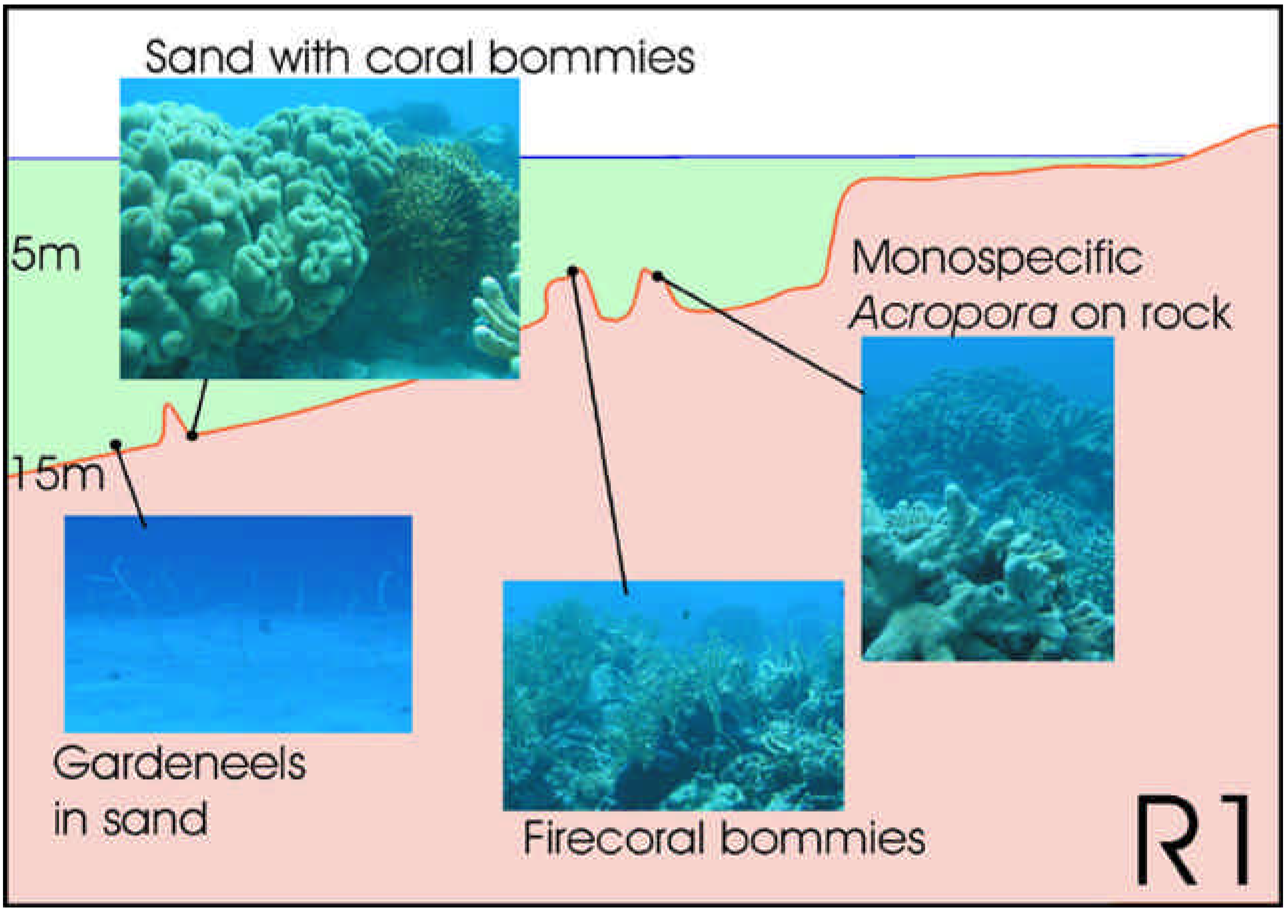
Visually estimated coral cover: 70%	**Measured coral cover:**			
	Shallow 61%	**Fish biomass:**	**Shallow**	**1.95 kg**
	Medium 2%	**4.46 kg (6.11)**	**Medium**	**0 kg**
	Deep 2%	**(2,500m^3 of water sampled)**	**Deep**	**11.4 kg**

Habitats:	**- biological**	**- topographical**
	Mixed corals	Slope (> 25°)
7 biological	Monospecific corals on rocky substrate	Steep wall w/ slope (> 60°)
9 topographical	Sand with coral bommies	High energy reef crest / top
	Sand	Flat reef

Description: Beach dive from Jaboan Point, where we saw several habitats on repetitive dives. This description is an account of many dives, but the transects and profile only represent one area (sandy flat to grooves and bommies). A more detailed description of Jaboan point is in the text of the Results section.

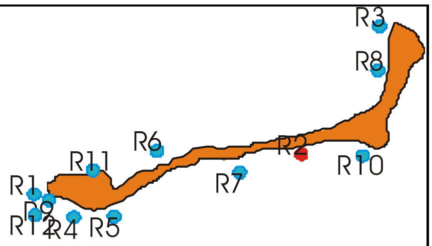
The site was rich with corals and fish. Abundant plankton and salps caused a low visibility. In the shallow area were complicated bommies creating caves and tunnels. Towards the western side there was a coral garden approaching 100% cover, which contained *Acropora palifera*, *Pocillopora spp* and *Montipora spp*. Large schools of parrotfish and humpback snappers (*Lutjanus gibbus*) and unicorn-fish (*Naso vlamingii* and *N. annulatus*). At 15m there were small coral bommies on a sandy flat that was home to expansive colonies of garden eels. In the south, we encountered a steep wall which slopes sideways towards the sand flat, interrupted by large patch reefs. We observed a tiger shark, saw several gra reef sharks, a nurse shark and eagle rays. Turtles constitute one of the tiger shark's favorite prey, and a half-eaten turtle was found on the reef flat. Large sea fans grew on the wall and soft corals (*Dendronephthya spp*) in small caves. Sometimes there was *Halimeda* seaweed hanging from the overhang. Channels occasionally led inshore into enclosed sandy patches surrounded by steep coral formations. Schools of unicorn-fish, blue-fin trevallies (*Caranx melampygus*), rainbow runners (*Elagatis bipinnulata*), and dog-tooth tunas hung around the wall.

Profile:


Sand with coral bommies
5m
15m
Monospecific
Acropora on rock
Gardeneels
in sand
Firecoral bommies
R1

R2:

Coordinates: N 11° 09.39472' E 166° 53.14641'



Conservation value: average

Fish species: 132 **Coral species: 53**

Visually estimated coral cover: 70 %	**Measured coral cover:** Shallow 27%, Medium 36%, Deep 41%	**Fish biomass: 5.57 kg (2.22) (2,500 m^3 of water sampled)**	**Shallow 7.72 kg, Medium 3.29 kg, Deep 5.71 kg**

Habitats:

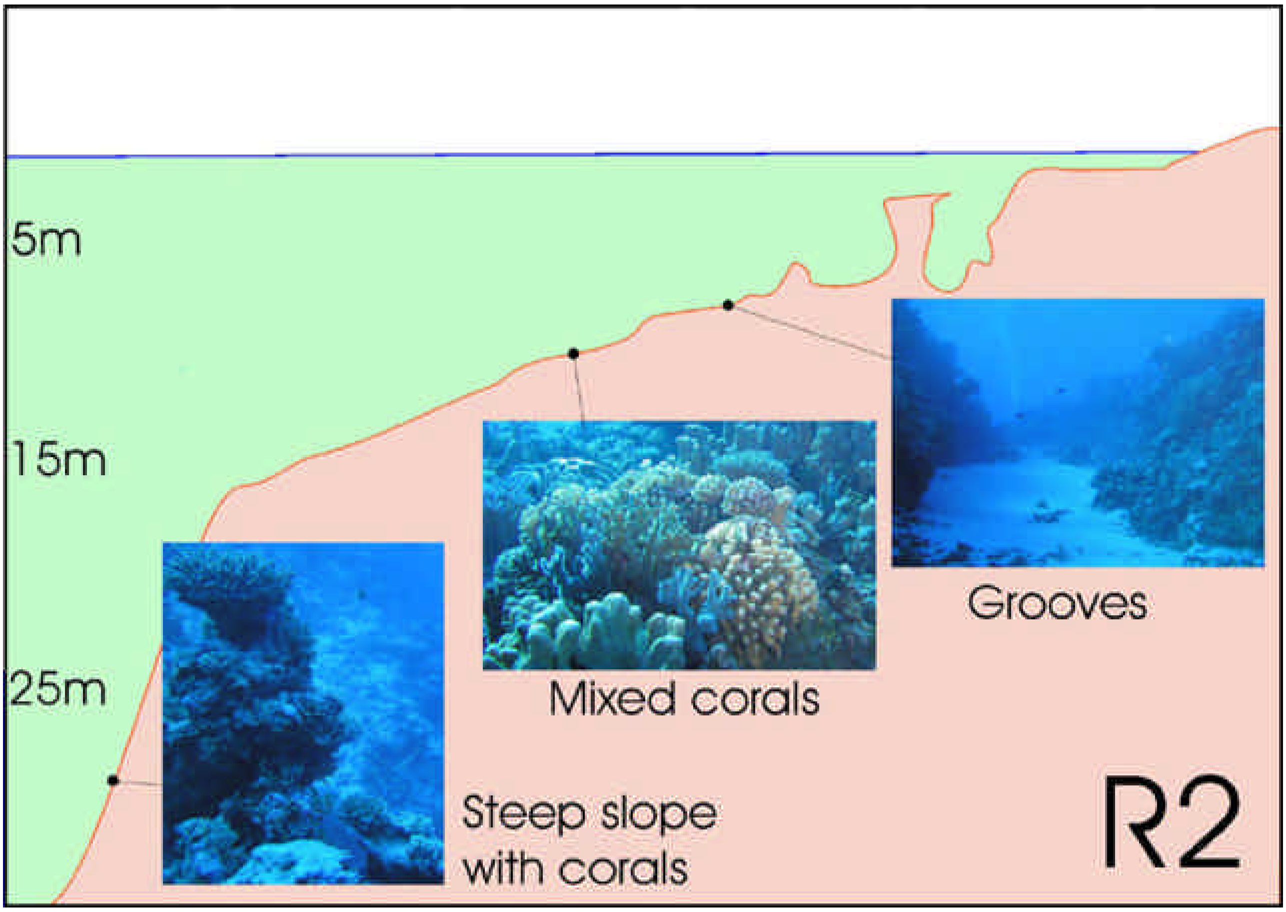
4 biological
7 topographical

- biological
- Mixed corals
- Bedrock w/ sparse corals
- Mixed coral on bommies and sand
- Monospecific corals on rocky substrate

- topographical
- Bommies
- Slope (> 45°)
- Steep wall w/ slope (> 60°)
- Flat reef

Description: Beach dive off far end of airport. A short entry because the reef flat has been filled in with the contaminated soil scraped from the living compound area, in support for the landing strip. Jumped off the edge crushed by waves at incoming tide, into deeper water. At 8-10 m the habitat was dominated by bedrock and deep sandy grooves. *Acropora palifera* and *cuneata*, *Heliopora coerulea* and *Tubipora musica* were the dominant coral forms, together with massive *Porites*. The gentle slope with grooves went to about 13m, where it abruptly turned into a steep wall sloping down into the blue. At the wall, there were many anthiases, surgeonfish *Acanthurus thompsoni* and the Multicolour Angelfish (*Centropyge multicolor*). Corals were a little less dense than nearer the surface, where the slope was less steep. Rich in life for both coral and fish. One eagle ray, one white tip shark and one gray reef shark. Two Napoleon wrasses, one small, one medium size. A few seaweeds, *Halimeda spp.* and coralline algae.

Profile:

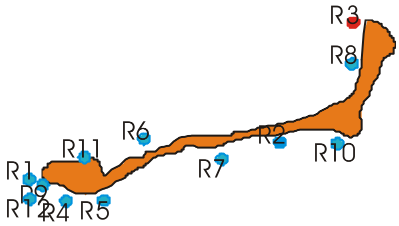


R3:

Coordinates: N 11° 10.74334' E 166° 53.74411'

Conservation value: very high

Fish species: 144 **Coral species: 38**

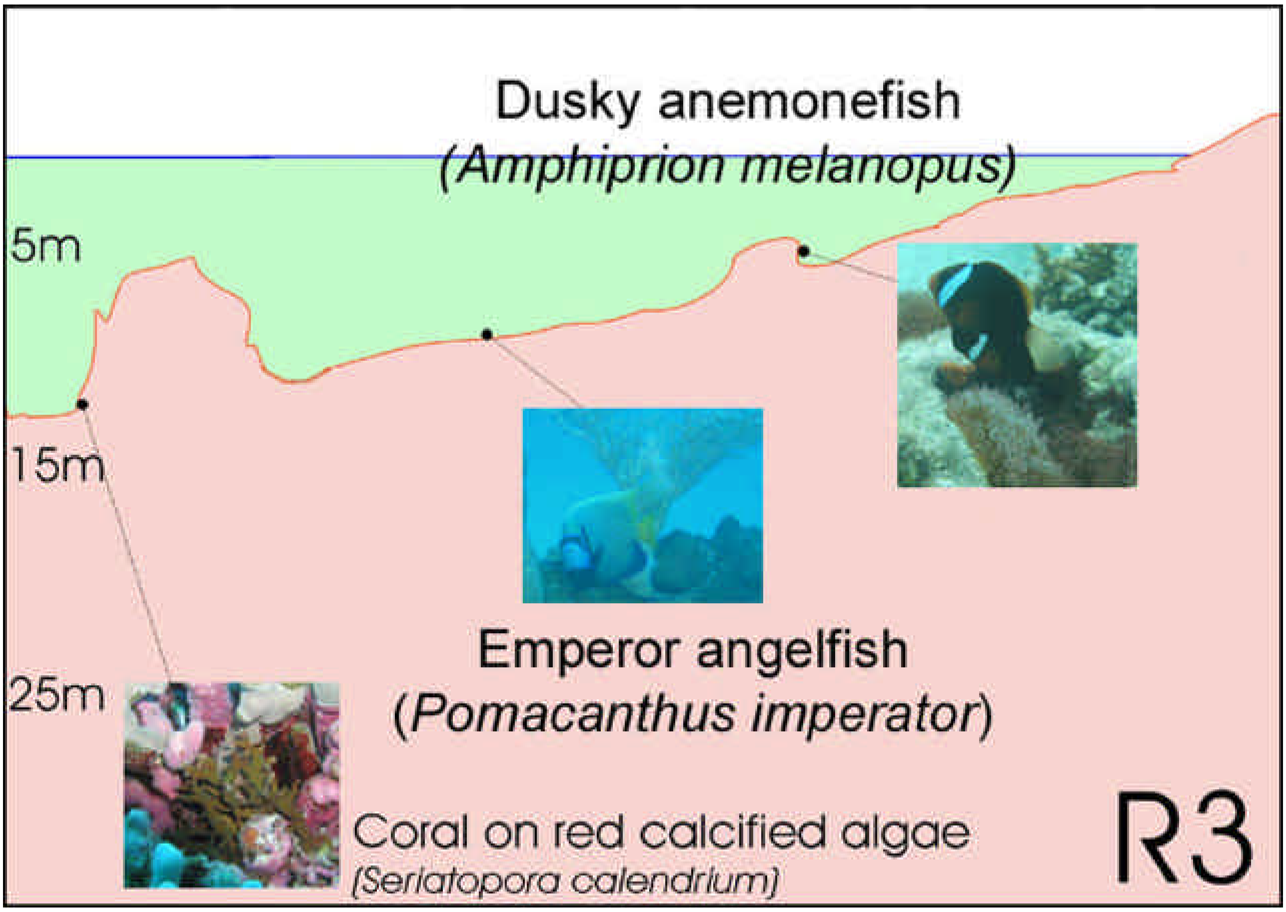


Visually estimated coral cover: 10 %	**Measured coral cover:**				
	Shallow	**12%**	**Fish biomass:**	**Shallow**	**3.98 kg**
	Medium	**7%**	**2.91 kg (1.12)**	**Medium**	**3.01 kg**
	Deep	**50%**	**(2,500 m^3 of water sampled)**	**Deep**	**1.75 kg**

Habitats:	**- biological**	**- topographical**
	Sand	Flat reef
6 biological	Mixed coral on bommies and sand	Bommies
3 topographical	Sand with algae	Monolith
	Monospecific corals on sandy substrate	

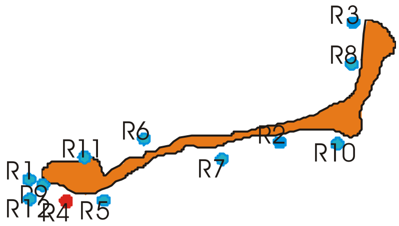
Description: Truck dive off northern side of Rongelap. Very gentle slope. Sandy substrate and some coral bommies with *Porites cylindrica* and *Favia spp.* and *Favites spp.*, branching *Acropora* (e.g. *A. muricatum),* bottlebrush *Acropora* and *Seriatopora hystrix*. On sand, lots of *Halimeda*. Lots of damsels and chromis. Giant clams. Many *Holoturia edulis*.

Profile:


Dusky anemonefish
(Amphiprion melanopus)
5m
15m
Emperor angelfish
(Pomacanthus imperator)
25m
Coral on red calcified algae
(Seriatopora calendrium)
R3

R4:

Coordinates: N 11° 09.10086' E 166 ° 50.32076'



Conservation value: high

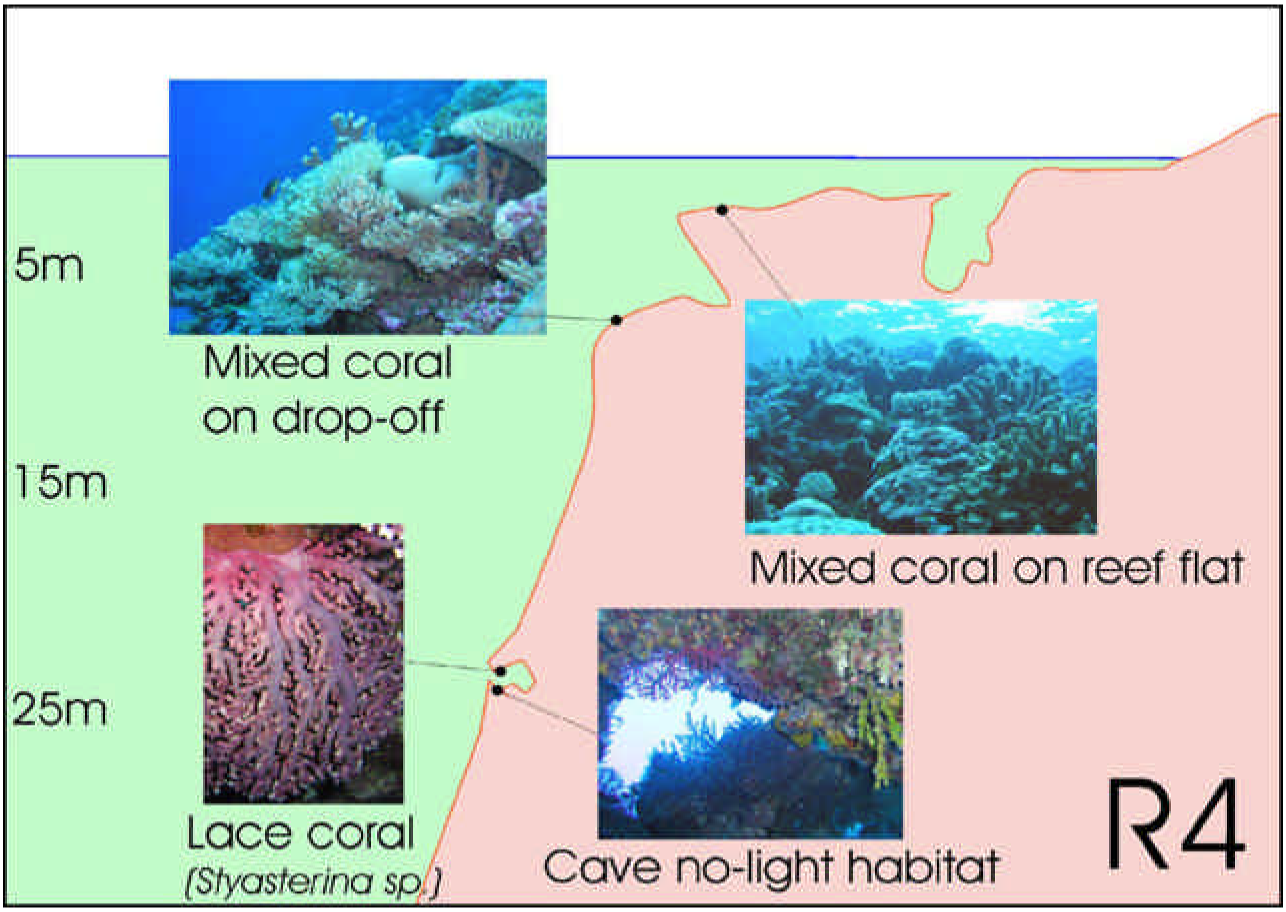
Fish species: 149 **Coral species: 58**

Visually estimated coral cover: 90 %	**Measured coral cover:** **Shallow 76%** **Medium 42%** **Deep 34%**	**Fish biomass: 4.9 kg (3.96) (2,500 m^3 of water sampled)**	**Shallow 9.44 kg** **Medium 2.16 kg** **Deep 3.09 kg**

Habitats:	**- biological**	**- topographical**
	Mixed corals	Steep wall fragmented
7 biological	Monospecific corals on rocky substrate	High energy reef crest / top
5 topographical	Macroalgae w/ sparse coral	Cave
	no light habitat	Slope (> 45°)

Description: Dive at the south end of Rongelap Island, off the wall on the ocean side, near the tip of the island. Departure from sandy beach, across an intertidal bedrock flat that ends in gullies and channels. After a quick jump over the reef edge, there was a deep gully which we followed down until it took us out to the steep slope / wall at 10 m. Extremely clear water. Steep wall with very diverse corals, many massive *Porites spp, Heliopora coerulea, Favia* and other mussids. High diversity of fish and many of large sizes. In the slope, small caves with the ornamental wrasse *Pseudocheilinus ocellatus* in it, and bushes of branching soft coral hanging in the water column. Going shallower, the good coral cover on the fragmented wall became even better, with about 95% or more of live coral coverage. The shallow ridge was covered by diverse abundant corals, like in a picture book. One gray reef at 25 m, one large Napoleon wrasse. Abundant (ca. 40%) of *Halimeda spp.* and fan seaweeds, some coralline algae, *Caulerpa racemosa* and C. *racemosa peltata.*

Profile:

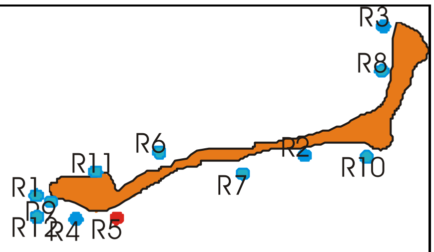

5m
15m
25m
Mixed coral
on drop-off
Mixed coral on reef flat
Lace coral
(Styasterina sp.)
Cave no-light habitat
R4

R5:

Coordinates: N 11° 08.93800' E 166 ° 50.58275'

Conservation value: average

Fish species: 124 **Coral species: 61**



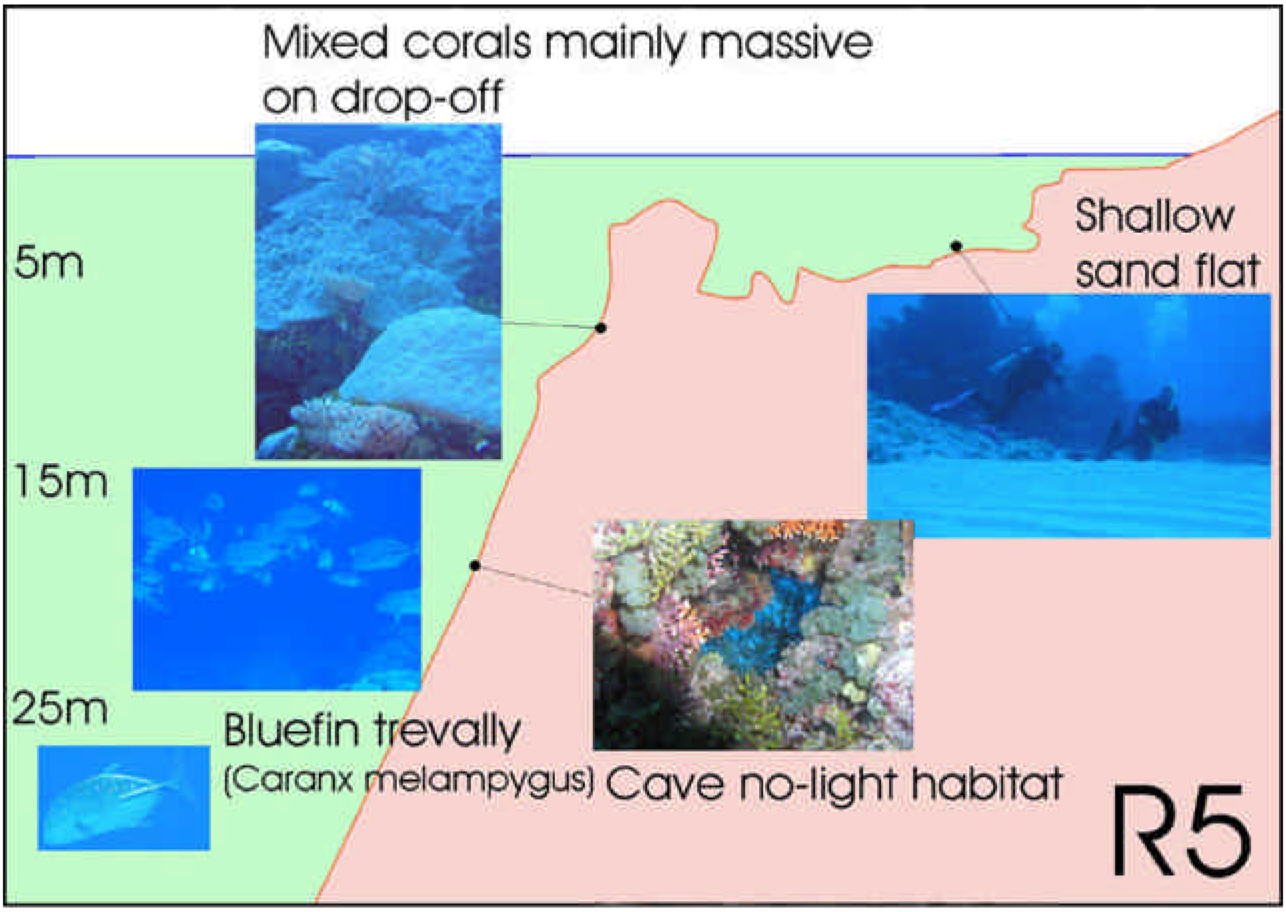
Visually estimated coral cover: 80 %	Measured coral cover:		Fish biomass		
	Shallow	**44%**		**Shallow**	**1.98 kg**
	Medium	**47%**	**4.9 kg (3.02)**	**Medium**	**4.7 kg**
	Deep	**54%**	**(2,500 m³ of water sampled)**	**Deep**	**8.02 kg**

Habitats:	**- biological**	**- topographical**
	Mixed corals	Steep wall fragmented
6 biological	Macroalgae w/ sparse coral	High energy reef crest / top
8 topographical	no light habitat	Grooves
	Monospecific corals on rocky substrate	Deep crevasse/ hole

Description: Truck dive off ocean side, side of the southern part of Rongelap- Rongelap Island, next to site R4. Entrance on deep gullies of bedrock and then on a bed of sand and a slope with bommies and a large mound (patch reef) reaching for the surface near the drop off. The wall was deep and steep. Abundant massive corals (*Porites*) and *Acropora palifera-cuneata* at shallow depths. A few fish on trail, mainly small damsels. Large school of rainbow runners, large school of blue-fin trevallies (*Caranx melampigus*), 2 green turtles (one very large male), one deep grey reef shark.

40% coverage of seaweeds, mainly *Halimeda* and *Caulerpa racemosa peltata*, and deeper (20m) *Microdyction*. On shallow water (shallower than 10m) pink coralline algae. Good visibility, 40 +, blue water.

Profile:

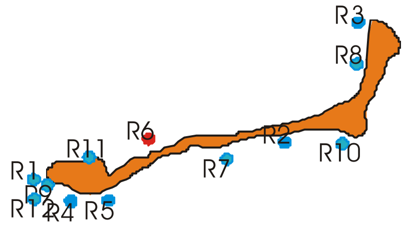

Mixed corals mainly massive
on drop-off
5m
15m
25m
Shallow
sand flat
Bluefin trevally
(Caranx melampygus)
Cave no-light habitat
R5

R6:

Coordinates: N 11° 09.46714’ E 166° 52.00121’

Conservation value: very high

Fish species: 178 **Coral species: 42**

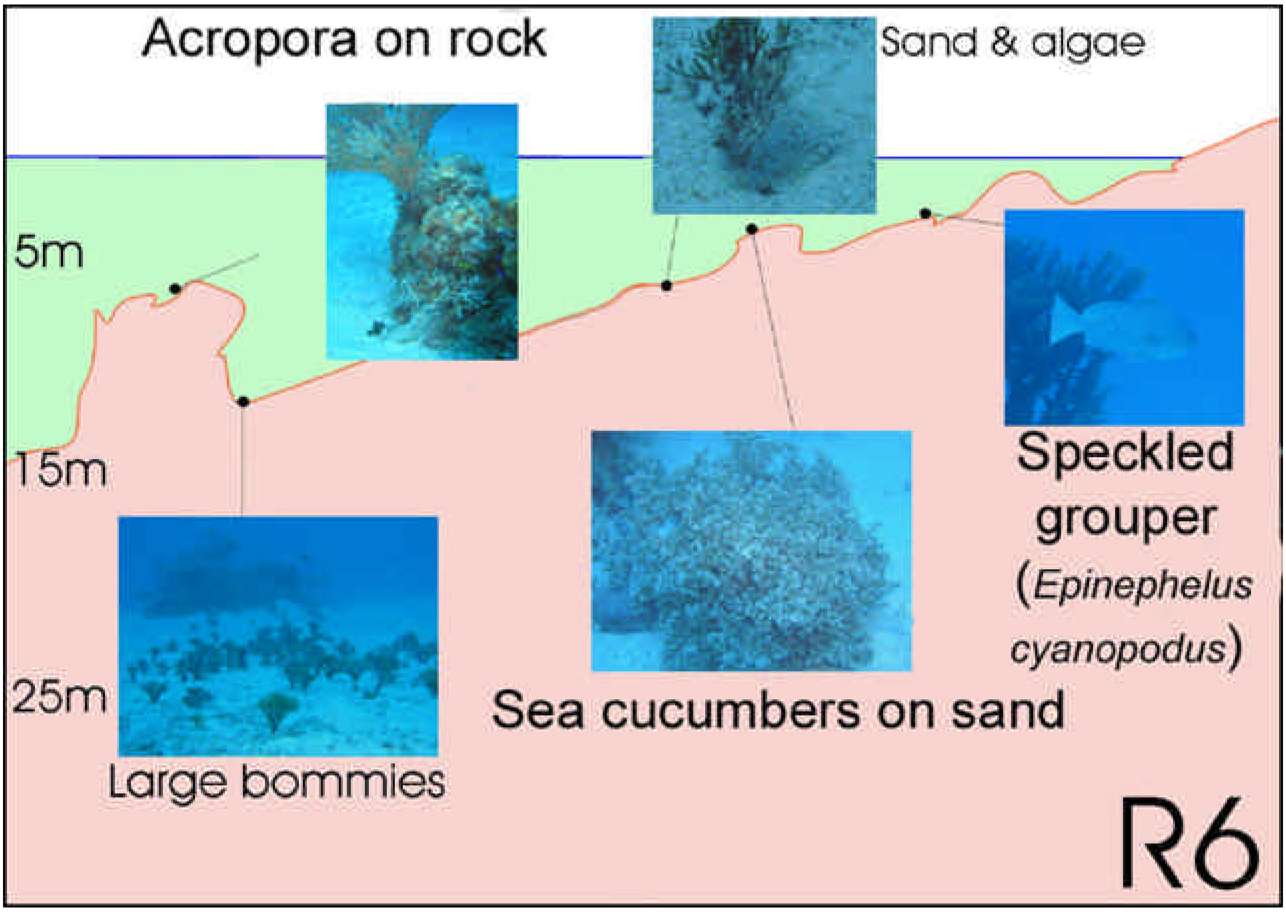


Visually estimated coral cover: 15 %	Measured coral cover:		Fish biomass:		
	Shallow	**4%**	**3.8 kg (2.84)**	**Shallow**	**0.79 kg**
70% on bommie	**Medium**	**6%**	**(2500m³ of water sampled)**	**Medium**	**no data**
	Deep	**3%**		**Deep**	**5.81 kg**

Habitats:	- biological	- topographical
	Mixed coral on bommies and sand	Bommies
8 biological	Sand	Slope (> 25°)
6 topographical	*Acropora* tables on rock	Patch reef
	Mixed corals	Patch reef

Description: Lagoon side off old house in Jaboan, half way between camp and Southern tip. Gently sloping sandy flat with coral bommies, with large schools of Parrotfish and Surgeonfish schooling around at 5m. Deeper, the bommies were fewer, and at 12 to 17m there were larger bommies/ patch reefs, that were highly diverse. Huge schools of Pacific long-nose Parrotfish (*Hipposcarus longiceps)* and Dash and Dot Goatfish (*Parupeneus barbarinus)*. Many groupers such as Speckled Grouper *(Epinephelus cyanopodus*) and High-fin Grouper (*E. maculatus*). One large ray. *Halimeda spp*. growing on sand and *Caulerpa serrulata* and *C. racemosa*. Very good spot, highest diversity so far.

Profile:



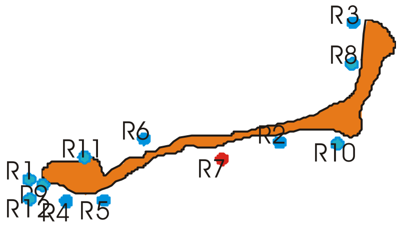
Acropora on rock
Sand & algae
5m
15m
25m
Speckled grouper (*Epinephelus cyanopodus*)
Sea cucumbers on sand
Large bommies
R6

R7:

Coordinates: N 11° 09.43624' E 166° 52.92400'

Conservation value: average

Fish species: 130 **Coral species: 67**

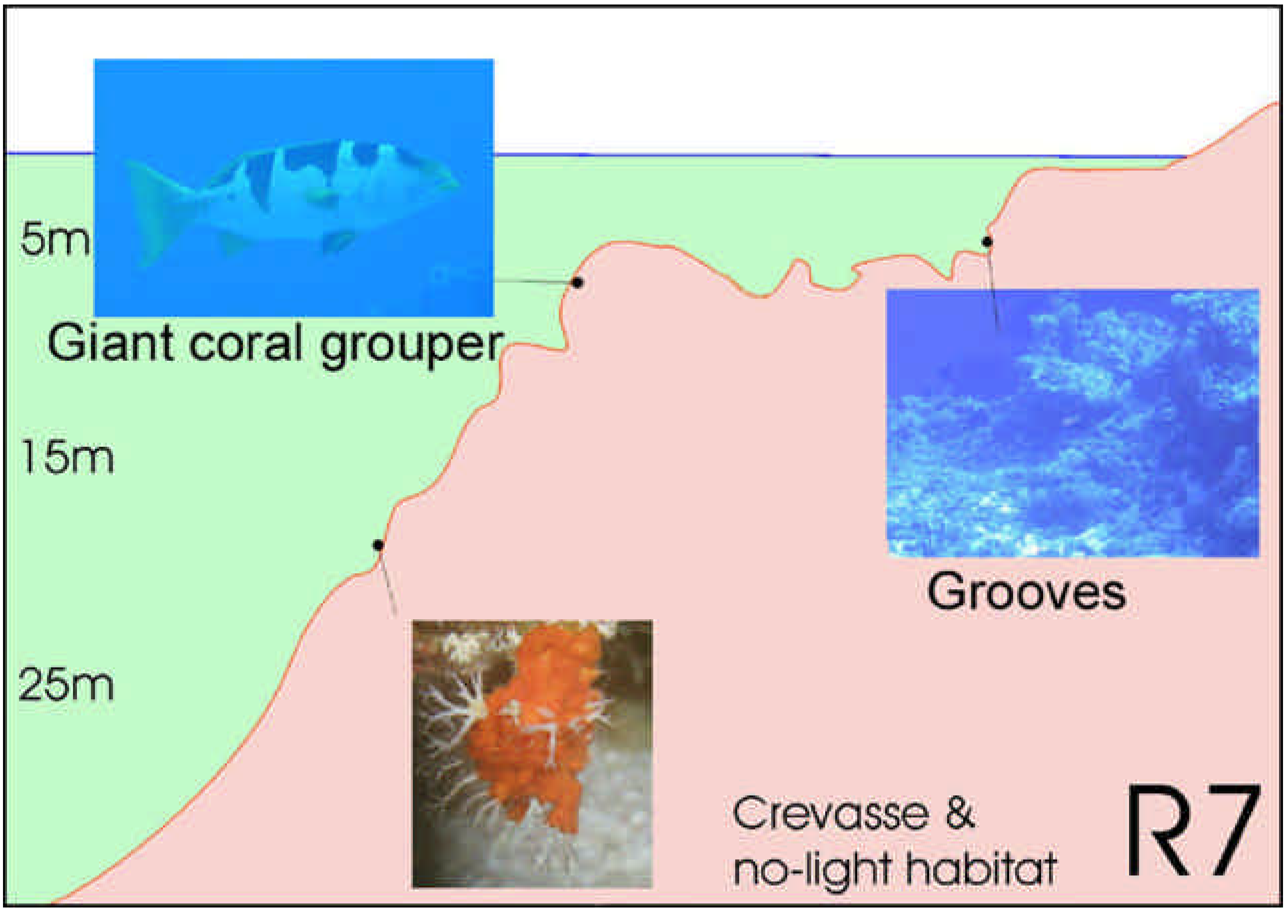


Visually estimated coral cover: 70 %	**Measured coral cover:**				
	Shallow	**34%**	**Fish biomass:**	**Shallow**	**7.7 kg**
	Medium	**47%**	**8.19 kg (3.02)**	**Medium**	**11.4 kg**
	Deep	**35%**	**(2500m^3 of water sampled)**	**Deep**	**5.44 kg**

Habitats:	**- biological**	**- topographical**
	Macroalgae w/ sparse coral	Steep wall w/ slope (> 60°)
6 biological	Mixed corals	High energy reef crest / top
9 topographical	no light habitat	Deep crevasse/ hole
	Sand	Grooves

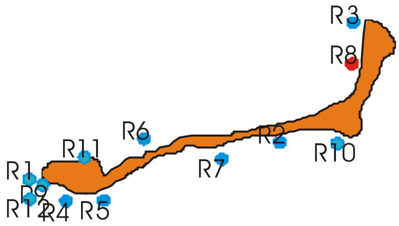
Description: Dive on ocean side at the end of the runaway. Entrance on bedrock, smooth surface, no problem, at in-coming tide. Long swim to 10 m depth, where substrate was mainly live coral in deep gullies, ups and downs. Abundant *Acropora palifera*, blue coral and organ-pipe coral dominated the coral community. The drop off was not as steep as at other places, perhaps 60 degrees. Fish were diverse and abundant, including large giant coral groupers (*Plectropomus laevis*), black and white snappers (*Macolor niger*) and emperors. We also recorded one gray reef shark, one large white tip shark, and one napoleon wrasse. Much *Halimeda spp.*, blue-green encrusting sheets. Coverage of 30-35% of total seaweed at 10 m. Good visibility.

Profile:


5m
15m
25m
Giant coral grouper
Grooves
Crevasse &
no-light habitat
R7

R8:

Coordinates: N 11° 10.43048’ E 166 ° 53.75506’



Conservation value: average

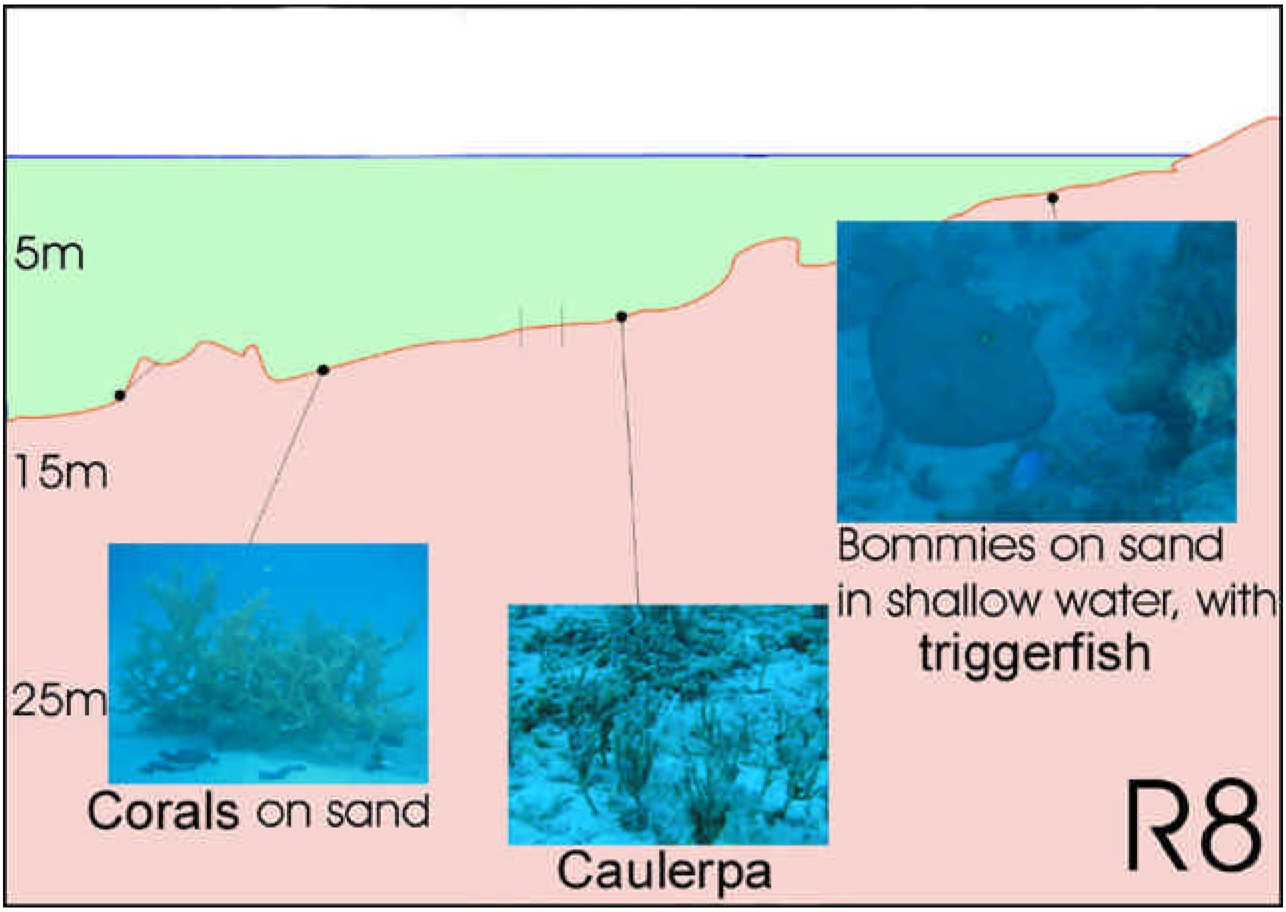
Fish species: 84 **Coral species: 31**

Visually estimated coral cover: 10 %	**Measured coral cover:**		**Fish biomass: 4.76 kg (2.31) (2500m^3 of water sampled)**		
50% on bommy	**Shallow**	**19%**		**Shallow**	**2.42 kg**
	Medium	**26%**		**Medium**	**7.04 kg**
	Deep	**9%**		**Deep**	**4.83 kg**

Habitats:	**- biological**	**- topographical**
	Sand	Slope (> 25°)
5 biological	Mixed coral on bommies and sand	Sheltered reef crest / top
3 topographical	*Acropora* tables on rock	Bommies
	Macroalgae	

Description: Late afternoon dive on sand, on NW point of island, by an old house. The substratum was mostly sand and a few coral bommies with the corals *Porites nigrescens* and *Acropora florida*. Some patches were covered by *Halimeda spp.* and some by *Caulerpa serrulata.* Lots of small damselfish and many cardinal fish were associated with the bommies. One large stingray was seen.

Profile:

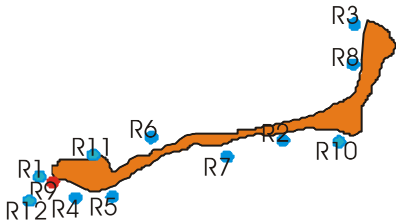


R9:

Coordinates: N 11° 09.12210’ E 166° 50.25059’

Conservation value: average

Fish species: 120 **Coral species: 65**



Visually estimated coral cover: 95 %	Measured **coral cover:**				
	Shallow	**63%**	**Fish biomass:**	**Shallow**	**41.9 kg**
	Medium	**68%**	**17.4 kg (21.2)**	**Medium**	**5.63 kg**
	Deep	**59%**	**(2500m^3 of water sampled)**	**Deep**	**41.9 kg**

Habitats:

3 biological

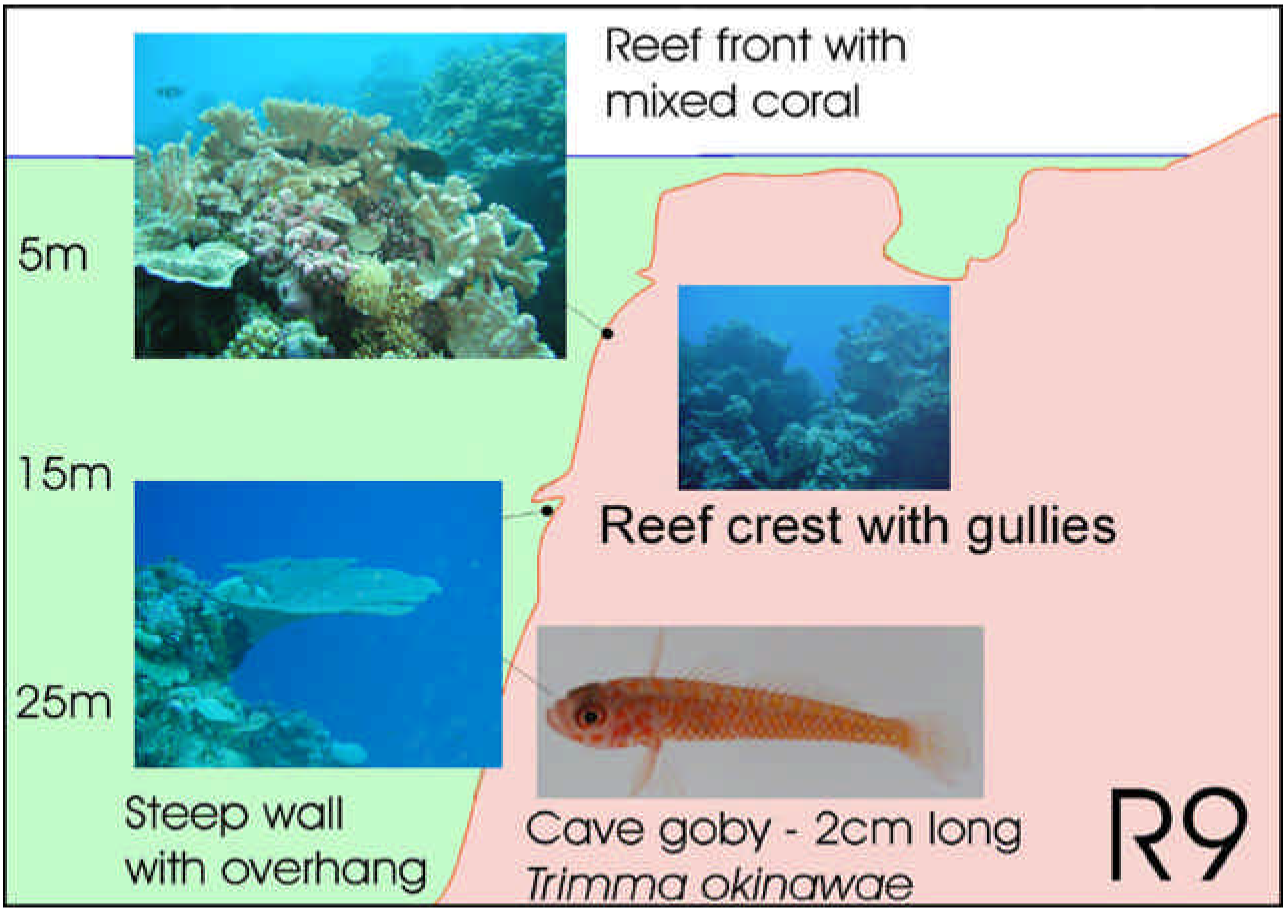
4 topographical

- biological
- Mixed corals
- Macroalgae w/ sparse coral
- Sand with algae

- topographical
- Steep wall fragmented
- High energy reef crest / top
- Cave
- Groves

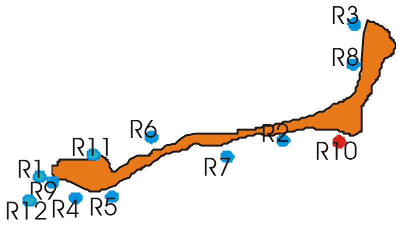
Description: Dive off the South wall, between R1 and R4. Nice wall, with access through shallow bedrock and channels surrounded by big bommies of large blue coral colonies, *Acropora palifera*, and pink coralline dam. The wall was vertical with small caves supporting good coral coverage. Algal coverage was up to 40%, with dominant *Halimeda spp.* and *Caulerpa racemosa*. Only few fish were seen on the steep wall. However on the fore reef there were many small fishes such as damselfishes, snappers and very large groupers. One turtle.

Profile:


Reef front with
mixed coral
5m
15m
25m
Reef crest with gullies
Steep wall
with overhang
Cave goby - 2cm long
Trimma okinawae
R9

R10:

Coordinates: N 11° 09.30557’ E 166° 53.40841’



Conservation value: high

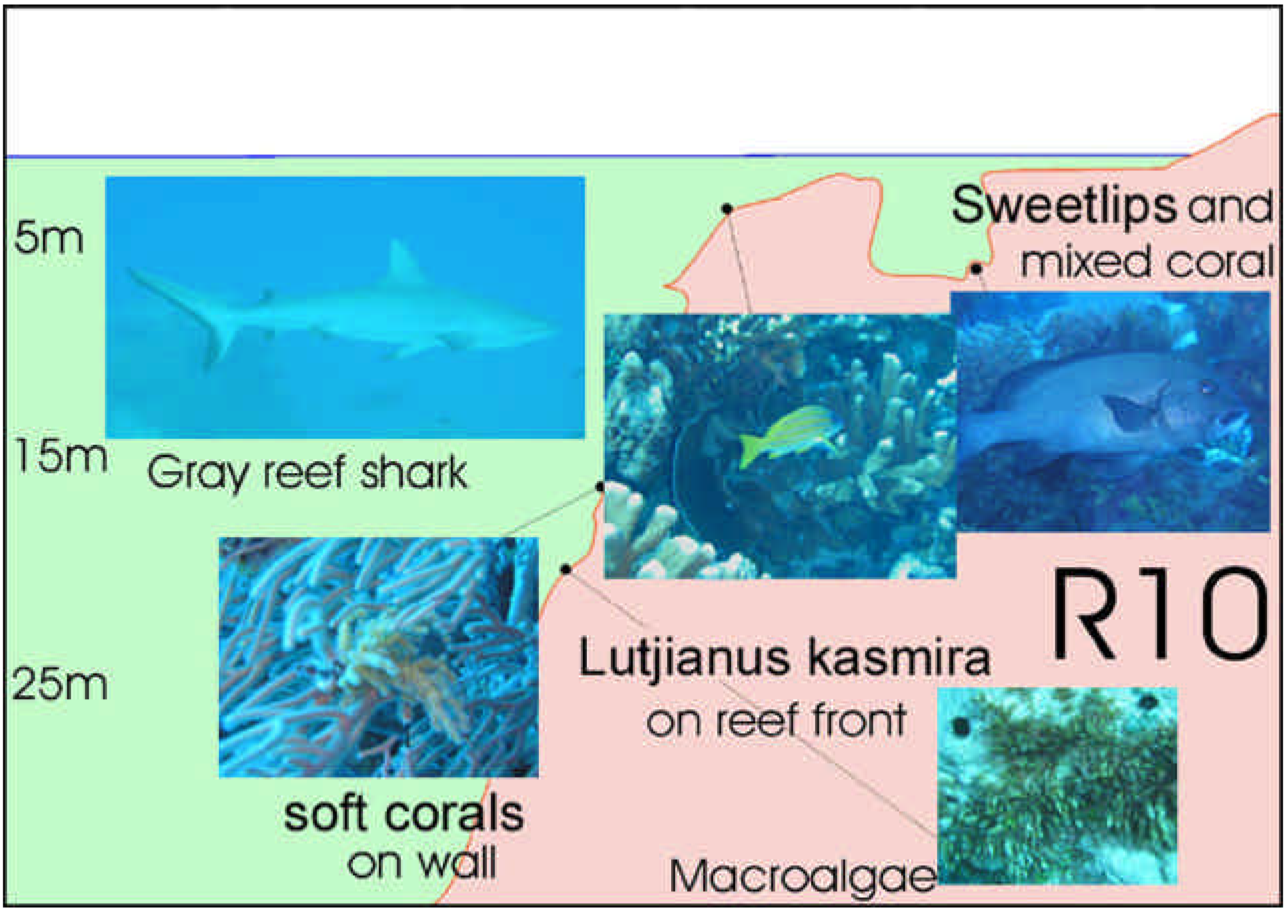
Fish species: 142 **Coral species: 64**

Visually estimated coral cover: 70 %	Visually estimated coral cover:		Fish biomass: 15.3 kg (6.11) (2500m^3 of water sampled)		
	Shallow	**55%**		**Shallow**	**14.0 kg**
	Medium	**0%**		**Medium**	**21.9 kg**
	Deep	**43%**		**Deep**	**9.91 kg**

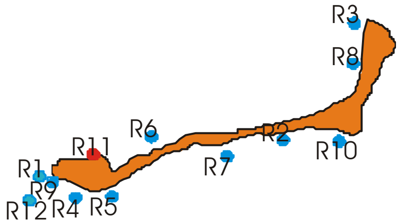
Habitats:	- biological	- topographical
	Mixed corals	Steep wall fragmented
6 biological	no light habitat	Steep wall w/ slope (> 60°)
8 topographical	Macroalgae w/ sparse coral	High energy reef crest / top
	Soft coral	Deep crevasse/ hole

Description: Opposite the airport terminal on ocean side. Parked on airstrip, walked down short “road” to the beach. There was a deep basin behind some wall breaking the waves, ideal for jumping in safely. The basin had intermittent surge channels connecting to the edge of the wall. One of these crevasses channels led through to the reef wall. The wall dropped steeply continuing well below 60 m, as seen from 30 m. At depth there were large cave structures, but were rather bare of fish. We recorded a high coral coverage of ca. 75%. With decreasing depth the coral cover increased to about 95% corals on the shallow fore reef. The substrate also supported small seaweeds (*Caulerpa spp.* and *Halimeda spp.*), and many hydrozoans. Sand covered the bottom of the canyons, otherwise the substratum consisted mainly of corals and bedrock, with large tabulate *Acropora spp.* colonies and large black corals. Large schools of Scarids and Acanthurids played in the surge, mainly *Scarus altipinnis* and *Chlorusus frontalis*, and *Acanthurus nigricans* and *A. guttatus*. We also saw 6 Napoleon wrasses and big groupers (brown-marbled grouper, *Epinephelus fuscoguttatus*, and giant coral-groupers, *Plectropomus laevis*)). A school of blue-fin trevallies (*Caranx melampygus*), two large black jacks (*Caranx lugubris*), one big stingray, one turtle, and one gray reef shark were sighted.

Profile:


5m
15m
25m
Gray reef shark
Sweetlips and
mixed coral
R10
Lutjianus kasmira
on reef front
soft corals
on wall
Macroalgae

R11:



Coordinates: N 11° 09.23958’ E 166° 50.62749’

Conservation value: average

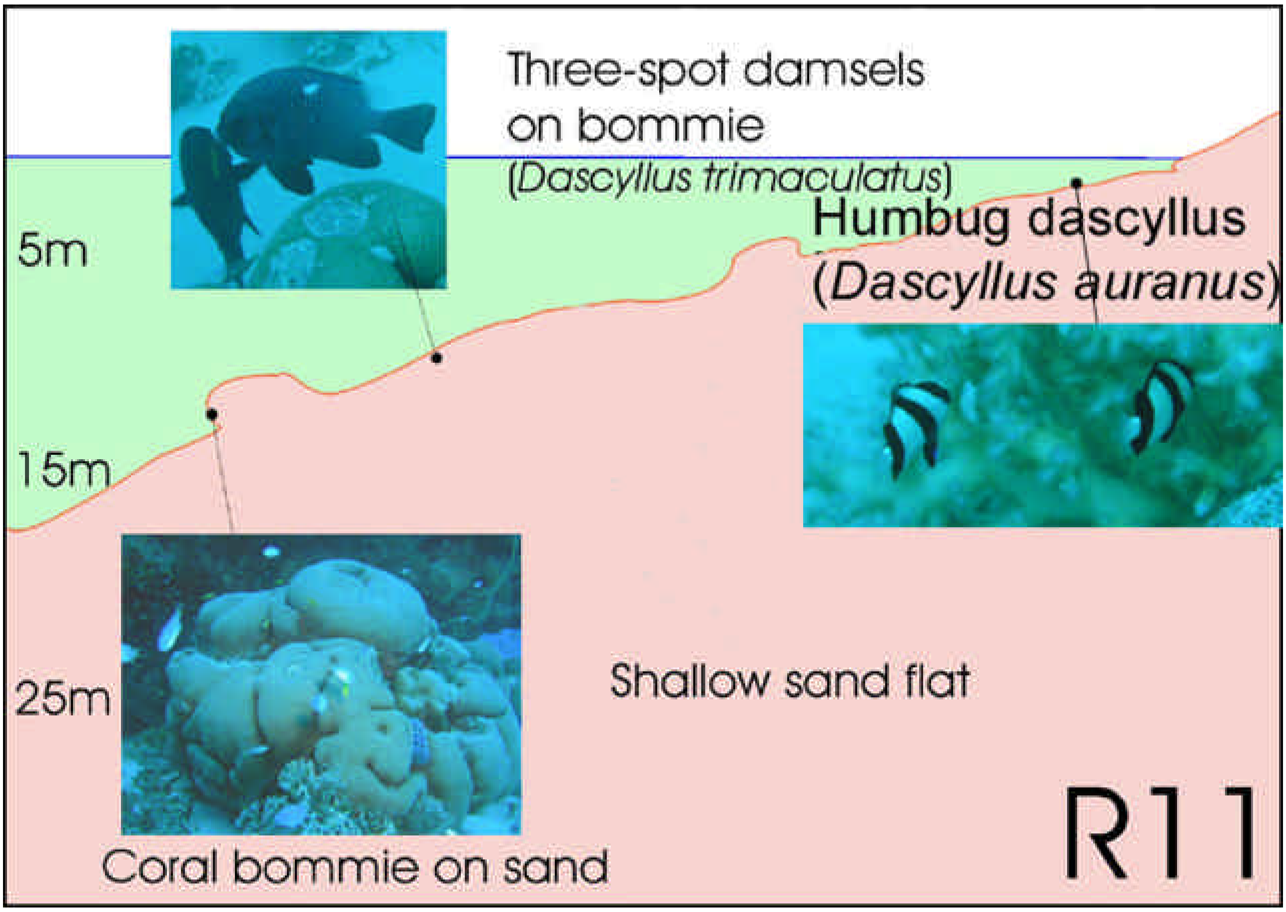
Fish species: 81 **Coral species: 33**

Visually estimated coral cover: 5 % **50% on bommie**	**Measured coral cover:** **Shallow** **4%** **Medium** **39%** **Deep** **13%**	**Fish biomass** **4.65 kg (5.38)** **(2500m^3 of water sampled)**	**Shallow**	**3.35 kg**
			Medium	**0.04 kg**
			Deep	**10.6 kg**

Habitats: **4** biological **3** topographical	**- biological** Sand Mixed coral on bommies and sand Sand with algae Macroalgae	**- topographical** Slope (> 25°) Sheltered reef crest / top Bommies

Description: Lagoon side between 2nd house and R1 (Jaboan), about 0.5 miles away from Jaboan point. Occasional small bommies on a lot of sand eventually sloping steeply down to 25-30m. Steep slope entirely composed of rubble. One Crown-of-Thorns starfish with around 200 small fish in it.

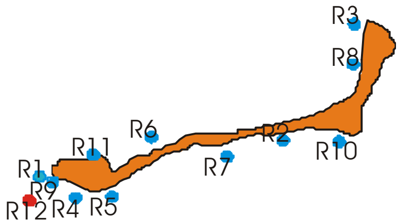
Profile:



Three-spot damsels
on bommie
(*Dascyllus trimaculatus*)
Humbug dascyllus
(*Dascyllus auranus*)
5m
15m
25m
Shallow sand flat
Coral bommie on sand
R11

R12:

Coordinates: N 11° 09.16394' E 166° 50.21003'



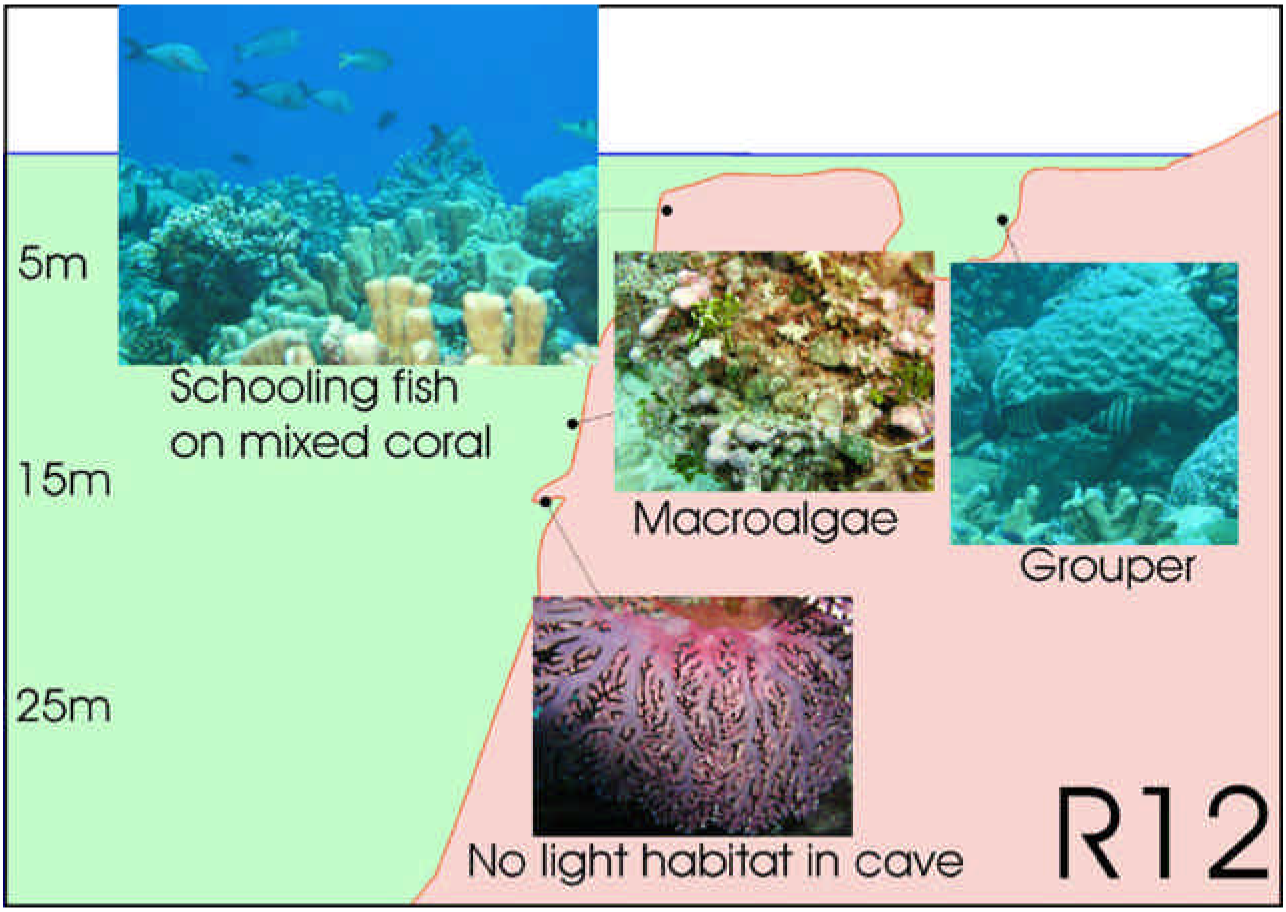
Conservation value: **high**

Fish species: **142** **Coral species:** **68**

Visually estimated coral cover: 95 %	**Visually estimated coral cover:** **Shallow** 57% **Medium** 69% **Deep** 67%	**Fish biomass: 6.02 kg (3.42) (2500m^3 of water sampled)** **Shallow** 9.95 kg **Medium** 4.42 kg **Deep** 3.7 kg
Habitats: **3** biological **4** topographical	**- biological** Mixed corals Macroalgae w/ sparse coral Sand with algae	**- topographical** Steep wall fragmented High energy reef crest / top Cave Grooves

Description: Survey dive on west tip wall off Jaboan Point. Transects at 20, 17 and 10m on the vertical wall. School of blue-fin trevallies (*Caranx melampygus*), dog-tooth tuna, small school of large snub-nose pompanos (*Trachinotus blochii*).

Profile:



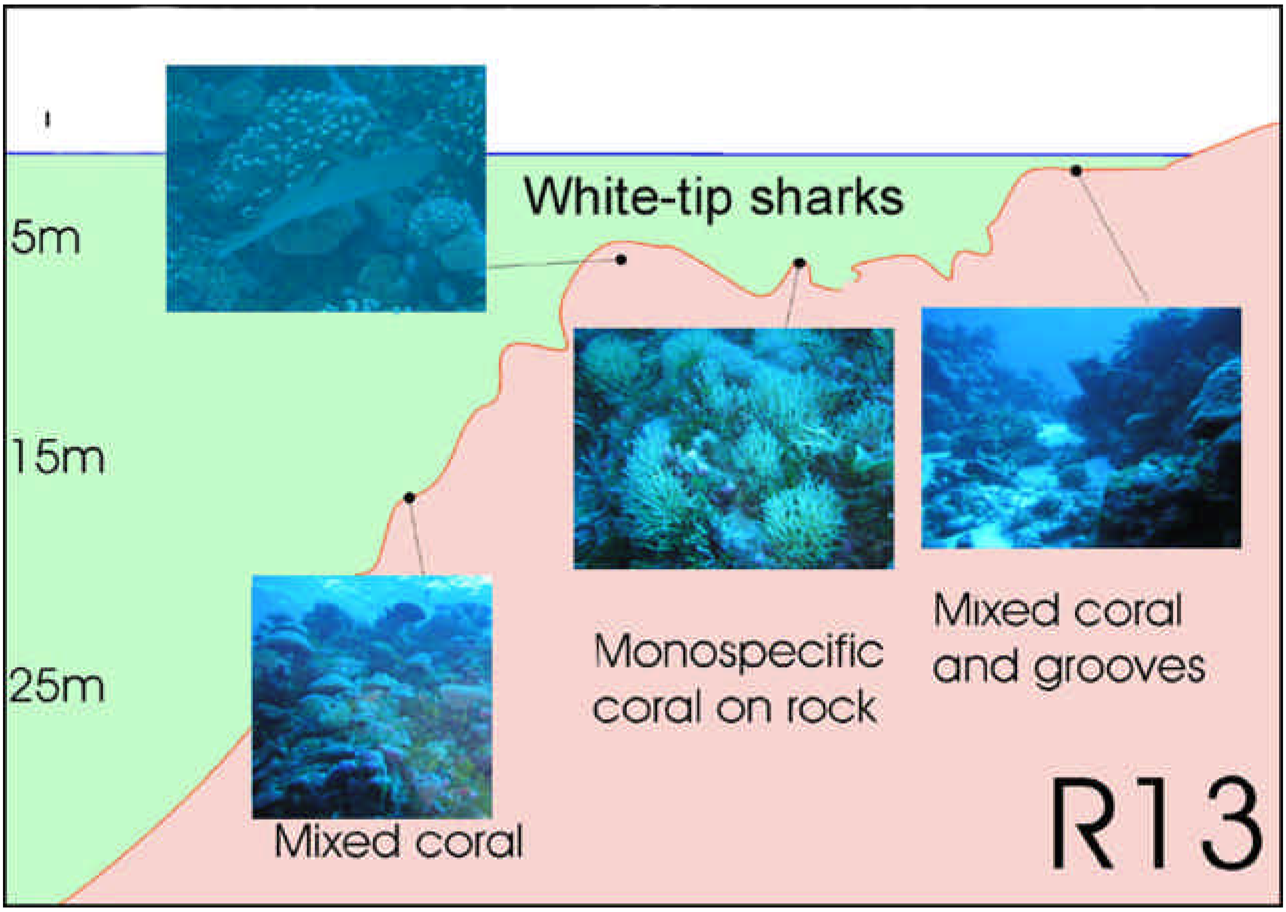
R13:	
Coordinates: N 11° 11.49714' E 166° 43.42705'	**Oceanside off Eniroruuri Island**
Conservation value: high	
Fish species: 147 **Coral species: 77**	

Visually estimated coral cover: 70 %	**Measured coral cover:**				
	Shallow	**60%**	**Fish biomass 46.4 kg (59.03) (2500m^3 of water sampled)**	**Shallow**	**10.9 kg**
	Medium	**45%**		**Medium**	**13.7 kg**
	Deep	**62%**		**Deep**	**114.57 kg**

Habitats:	**- biological**	**- topographical**
	Mixed corals	Slope (>45°)
7 biological	Sand	High energy reef crest / top
9 topographical	Macroalgae w/ sparse coral	Grooves
	Rubble with encrusted life	Steep wall w/ slope (>60°)

Description: Dive on the south ocean side, at the end of the island of Eniroruuri. Nice drop-off starting at 20 m, not a real wall but a steep slope. Small sand patches on shallow water (<10), with nice coral bommies and surge channels, or grooves. The valleys of the grooves have sandy bottoms and the outcrops were covered with rich mixed coral assemblages. Very shallow, there was a bare rock with bommies, and huge quantities of the endemic damselfish *Pomachromis exilis*. One grey reef sharks and lots of large black and white snappers (*Macolor niger*) and two-spot snappers (*Lutjanus bohar*).

Profile:



5m
15m
25m
White-tip sharks
Monospecific
coral on rock
Mixed coral
and grooves
Mixed coral
R13

R14:

Coordinates: N 11° 10.09542' E 166° 46.79730'

Arubaru (Southern Island) on eastern tip outside the pass.

Conservation value: high

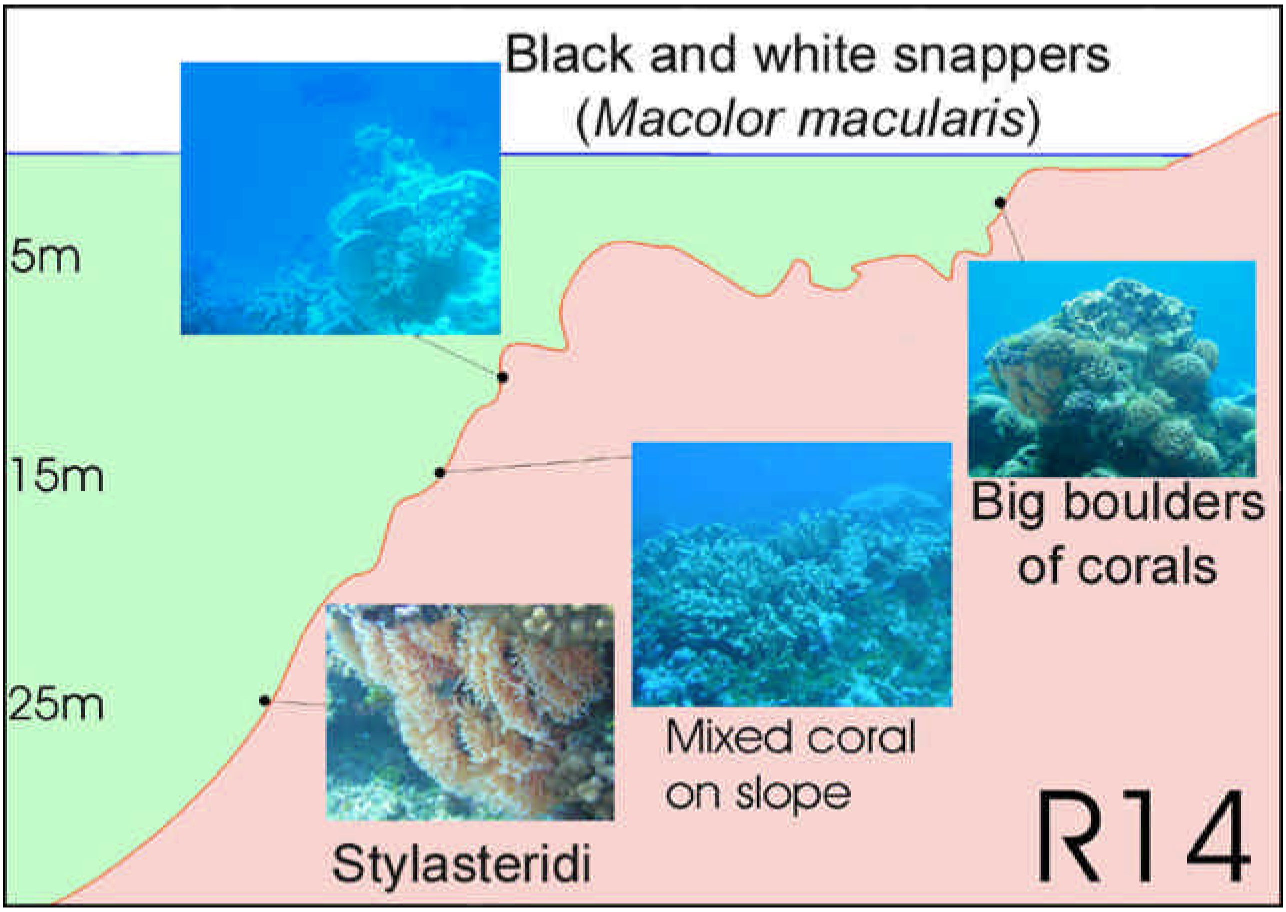
Fish species: 145 **Coral species: 61**

Visually estimated coral cover: 70 %	**Measured coral cover:**				
	Shallow	**30%**	**Fish biomass:**	**Shallow**	**15.4 kg**
	Medium	**28%**	**12.9 kg (2.32)**	**Medium**	**12.4 kg**
	Deep	**32%**	**(2500m^3 of water sampled)**	**Deep**	**10.9 kg**

Habitats:	**- biological**	**- topographical**
	Macroalgae w/ sparse coral	Slope (> 25°)
6 biological	Macroalgae	Slope (> 45°)
6 topographical	Mixed corals	High energy reef crest / top
	Rubble with encrusted life	Flat reef

Description: Second dive of day, by the pass, island facing the ocean side. Murky water for tide coming in. Gentle sandy gentle slope with bommies going down gradually with grooves, with coarse sand at bottom of the valleys between the outcrops. The cover was at least 50% algae and only sparse corals for most of the 20 to 7 m depth portion of the reef. Shallower, there was a lot of rubble, and near the beach a rock ledge. High presence of seaweeds as well, somewhere up to 60 %. *Caulerpa serrulata*, *Halimeda spp.*, *Caulerpa racemosa*, *Microdyction spp.* and blue green algae were the dominant types. Big schools of large black and white snappers, several grey reef sharks, one turtle.

Profile:


Black and white snappers
(*Macolor macularis*)
5m
15m
25m
Big boulders
of corals
Mixed coral
on slope
Stylasteridi
R14

6. Recommendations

The results of this study documented an outstandingly pristine and healthy coral reef ecosystem on Rongelap Island. This detailed survey provided a baseline for future changes and impacts that might occur as a result of resettlement. The most important and foremost recommendation is that the resettlement should be carried out in a well-controlled and regulated manner, concerning all activities that may impact the coral reef ecosystem. A completely intact and prosperous coral reef is a highly valuable resource, which is becoming extremely scarce on a global scale. The Rongelapese people now have the unique chance to prove that reef deterioration must not always be the inevitable results of human habitation. Wisely managed uses of the resource as well as well managed land-based activities would ensure that human populations and thriving coral reefs can co-exist.

We provide below a list of important issues to consider in the context of coral reef management and conservation. These include but are not limited to:

- Fisheries,
- Waste disposal,
- Tourism,
- Traditional use,
- Aquaculture and pen holding, and
- Energy use.

One of the most efficient methods of reef management is the establishment of no-take reserves (sanctuaries) in combination with management of the adjacent reef zones. We will consider each point below.

6.1 Fisheries

Artisanal fisheries can provide a source of income and food if properly managed. It is important to establish the status of the resource by continuous monitoring and adapt exploitation accordingly. Recreational fisheries are likely to target pelagic fish such as tuna, but also reef fishes such as groupers or snappers. While this fishery appears fairly small compared to commercial operations, it is important to keep track of quantities being caught as this usually is easily overlooked.

Industrial fishing activities such as shark fishing should be approached with caution. While allowing foreign vessels into the local waters will generate short-term income by fees, on a long-term basis it could destroy the resource. Fishing on an industrial scale is likely to overexploit the resources, particularly when foreigners move into new fishing grounds and become a main cause of depletion of resources, since they use high extractive methods and are not concerned about future uses and impacts on sites that belong to another country. It is very difficult to establish the status of top-predators such as sharks or tuna. Sharks have a very low reproductive efficiency, they mature late and only produce a few young. For animals with such characteristics, it is often too late to maintain populations by the time it is realised that they are severely depleted.

6.2 Waste management

Waste disposal on land is extremely important for the management of coral reefs. Nutrients from effluents can cause the reef to experience a phase shift from coral reef to algal reef, as nutrients facilitate algal growth, whereas corals require low nutrient levels. Garbage such as plastic bags, soft drink cans and Styrofoam plates are easily removed from site on land by throwing them into the sea, however this creates new problems. This waste smothers the corals, kills sea turtles that eat plastic bags thinking they are jellyfish, suffocate seabirds and poison the waters. We recommend a careful solid waste management. A well designed dumping site should be created, featuring (a) a strong containing wall ensuring waste cannot be blown out of the pit, (b) a sealed bottom to prevent seepage into the groundwater and the sea, and (c) a control outlet to monitor the toxic and nutrient concentrations in the liquid collecting at the bottom of a pit.

Prevention is the best cure, so we recommend a wise use of one-way non-recyclable items such as Styrofoam plates or cups. Drink cans should be recycled for their metal content. Household sewage should be treated in three stages before disposal.

6.3 Tourism

Tourists can be attracted by healthy and abundant marine resources, which they like to view and experience. Fully protected marine reserves can be highly attractive to tourists as the habitat is protected from any activities and is pristine; larger fish and large school of big fish accumulate in the area. Sustainable and environmentally sound tourism would be provided by ecotourism, where tourists would benefit the island but not begin to take it over or degrade its environment. Tourism can also bring prosperity to an area with creation of job opportunities (boat taxing, local shops, dive shops, hotels), alternative livelihood, - often better than fishing - , and increased income. However tourism always damage to a certain extent marine reserves and coral reefs in general. Coral reefs are particularly susceptible to sediment release during hotel construction (sediments can smother and kill corals), algal growth boosted by nutrient input from tourist sewage facilities, anchor drops from boats. Tourist themselves can also create considerable damage by breaking corals while diving or snorkeling.

We recommend strictly limiting numbers of tourists and utilising environmentally sound hotel management practises, including composting food wastes and sewage treatment. Mooring buoys prevent anchor damage and breakage of tourists has been proved to be reduced through education and making them wear lifevests when snorkeling. This also increases their safety if they are not confident swimmers. It is important to ensure that tourism development is properly regulated so that it does not exceed the sustainable capacity of the environment. With careful management it is possible to achieve a balance that is favourable to both environment and tourism.

6.4 Aquaculture

Aquaculture is a promising income generating venture for the people of Rongelap. It involves growing marine species from a larval or young stage to saleable size. However, it can severely impact reefs through nutrient enrichment of the water and catches of young or adult fish. There have been proven successful aquaculture ventures in Majuro and the other atolls that have good airfreight connections. The success of Rongelap aquaculture would depend upon improved and reliable air services, or high speed catamaran sea freight. The species proven to be good for atoll aquaculture are giant clams and pearl oysters. Local businesses in Majuro have profited from oyster and giant clam farming. Simon Ellis was quoted to say that the southeast of Rongelap atoll

was promising for clam farming while the northwest has deep waters suitable for pearl production (Pacific Business News, 18 June 2002).
Trade of fish and corals for the aquarium market is a temptation in the economic development of Rongelap. This temptation will be enhanced since the Great Barrier Reef Marine Park Authority and Queensland Government will be either closing or severely restricting this industry in Australia. Australia is lucky to have alternative industries that have proven to yield export earnings. In the case of RMI, the aquarium trade is one of the few private industries that have earned export earnings. We are not advocating a blanket ban on all aquarium trade, but we unequivocally ask RALgov to give Napoleon-wrasse and other endangered species full protection within the local government area.

Personnel associated with Australian aquaculture and aquarium-trade industries are familiar with opportunities in RMI, and so there may be opportunities for collaborative development. Beware that opportunities come with risks, and so RALGov should be cautious with extraction of fish and corals for the aquarium trade. In the case of the Great Barrier Reef, tourism has proven to be far more valuable that extractive fishing, and so the Australian Government has applied very strict regulations of fishing and vastly expanded the extent of marine protected areas. We recommend that all aquaculture or aquarium industry proponents be required to provide a complete business plan, including marketing research and an analysis of transport costs, environmental impacts and risks.

Already there have been investment ventures aquaculture/aquarium trade from Rongelap. Sea cage holding pens have been proposed for live fish trade (Pacific Island Report, 2001). This would involve catching the fish on the adjacent reefs and storing them in holding pens until the fish can be collected by freight ship. The impact of such an operation could be substantial, as it would remove large quantities of fish to export it to the Asian markets. This could result in a severe depletion of target species as well as the fish caught to feed them, and should be approached with care. Again, a detailed business plan and environmental impact assessment should be required from any proponent and scrutinized by third-party experts.

6.5 Energy use

Stage I of the Rongelap resettlement has included two 225 Kw diesel generators, a reverse-osmosis desalinisation plant 40,000 gallons freshwater storage, warehouse and maintenance buildings, and a Field Station to accommodate 40 people, including a kitchen, food storage, dining area, and recreation room.
Stage II has been proposed to include over 50 family homes; Medical Centre; School; Library; Municipal Buildings; Port and Airport Buildings; and a bulk fuel storage and loading facility. The later would be tank farm that holds 150,000 gallons, with provision for expansion to 500,000 gallons (RALGov, 2002).

Non-renewal energy resources are extremely expensive on atolls, and should be used wisely. Although this is only indirectly related to the health and status of reefs, there are some important impacts:

- Firstly, the shipping of generator fuel increases the threat of oil and fuel spills in the lagoon.
- More importantly, burning fossil fuel increases the output of CO_2, which feeds the global climate change tendencies towards higher temperatures. This in turn has heavy impacts on reefs as it is the major cause for coral bleaching (Reaser et al. 2000, Hughes et al. 2002).
- The lighting and cooling of all buildings on Rongelap Island are currently dependent on a diesel-electric power plant. This facility creates a large amount of noise pollution and runs 24 hours per day.

We recommend that acoustic attenuation be provided by way of a block wall screening around the power plant. We also recommend that an energy audit be conducted to establish what size of population the existing power plant is capable of servicing.

It is expected that diesel power generation requirements would be maximum during night-time, while photovoltaic (PV) panels could provide a substantial amount of electric power during daylight hours, when air-conditioning loads are greatest.

The existing power plant might suffice without added PV capacity if other renewable energy resources were exploited. Ocean thermal energy conversion (OTEC) has been demonstrated in Hawaii (Halloran, 1990). The OTEC principle is to extract cold water available off the continental shelf for air-conditioning purposes (Van Ryzin and Leraand, 1991). A by-product of OTEC is the production of freshwater, as it condenses on air-conditioning cooling coils.

6.7 Marine protected areas

Marine conservation areas are needed to preserve these regions of reefs that are particularly high in biodiversity, i.e. rich in species, as stated by the Biodiversity Strategy and Action Plan, Goal A1, Strategic Theme A, B and D (Conservation of biodiversity and the marine environment). These conservation sites would be a revitalization of traditional environmental practices, enhanced by modern knowledge and scientific understanding. The need to reinvigorate the "*traditional environmental conservation practices*" in order to "*harmonize development with environmental sustainability*" is also stated in Vision 2018, Goal 10, Objective 5 (RMI, 2001). Also internationally, the interest in MPAs has increased widely.

We recommend to establish a community-based coastal resource management plan that can apply the principles of participation, social equity, productivity and self-reliance along with environmental sustainability. It should aim to (a) manage the fishery resources, (b) protect reef ecosystems and all the goods and services they provide, and (c) mange land-based activities to minimize impacts on reefs. We stress the importance on the community-based approach, since when a community becomes responsible of its fishery resources, the people develop a sense of ownership and become protective users.

This proposed action plan is the constitution of a network of small marine protected areas or no-fishing zones, to be created around the atoll and monitored for a minimum of 5 years.

6.6.1 Why establishing a marine conservation site?

There are several benefits to establishing a marine reserve. We define a marine reserve as an area of reef, ocean and adjacent intertidal zone where management measures are applied; these also include sanctuaries or no-take areas, where no extractive activities are allowed. Conservation measures should be applied on pristine reefs as well as on damaged or over-fished reefs. Pristine reefs that were protected are found for example in the Great Barrier Reef in Australia and in Papua New Guinea. Following the *Precautionary Principle,* the local government should facilitate conservation of biodiversity and pristine habitats. Excellent results from the establishment of marine protected areas are being witnessed all around tropical areas. The positive effects of no-take zones are numerous:

- ***protection of areas of habitat in pristine conditions***. Pristine habitats are more likely to receive higher levels of recruitment as a result of providing the correct environment for young fish (Roberts and Polunin 1991);
- ***enhanced social and economic opportunities***, including activities such as wilderness experiences, ecotourism, diving, underwater photography and advanced marine education (Murray et al., 1999); in some regions the economical benefits originating from these activities may exceed the extractive uses of marine reserves (Brock, 1994). Sanctuaries are luring divers looking for healthy reefs and dense fish populations;
- ***increased scientific knowledge and understanding of marine ecosystems*** and their management (Murray et al., 1999). No-take marine ecological reserves are necessary to provide essential reference areas to evaluate impacts of fishing and other human activities on the ecosystem and to allow a better understanding of ecosystem structure, function and performance. Reserves provide monitoring sites so that natural long-term changes can be distinguished from anthropogenic changes;
- ***conservation of large predatory fish*** - often the target of fishermen and the first to decline on coral reefs (Russ and Alcala, 1996);
- ***maintenance of intra-specific genetic diversity*** (Roberts and Polunin, 1991);
- ***species and biological diversity and ecosystem structure conservation***. Fishing activities change species composition and alter the food web structure. Changes in ecosystem structure and functioning become more likely as the pressure of fishing and other activities increase (Murray et al., 1999);
- ***increase in abundance, mean size and biomass of fish populations in overfished areas*** (Bohnsack, 1995; Roberts and Polunin, 1991; Roberts et al., 1995; Rowley, 1994);
- ***control of male-female sex ratio***, that heavy fishing tends to change into a smaller sized female dominated ratio (Bohnsack, 1998; Law et al., 1993; Ricker, 1981);
- ***enhanced yield in adjacent areas via emigration of fishes from the reserves*** (Bohnsack, 1998; Robert and Polunin, 1991; Rowley, 1994; Russ and Alcala, 1989);
- ***higher production of eggs by larger females*** (Roberts and Polunin, 1991).

The location of MPA should be based on:

- Local needs (good fishing spots, accessibility, uses, heritage value, recreation);
- Resource assessment (reef health, coral cover, fish abundance & size, diversity);
- Enforcement ease (accessibility, observation);
- Threats potential (pollution, erosion, coral bleaching);
- Economics (potential for tourism).

Sizing a marine reserve is an important issue. Form a biological standpoint, the bigger a reserve the better. However large areas are difficult to enforce, while small areas usually include fewer features. In order to meet goals for fisheries and biodiversity conservation, reserves must encompass the diversity of marine habitats. The concept of adding many small areas into a “chain of pearls” leads to a large reserve, thereby facilitating connectivity between protected areas, including larval exchange and adult fish migration. Sizes of reserves around the world vary greatly, as do their zonation and management concepts. Below we provided examples of sizes from MPAs around the world.

- St Lucia – 2.6ha
- Apo Island – 12 ha
- Danjugan Island – 60ha
- Bunaken NP – 1300ha
- Tubbataha WHS – 33 200 ha

- Great Barrier Reef - 2000km long, 100km wide

Recommended sizes of marine reserves range from 10%, 25% to 30-50% of the total available reef area that should be protected as "no-take" marine reserves (Salm 1984, Salm et al. 2000, Hughes et al. 2002). The large distances between oceanic reef habitats and sources of larvae means atoll reefs may largely self-recruit. If this is the case, breeding populations of all species on the reef must remain intact to ensure the integrity of the reef. Other features of the reef system that must be managed include key functional groups and food webs. The structure of the reef must also be protected to ensure that rates of reef growth balance rates of erosion or sea-level rise.

6.6.3 Marine reserve at Rongelap Island

Marine reserves should be established based on several factors to ensure maximum conservation efficiency. The major selection criteria are (a) biological integrity, (b) low threats potential, (c) social acceptance, and (d) logistical ease.

6.6.2.1 Selecting a location

The survey results suggested that there were two major biological zones on Rongelap island, the lagoonal and outer reef ecosystems. An adequate portion of each habitat should be included in a reserve network. We recommend here to locate a marine reserve at Jaboan, where the outer reef and the lagoon habitats meet, and where there are also habitat features that do not occur elsewhere. The highest count of fishes was found here. As the size of the proposed reserve will by far exceed the size of our survey plots, several of the survey sites would be included in the proposed reserve, thus incorporating sites that supported a high coral species count. Threat potentials are low as there is adequate flushing through the pass, lower settlement potential and good forest cover on land to prevent sedimentation. However, should there be the need to choose a different site arrangement, other sites could also be selected. This should incorporate the outer site R10 (opposite the airport terminal) and R6 (lagoonal site half way between airport and Jaboan point) where a large patch-reef is located. As this is an alternative suggestion that would require a higher effort (i.e. 2 reserves), we will focus on Jaboan Point in the following part of the report.

There are several issues to be considered in establishing a marine reserve that are beyond biological suitability. Consideration should be given also to the socio-economic and customary use, the accessibility of the site and the ease of surveillance in addition to the biological factors (Table 21).

Table 21. Factors to be considered when creating a MPA at Jaboan Point.

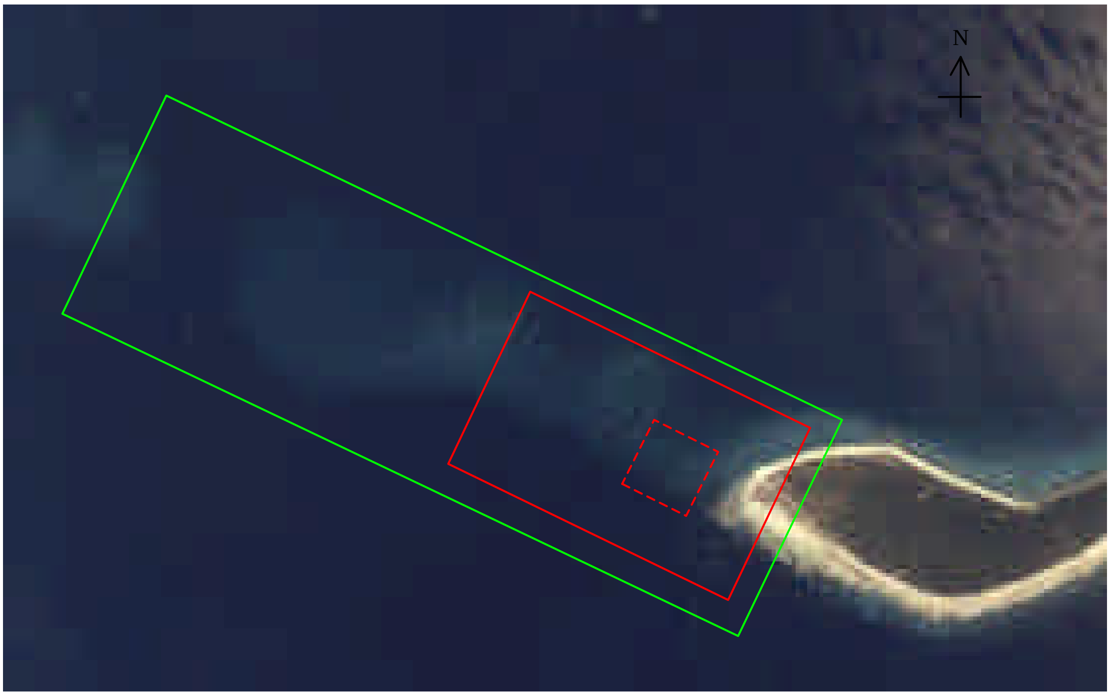
Positive factors	Negative factors
High biological integrity, including the presence of sharks and turtles; they also act as tourist magnets.	Other users (e.g. fishing) loose a good spot.
Water exchange	Potential exit point for rubbish entering the lagoon (but this must be avoided by proper waste management)
Sheltered from prevailing wind	High exposure to currents during tidal changes
Easy access by track or sea	Potential for pollution from ship traffic through the pass, e.g. by oil-spills
Easy to enter and exit the water from the shore (diving or snorkelling)	Exposure to currents may translate into higher maintenance of facilities such as buoys.
Furthest site from population pressures	Safety issues for diving and snorkelling due to exposedness

The factors against establishing the sanctuary at Jaboan would be mitigated by creating a buffer zone around the core zone. The buffer zone will protect sites R1 through R9 (all around Jaboan point). Jaboan is owned by the *alap* Hemos Jiles and his permission will have to be sought to establish an MPA on his property. Finally, a sanctuary at Jaboan achieves the aims of protecting a high diversity of Marshallese food-fish and edible invertebrates within a biologically superior area to encourage ecotourism.

6.6.2.2 Size of the proposed sanctuary

Literature suggests that a small MPA is better than no MPA at all (Dayton, 2000, Jones, 1992, Ballantine, 1991), but also that any MPA should be accompanied by other management and conservation measures of the surrounding reefs (Allison, 1998). The minimum size for an MPA recommended in literature ranges from 20 to 50 % of the total reef area (Day, in press, Hughes, 2002). In the case of Rongelap Island, 20% area is from R1 to R9 extending out past the reef into the pass, calculated using MapInfo® (Figure 39). The sanctuary in total should be comprised of an area of land, a core zone and a buffer zone to be fully successful. The buffer zone protects the core of the sanctuary with restrictions both on the land and in the sea. The buffer zone was drawn from the chart and aerial photographs of the island around the reef surrounding the core zone (Figure 40).

Figure 39. Core zone and buffer zone of sanctuary at Jaboan.



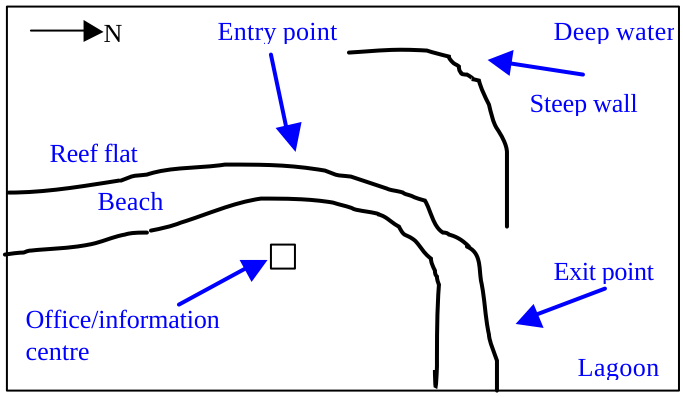
Key:

Core zone

Buffer zone

Area sketched in figure 5.4.

Figure 40. Jaboan point as a marine sanctuary.



6.6.2.3 Guidelines for the establishment of the sanctuary and its management plan

The creation of an effective marine reserve is and ongoing, interactive process that does not end with passing it into law. To maintain efficacy and satisfy all stakeholders in a long term, adequate measures for monitoring (measuring the effect of the reserve), surveillance (enforcement) and education (let local people experience their own reef) are crucial.

As outlined in the MIMRA Act, 1997, a management plan shall include a description of the fishery by reference to the area, fish species and present state, objectives to be achieved and an outline strategy to achieve these, methods for evaluating effectiveness and a date to review the performance. A management plan should also address:

- other beneficial objectives (ie conservation of biodiversity),
- management of pollution,
- user profiles and permits,
- land- based activities in coastal strip,
- waste disposal and sewage discharge,
- social implications,
- exceptions (if applicable),
- monitoring,
- surveillance, and
- guidelines for future adaptive measures if necessary.

Non-negotiable guidelines on the sanctuary rules will be clearly displayed in English and the local language of Marshallese.

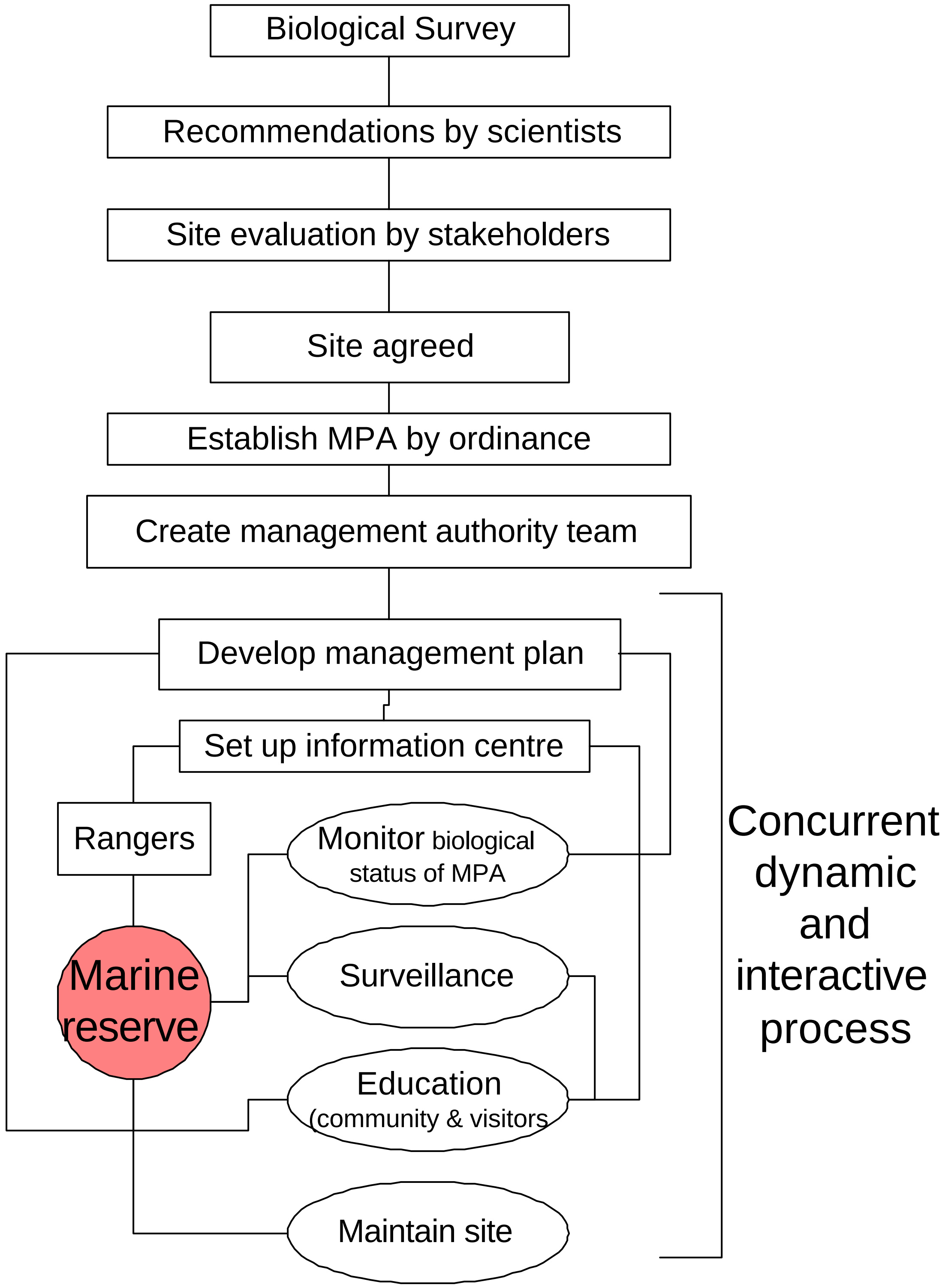
The researched sanctuary eventually will be based within a wider scale management plan of the whole atoll and possibly even the three atolls governed by RALGov. Linking the protected areas means that they all benefit from each other, particularly the smaller sanctuaries, which can be destroyed in single disaster events.

A marine sanctuary on the community's doorstep may give it a better understanding of the other proposed protected areas in the atoll. It is also important to establish the sanctuary well before the resettlement, and commencement of anthropogenic uses and impacts in the surrounding area. The present data set will provide a baseline for monitoring.

The permanent transect laid provide an ideal means for monitoring. It can be compared to the other permanent transect laid outside the proposed reserve area, this will allow the community to see the changes (growth, decline or stability). The monitoring will assess the impact over time from fishing and diving activities as well as natural processes such as recruitment or coral bleaching.

Once the MPA management plan is approved by RALGov and the other authorities involved, the plan will represent the first example of coral reef conservation in the RMI and the model of establishment could be used to help conserve further atolls in the country.

Figure 41. Steps to MPA establishment on Rongelap Island.



6.6.4 Community-based management planning

Community-based resource management is taking force all over the world as new and best practice for use of coastal resources in a sustainable manner. It is recognized that ***humans are part of the ecological system***: coastal habitats are the results of complex interactions among physical, biological and human forces. Community based management should involve all level of users into the detection of issues or problems (natural, environmental, economic problems) and the determination of solutions. Through participatory approach, management gains several advantages:

?? ***Enforcement is easier:*** support (financial political, practical) is obtained from local communities that recognize the need for conservation. The use of participatory techniques reinforces people awareness, knowledge, ability, and motivation to make decisions about their future. The community understands the principles involved. The outcome is a guarantee of success that is much greater than when running a project from a governmental agency. In return the communities benefit from shared income generated by MPAs, through improved fishery yields, through increased employment.

?? ***Education***: Community-level monitoring or participatory approach is an important way to increase understanding of causes or resources degradation. Information an education are to provide the community the necessary material and tools to increase their knowledge and appreciation of coastal and marine environment, basic ecological principles, the various threats to the environment, and what community members can do to help promote coastal resource management.

6.6.3.1 Requirements for Community-Based Management

- ***Information***: The users should be informed at all stages of a management plan development: they should be consulted and involved in the process. Resources cannot be managed or protected in a sustainable manner unless those who exploit them are committed to this goal and involved in the management process (White, 1989).

- ***Education*** is important in order to build capacity for self-organization and self responsibility. Education can help people understand why management is necessary and may help initiate their participation. Workshops, public meetings, campaigns, citizen groups, school programs and special projects involving the community can be used as participatory tools.

- Traditional leaders support. Lessons from different regions of the world highlight the need to take into account customary supporting frameworks provided by traditional kings or leaders, chiefs, religious leaders. These powerful key players must be fully involved in developing strategies for wise use of resources. Future marine management plans need to include all levels of the governmental hierarchy, the national government, local government, the *iroij* and the *alaps* (traditional landowners).

- Traditional knowledge**:** The natural world has been protected from the most disruptive human influences through laws or cultural or religious taboos preventing overexploitation. The loss of traditional knowledge about resource use in one of the central problems of our times. Local people have a knowledge of ecology in their context that is far subtler and sometimes superior to that of outside "experts". Traditional practices can be invaluable tools for management. However, "*traditional practices do not necessarily result in environmental sustainability*" and they must be assessed in the light of changes in population dynamics and pressures. Local explanations may need to be reviewed in light of scientific understanding. It is important that researchers working with local people *ensure a two-way exchange of information, ensuring that local wisdom is incorporated into management strategies, and feeding back scientific knowledge and data to the communities.* Local environmental knowledge can be a powerful source of authority. Moreover, when park regulations for resource use are based on local traditions, the local people take an active role in ensuring the respect of the rules.

- Coordination. Decentralization can lead to greater efficiency and reliance on co-management structures, but if this decentralization is not coordinated it can result in competing and overlapping jurisdictions, conflicts or a total abandonment of responsibility by government agencies. The focal point of a community-based management and conservation plan should include education of local communities and formation of *marine management committees*.

- Participatory Monitoring Programs**:** Important part in a management program is to monitor for changes over a year or so to determine if changes are taking places and whether the reef is improving or getting worse. Monitoring for changes and success of management is essential to detect how systems are performing.

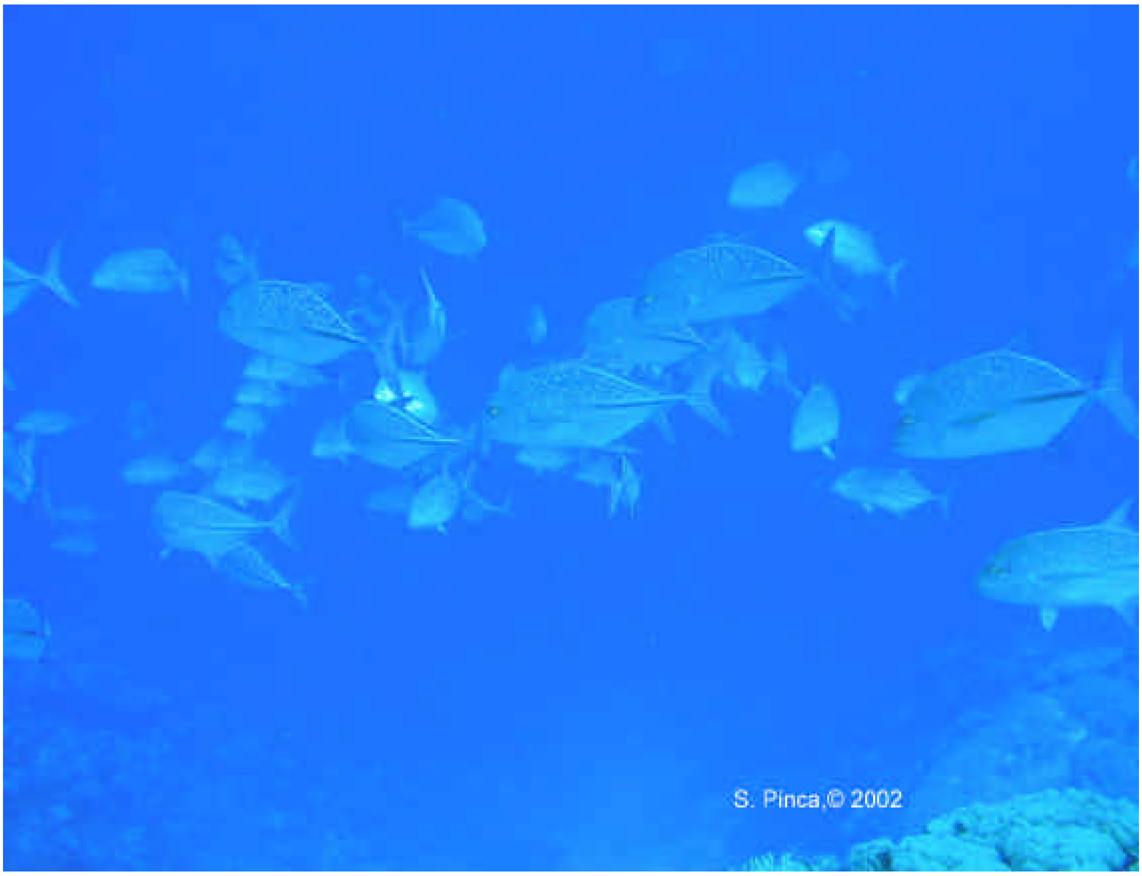
✍ Moreover, the government and the decision makers in the atoll *need to know with more scientific certainty how forces such as migration, urbanization, rapid population growth, tourism and high rates of resource consumption will affect and are affecting the natural ecosystems*. At the same time it is important that the community itself participates in this analysis. Communities involved in monitoring see for themselves the impacts of interventions and can recommend corrective actions if necessary. In this way baseline and monitoring surveys can build awareness.

6.6.3.2 Job opportunities

With the creation of marine parks or conservation sites, there would be availability of local employment opportunities for skilled marine surveyors and marine park rangers.

Marine park rangers would be needed to patrol and monitor marine reserves for local and global threats. Specialized marine technicians could become the work force able to monitor reefs for global warming effects, as part of a local plan "*to counter the emerging threats resulting from the adverse effects of Climate Change*" (Goal 10 –Environmental Sustainability – Objective 2, Vision 2018 – RMI, 2001). Including local users of resources in their management would be part of the process of instigating "*the sense of ownership and responsibility*" in people from all levels of society (as demanded by Goal 5 – A productive people- Objective 2-4, Vision 2018 – RMI, 2001).

Tourist guides and awareness leaders for tourists would be especially needed as well. These guides would not only have the responsibility of leading visitors groups in marine parks, but would also be in charge of giving biological information on the local natural ecosystems as well as on how to behave in the respect of the marine environment.
These people would have the skills to become the educators on atoll environments for both visitors and the community, and thus they would take part in the environmental awareness promotion whose necessity is claimed by Vision 2018, Goal 10, Objective 2-4 and Objective 5-2 and by BSAP, goal D2 (RMI, 2001).


S. Pinca,© 2002

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Appendix 1

SUBSTRATUM, CORAL LIFE FORMS, CORAL TARGET SPECIES.

On the LIT two different information are acquired: 1) substratum types and 2) coral life form and species/genera.
Substratum

The habitat type is linked to species ID as some species can only be found on a certain substratum (e.g. sea pen on sand and mud). Reef health is often indicated by the presence of dead coral or rubble, which will be found to support different species types.

Bedrock	Rock, or coral rock, coral features (e.g. corallites) or life forms can not be distinguished, on dense or medium dense coral cover this is the most likely substratum.
Dead coral	Recently dead hard coral, newly dead still white) or longer dead. Former corallites and / or coral life form are still visible and distinguishable.
Rubble	Loose small to medium coral rock, mainly stemming from branching or submassive coral, normally substratum for red coralline algae. Not much grows on rubble, due to its loose status. Often accumulates below walls. Sometimes indicates recent damage, e.g. due to destructive fishing or bleaching.
Sand	Sand – grains can be seen.
Mud	Mud, if disturbed the water becomes cloudy, grains cannot be distinguished.

CORAL LIFE FORMS

LIFE FORMS	SYMBOL	EXAMPLES		
Stony corals				
Acropora				
Acropora branching	A-B	*A.formosa, A.teres*	S	
Acropora encrusting	A-E/Sm	*A.-Isopora cuneata, A.-Isopora palifera*	S	
Acropora digitate	A-D	*A. digitifera, A. humilis*	S	
Acropora tabulate	A-T	*A. hyacinthus, A. irregularis*	S	
Acropora bottlebrush	A-Bb	*A. subglabra*	S	
Non Acropora				
Branching	N-Br	*Seriatopora hystrix*	S	
Encrusting	N-E	*Astreopora listeri*	S	
Massive	N-M	*Favia speciosa*	S	
Submassive	N-Sm	*Alveopora, Goniopora, Leptoria phygia*	S	
Foliose	N-F	*Montipora foliosa, Pachyserius speciosa*	S	
Mushroom	Mu	*Cycloseris*	S	
Tube coral	Tub	*Tubastrea*	S	
Blue coral	Bl	*Heliopora*	O	8
Organ pipe	Op	*Tubipora*	O	8
Fire coral	Fire	*Millepora*	H	
Lace coral	Lc	*Distichopora*	H	
Fine Lace coral	FLc	*Stylaster*	H	
Soft exacorals				
Anemone	An		A	6
bottle-cap	Bc	*Zoanthus, Palythoa*	Z	6
mushroom anemone	MA	*Discosoma*	C	6
Soft octocoral (Alcyonacea)				
Leather coral	SLe	*Sarcophyton*	O-S	8
Stiff Leather coral	Sle	*Lobophytum*	O-S	8
Soft finger coral	Sfn	*Sinularia*	O-S	8
Soft Christmas tree coral	SCt	*Dendronephtya*	O-S	8
Soft Cauliflower coral	SCf	*Lemnalia, Paralemnalia*	O-S	8
Soft Flower	SFl	*Clavularia*	O-S	8
Pulsing flower	SPf	*Xenia*	O-S	8
Fan coral	SFan	*Subergorgia*	O-S	8
Bamboo coral	SBc	*Melithaea*	O-S	8
Whip coral	SWc	*Ctenocella, Junceella*	O-S	8

8 = octocorals, 6 = exacorals, A= Actiniaria, O = Octocorals, O-S = Octocorals soft, Z = Zoanthidea, C = corallimorphs, S = Scleractinia

CORAL TARGET GENERA/SPECIES

TARGET GENERA		
Scleractinia genera	**code**	***example***
Cricket-bat coral	Cb	*A. palifera*
Bottlebrush *Acropora*	Bb	*A. subglabra/echinata/speciosa*
Angular crater coral	Ac	*Leptastrea*
Broccoli coral	Bc	*Pocillopora damicornis*
Cabbage coral	Cb	*Turbinaria*
Crater coral sharing	Cs	*Favites*
Crater coral with valleys	Cv	*Favia*
Cup mushroom	Cup	*Halomitra spp.*
Cylindrical brain coral	Cbr	*Scaphophyllia cylindrica*
Daisy corals	Ds	*Alveopora/Goniopora*
Donut coral	Dt	*Lobophyllia*
Elephant coral	El	*Pachyseris speciosa*
Fine brain coral	Fbr	*Goniastrea*
Finger coral	Fn	*Stylophora pistillata*
Flat spiny cup coral	Fsc	*Acanthastrea echinata*
Furry mushroom coral	Fmu	*Polyphillia talpina*
Gingerroot coral	Gr	*P. cylindrica*
Large brain coral	Lbr	*Oulophyllia*
Large Broccoli coral	LBc	*Pocillopora Eydouxi, meandrina*
Lobe coral	Lob	*Porites lobata, P.australiensis, P.lutea*
Long mushroom	Lmu	*Ctenactis echinata, H. limax*
Majuro coral	Mj	*P. rus*
Medium Broccoli coral	MBc	*Pocillopora verrucosa*
Mushrooms	Mu	*Fungia, Cycloseris*
Sand paper coral	Sdp	*Montipora*
Sandy coral	Snd	*Psammocora*
Sausage brain coral	SBr	*Symphyllia*
Small brain coral	Sbr	*Leptoria*
Spaghetti coral	Sp	*Euphyllia*
Star coral	St	*Pavona*
Thorn coral	Th	*Seriatopora hystrix*
Volcano coral	Vo	*Astreopora*

Appendix 2

TARGET FISHES

Family	Name (Engl)	*Species*	Common
Charcharinidae		*Carcharinus melanopterus* *Triaenodon obesus* *C. amblyrhynchos* *C. albimarginatus*	Black-tip shark White-tip shark Gray-reef shark Silver-tip shark
Myliobatidae		*Aetobatis narinari*	Spotted eagle ray
Muraenidae	Morays	*Gymnothorax javanicus*	Giant morey eel
Synodontidae	Lizardfish		
Mugilidae	Mullets		
Holocentridae	Squirrelfish		
	Soldierfish		
Scorpaenidae	Scorpionfish	*Pterois spp.*	lionfish
Serranidae	Groupers	*Anyperodon leucogrammicus* *Cephalopholis argus* *C. miniata* *C. urodeta* *Epinephelus fuscoguttatus* *E. merra* *Plectropomus laevis* *Variola louti* *Pseudanthias sp.*	Slender grouper Peacock grouper Coral hind Flagtail grouper Brown-marble g. Honeycomb g. Giant coral g. Lyretail g. Anthias
Cirrithidae	Hawkfish	*Paracirrhites arcatus*	Arc-eye hawk
Apogonidae	Cardinalfish		
Carangidae	Trevallies Jacks	*Caranx sexfasciatus* *C. ignobilis* *C. lugubris* *C. melampygus* *Carangoides orthogramus* *Elegatis bipinnulata*	Big-eye trevally Giant trevally Black jack Bluefin trevally Yellow-spotted t Rainbow runner
Lutjanidae	Snappers	*Aprion virescens* *Lutjanus. bohar* *L. gibbus* *L.kasmira* *Macolor macularis*	Green jobfish Twinspot s. Humpback s. Blue-lined s. Black & white s.
Caesionidae	Fusiliers		
Haemulidae	Sweetlips	*Plectorhinchus lineatus* *P. picus*	Lined sweetlips Spotted sweetlips
Lethrninidae	Emperors	*Lethrinus olivaceus* *Monotaxis grandoculis*	Longface e. Big-eye emperor
Mullidae	Goatfish	*Parupeneus barberinus* *P. pleurostigma* *Mulloidichthys vanicolensis*	Dash and dot g. Sidespot goat Yellowfin goatf.
Chaetodontidae	Butterflyfish	*Chaetodon auriga* *C. reticulatus* *C. lunulatus* *C. punctatofascaitus* *C. vagabundus* *Forcipiger flavissimus* *Hemitaurichthys polylepis* *Heniocus chrysostomus*	Threadfin buttrf. Reticulated buttrf Redfin/oval buttf Spot-banded b. Vagabond buttrf Forcepsfish Pyramid buttrf. Pennant banner
Pomacanthidae	Angelfish	*Centropyge bicolor*	Bicolor angelfish

		C. flavissima *C. loricula* *Pygoplites diacanthus* *Pomacanthus imperator*	Lemonpeel an. Flame angelfish Regal angelfish Emperor a.
Kyphosidae	Rudderfish		
Pomacentridae	Damselfish	*Amphripion spp.* *Plectroglyphidodon dickii* *Chromis spp.* *Dascyllus auranus* *D. reticulates* *Adudefduf* *Pomacentrus coelestis*	Anemonefish Three banded an. Chromis Humbug dascyl. Reticulated Dam. Sergeants Neon damsel
Labridae	Wrasses	*Gomphosus varius* *Hemigymnus melapterus* *Labroides sp* *Epibulus insidiator* *Cheilinus undulates* *C. fasciatus* *Corys aigula* *Halichoeres trimaculatus* *Cirrhilabrus balteatus*	Bird wrasse Blackeye thicklip Cleaners Slingjaw wrasse Napoleon wrasse Red breasted-wr. Clown coris Threespot wrasse Girdled wrasse
Scaridae	Parrotfish	*Bolbometapon muricatum* *Chloruus microrinhos* *Cetoscarus bicolor* *Hipposcarus longiceps*	bumphead parrot Pacific steephead Bicolor parrot Pacific longnose
Blenniidae	Blennis		
Gobiidae	Gobies		
Microdesmidae	Dartfish		
Siganidae	Rabbitfish	*Siganus puellus* *S. argenteus*	Masked rabbitfsh Forktail rabbit
Zanclidae	Moorish idol	*Zanclus cornutus*	
Acanturidae	Surgeonfish	*Acanthurus olivaceus* *A. nigricans* *A. achilles* *A. blochii* *A. triostegus* *A. lineatus* *Ctenochaetus striatus* *Naso lituratus* *Naso vlamingii* *Zebrasoma scopas*	Orangeband s. Whitecheeck Achille's tang Ringtail s. Convict s. Bluebanded s Striped br.letooth Orange spine u. Bignose u. Sailfin tang
Sphyraenidae	Barracudas		
Scombridae	Tunas Makerels		
Balistidae	Triggerfish	*Balistapus undulates* *Balistoides viridescens* *B . melichthys vidua* *Rhinecanthus aculeatus* *Sufflamen bursa*	Orange-stripe tri. Titan triggerfish Pinktail tri. Picassofish Scythe trigger
Monacanthidae	Filefish		
Ostraciidae	Trunkfish	*Ostracion spp.*	Boxfish-trunkf
Tetraodontidae	Pufferfish Tobies		
Diodontidae	Porcupinefish		

Appendix 3

TARGET INVERTEBRATES

	Latin name
SPONGES	
Branching	
elephant ear	
Lumpy	
CRUSTACEANS	
Lobster	
MOLLUSCS	
Cowrie	
Oyster	
Pearl oyster	
small giant calm	*T. maxima*
real giant clam	*Tridacna gigas*
fluted giant clam	*T. squamosa*
smooth clam	*T. derasa*
horse’s hoof giant clam	*Hippopus hippopus*
Cuttlefish	
Squid	
Octopus	
ECHINODERMS	
Long-spined black sea urchins	*Diadema spp.*
Pencil urchin	
black sea cucumber	
spiky sea cucumber	*Telenota ananas*
giant sea cucumber	*Telenota anas*
Crown-of-thorns starfish	*Achantaster plancii*
Cushion star	
skinny star	*Linckia*
chocolate chip star	

Appendix 4

TARGET ALGAE SPECIES AND GENERA

Microdyction spp.
Halimeda spp.
Udotea spp.
Avrainvillea spp.
Dictyosphaeria cavernosa
Dictyosphaeria versluysii
Ventricaria ventricosa
Valonia aegagrophila
Caulerpa serrulata
Caulerpa racemosara
Codium spp.
Neomeris spp.
Jania spp.
Galaxaura spp.
Lithophyllum spp.
Peyssonnelia spp.
Schizothrix spp.
Phormidium spp.
Hydrocoleum coccineum

Appendix 5

PRESENCE AND ABUNDANCE OF CORAL REEF FISHES AT RONGELAP ATOLL, BY MARIA BEGER.

Family	Genus	species	All	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
Ginglymostomatidae	*Nebrius*	*ferrugineus*	x	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Carcharhinidae	*Carcharhinus*	*albimarginatus*	x	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Carcharhinus	*amblyrhynchos*	x	2	0	0	0	1	0	1	0	2	1	0	1	2	3
	Carcharhinus	*melanopterus*	x	0	1	0	2	0	0	0	0	0	0	0	0	0	0
	Galeocerdo	*cuvrier*	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Triaenodon	*obesus*	x	0	2	0	0	0	1	0	0	0	0	0	0	1	0
Mylobatidae	*Aetobatus*	*narinari*	x	2	1	0	0	1	0	0	0	0	0	0	0	0	0
Muraenidae	*Echidna*	*polyzona*	x	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Gymnothorax	*flavimarginatus*	x	0	0	0	0	0	0	0	0	0	0	2	0	0	0
	Gymnothorax	*meleagris*	x	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Congridae	*Heteroconger*	*haaser*	x	5	0	0	0	0	0	0	0	0	0	3	0	0	0
	Gorgasia	*spA*	x	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Synodontidae	*Synodus*	*dermatogenys*	x	0	0	0	0	0	2	0	0	0	0	0	0	0	0
	Synodus	*variegatus*	x	2	0	0	0	0	1	1	0	1	0	0	1	0	1
Holocentridae	*Myripristis*	*berndti*	x	1	1	1	1	0	3	1	2	1	0	0	0	1	1
	Neoniphon	*argenteus*	x	0	0	2	0	0	2	0	2	0	0	0	0	0	0
	Neoniphon	*opercularis*	x	0	0	3	0	0	2	0	0	1	0	0	0	0	0
	Neoniphon	*sammara*	x	0	0	3	1	0	2	0	0	1	0	0	0	0	0
	Sargocentron	*spiniferum*	x	2	0	2	0	3	3	2	1	0	1	1	1	0	0
	Sargocentron	*cfrubrum*	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aulostomidae	*Aulostomus*	*chinensis*	x	2	0	1	0	0	0	0	0	0	1	0	0	0	0
Fistularidae	*Fistularia*	*commersonii*	x	2	0	0	0	0	0	1	0	0	0	0	1	1	0
Syngnathidae	*Corythoichthys*	*intestinalis*	x	0	0	0	0	0	2	0	0	0	0	0	0	0	0
	Corythoichthys	*schultzi*	x	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Corythoichthys	*sp*	x	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Caracanthidae	*Caracanthus*	*maculatus*	x	0	1	0	1	0	0	0	0	0	0	0	0	1	2
	Caracanthus	*unipinna*	x	0	0	0	2	2	0	0	0	0	0	0	0	0	1
Serranidae	*Anyperodon*	*leucogrammicus*	x	2	1	2	1	1	1	1	1	2	1	0	0	2	1
	Cephalopholis	*argus*	x	1	0	0	0	0	0	0	0	0	1	0	1	0	1
	Cephalopholis	*leopardus*	x	0	0	2	1	0	2	1	2	1	1	0	0	0	0
	Cephalopholis	*miniata*	x	0	0	0	0	0	2	0	1	0	0	2	0	0	0
	Cephalopholis	*spiloparaea*	x	0	0	1	0	0	1	0	0	1	1	1	0	1	0
	Cephalopholis	*urodeta*	x	1	1	3	0	0	1	1	2	1	1	2	1	1	2
	Epinephelus	*corallicola*	x	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	Epinephelus	*cyanopodus*	x	0	0	1	0	0	2	0	1	0	0	0	0	0	0
	Epinephelus	*fasciatus*	x	0	0	0	0	0	1	1	0	0	0	0	0	0	0
	Epinephelus	*fuscoguttatus*	x	0	0	0	0	1	0	0	0	0	0	0	0	1	1

	Epinephelus	*hexagonatus*	**x**	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Epinephelus	*maculatus*	**x**	0	0	4	0	0	3	0	2	0	0	1	0	0	0
	Epinephelus	*merra*	**x**	0	0	2	0	0	2	0	2	1	0	2	0	0	0
	Epinephelus	*polyphekadion*	**x**	1	0	1	0	0	0	2	0	0	0	0	0	0	0
	Epinephelus	*spilotoceps*	**x**	0	1	0	0	0	0	1	0	0	0	0	0	2	0
	Gracila	*albimarginata*	**x**	1	1	0	0	0	0	1	0	1	1	0	1	3	0
	Plectropomus	*aerolatus*	**x**	1	2	2	2	2	2	1	1	2	2	0	1	2	1
	Plectropomus	*laevis*	**x**	2	2	1	1	1	2	2	0	2	3	0	3	1	2
	Plectropomus	*oligacanthus*	**x**	2	0	0	1	0	0	1	0	2	0	0	0	0	2
	Variola	*louti*	**x**	2	0	1	1	1	2	2	1	0	0	1	1	1	3
	Belonoperca	*chabanaudi*	**x**	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Pseudanthias	*pascalus*	**x**	4	3	0	4	2	0	2	0	3	4	0	3	3	3
Pseudochromidae	*Pseudochromis*	*bitaeniatus*	**x**	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Pseudochromis	*marshallensis*	**x**	0	0	2	0	0	1	0	1	2	0	0	1	0	0
Kuhlidae	*Kuhlia*	*mugil*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apogonidae	*Apogon*	*apogonoides_cf*	**x**	0	0	0	0	0	2	0	0	0	0	0	0	0	0
	Apogon	*exostigma*	**x**	0	0	3	0	0	3	0	0	0	0	3	0	0	0
	Apogon	*fragilis*	**x**	0	0	4	0	0	0	0	4	0	0	0	0	0	0
	Apogon	*luteus*	**x**	0	0	3	0	0	3	0	3	0	0	3	0	0	0
	Apogon	*savayensis_cf*	**x**	0	0	0	0	0	2	0	0	0	0	0	0	0	0
	Apogon	*taeniophorus*	**x**	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Apogon	*Y stripe sm*	**x**	0	0	2	0	0	0	0	0	0	0	1	0	0	0
	Archamia	*fucata*	**x**	0	0	4	0	0	4	0	0	0	0	1	0	0	0
	Cheilodipterus	*macrodon*	**x**	0	0	3	1	0	2	0	0	0	0	0	1	0	0
	Cheilodipterus	*quinquelineatus*	**x**	0	0	3	1	1	4	0	3	0	2	3	0	0	0
	Rhabdamia	*gracilis*	**x**	0	0	0	0	0	3	0	4	0	0	3	0	0	0
Malacanthidae	*Hoplolatilus*	*starcki*	**x**	3	0	0	0	0	0	0	0	0	2	0	0	0	0
	Malacanthus	*brevirostris*	**x**	2	1	0	0	0	0	0	0	0	0	0	1	1	0
	Malacanthus	*latovittatus*	**x**	1	0	1	0	1	0	0	0	0	0	0	0	0	2
Echeneidae	*Echeneis*	*naucrates*	**x**	1	0	1	1	0	0	0	1	0	0	0	0	0	0
Carangidae	*Carangoides*	*ferdau*	**x**	0	0	0	0	0	1	0	1	0	0	1	0	0	0
	Caranx	*ignobilis*	**x**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Caranx	*lugubris*	**x**	0	0	0	0	0	2	0	0	0	0	0	0	0	0
	Caranx	*melampygus*	**x**	3	1	1	3	3	1	3	1	3	1	2	4	1	0
	Decapturus	*macarellus*	**x**	0	3	0	0	0	0	0	0	0	0	0	0	0	0
	Elegatis	*bispinnulata*	**x**	0	3	0	0	3	0	0	0	0	3	0	0	4	0
	Trachinotus	*blochii*	**x**	0	0	0	1	0	0	0	0	0	0	0	3	0	0
Lutjanidae	*Aphareus*	*furca*	**x**	1	1	1	2	0	2	1	0	1	0	0	2	2	1
	Aprion	*virescens*	**x**	2	0	0	1	3	1	3	0	1	0	1	3	1	1
	Lutjanus	*bohar*	**x**	3	3	2	2	2	3	2	0	2	2	1	2	3	3
	Lutjanus	*fulvus*	**x**	1	0	0	0	0	0	0	1	0	2	0	2	0	0
	Lutjanus	*gibbus*	**x**	2	2	4	3	1	1	3	0	2	2	0	1	2	2

	Lutjanus	*kasmira*	**x**	2	0	2	2	0	2	0	1	0	0	0	0	0	3
	Lutjanus	*monostigma*	**x**	2	1	2	3	1	0	0	0	0	3	0	1	0	0
	Macolor	*niger*	**x**	2	3	2	2	2	1	3	0	2	2	0	2	3	3
Caesionidae	*Caesio*	*teres*	**x**	0	0	0	3	0	2	0	0	0	0	0	0	0	0
	Pterocaesio	*marri*	**x**	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Pterocaesio	*tile*	**x**	3	2	0	2	2	1	3	0	3	3	0	3	3	0
	Pterocaesio	*trilineata*	**x**	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Haemulidae	*Plectorhinchus*	*picus*	**x**	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Nemipteridae	*Pentapodus*	*caninus*	**x**	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Lethrinidae	*Gnathodentex*	*aurolineatus*	**x**	0	0	2	2	0	2	3	2	0	0	0	1	0	0
	Gymnocranius	*spA*	**x**	0	0	2	0	0	0	0	0	0	0	1	0	0	0
	Lethrinus	*erythracanthus*	**x**	2	2	0	2	2	0	1	0	2	1	0	1	2	2
	Lethrinus	*obsoletus*	**x**	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Lethrinus	*olivaceus*	**x**	2	0	1	0	1	1	0	0	2	1	0	1	1	0
	Lethrinus	*xanthochilus*	**x**	0	0	0	0	0	0	0	0	0	1	0	0	1	0
	Monotaxis	*grandoculis*	**x**	4	3	2	4	2	3	2	2	2	1	1	3	1	3
Mullidae	*Mulloidichthys*	*flavolineatus*	**x**	0	1	2	0	0	3	0	3	0	0	0	0	0	0
	Mulloidichthys	*vanicolensis*	**x**	0	0	0	0	0	2	0	1	0	0	0	0	0	0
	Parupeneus	*barberinoides*	**x**	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Parupeneus	*barberinus*	**x**	0	0	3	0	1	4	0	1	0	0	1	0	0	0
	Parupeneus	*bifasciatus*	**x**	1	0	0	2	0	0	1	0	1	2	0	0	0	0
	Parupeneus	*cyclostomus*	**x**	1	1	0	1	0	2	0	0	0	1	0	0	1	2
	Parupeneus	*multifasciatus*	**x**	2	3	0	2	3	1	3	0	1	3	0	3	2	2
	Parupeneus	*pleurostigma*	**x**	0	0	0	0	1	2	0	0	0	0	0	0	0	3
Pempheridae	*Pempheris*	*oualensis*	**x**	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Kyphosidae	*Kyphosus*	*sp.*	**x**	0	1	2	0	0	1	0	0	2	1	0	0	0	0
Chaetodontidae	*Chaetodon*	*auriga*	**x**	1	1	2	1	0	3	0	3	0	1	2	2	0	0
	Chaetodon	*benetti*	**x**	0	0	0	1	1	0	0	0	0	0	0	0	2	0
	Chaetodon	*citrinellus*	**x**	2	1	2	2	0	2	1	1	0	0	1	1	1	2
	Chaetodon	*ephippium*	**x**	2	2	1	1	1	2	1	2	0	1	1	1	2	1
	Chaetodon	*lineolatus*	**x**	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Chaetodon	*lunula*	**x**	1	1	1	0	0	2	0	0	0	0	2	0	0	0
	Chaetodon	*lunulatus/ tritus*	**x**	3	2	2	2	2	2	2	0	2	2	0	3	2	3
	Chaetodon	*melannotus*	**x**	0	2	0	0	0	0	2	0	0	2	0	0	0	0
	Chaetodon	*mertensi*	**x**	1	0	0	0	1	2	2	0	0	0	0	0	0	2
	Chaetodon	*ornatissimus*	**x**	0	1	0	1	0	0	0	0	0	0	0	1	0	0
	Chaetodon	*punctatofasciatus*	**x**	3	2	1	3	3	2	2	0	1	2	0	3	2	3
	Chaetodon	*quadrimaculatus*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chaetodon	*reticulatus*	**x**	2	2	1	3	2	2	1	1	2	2	0	1	2	2
	Chaetodon	*semeion*	**x**	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Chaetodon	*trifascialis*	**x**	2	0	2	1	1	2	0	2	1	2	1	1	1	1
	Chaetodon	*ulietensis*	**x**	2	1	0	1	1	1	2	0	0	0	0	1	2	2

	Chaetodon	*unimaculatus*	**x**	2	0	0	0	0	0	0	0	1	1	0	1	1	2
	Chaetodon	*vagabundus*	**x**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Forcipiger	*flavissimus*	**x**	1	2	0	2	1	3	2	0	1	2	0	2	2	2
	Hemitaurichthys	*polylepsis*	**x**	0	0	0	0	2	0	0	0	0	1	0	0	0	3
	Heniochus	*accuminatus*	**x**	2	0	0	0	0	1	0	0	0	0	0	0	0	0
	Heniochus	*chrysostomus*	**x**	2	0	0	0	2	2	1	0	2	0	0	1	1	0
	Heniochus	*monoceros*	**x**	2	0	0	0	0	2	0	0	0	0	0	0	0	0
	Heniochus	*varius*	**x**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacanthidae	*Centropyge*	*bicolor*	**x**	0	0	0	0	0	2	0	0	0	0	0	1	0	0
	Centropyge	*bispinosus*	**x**	2	2	1	3	2	2	2	0	2	0	0	2	3	3
	Centropyge	*flavissimus*	**x**	2	1	2	2	2	2	1	2	1	2	2	2	3	2
	Centropyge	*heraldi*	**x**	2	2	0	0	0	2	1	0	0	1	0	0	0	3
	Centropyge	*loriculus*	**x**	0	2	0	3	2	0	1	0	2	1	0	3	1	1
	Centropyge	*multicolor*	**x**	2	3	0	2	0	0	0	0	1	1	0	1	0	0
	Centropyge	*multifasciatus*	**x**	1	0	0	1	0	0	0	0	1	0	0	1	0	0
	Centropyge	*vrolikii*	**x**	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Pomacanthus	*imperator*	**x**	2	0	0	0	0	1	2	0	0	0	0	0	0	1
	Pygoplites	*diacanthus*	**x**	2	2	0	2	1	2	2	0	1	1	0	1	2	2
Pomacentridae	*Abudefduf*	*septemfasciatus*	**x**	0	0	3	0	0	0	0	0	0	0	0	0	0	0
	Abudefduf	*sordidus*	**x**	0	0	2	0	0	1	0	0	0	0	1	0	0	0
	Abudefduf	*vaigiensis*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Amblyglyphidodon	*aureus*	**x**	3	0	0	2	0	0	0	0	2	1	0	2	2	0
	Amblyglyphidodon	*curacao*	**x**	0	0	3	0	0	3	0	1	0	0	0	0	0	0
	Amblyglyphidodon	*leucogaster*	**x**	0	0	0	2	0	2	0	0	0	0	0	0	0	0
	Amphiprion	*melanopus*	**x**	0	0	3	0	0	0	0	0	0	0	0	0	0	0
	Amphiprion	*perideraion*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Amphiprion	*tricinctus*	**x**	0	2	2	0	0	0	0	0	2	0	0	2	0	0
	Chromis	*acares*	**x**	0	1	0	3	2	0	0	0	3	3	0	0	3	0
	Chromis	*agilis*	**x**	4	3	2	4	3	2	3	0	3	4	0	4	5	3
	Chromis	*alpha*	**x**	1	1	0	2	0	0	1	0	0	3	0	0	2	2
	Chromis	*amboinensis*	**x**	4	3	0	4	3	1	2	0	4	4	0	4	3	3
	Chromis	*atripectoralis*	**x**	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Chromis	*lepidolepsis*	**x**	2	0	0	0	0	0	0	0	0	0	2	0	0	0
	Chromis	*margaritifer*	**x**	3	2	1	2	0	2	0	2	2	2	1	1	3	3
	Chromis	*ternatensis*	**x**	2	0	0	2	0	2	0	0	0	0	0	2	3	2
	Chromis	*vanderbilti*	**x**	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	Chromis	*viridis*	**x**	3	0	3	0	0	3	0	2	0	0	3	2	0	0
	Chromis	*xanthura*	**x**	2	0	0	2	3	0	1	0	0	0	0	0	1	2
	Chrysiptera	*biocellata*	**x**	0	2	2	0	0	2	3	2	0	0	0	0	0	0
	Chrysiptera	*glauca*	**x**	3	0	2	2	0	2	0	0	0	0	0	0	0	0
	Chrysiptera	*leucopoma*	**x**	2	0	1	3	0	2	1	0	0	0	0	2	0	1
	Chrysiptera	*trayceyi*	**x**	2	0	1	2	2	1	1	0	2	0	0	0	3	2

	Dascyllus	*aruanus*	**x**	0	0	3	0	0	2	0	3	0	0	3	0	0	0
	Dascyllus	*reticulatus*	**x**	2	2	0	0	1	3	2	0	0	2	3	0	2	3
	Dascyllus	*trimaculatus*	**x**	1	0	1	0	0	2	0	0	0	0	0	0	0	0
	Plectroglyphidodon	*dickii*	**x**	3	2	0	3	2	1	3	0	2	2	0	3	1	2
	Plectroglyphidodon	*johnstonianus*	**x**	3	2	0	3	3	1	3	1	3	3	0	4	3	2
	Plectroglyphidodon	*lacrymatus*	**x**	2	3	0	2	2	0	2	0	3	2	0	2	2	2
	Plectroglyphidodon	*phoenixensis*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Pomacentrus	*amboinensis*	**x**	3	0	0	2	0	2	0	0	2	1	1	2	3	3
	Pomacentrus	*brachialis*	**x**	1	0	1	0	0	2	0	0	0	0	0	0	0	0
	Pomacentrus	*coelestris*	**x**	3	0	2	0	0	2	0	0	0	0	2	0	3	0
	Pomacentrus	*pavo*	**x**	3	0	4	0	0	4	0	2	0	0	3	0	0	0
	Pomacentrus	*vaiuli*	**x**	3	3	1	2	3	2	3	1	4	2	0	3	3	3
	Pomachromis	*exilis*	**x**	0	0	1	0	0	0	0	0	0	0	1	0	4	3
	Stegastes	*fasciolatus*	**x**	0	2	0	0	1	2	3	0	2	2	1	3	2	3
	Stegastes	*nigricans*	**x**	0	0	3	0	0	0	0	2	0	0	0	0	0	0
	Stegastes	*lividus*	**x**	0	0	3	0	0	2	0	3	0	0	0	0	0	0
Cirrhitidae	*Paracirrhitus*	*hemistictus*	**x**	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	Cirrhitus	*pinnulatus*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Paracirrhites	*arcatus*	**x**	2	2	0	2	2	0	3	1	2	1	3	2	2	2
	Paracirrhites	*forsteri*	**x**	1	0	0	0	0	1	0	0	0	0	0	0	1	0
Sphyranidae	*Sphyraena*	*barracuda*	**x**	1	0	0	1	0	0	0	0	0	0	0	0	0	0
	Sphyraena	*helleri*	**x**	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	*Anampses*	*caeruleopunctatus*	**x**	1	1	0	0	1	0	1	0	0	2	0	0	0	0
	Anampses	*melanurus*	**x**	0	2	0	0	0	0	0	0	0	2	0	0	0	0
	Anampses	*twistii*	**x**	1	2	0	2	2	0	2	0	1	1	0	3	3	0
	Bodianus	*anthioides*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bodianus	*axillaris*	**x**	0	0	0	0	0	0	1	0	0	0	0	0	1	0
	Cheilinus	*chlourosus*	**x**	0	2	1	1	0	0	1	0	0	3	0	0	1	1
	Cheilinus	*digrammus*	**x**	2	0	2	1	0	0	2	0	1	0	0	0	0	1
	Cheilinus	*fasciatus*	**x**	1	0	0	2	2	1	1	0	1	0	0	2	2	2
	Cheilinus	*orientalis*	**x**	1	0	0	0	0	2	1	0	1	1	0	1	0	1
	Cheilinus	*oxycephalis*	**x**	0	2	0	1	2	1	0	0	2	0	0	0	3	1
	Cheilinus	*trilobatus*	**x**	0	0	1	1	1	1	0	0	0	0	2	1	0	0
	Cheilinus	*undulatus*	**x**	1	1	0	1	0	0	1	0	0	0	0	0	0	0
	Cheilinus	*unifasciatus*	**x**	2	2	0	1	2	0	0	0	0	1	0	1	3	3
	Cirrhilabrus	*balteatus*	**x**	2	0	0	2	2	0	2	0	0	2	0	0	2	2
	Cirrhilabrus	*katharinae*	**x**	2	2	2	2	0	1	2	0	3	2	0	1	3	3
	Cirrhilabrus	*luteovittatus*	**x**	2	0	0	0	0	3	2	0	2	0	0	3	0	0
	Cirrhilabrus	*rhomboidalis*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Coris	*aygula*	**x**	1	3	1	0	1	2	0	0	0	1	0	2	2	2
	Coris	*batuensis*	**x**	0	0	1	0	0	3	0	1	0	0	1	1	0	0
	Coris	*gaimard*	**x**	1	2	1	1	0	0	0	0	0	1	0	0	0	1

	Epibulus	*insidiator*	**x**	3	1	0	2	2	1	2	2	0	1	0	2	3	2
	Gomphosus	*varius*	**x**	3	2	2	2	2	3	2	2	0	2	0	2	2	2
	Halichoeres	*biocellatus*	**x**	3	3	0	2	2	1	2	0	0	2	0	3	3	4
	Halichoeres	*chrysus*	**x**	2	0	0	0	0	2	0	0	0	0	3	0	0	0
	Halichoeres	*hortulanus*	**x**	2	2	1	2	2	2	2	1	2	2	0	2	3	3
	Halichoeres	*margaritaceus*	**x**	1	2	2	2	3	1	3	0	0	1	1	3	2	2
	Halichoeres	*marginatus*	**x**	1	1	0	2	2	1	0	0	0	1	0	2	1	0
	Halichoeres	*melanurus*	**x**	0	0	0	1	0	1	0	1	0	0	2	0	0	0
	Halichoeres	*melasmapomus*	**x**	2	0	0	0	0	0	0	0	1	0	0	0	0	0
	Halichoeres	*trimaculatus*	**x**	2	2	3	2	1	3	0	3	2	0	2	3	2	0
	Hemigymnus	*fasciatus*	**x**	0	1	0	1	1	1	2	0	0	1	0	2	0	3
	Hemigymnus	*melapterus*	**x**	1	1	1	0	0	0	0	1	0	1	0	1	1	0
	Labrichthys	*unilineatus*	**x**	0	0	1	0	0	0	0	1	0	0	0	2	0	1
	Labroides	*bicolor*	**x**	2	1	1	1	1	1	2	0	2	0	0	2	2	2
	Labroides	*dimidiatus*	**x**	2	2	2	3	2	2	2	2	3	2	2	3	2	3
	Labroides	*pectoralis*	**x**	2	0	2	2	1	0	2	0	2	1	0	1	2	0
	Labropsis	*micronesia*	**x**	1	1	1	2	1	1	1	0	1	1	0	1	1	2
	Labropsis	*xanthonota*	**x**	0	0	0	0	0	0	0	0	0	1	0	0	2	0
	Macropharyngodon	*meleagris*	**x**	3	2	1	2	1	0	1	0	2	3	0	3	2	3
	Macropharyngodon	*negrosensis*	**x**	0	0	0	0	1	0	0	0	0	1	0	0	0	0
	Novaculichtys	*taenirourus*	**x**	1	1	1	0	0	1	0	0	0	0	2	2	0	2
	Pseudocheilinus	*evanides*	**x**	1	2	1	3	2	0	1	0	2	2	0	3	2	2
	Pseudocheilinus	*hexataenia*	**x**	2	2	2	3	1	1	3	2	3	2	0	3	3	2
	Pseudocheilinus	*tetrataenia*	**x**	2	1	0	3	2	0	1	0	3	1	0	2	2	1
	Pseudocheilinus	*ocellaris*	**x**	2	0	0	2	2	0	1	0	1	0	0	0	2	0
	Pseudocoris	*aurantiofasciata*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Pseudocoris	*yamashiroi*	**x**	3	0	0	0	0	0	0	0	0	2	0	0	2	0
	Pseudodax	*moluccans*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Pteragogus	*cryptus*	**x**	0	0	2	0	0	1	0	0	1	0	0	0	0	0
	Stethojulis	*bandanensis*	**x**	1	2	0	2	1	1	0	1	1	3	0	2	1	2
	Thalassoma	*amblycephalum*	**x**	2	0	1	2	0	2	1	0	0	0	2	2	3	1
	Thalassoma	*hardwicke*	**x**	1	0	1	1	0	0	0	2	0	0	0	1	0	0
	Thalassoma	*lunare*	**x**	0	0	0	0	0	2	0	0	0	0	2	0	0	0
	Thalassoma	*lutescens*	**x**	3	3	0	3	2	2	2	0	2	2	0	2	3	3
	Thalassoma	*pupureum*	**x**	1	3	2	3	3	3	3	0	2	3	2	2	2	4
	Thalassoma	*quinquevittatum*	**x**	1	2	0	1	2	0	2	0	2	3	0	1	2	2
	Thalassoma	*trilobatum*	**x**	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Scaridae	*Calotomus*	*spinidens*	**x**	0	0	0	0	0	0	0	0	2	0	0	0	0	1
	Cetoscarus	*bicolor*	**x**	2	2	1	3	2	1	2	0	2	2	0	2	2	2
	Chlorurus	*pyrrhurus*	**x**	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Hipposcarus	*longiceps*	**x**	1	3	3	3	2	4	0	1	1	2	2	2	1	2
	Scarus	*altipinnis*	**x**	2	1	0	1	1	4	1	0	2	3	0	2	0	0

	Scarus	*forsteni*	**x**	3	2	0	2	2	0	3	0	0	2	0	1	2	2
	Scarus	*frenatus*	**x**	1	2	0	1	1	0	1	0	0	2	0	2	0	1
	Scarus	*frontalis*	**x**	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	Scarus	*ghobban*	**x**	2	0	0	0	0	1	0	0	0	1	0	0	0	0
	Scarus	*globiceps*	**x**	1	2	0	0	0	0	0	0	0	2	0	0	0	0
	Scarus	*microrhinos*	**x**	2	2	2	3	2	3	1	0	3	2	2	3	3	3
	Scarus	*niger*	**x**	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Scarus	*oviceps*	**x**	0	1	2	0	0	0	0	1	0	2	0	1	1	1
	Scarus	*rubroviolacens*	**x**	0	0	0	0	0	0	0	0	0	1	0	0	2	0
	Scarus	*schlegeli*	**x**	3	3	0	3	2	2	3	0	2	3	0	2	2	3
	Scarus	*sordidus*	**x**	3	3	2	3	1	2	3	2	3	3	0	3	3	3
Pinguipedidae	*Parapercis*	*clathrata*	**x**	0	2	0	0	1	2	1	0	1	0	1	1	1	0
	Parapercis	*xanthozona*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tripterygiidae	*Helcogramma*	*striata*	**x**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aspidontus	*dussimieri*	**x**	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Blenniidae	*Blennieella*	*chrysospilos*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ecsenius	*opsifrontalis*	**x**	0	0	2	1	0	3	0	1	2	0	3	0	0	0
	Exallias	*brevis*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Plagiotremus	*laudandus*	**x**	2	2	0	3	1	2	1	0	3	1	0	2	4	2
	Plagiotremus	*rhinorhynchus*	**x**	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Plagiotremus	*tapeinosoma*	**x**	0	1	1	1	1	2	1	1	1	2	1	0	2	1
Gobiidae	*Amblyeletoris*	*guttata*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Amblyeletoris	*steinitzi*	**x**	0	0	0	0	0	1	0	1	0	0	2	0	0	0
	Amblygobius	*phalaena*	**x**	0	0	2	0	0	3	0	1	0	0	2	0	0	0
	Amblygobius	*rainfordi*	**x**	0	1	1	0	0	1	0	0	0	0	0	0	0	0
	Asterropteryx	*semipunctatus*	**x**	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	Bryaninops	*yongei*	**x**	0	0	0	0	0	3	0	0	0	0	3	0	0	0
	Coryphopterus	*signipinnis*	**x**	0	0	2	2	0	0	0	0	0	0	1	0	0	0
	Cryptocentrus	*strigilliceps*	**x**	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Ctenogobiops	*sp2*	**x**	0	0	2	0	0	3	0	1	0	0	0	0	0	0
	Ctenogobiops	*tangaroai*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Ctenogobiops	*sp1*	**x**	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Eviota	*guttata*	**x**	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Eviota	*melasma*	**x**	0	0	1	2	0	2	0	0	0	0	0	0	0	1
	Eviota	*prasites*	**x**	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Eviota	*sebreei*	**x**	0	0	0	1	0	3	0	0	1	0	2	2	0	0
	Eviota	*cometae*	**x**	0	0	2	1	0	1	0	0	1	0	1	1	0	0
	Gnatholepsis	*cauerensis*	**x**	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Gobidon	*citrinus*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Gobidon	*okinawae*	**x**	0	0	3	0	0	0	0	2	0	0	0	0	0	0
	Istigobius	*decoratus*	**x**	0	0	1	0	1	0	0	1	0	0	2	0	0	0
	Lotilia	*graciliosa*	**x**	0	0	0	0	0	0	0	1	0	0	0	0	0	0

	Paragobidon	*echinocephalus*	**x**	0	0	1	1	0	0	1	1	0	0	0	0	1	0
	Paragobidon	*xanthosoma*	**x**	0	0	0	1	0	0	2	3	3	0	2	1	2	0
	Pleurosicya	*micheli*	**x**	0	0	0	0	0	0	0	0	1	0	0	0	2	0
	Trimma	*caesiura*	**x**	0	0	2	0	1	0	0	0	0	0	0	0	0	0
	Trimma	*naudei*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Trimma	*tevegae*	**x**	2	0	0	3	2	0	0	0	3	3	0	2	0	0
	Trimma	*benjamini*	**x**	0	2	0	1	0	1	0	0	0	0	0	0	0	0
	Valenciennea	*puellaris*	**x**	0	0	1	0	0	2	0	1	0	0	0	0	0	0
	Valenciennea	*sexguttata*	**x**	0	0	0	0	0	1	0	1	0	0	0	0	0	0
	Valenciennea	*strigata*	**x**	0	1	0	0	0	0	0	0	0	2	0	0	0	0
Microdesmidae	*Nemateleotris*	*helfrichi*	**x**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nemateleotris	*magnifica*	**x**	1	0	0	0	0	0	1	0	0	0	0	0	1	2
	Ptereleotris	*evides*	**x**	3	2	0	1	2	1	3	0	2	1	0	2	3	3
	Ptereleotris	*heteroptera*	**x**	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ptereleotris	*microlepsis*	**x**	1	0	2	0	0	4	0	1	0	0	1	0	0	0
	Ptereleotris	*zebra*	**x**	2	0	0	0	0	1	1	0	0	0	0	0	3	0
Acanthuridae	*Acanthurus*	*achilles*	**x**	0	2	0	0	1	0	1	0	1	2	0	0	2	2
	Acanthurus	*blochii*	**x**	0	0	0	0	0	3	0	0	0	0	0	0	0	0
	Acanthurus	*guttatus*	**x**	0	2	0	3	1	0	0	0	1	2	0	3	0	1
	Acanthurus	*lineatus*	**x**	0	2	0	0	0	0	1	0	0	2	0	2	0	2
	Acanthurus	*nigricans*	**x**	3	3	0	2	2	0	3	0	2	3	0	2	3	2
	Acanthurus	*nigricauda*	**x**	0	0	2	0	0	4	0	1	1	1	4	3	2	0
	Acanthurus	*nigrofuscus*	**x**	3	0	0	0	0	2	0	0	0	0	2	0	3	2
	Acanthurus	*nigroris*	**x**	2	3	1	3	2	3	3	0	0	4	0	3	0	2
	Acanthurus	*olivaceus*	**x**	3	0	0	0	1	3	2	0	0	0	2	2	3	2
	Acanthurus	*pyroferus*	**x**	2	2	0	3	3	0	3	0	2	3	0	3	3	3
	Acanthurus	*thompsoni*	**x**	3	3	0	2	3	0	2	0	3	3	0	3	2	3
	Acanthurus	*triostegus*	**x**	0	0	2	2	0	0	3	2	0	1	3	1	0	1
	Acanthurus	*xanthopterus*	**x**	0	0	3	0	0	1	0	0	0	0	0	0	0	0
	Ctenochaetus	*binotatus*	**x**	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	Ctenochaetus	*hawaiiensis*	**x**	0	0	0	1	0	2	2	0	0	2	2	0	3	2
	Ctenochaetus	*striatus*	**x**	2	3	1	3	2	2	0	0	2	3	3	4	3	2
	Ctenochaetus	*strigosus*	**x**	3	2	1	0	2	0	0	0	2	2	0	2	3	3
	Naso	*annulatus*	**x**	2	0	0	0	0	0	0	0	1	0	0	1	2	2
	Naso	*brevirostris*	**x**	0	0	0	0	0	2	0	0	0	0	0	0	4	1
	Naso	*caesius*	**x**	4	2	0	2	1	0	0	0	3	0	0	2	4	2
	Naso	*lituratus*	**x**	2	3	1	1	1	2	1	1	2	1	0	2	2	2
	Naso	*unicornis*	**x**	1	0	1	0	2	0	1	0	2	0	0	0	1	0
	Naso	*vlamingii*	**x**	2	1	0	0	2	1	2	0	3	1	0	1	0	1
	Zebrasoma	*flavescens*	**x**	2	0	0	1	1	2	0	0	0	0	0	0	2	1
	Zebrasoma	*scopas*	**x**	2	0	2	2	2	2	1	0	2	2	0	2	2	3
	Zebrasoma	*veliferum*	**x**	2	2	0	2	2	2	2	0	2	1	0	2	2	1

Zanclidae	*Zanclus*	*cornutus*	**x**	2	3	2	2	0	2	1	2	2	2	1	2	2	3
Siganidae	*Siganus*	*argenteus*	**x**	3	0	2	3	3	2	2	0	0	2	0	2	3	2
	Siganus	*puellus*	**x**	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Siganus	*punctatus*	**x**	2	2	2	2	0	2	0	0	0	0	0	0	0	2
	Siganus	*spinus*	**x**	0	0	0	0	0	0	0	2	0	0	0	0	0	1
Scombridae	*Grammatorcynus*	*bilineatus*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gymnosarda	*unicolor*	**x**	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	Rastrelliger	*kanagurta*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Bothidae	*Arnoglossus*	*intermedius*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balistidae	*Balistapus*	*undulatus*	**x**	2	1	1	2	2	1	1	0	2	1	1	2	3	2
	Balistoides	*viridescens*	**x**	1	1	0	0	0	1	0	1	0	1	0	0	1	2
	Melichthys	*vidua*	**x**	2	2	0	0	0	0	2	0	0	0	0	0	3	2
	Melichthys	*niger*	**x**	0	0	0	0	0	0	0	0	0	0	0	2	0	1
	Pseudobalistes	*flavimarginatus*	**x**	0	0	3	0	0	2	0	1	0	0	0	0	0	0
	Pseudobalistes	*fuscus*	**x**	0	0	2	0	0	2	0	1	0	0	1	0	0	0
	Rhinecanthus	*aculeatus*	**x**	0	0	1	0	0	2	0	1	0	0	2	0	0	0
	Rhinecanthus	*rectangulus*	**x**	1	0	0	1	0	0	2	0	0	0	0	1	0	0
	Sufflamen	*bursa*	**x**	1	2	0	1	2	0	1	0	1	1	0	0	2	2
	Sufflamen	*chrysopterus*	**x**	2	0	0	0	1	3	1	0	1	0	1	2	1	1
Monacanthidae	*Amanses*	*scopas*	**x**	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Cantherhines	*perdalis*	**x**	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Oxymonacanthus	*longirostris*	**x**	2	0	0	2	2	0	1	0	1	0	0	1	1	0
	Paraluteres	*prionurus*	**x**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pervagor	*alternans*	**x**	0	2	0	1	0	0	0	0	0	1	0	0	2	3
Ostraciidae	*Ostracion*	*cubicus*	**x**	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Ostracion	*meleagris*	**x**	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Tetraodontidae	*Arothron*	*caeruleopunctatus*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Arothron	*meleagris*	**x**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Arothron	*nigropunctatus*	**x**	1	0	1	1	0	0	0	0	1	0	0	0	1	0
	Arothron	*stellatus*	**x**	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Canthigaster	*Solandr*	**x**	2	1	0	1	1	0	0	0	1	0	0	0	0	0
	Canthigaster	*valentini*	**x**	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Chilomycterus	*reticulatus*	**x**	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Diodontidae	*Diodon*	*hystrix*	**x**	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		Total	**361**	179	132	144	148	124	179	130	83	120	136	80	142	147	145

Appendix 6

CORAL PRESENCE AND ABUNDANCE AT RONGELAP ATOLL, BY Z. RICHARDS

Genus	Species	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
Acropora	*acuminata*	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	cerealis	0	1	0	0	1	1	2	0	0	1	2	1	0	1
	grandis	0	0	1	0	0	2	0	0	0	0	1	0	0	0
	muricata	1	0	2	2	0	3	0	0	0	1	0	0	0	0
	solitaryensis	0	0	0	0	0	0	0	0	0	1	1	0	0	0
	granulosa	0	0	0	2	2	3	0	2	0	0	2	0	0	0
	loripes	1	0	0	0	0	0	0	0	0	0	1	0	1	1
	gemmifera	1	2	0	1	2	0	1	0	0	0	0	0	2	2
	robusta	2	0	0	1	2	0	1	0	2	1	0	2	0	2
	cytherea	1	3	3	2	0	2	2	3	2	2	2	2	2	2
	monticulosa	2	0	0	0	0	0	1	0	0	1	0	0	1	2
	humilis	1	0	0	0	0	0	1	0	0	1	0	1	2	1
	austera	0	0	0	0	2	0	0	0	0	0	0	1	0	1
	nana	0	0	0	0	0	0	1	0	1	1	0	2	2	1
	speciosa	0	0	0	0	0	0	0	0	0	0	1	1	0	0
	elseyi	0	0	0	0	0	2	0	0	0	0	1	2	0	0
	digitifera	1	0	1	0	0	0	1	0	1	0	0	1	0	0
	florida	0	0	1	1	0	3	0	3	0	0	2	0	0	0
	nasuta	2	3	2	2	2	2	2	2	2	2	0	2	3	2
	subulata	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	intermedia	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	secale	0	0	0	0	1	0	0	0	0	2	0	0	0	0
	valida	2	2	1	1	2	1	0	0	2	0	0	1	1	2
	millepora	1	1	0	1	1	0	0	0	1	2	1	0	0	1
	hyacinthus	1	2	2	1	0	0	1	2	1	1	0	2	0	0
	sarmentosa	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	vaughani	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	unidentified	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	striata	1	0	1	1	1	1	0	1	2	2	0	0	1	0
	verweyi	0	0	1	0	0	0	0	0	0	0	0	0	1	0
	loisettae	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	unidentifiedsp1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	lutkeni	0	0	0	1	1	0	1	0	0	0	0	1	1	1
	tenuis	0	0	0	0	0	0	1	0	0	1	0	0	0	0
	elseyi	0	0	0	0	0	0	1	0	1	1	0	0	0	0
	selago	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	unidentifiedsp2	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	aculeus	0	0	0	0	0	0	0	0	0	1	1	0	0	0
	unidentifiedsp3	0	0	0	0	0	0	0	0	0	0	1	0	0	0

	unidentifiedsp4	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	unidentifiedsp5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	horrida	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Isopora cuneata	1	0	0	0	0	0	3	0	2	2	0	1	0	2
	Isopora palifera	4	4	1	3	3	3	0	2	3	3	0	4	3	3
Montipora	*crassituberculata*	0	0	0	0	0	1	1	0	0	0	0	0	0	0
	tuberculosa	3	3	0	2	2	0	1	0	1	2	0	2	1	1
	aequituberculosa	2	0	0	0	0	0	0	0	1	1	0	0	0	1
	monasteriata	0	1	1	0	0	0	0	0	0	0	0	0	0	0
	foliosa	0	1	0	0	0	0	0	0	1	0	1	0	0	0
	verrucosa	1	3	1	0	1	2	2	1	2	1	0	2	1	1
	danae	0	0	0	0	0	0	0	2	0	1	0	1	2	0
	nodosa	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	informis	2	1	0	0	0	0	2	0	1	0	2	3	0	0
	foveolata	1	2	0	0	2	2	1	1	0	1	0	0	0	0
	caliculata	0	0	0	0	0	0	1	0	1	1	0	0	0	0
	venosa	0	1	1	2	2	0	0	0	0	0	0	0	0	0
	efflorescens	2	1	0	2	2	1	2	0	2	0	1	0	0	0
	mollis	1	0	0	0	0	2	1	0	2	0	0	0	2	1
	peltiformis	0	0	1	1	0	0	1	0	0	2	0	2	2	2
	capitata	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	unidentifiedsp6	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	incrassata	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	unidentifiedsp7	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	unidentifiedsp8	0	0	0	0	0	0	0	0	0	0	0	0	2	2
	unidentifiedsp9	0	0	0	0	0	0	0	0	1	0	0	0	1	0
	myriophthalma	2	2	3	2	3	2	1	0	2	2	2	0	1	1
	gracilis	0	1	0	0	1	0	0	1	0	1	0	1	1	0
Seriatopora	*hystrix*	0	2	1	3	2	1	2	2	3	2	2	2	3	2
	caliendrum	0	0	1	0	1	0	0	0	0	0	0	0	0	0
	dentritica	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Pocillopora	*eydoxyi*	0	0	0	1	1	0	1	0	1	2	0	2	2	2
	verruosa	3	0	3	3	2	3	0	2	2	3	3	2	3	2
	damicornis	1	0	2	1	2	3	1	2	1	2	3	2	0	0
	meandrina	0	1	0	0	0	0	0	0	0	0	0	0	1	1
	woodjonesi	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Stylophora	*pistillata*	2	3	2	3	2	0	2	2	2	1	0	2	2	2
Fungia	*scutaria*	0	1	0	0	2	0	0	0	0	1	0	2	2	1
	danai	0	1	0	0	0	0	1	0	1	0	0	0	1	0
	repanda	1	0	0	0	0	0	1	0	0	0	0	0	1	1
	concinna	0	0	1	0	0	0	0	0	0	1	0	1	0	1
	scruposa	0	1	0	0	0	0	1	2	1	0	0	0	0	0
	horrida	0	0	0	0	0	0	0	0	0	0	0	0	2	0
	paumotensis	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Herpolitha	*weberi*	0	0	0	0	1	2	2	0	1	0	0	0	1	0
	limax	0	1	0	1	0	0	0	0	1	1	0	2	2	1
Halomitra	*pileus*	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Cycloseris	*vaughani*	0	0	0	1	0	0	1	0	0	0	0	0	0	0
	tenuis	0	1	0	0	2	0	1	0	1	0	0	1	2	0
Ctenactis	*crassa*	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Favities	*pentagona*	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	abdita	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	halicora	0	0	0	1	0	0	1	2	0	0	1	1	0	1
	chinensis	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	complanata	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	flexuosa	0	0	0	0	1	0	0	0	0	0	0	1	0	0
	unidentifiedsp10	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Favia	*matthaii*	0	0	0	0	0	0	0	1	1	1	0	1	1	0
	pallida	0	2	0	0	0	0	1	0	1	0	0	0	0	0
	rotumana	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	stelligera	2	0	0	0	0	0	1	0	1	2	0	1	2	1
	speciosa	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	rotundata	1	0	0	2	0	0	0	0	2	2	0	0	1	1
	unidentifiedsp11	1	1	0	1	1	0	0	1	0	0	0	0	1	0
Montastrea	*curta*	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	salebrosa	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Plesiastrea	*versipora*	2	1	2	0	1	0	0	0	0	1	0	0	1	0
Cyphastrea	*microphthalma*	1	0	0	2	1	0	2	2	2	1	0	1	1	1
	serialia	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Platygyra	*sinensis*	0	0	0	0	1	0	0	0	1	2	0	2	1	1
	ryukyuensis	1	0	1	0	0	1	1	0	1	2	0	2	0	0
	pini	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Goniastrea	*edwardsi*	2	2	1	2	1	0	0	0	1	0	1	1	1	1
	favulus	0	0	0	0	2	1	2	2	0	1	1	2	2	2
Leptastrea	*transversa*	0	2	1	2	1	0	1	0	2	2	0	0	1	1
	pruinosa	1	0	0	0	0	0	1	0	3	0	0	0	1	0
Goniopora	*columna*	0	0	0	0	0	0	0	0	0	0	2	1	0	0
	marionensis	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Porites	*lobata*	2	0	0	2	0	0	0	0	0	0	0	0	1	1
	lutea	2	3	3	3	4	3	3	3	3	3	3	3	3	2
	cylindricata	2	0	0	3	0	2	1	2	0	0	2	3	2	1
	rus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	vaughani	0	2	2	1	0	0	0	0	0	0	0	0	0	0
	horizontalata	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	lichen	0	0	0	2	1	0	0	0	0	0	0	0	0	0
Lobophyllia	*hemprichii*	0	1	0	0	1	1	1	1	2	2	1	2	1	1
	corymbosa	2	2	0	2	2	1	0	0	1	1	0	1	0	1
	pachysepta	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Symphyllia	*recta*	0	0	1	0	0	0	0	0	0	0	0	0	1	1
	valencinessi	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Acanthastrea	*hemprichii*	0	0	0	1	2	0	0	0	2	0	0	2	1	0
	brevis	1	1	1	1	0	0	0	0	1	1	0	0	0	0
	echinata	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolymia	*vitiensis*	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Leptoseris	*myceteroides*	0	1	0	1	1	0	1	0	2	1	0	1	2	1
Pavona	*maldiviensis*	1	0	0	0	0	0	0	0	0	0	0	2	0	0
	duerdeni	1	2	0	1	0	0	1	0	2	2	0	2	1	1
	varians	2	2	1	0	2	1	2	0	2	0	1	1	1	2
	clavus	0	0	0	2	1	0	1	2	2	0	0	1	2	1
Gardinoseris	*planulata*	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Galaxea	*horrescens*	0	0	0	0	0	2	0	2	0	0	2	0	0	0
Psammocora	*haimeana*	0	2	0	0	1	1	2	0	2	2	0	2	2	2
	profundacella	1	0	0	0	0	1	0	0	2	1	0	1	1	0
	vaughani	0	0	0	0	1	0	2	2	0	0	1	0	0	0
	explanulata	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	superficialis	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	nietzraszi	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Coscinarea	*columna*	0	0	0	0	0	1	0	0	1	1	0	1	1	0
	monile	1	1	0	0	2	0	0	0	0	2	0	0	0	0
Pseudosideras trea	*tayami*	0	0	0	3	2	1	2	0	3	2	0	1	1	1
Stylocoeniella	*guentheri*	1	1	1	2	2	2	1	2	2	0	2	0	2	1
	armata	1	0	0	0	0	0	0	0	0	0	1	0	1	0
Turbinarea	*retiformis*	1	1	0	1	1	0	1	0	0	0	0	0	1	1
	stellulata	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	microconos	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	pilosa	1	1	0	0	0	0	1	0	0	1	0	1	1	1
	rigida	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Hydnophora	*exesa*	0	0	0	1	0	0	1	0	0	0	0	0	1	0
Echinopora	*lamellosa*	0	0	0	2	2	0	2	0	3	0	0	2	1	1
Merulina	*ampliata*	0	0	0	1	1	0	0	0	0	0	0	1	0	0
Scapophyllia	*cylindrica*	0	0	1	2	2	0	1	1	2	1	0	2	2	1
Plerogyra	*sinuosa*	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Euphyllia	*glabrescens*	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinophyllia	*aspera*	0	2	0	0	1	0	0	0	1	0	1	1	1	0
Ouphyllia	*crispa*	0	1	0	0	0	0	1	0	2	1	0	1	1	1
Podobacia	*motuporensis*	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Heliopora	*coerulea*	0	2	1	2	1	0	2	0	2	1	0	1	1	0
Tubipora	*musica*	0	3	0	3	2	0	4	0	2	2	1	1	2	0
	OrderStylasterina Distichopora	0	1	0	1	0	0	1	0	1	2	0	2	2	1
	OrderStylasterina Stylaster	0	1	0	2	2	0	1	0	2	2	0	2	1	2
	OrderMillepora Millepora	2	2	1	0	0	1	2	0	1	1	0	2	1	0
	OrderMillepora unidentifiedsp12	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Appendix 7

CHECKLIST OF CORAL SPECIES AT RONGELAP ATOLL, BY ZOE RICHARDS.

Genus	Species	NRAS, 2002	Wells, 1956
Acropora	*acuminata*	*	
	cerealis	*	
	grandis	*	
	muricata	*	*
	granulosa	*	
	loripes	*	
	gemmifera	*	
	robusta	*	
	cytherea	*	
	monticulosa	*	
	humilis	*	
	austera	*	
	nana	*	
	speciosa	*	
	elseyi	*	
	digitifera	*	
	florida	*	
	nasuta	*	
	subulata	*	
	intermedia	*	
	secale	*	
	valida	*	*
	millepora	*	
	hyacinthus	*	*
	sarmentosa	*	
	vaughani	*	*
	striata	*	
	verweyi	*	
	loisettae	*	
	lutkeni	*	
	tenuis	*	
	elseyi	*	
	selago	*	
	aculeus	*	
	solitaryensis	*	
	horrida	*	*
	unidentified sp.1	*	
	unidentified sp. 2	*	
	unidentified sp. 3	*	
	unidentified sp. 4	*	
	unidentified sp. 5	*	
	danai		*
	squarrosa		*
	longicyathus		*

	teres distans		
Isopora	*cuneata*	*	
	palifera	*	*
Montipora	*crassituberculata*	*	
	tuberculosa	*	
	aequituberculosa	*	
	monasteriata	*	
	foliosa	*	
	verrucosa	*	
	danae	*	
	nodosa	*	
	informis	*	
	foveolata	*	*
	caliculata	*	*
	venosa	*	
	efflorescens	*	
	mollis	*	
	peltiformis	*	
	capitata	*	
	unidentified sp. 6	*	
	incrassata	*	
	unidentified sp.7	*	
	unidentified sp. 8	*	
	unidentified sp. 9	*	
	socialis		*
Astreopora	*myriophthalma*	*	
	gracilis	*	
Anacropora	*forbesi*		*
Seriatopora	*hystrix*	*	
	caliendrum	*	
	dentritica	*	
Pocillopora	*eydoxyi*	*	
	verruosa	*	*
	damicornis	*	
	meandrina	*	
	woodjonesi	*	
	elegans		*
Stylophora	*pistillata*	*	
Fungia	*scutaria*	*	*
	danai	*	
	repanda	*	
	concinna	*	
	scruposa	*	
	horrida	*	
	paumotensis	*	
fungities	*dentata*		*
fungities	*haimei*		*
fungities	*incisa*		*
Herpolitha	*weberi*	*	

	limax	*	*
Halomitra	*pileus*	*	
Cycloseris	*vaughani*	*	
	tenuis	*	
Ctenactis	*crassa*	*	
Concinna	*serrulata*		*
Favities	*pentagona*	*	
	abdita	*	
	halicora	*	
	chinensis	*	
	complanata	*	
	flexuosa	*	
	unidentified sp.10	*	
Favia	*matthaii*	*	
	pallida	*	
	rotumana	*	
	stelligera	*	
	speciosa	*	
	rotundata	*	
	unidentified sp. 11 11	*	
Montastrea	*curta*	*	
	salebrosa	*	
Plesiastrea	*versipora*	*	
Cyphastrea	*microphthalma*	*	
	serialia	*	
Platygyra	*sinensis*	*	
	ryukyuensis	*	
	pini	*	
	rustica		*
Goniastrea	*edwardsi*	*	
	favulus	*	
Leptastrea	*transversa*	*	
	pruinosa	*	
Goniopora	*columna*	*	
Alveopora	*marionensis*	*	
	allingi		*
Porites	*lobata*	*	
	lutea	*	*
	cylindricata	*	
	vaughani	*	
	horizontalata	*	*
	lichen	*	
	austrialiensis		*
	superfusa		*
Lobophyllia	*hemprichii*	*	
	corymbosa	*	
	pachysepta	*	
Symphyllia	*recta*	*	
	valencinessi	*	

	nobilis		*
Acanthastrea	*hemprichii*	*	
	brevis	*	
	echinata	*	
Scolymia	*vitiensis*	*	
Leptoseris	*myceteroides*	*	
Pavona	*maldiviensis*	*	
	duerdeni	*	
	varians	*	*
	clavus	*	
Gardinoseris	*planulata*	*	
Galaxea	*horrescens*	*	
Psammocora	*haimeana*	*	
	profundacella	*	
	vaughani	*	
	explanulata	*	
	superficialis	*	
	nietzraszi	*	
Coscinaraea	*columna*	*	
	monile	*	
Pseudosiderastrea	*tayami*	*	
Stylocoeniella	*guentheri*	*	
	armata	*	
Turbinaria	*retiformis*	*	
	stellulata	*	
Hydnophora	*microconos*	*	*
	pilosa	*	
	rigida	*	
	exesa	*	
Echinopora	*lamellosa*	*	
Merulina	*ampliata*	*	
Scapophyllia	*cylindrica*	*	
Plerogyra	*sinuosa*	*	
Euphyllia	*glabrescens*	*	
Echiniphyllia	*aspera*	*	*
Ouphyllia	*crispa*	*	
Podobacia	*motuporensis*	*	
Order Helioporacea	*Heliopora coerulea*	*	*
Order Alcyonacea	*Tubipora musica*	*	
Order Stylasterina	*Distichopora*	*	*
	Stylaster	*	
Order Millepora	*Millepora*	*	*

Appendix 8

SPECIAL FEATURES OF CORAL SPECIES AT RONGELAP ATOLL, BY ZOE RICHARDS.

Family	Genus	Species	Special Features
Acroporidae	*Acropora*	*acuminata*	site restricted - R14: South Pass Wall
		gemmifera	minor range extension
		monticulosa	minor range extension
		nana	major range extension
		speciosa	major range extension
		digitifera	minor range extension
		subulata	site restricted - R6: Lagoon
		intermedia	minor range extension/site restricted - R8: Lagoon
		secale	minor range extension
		sarmentosa	minor range extension
		vaughani	minor range extension
		loisettae	major range extension/site restricted - R3: Wall
		elseyi	minor range extension
		selago	site restricted - R10: Wall
		solitaryensis	minor range extension
		horrida	minor range extension/site restricted: R12: Wall
		unid. sp.1	site restricted - R2: Wall
		unid. sp. 2	site restricted - R4: Wall
		unid. sp. 3	site restricted - R10: Wall
		unid. sp. 4	site restricted - R11: Lagoon
		unid. sp. 5	site restricted - R14: South Pass Wall
		palifera	minor range extension
		nodosa	site restricted - R7: Wall
		capitata	site restricted - R12: Wall
		unid. sp. 6	site restricted - R2: Wall
		unid. sp.7	site-restricted - R6: Lagoon
Pocillopora	*Seriatopora*	*dentritica*	major range extension / site-restricted - R12: Wall
Fungidae	*Fungia*	*horrida*	site-restricted - R13: South Wall
		paumotensis	site-restricted - R10: Wall
	Herpolitha	*pileus*	site-restricted - R7: Wall
	Cycloseris	*crassa*	site-restricted - R12: Wall
		pentagona	site-restricted - R9: Wall
	Ctenactis	*abdita*	site-restricted - R1: Jaboan Pass
Faviidae	*Favites*	*chinensis*	site-restricted - R4: Wall
		complanata	site-restricted - R4: Wall
		flexuosa	site-restricted - R5: Wall
		unid. sp.10	site-restricted - R13: South Wall
	Favia	*rotumana*	site-restricted - R6: Lagoon
		speciosa	site-restricted - R13: South Wall
	Montastrea	*curta*	site-restricted - R3: Wall
		salebrosa	major range extension
	Plesiastrea	*serialia*	site-restricted - R4: Wall

Poritidae	*Goniopora*	*marionensis*	site-restricted - R1: Jaboan Pass
	Porites	*horizontalata*	site-restricted - R9: Wall
Mussidae	*Lobophyllia*	*pachysepta*	site-restricted - R4: Wall
		valencinessi	site-restricted - R12: Wall
	Acanthastrea	*brevis*	major range extension
		echinata	site-restricted - R1: Jaboan Pass
Siderastreidae	*Psammocora*	*superficialis*	site-restricted - R10: Wall
	Coscinaraea	*monile*	major range extension
Dendrophllidae	*Turbinaria*	*stellulata*	site-restricted - R4: Wall
Merulinidae	*Hydnophora*	*microconos*	site-restricted - R2: Wall
		rigida	site-restricted - R3: Wall
Euphyllidae	*Euphyllia*	*glabrescens*	site-restricted - R1: Jaboan Pass
	Podobacia	*motuporensis*	site-restricted - R9: Wall
unid. sp.12			site-restricted - R9: Wall

Appendix 9

HABITAT CATEGORIES

Surveyor:		
Location:	Transect/ Survey No:	Date:
Water temp:	Horizontal visibility:	
Type of Main Survey:		
Comments:		

* Any area larger than 5 m across is recorded as a separate habitat, cave habitats are recorded as any overhanging structure with at least 2 m depth, length or height.

DEPTH:

- ☐ 0-2 m
- ☐ 2-6 m
- ☐ 6-15 m
- ☐ 15-25 m
- ☐ 25-45
- ☐ Below 45

BIOLOGICAL DESCRIPTION:

- ☐ Sand with seagrass
- ☐ Sand
- ☐ Sand and mud
- ☐ Sand with coral
- ☐ Dense seagrass cover
- ☐ Monospecific corals on sandy substrate
- ☐ Monospecific corals on rocky substrate
- ☐ Sparse coral on rock w/ algae (>50% coral)
- ☐ Sparse coral, algae w/ recently dead coral (>5% dead)
- ☐ Mixed corals
- ☐ Mixed corals mainly massive
- ☐ Mixed coral mainly encrusting
- ☐ Mixed coral on bommies and sand
- ☐ Soft coral
- ☐ Soft coral forests
- ☐ Macroalgae w/ sparse coral (>50% algae)
- ☐ Macroalgae
- ☐ Filamentous algae and turf
- ☐ Bluegreen algae
- ☐ Rubble with encrusted life
- ☐ Bedrock w/ sparse corals
- ☐ Bedrock w/ sparse SC
- ☐ Black Coral shelter trees (> 2m)
- ☐ No light habitat

TOPOGRAPHICAL DESCRIPTION:

- ☐ Cave
- ☐
- ☐ Overhanging steep wall
- ☐ Steep wall fragmented
- ☐ Steep wall w/ slope (>60^o)
- ☐ Slope (>45^o)
- ☐ Slope (>25^o)
- ☐ Deep ridge (>14 m depth)
- ☐ High energy reef crest / top
- ☐ Sheltered reef crest / top
- ☐ Flat reef crest
- ☐ Lagoon / reef flat
- ☐ Flat reef
- ☐ Groves
- ☐ Bommies
- ☐ Monolith
- ☐ Deep crevasse / hole

Appendix 10

PARTICIPANTS

NAME	AFFILIATION AND LEVEL OF EDUCATION	NATIONALITY	PREVIOUS EXPERIENCE IN UW RESOURCE ASSESSMENTS	DUTIES
PROJECT LEADERS				
Silvia Pinca, Project Leader	CMI, PhD	Italian	Previous experience in coral reef assessments; Coral Cay Conservation, Philippines (4 months, 150 dives	Organization design, fund raising, transects; algae expert
Maria Beger, Project Co-Leader	University of Queensland, PhD student	German	Several expeditions in the Philippines, PNG, Australia for coral reef assessments. (hundreds of survey dives). Speciality: fish.	Methods design; Fish experts: Fish biodiversity & assessment
PARTICIPANTS WITH PREVIOUS EXPERIENCE IN UNDERWATER ASSESSMENTS				
Dan Barshis	University of Hawaii, PhD student	American	CMI, 3 months, 40 survey dives Gastropod biodiversity	Transects, physical, permanent transects
Benjiamin Dominici		British	Coral Cay Conservation, 4 months, 80 assessment dives	Transects, physical, permanent transects
Sacha Jellinek, MsC	University of Tasmania, Honors	Australian	4 yrs experience in coral reef ecology and Assessments. Coral Cay Conservation, Science Officer, 3 months, 60 assessment dives, GBR	Transects, physical, permanent transects
Craig Musburger	University of Hawaii, PhD student	American	Research at UH on fish aggregations	Fish expert: fish biodiversity; permanent transects
Emma Reeves	University of Borthmouth, Master of Science in Coastal Management	British	Coral Cay Conservation, Science Officer, 3 months, 120 assessment dives; Likiep assessment expedition 2001	Transects, physical, permanent transects
Zoe Richards	Museum of Tropical Queensland, AU	Australian	Collaboration as coral expert at the Museum; speciality: *Acropora* corals ID	Coral expert: coral biodiversity
LOCAL TRAINEES				

Melba White	CMI AA graduate, with speciality in Marine Science, Candidate student at Florida International University	Marshallese	Bikini surveys 2002; total dives for surveys 30	
VOLUNTEERS				
Ingolf Kuhrt		German	trainee	physical
Anna McMurray		American	trainee	physical, invertebrates, corals
Eric Peterson	Adjunct Senior Research Fellow, Centre for Marine Studies, University of Queensland, Brisbane, Australia	Australian	Trainee	physical, invertebrates, corals
PHOTOGRAPHER				
Robert Fournier		American	200 dives for coral reef surveys in Belize, Fiji, Raratonga; research dives for shark studies; director for whale shark film in Australia; photographic expedition in Thailand	photographer

Silvia Pinca

Date of Birth: February 24, 1967
Citizenship: Italian

EDUCATION

1994 PhD Marine Environmental Sciences, University of Genoa, Italy.
1990 MSc in Natural Sciences, University of Genoa, Italy. Best mention.

Specialization courses

2002 Coastal Management Workshop, College of the Marshall Islands and University of Rhode Island
2002 Community-Based Fisheries Training, Secretariat of the Pacific Community
2001 Environmentally Sustainable Development in the Rep. of the Marshall Islands Workshop
1995 Numerical Analysis in Marine Ecology, University of Paris VI.
1991 Numerical Analysis of data and signals in Marine Ecology, University of Paris VI.
1989 Oceanology Course, University of Trieste.

WORK EXPERIENCE

Research positions held

***Present coral reef research**: coral reef management and conservation. Grant writing and fund raising, project design, capacity building, field work, data collection, data analysis, report writing.*

2002 World Heritage Site selection in Ailininae atoll, RMI. Participation to surveys with University of Hawaii and US Fish and Wildlife and Service. Underwater assessments of marine resources and biodiversity. Seaweed biodiversity.

2002 Bikini atoll coral reef resources assessments. Principal investigator.

2002 Resource assessment and conservation in the Marshall Islands. "NRAS 2002: Natural resources assessments surveys in the atolls of Bikini and Mili". Principal investigator

2001 Resource assessment in the Marshall Islands: "Marine Resources Assessment: Likiep Atoll 2001". Principal investigator.

Previous ecology academic research

1999-2000 Research assistant at Department of Ecology and Evolution, University of Chicago.

1995-1997 Research assistant at the Marine Biology Research Division, Scripps Institution of Oceanography, University of California San Diego.

1996 Research assistant at Station Zoologique, University Pierre et Marie Curie, Paris VI.

Other professional experiences

***College-level teaching*:**

2001-ongoing Marine Science Instructor and Marine Science Program Coordinator, College of the Marshall Islands.

Teaching work: Courses: Introduction to Marine Biology, Tropical Reef Ecosystems of the Pacific, Ocean Management, Oceanography. Training for underwater coral reef assessments.

2001-ongoing MSc Mentor: External Supervisor for Anir Lal's Master degree thesis of, University of the South Pacific (benthic algae)

2002 MSc Mentor: Supervision of Coastal Zone Management Master Degree graduate student Emma Reeves from Bournemouth University, UK (conservation study in RMI)

2001 Honors Mentor: Supervisor to undergraduate Honors in Zoology student from UK: Lucy Horton from Edinburgh University, UK (fish assessments in RMI and sociological analysis at the College of the MI)

1997 Marine Biology Lecturer at a Biological Oceanography summer course at the University of Southern California, LA.

Extension work and outreach:

2001-ongoing Translate coastal management and conservation material into vernacular, targeting different groups in the community of the Marshall Islands: grade school students, government officials, women groups.

2002 Collaboration on environment conservation with other conservation practitioners at national (Environmental Protection Authority,- RMI-EPA, Marshall Islands Marine Resources Authority - MIMRA) and international (Rhode Island University, US Fishery and Wildlife Service,) level.

2002 Facilitation of the formation of a local NGO in the Marshall Islands: Nature Conservation Communities of the MI, to involve more people college students, government officials and citizens - into marine management and conservation issues, related to local traditions and needs.

2000 Science Officer: science coordinator, instructor and surveyor for Coral Reefs Conservation project, The Philippines.

1999 & 1995 Environmental education coordinator in coral reefs ecosystems, Maldive islands.

SCHOLARSHIPS

2002 US National Fishery and Wildlife Foundation Grant for coral reef conservation

2002 US Department of the Interior, Insular Affairs grant 2002 Marine Resources Pacific Consortium grant

2002 Marshall Islands Marine Resources Authority grant for education and capacity building

2002 Marshall Energy Company grant

2002 Rufford small grant, Whitley Conservation Society

1995-1997 Two years scholarship from the University of Genoa for Specialization abroad1996 Scholarship from European Union for the "Advanced Study Course in Marine Science and Technology".

1992 Scholarship form the European Community for Science Activity Abroad

1991-1994 Scholarship from the University of Genoa for the Research Doctorate (Ph.D.)

OCEANOGRAPHIC MISSIONS

1997 Oceanographic cruise J-GOFS in the Ross Sea, Antarctica
1996 Oceanographic cruises in the Pacific Ocean, project HOTS: Hawai'i
1988-89 Oceanographic cruises for the University of Genova

AFFILIATIONS AND CERTIFICATES

2000 Member of Royal Geographical Society
2000 Scuba dive certification Dive Master PADI
1997 Member of Nature Conservancy: project, Rescue the Reef
1989 Underwater photographer certification

PUBLICATIONS

2000 Pinca S. "Spatial organization of plankton size composition in an eddy-jet system, obtained through contiguity-constrained analysis", *Deep-Sea Research* I, 47, 973-996

1997 Pinca S., Dallot S. "Zooplankton community structure in the Western Mediterranean sea related to mesoscale hydrodynamics", *Hydrobiologia*, 356, 127-142.

1995 Pinca S., Dallot S. "Meso- and macrozooplankton composition patterns related to hydrodynamic structures in the Ligurian Sea (Trophos 2 experiment, April-June 1986), *Marine Ecology Progress Series*,126, 49-65..0

ABSTRACTS

1996 Pinca S., Zhu Y., Zhou M., Huntely M.: "Small-scale zooplankton distribution in the California Current System related to the hydrodynamic features", EOS Transactions, American Geophysical Union, 76, 3 suppl.

1994 Pinca S. " Distribution et structure de la communaute zooplanctonique superficielle de Trophos II", Traveaux de l'Observatoire Oceanologique de Villefranche-sur-Mer.

1994 Pinca S., Dallot S. "Repartition et structure de la communaute zooplanctonique superficielle dans la region du front Liguro-Provencal", Proceedings of the International Meeting "Ecologie et methods statistiques", Niort, 5-6 October 1994.

1994 Di Natale, A., Mangano A., Maurizi A., Montaldo L., Navarra E., Pinca S., Schimmenti G., Torchia G., Valastro M.: "A review of drifnet catches by the Italian fleet: species, composition, observers data and distribution along the net". Third GFCM-ICCAT Expert Consultation on Stocks of Large Pelagic Fishes in the Mediterranean, Fuengirola (Spain), September 1994.

1993 Di Natale, A., Mangano A., Maurizi A., Montaldo L., Navarra E., Pinca S., Schimmenti G., Torchia G., Valastro M.: "Swordfish (*Xiphias gladius*, L.) drifnet fishery in the Western Italian Seas: 1990-1991 report". Second GFCM-ICCAT

Expert Consultation on Stocks of Large Pelagic Fishes in the Mediterranean, Crete, September 1992, 18 pp.

1993 Pinca S.: ”Meso- et macrozooplancton de la mission Trophos II”, Traveaux de l'Observatoire Oceanologique de Villefranche-sur-Mer.

1992 Di Natale, A., Mangano A., Maurizi A., Montaldo L., Navarra E., Pinca S., Schimmenti G., Torchia G., Valastro M.: “Swordfish (*Xiphias gladius*, L.) long-line fishery in the Western Italian seas and in the Sicily Channel: 1991 report”, ICCAT, SCRS, Coll. Vol. Sci. Pap, 11 pp.

1991 Orsi Relini L., Pinca S.: ”Reproductvie patterns of *Pasiphaea sivado* in the Ligurian Sea”, Rapport de la Communaute Internationale de la Mer Mediterranee, 32, 1.

REPORTS

2001 Pinca, S. “Marine Resources Assessment: Likiep Atoll 2001, final report”, MIMRA, Republic of the Marshall Islands.

1993 Pinca, S. “Description of the distribution and structure of the surface zooplankton community in the region of the Liguro-provencal front”, PhD thesis, University of Genova, 156 + 65 pp.

1992 DiNatale A., Labanchi L., Mangano A., Maurizi A., Montaldo L., Montebello O., Navarra E., Pederzoli A., Pinca S., Placenti V., Schimmenti G., Sieni E., Torchia G., Valastro M. "Pelagic drifting tools used for the fishing of the adult swordfish (*Xiphias gladius*, L.): compared evaluation of functionality, capture capability, global impact and economy of systems and re-conversion", Reserved report to the Minister of the Navy.

1990 Pinca S.: Biological observations on pelagic decapods of the genus *Pasiphaea* in the Ligurian Sea”, MSc Thesis, University of Genova.

Maria Beger

Interests Marine Protected Areas: selection, implementation and management
Biodiversity on reefs, specifically fish
Monitoring of coral reefs

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Education

1993- '94 Heriot Watt University, Edinburgh, UK
MSc Marine Resource Development and Protection

1994- '96 Technische Universität Dresden, Germany
1990- '93 Dipl.- Ing.:Wasserwirtschaft, Fachrichtung Grundwasserbewirtschaftung

Sept 2002- present University of Queensland, Australia
enrolled as PhD candidate, Supervisor Professor Hugh Possingham.

Marine Work Experience

Oct 2002 The Nature Conservancy, PNG, Eastern Kimbe Bay — Fish Expert Consultant
Biodiversity survey for reef fishes as part of TNC's rapid ecological assessment programme.

Nov 01- Sep 2002 Marshall Islands Marine Conservation Expedition — Co-Leader
Co-prepared and organised a reef survey expedition with the aim to train local students, collect reef biodiversity and health status data and contribute to global databases.

Oct 2000 – Nov 2001 James Cook University, Australia — Visiting Researcher
Coral reef research answering the following questions: How efficiently does a biodiversity approach work to select tropical Marine Protected Areas (MPA's)? Does reef size matter to fish diversity?

Ongoing since 2000 Danjugan Island Marine Reserve & Sanctuary Monitoring, Philippines
Designed and implemented an annual monitoring and training programme on behalf of the Philippine Reef and Rainforest Conservation Foundation Inc. http://www.whitley-award.org/rsg/beger.html

Sept 2000 Department of Fisheries Malaysia, — Scientific Team Leader
Led a team of five experts engaged in a rapid assessment of coral reef biodiversity, habitat and health in MPA's on the Malaysian peninsula. Responsible for fish biodiversity assessment.

Jun 98 – Aug 2000 Coral Cay Conservation Ltd., UK — Indo Pacific Marine Scientist
Responsible for managing the coral reef assessment programme of Coral Cay Conservation Ltd., whose paying volunteers survey natural resources in countries within the Indo-Pacific region.

Voluntary Marine Work Experience

Apr 2000 Eritrea's Coastal, Marine and Island Biodiversity Project, Eritrean Ministry of Fisheries/ UNDP — Voluntary Trainer, Eritrea

Jul97- Apr 98 Coral Cay Conservation Ltd. — Science Officer, Philippines and Indonesia

Professional Affiliations

Marine Conservation Society, UK; Reef Conservation UK; International Society for Reef Studies (ISRS); ReefCheck Europe (Founding member); Royal Geographical Society, UK, (Fellow).

Publications and Presentations

Journals

Beger, M., Jones, G. and P.L. Munday. In press. Selecting sites for coral reef protected areas: a comparison of biodiversity approaches for corals and fish. Biological Conservation.

Beger, M., T.P. Dacles, A.R. Harborne, G.L. Ledesma, A.W.M. Page, and P.S. Raines. In prep. Addressing the problems of establishing and managing marine protected areas: a case study in the Philippines. To be submitted to Environmental Conservation.

Beger, M., Jones, G. in prep. Marine biogeography theory: Does reef size matter to biodiversity?

Reports and Project Descriptions

Beger, M., J-L. Solandt, and T.P. Dacles. 2001. Coral Reef Bleaching at Danjugan Island, Negros Occidental, Philippines. A two year monitoring programme. Danjugan Island Survey Summary Report 2 to the Philippines Reef and Rainforest Conservation Foundation Inc.

Solandt, J-L, M. Beger and A.R. Harborne. 2001. Reef fish populations around Danjugan Island, Negros Occidental, Philippines. Danjugan Island Survey Summary Report 3 to the Philippines Reef and Rainforest Conservation Foundation Inc.

Harborne, A.R., D. Fenner, A.R. Barnes, M. Beger, S.P. Harding, and T. Roxburgh. 2000. Status report on the coral reefs of the east coast of Peninsula Malaysia. 50 pp. Report to Department of Fisheries, Malaysia. Kuala Lumpur.

Beger, M. and G.L. Ledesma. 2000. Taytay Bay Conservation Project — Project Proposal. Project summary document submitted to Palawan Council of Sustainable Development, Palawan, Philippines. 80 pp. Coral Cay Conservation Ltd. London.

Beger, M. and A.R. Harborne. 2000. Southern Negros Coastal Development Programme — Municipality of Sipalay. Internal report. 100 pp. Coral Cay Conservation Ltd. London.

Beger, M., J.A. Ellis, and A.R. Harborne. 2000. Taytay Bay Conservation Project, Phase 1 — Cagdanao Island. Internal report. 70 pp. Coral Cay Conservation Ltd. London.

Beger, M. 1999. Marine Science Staff Manual — Philippines. Internal working manual. 500 pp. Coral Cay Conservation Ltd. London.

Conference Presentations

Beger, M., T.P. Dacles, A.R. Harborne, G.L. Ledesma, A.W.M. Page, and P.S. Raines. 2000. Danjugan Island: A unique integrated approach to establish a community-based Marine Protected Area in the Philippines. Presented at 9th International Coral Reef Symposium, Bali, 2000.

Teleki, K.A., A.R., Harborne, H. Hall, M. Beger, and E.M. Wood. 2000. Reef Conservation UK: Carrying the philosophy of International Year Of The Reef into the future. Poster at 9th International Coral Reef Symposium, Bali, 2000.

Ledesma, G.L., M. Beger, G. Goby, A.R. Harborne, and P.S. Raines. 1999. The Philippine Reef and Rainforest Project: An integrated approach to establishing marine protected areas. Proceedings: The Symposium on Marine Biodiversity in the Visayas and Mindanao, 1998, Ilo Ilo, Philippines.

Appendix 11

GRANTS

RALGOV (RONGELAP LOCAL GOVERNMENT)

US DEPARTMENT OF INTERIOR

MIMRA (MARSHALL ISLANDS MARINE RESOURCES AUTHORITY) FUND

WHITLEY AWARD – RUFFORD SMALL GRANT

REEFCHECK

MEC (MARSHALL ISLANDS ENERGY COMPANY)

MAREPAC (MARINE RESOURCES PACIFIC CONSORTIUM)

IN - KINDS

OUTRIGGER HOTEL

CMI, COLLEGE OF THE MARSHALL ISLAND

Contributions:

- ?? Use of facilities and library for training
- ?? Use of digital camera and underwater housing
- ?? Use of laptop computer and projector
- ?? Use of photocopy machine

Appendix 12

SCHEDULE OF FIELD ACTIVITIES

date	name of site	consecutive dive number	location	activity	# divers	transportation
2/8/2002	R1	1	Jaboan lagoon side	3 transects + corals&fish biodiversity	13	truck
2/8/2002	R2	2	ocean wall, S side	3 transects + corals&fish biodiversity	13	truck
3/8/2002	R3	3	lagoon, N-W	3 transects + corals&fish biodiversity	13	truck
4/8/2002	R4	4	ocean wall, S side	3 transects + corals&fish biodiversity	11	truck
5/8/2002	R5	5	ocean wall, S side	3 transects + corals&fish biodiversity	11	truck
6/8/2002	R6	6	lagoon, west	3 transects + corals&fish biodiversity	11	truck
6/8/2002	R7	7	ocean wall, off runway	3 transects + corals&fish biodiversity	11	truck
7/8/2002	ReefCheck	8	Jaboan, lagoon side	ReefCheck	11	truck
7/8/2002	Perm.trans.	9	Jaboan, lagoon side	permanent transect	11	truck
7/8/2002	R8	10	lagoon side, N tip	3 transects + corals&fish biodiversity	11	truck
8/8/2002	R9	11	ocean wall, Jaboan	3 transects + corals&fish biodiversity	11	truck
8/9/2002	R10	12	S wall, E end of runway	3 transects + corals&fish biodiversity	10	truck
8/9/2002	R11	13	lagoon E of Jaboan	3 transects + corals&fish biodiversity	10	truck
8/10/2002	descriptive	14	descriptive dive off Jaboan	dives off wall	11	truck
8/10/2002	R12	15	wall at Jaboan	3 transects + corals&fish biodiversity	11	truck
8/11/2002	R10Ph1	16	S wall, E end of runway	topographical description + biodiversity	11	truck
8/12/2002	R1Ph1	17	Jaboan wall	topographical description + biodiversity	11	truck

8/12/2002	R1Ph2	18	Jaboan wall	topographical description + biodiversity	9	truck
8/15/2002	R13	19	Enirouuri wall	3 transects + corals&fish biodiversity	9	boat
8/15/2002	R14	20	Arubaru, E channel side	3 transects + corals&fish biodiversity	9	boat
8/17/2002	PT2	21	airport terminal, ocean side	permanent transect	9	walk
8/17/2002	PT1	22	Jaboan	mapped permanent transect	9	truck

Appendix 13

REEF CHECK RESULTS

Jaboan Point:

Site name	**Shark Alley Jabwan, Rongelap Atoll**			
Date	8/7/2002			
Time of day that work started	10am			
Time of day that work ended	11am			
Longitude of transect start point				
Latitude of transect start point				
From chart or by GPS? (If GPS, indicate units)	chart_____	GPS 11deg 9' 12" N, 166 deg 50' 11"		
Orientation of transect	N-S___	NE-SW__X_	E-W___	
Distance from shore	100 m			
Distance from nearest river	Atoll			
River mouth width	<10m__	11-50m__	51-100m__	101-500m__
Weather	sunny_X__	cloudy_____	raining_____	
Air temperature	34 degrees C			
Water temperature at surface	27 degrees C			
Water temperature at 3 m	27 degrees C			
Water temperature at 10 m	27 degrees C			
Distance to nearest population centre	5 km			
Approximate population size	100 people			
Horizontal visibility in water	25 m			
Why was this site selected?	Good site, easily accessable			
Is this site -	sheltered_____	exposed_X____		
Any major coral damaging storms in past years?	yes_____	no_____	unknown_X____	
How do you rate this site overall in terms of anthropogenic impact?	none_X___	low____	moderate____	heavy____
What types of impacts do you believe occur?				
Dynamite fishing	none_X___	low____	moderate____	heavy____
Poison fishing	none_X___	low____	moderate____	heavy____
Aquarium fish collection	none_X___	low____	moderate____	heavy____
Harvest of invertebrates for food	none_X___	low____	moderate____	heavy____
Harvest of invertebrates for curio sales	none_X___	low____	moderate____	heavy____
Tourist diving	none_X___	low____	moderate____	heavy____
Sewage pollution	none_X___	low____	moderate____	heavy____
Industrial pollution	none_X___	low____	moderate____	heavy____
Other forms of fishing? (Specify)	none_X___	low____	moderate____	heavy____
Other impacts? (Specify)	none_X___	low____	moderate____	heavy____

Is there any form of protection (statutory or other) at this site? yes_____ no_X____

If yes, what type of protection?

Other comments

Submitted by (enter TL/TS and your name) S Pinca

Fish "deep"

Site Name:	**Shark Alley Jaboan, Rongelap Atoll**		
Depth:	9m	Team Leader:	Dr Silvia Pinca
Date:	8/7/2002	Time:	10.00-11

Indo-Pacific Belt Transect : Fish

Data recorded by: Craig Musburger, Maria Beger

	0-20m	25-45m	50-70m	75-100m	Total	Mean	Standard deviation
Butterfly fish	2	5	8	7	22	8.8	2.65
Sweetlips (Haemulidae)	0	0	0	0	0	0	0.00
Snapper (Lutjanidae)	8	1	15	17	41	16.4	7.27
Barramundi Cod (*Cromileptes*)	0	0	0	0	0	0	0.00
Grouper >30cm (Give sizes in comments)	0	2	2	3	7	2.8	1.26
Humphead wrasse	0	0	0	1	1	0.4	0.50
Steephead parrot	0	0	1	0	1	0.4	0.50
Other Parrotfish (>20cm)	17	3	3	4	27	10.8	6.85
Moray eel	0	0	0	1	1	0.4	0.50

Indo-Pacific Belt Transect : Invertebrates

Data recorded by: Eric Peterson, Dan Barshis

	0-20m	25-45m	50-70m	75-100m	Total	Mean	Standard deviation
Banded coral shrimp (*Stenopus hispidus*)	0	0	0	0	0	0	0.00
Diadema urchins	2	0	0	0	2	0.8	1.00
Pencil urchin (*Heterocentrotus mammilatus*)	0	0	0	0	0	0	0.00
Sea cucumber (edible only)	0	3	0	0	3	1.2	1.50
Crown-of-thorns star (*Acanthaster*)	0	0	0	0	0	0	0.00
Giant clam (*Tridacna*)	1	0	0	1	2	0.8	0.58
Triton shell (*Charonia tritonis*)	0	0	0	0	0	0	0.00
Lobster	0	0	0	0	0	0	0.00
For each segment, rate the following as: None=0, Low=1, Medium=2, High=3							
Coral damage : Anchor	0	0	0	0	0	0	0.00
Coral damage:Dynamite	0	0	0	0	0	0	0.00
Coral damage : Other	0	0	0	0	0	0	0.00
Trash : Fish nets	0	0	0	0	0	0	0.00
Trash : Other	0	0	0	0	0	0	0.00

Comments:			1 gray reef shark, 1 nurse shark, 1 tiger shark
Grouper sizes (cm)	35 & 30cm	30 & 60cm	30, 30 & 15cm
Bleaching (% of coral population)			
Bleach (% of colony)			
Suspected disease (type/%):			
Rare animals sighted (type/#):			
Other:			

Corals "deep"

Site name: **Shark Alley Jaboan, Rongelap Atoll**

Depth: 9m Date: 8/7/2002

Team Leader: Silvia Pinca Data recorded by: Eric Peterson, Dan Barshis

Time: 10

Substrate Code

HC hard coral	**SC** soft coral	**RKC** recently killed coral
FS fleshy seaweed	**SP** sponge	**RC** rock
RB rubble	**SD** sand	**SI** silt/clay
OT other		

(For first segment, if start point is 0 m, last point is 19.5 m)

SEGMENT 1		**SEGMENT 2**		**SEGMENT 3**		**SEGMENT 4**	
0 - 19.5 m		**25 - 44.5 m**		**50 - 69.5 m**		**75 - 94.5 m**	
1 RC	21 SD	41 RC	61 RC	81 SD	101 HC	121 HC	141 SC
2 SD	22 RB	42 HC	62 HC	82 SD	102 FS	122 SD	142 SC
3 SD	23 RC	43 RB	63 RB	83 SD	103 RB	123 HC	143 DC
4 RC	24 SD	44 FS	64 HC	84 RB	104 RB	124 RB	144 RC
5 SD	25 RC	45 HC	65 RC	85 RB	105 RB	125 SD	145 RC
6 RC	26 SD	46 SC	66 HC	86 RB	106 HC	126 HC	146 RKC
7 SC	27 RB	47 HC	67 HC	87 RB	107 HC	127 HC	147 SD
8 RC	28 RB	48 RB	68 HC	88 SD	108 SC	128 HC	148 HC
9 SD	29 HC	49 HC	69 SD	89 HC	109 SD	129 DC	149 HC
10 SD	30 RC	50 RC	70 FS	90 RB	110 SD	130 HC	150 HC
11 HC	31 SC	51 RB	71 HC	91 RB	111 FS	131 HC	151 HC
12 HC	32 HC	52 RC	72 RC	92 RB	112 RB	132 SD	152 RC
13 RC	33 RB	53 RC	73 HC	93 HC	113 RC	133 HC	153 SD
14 SD	34 HC	54 RC	74 RB	94 HC	114 SD	134 RKC	154 FS
15 SD	35 RC	55 HC	75 RB	95 RC	115 RC	135 HC	155 HC
16 SD	36 RC	56 RC	76 RB	96 HC	116 RB	136 HC	156 HC
17 HC	37 SD	57 SD	77 RB	97 HC	117 HC	137 HC	157 HC

18	HC	38	RC	58	SD	78	RB	98	SC	118	RC	138	HC	158	HC
19	HC	39	RB	59	SD	79	SD	99	RB	119	RB	139	HC	159	HC
20	SD	40	HC	60	RB	80	RC	100	RB	120	HC	140	RC	160	SC

DO NOT TYPE DATA BELOW THIS LINE

Total S1		**Total S2**		**Total S3**		**Total S4**		**Grand total**		**Mean**		**SD**
HC	9	HC	9	HC	12	HC	12	HC	42	HC	10.5	HC	4.93
SC	2	SC	2	SC	1	SC	1	SC	6	SC	1.5	SC	0.837
RKC	0	RKC	0	RKC	0	RKC	0	RKC	0	RKC	0	RKC	0
FS	0	FS	1	FS	2	FS	1	FS	4	FS	1	FS	0.837
SP	0	SP	0	SP	0	SP	0	SP	0	SP	0	SP	0
RC	11	RC	12	RC	10	RC	5	RC	38	RC	9.5	RC	5.03
RB	5	RB	9	RB	10	RB	15	RB	39	RB	9.75	RB	5.63
SD	13	SD	7	SD	5	SD	6	SD	31	SD	7.75	SD	4.658
SI	0	SI	0	SI	0	SI	0	SI	0	SI	0	SI	0
OT	0	OT	0	OT	0	OT	0	OT	0	OT	0	OT	0
#	40	#	40	#	40	#	40		160				

Comments:

Fish "shallow"

Site Name: **Shark Alley Jaboan, Rongelap Atoll**

Depth: 5-7m | Team Leader: Dr Silvia Pinca

Date: 8/7/2002 | Time: 10.00-11

Indo-Pacific Belt Transect : Fish

Data recorded by: Sacha Jellineck | Emma Reeves

	0-20m	**25-45m**	**50-70m**	**75-100m**	**Total**	**Mean**	**Standard deviation**
Butterfly fish	7	7	9	11	34	8.5	1.914854
Sweetlips (Haemulidae)	0	0	0	1	1	0.25	0.5
Snapper (Lutjanidae)	2	2	4	1	9	2.25	1.258306
Barramundi Cod (*Cromileptes*)	0	0	0	0	0	0	0
Grouper >30cm (Give sizes in comments)	1	3	1	0	5	1.25	1.258306
Humphead wrasse	0	0	0	0	0	0	0
Steephead parrot	0	0	0	0	0	0	0
Other Parrotfish (>20cm)	9	2	1	5	17	4.25	3.593976
Moray eel	0	0	0	0	0	0	0

Indo-Pacific Belt Transect : Invertebrates

Data recorded by:	Anna McMurray		Zoe Richards				
	0-20m	**25-45m**	**50-70m**	**75-100m**	**Total**	**Mean**	
Banded coral shrimp (*Stenopus hispidus*)	0	0	0	0	0	0	0
Diadema urchins	2	5	8	3	18	4.5	2.645751
Pencil urchin (*Heterocentrotus mammilatus*)	0	0	0	0	0	0	0
Sea cucumber (edible only)	0	0	0	0	0	0	0
Crown-of-thorns star (*Acanthaster*)	0	0	0	0	0	0	0
Giant clam (*Tridacna*)	0	1	1	0	2	0.5	0.57735
Triton shell (*Charonia tritonis*)	0	0	0	0	0	0	0
Lobster	0	0	0	0	0	0	0
For each segment, rate the following as: None=0, Low=1, Medium=2, High=3							
Coral damage : Anchor	0	0	0	0	0	0	0
Coral damage:Dynamite	0	0	0	0	0	0	0
Coral damage : Other	1	0	1	0	2	0.5	0.57735
Trash : Fish nets	0	0	0	0	0	0	0
Trash : Other	0	0	0	0	0	0	0
Comments:	Good condition						
Grouper sizes (cm)	60+cm		30cm Lyretail				
Bleaching (% of coral population)							
Bleach (% of colony)							
Suspected disease (type/%):							
Rare animals sighted (type/#):							
Other:							

Corals "shallow"

Site name:	**Shark Alley Jaboan, Rongelap Atoll**		
Depth:	5-7m	Date:	8/7/2002
Team Leader:	Silvia Pinca	Data recorded by:	Anna McMurray, Zoe Richards
Time:	10		

Substrate Code

HC hard coral	**SC** soft coral	**RKC** recently killed coral
FS fleshy seaweed	**SP** sponge	**RC** rock
RB rubble	**SD** sand	**SI** silt/clay
OT other		

(For first segment, if start point is 0 m, last point is 19.5 m)

SEGMENT 1		SEGMENT 2		SEGMENT 3		SEGMENT 4	
0 - 19.5 m		**25 - 44.5 m**		**50 - 69.5 m**		**75 - 94.5 m**	
1 HC	21 RC	41 RC	61 FS	81 RKC	101 SD	121 HC	141 HC
2 RC	22 FS	42 FS	62 FS	82 SD	102 SD	122 HC	142 RC
3 FS	23 HC	43 HC	63 FS	83 SD	103 RC	123 RB	143 RC
4 HC	24 HC	44 HC	64 RC	84 SD	104 SD	124 RB	144 RC
5 RC	25 HC	45 FS	65 FS	85 FS	105 RC	125 SD	145 RC
6 RB	26 HC	46 RC	66 HC	86 HC	106 SD	126 RC	146 RB
7 HC	27 HC	47 HC	67 FS	87 FS	107 HC	127 SD	147 RB
8 HC	28 RC	48 HC	68 RC	88 FS	108 HC	128 HC	148 RB
9 RC	29 RC	49 RB	69 HC	89 RC	109 RB	129 RC	149 HC
10 RC	30 RC	50 RB	70 HC	90 RB	110 HC	130 RC	150 RC
11 RC	31 HC	51 FS	71 FS	91 HC	111 RB	131 HC	151 HC
12 RC	32 HC	52 FS	72 RC	92 RC	112 SD	132 RB	152 HC
13 HC	33 HC	53 RC	73 FS	93 RC	113 SD	133 RB	153 RC
14 RC	34 RC	54 RC	74 HC	94 FS	114 RB	134 FS	154 HC
15 RC	35 HC	55 HC	75 FS	95 SD	115 SD	135 HC	155 HC
16 HC	36 HC	56 RKC	76 HC	96 HC	116 SD	136 HC	156 HC
17 HC	37 HC	57 HC	77 RC	97 RC	117 RC	137 HC	157 RC
18 HC	38 RC	58 RC	78 RC	98 SD	118 HC	138 HC	158 HC
19 FS	39 RC	59 HC	79 RB	99 SD	119 FS	139 HC	159 HC
20 RC	40 RB	60 FS	80 RB	100 SD	120 HC	140 HC	160 HC

DO NOT TYPE DATA BELOW THIS LINE

Total S1		**Total S2**		**Total S3**		**Total S4**		**Grand total**	**Mean**		**SD**	
HC	19	HC	18	HC	12	HC	8	57	HC	14.25	HC	5.188
SC	0	SC	0	SC	0	SC	0	0	SC	0	SC	0
RKC	0	RKC	1	RKC	1	RKC	1	3	RKC	0.75	RKC	0.5
FS	3	FS	6	FS	13	FS	12	34	FS	8.5	FS	4.796
SP	0	SP	0	SP	0	SP	0	0	SP	0	SP	0
RC	16	RC	12	RC	10	RC	9	47	RC	11.75	RC	3.096
RB	2	RB	3	RB	4	RB	3	12	RB	3	RB	0.816
SD	0	SD	0	SD	0	SD	7	7	SD	1.75	SD	3.5
SI	0	SI	0	SI	0	SI	0	0	SI	0	SI	0
OT	0	OT	0	OT	0	OT	0	0	OT	0	OT	0
#	40	#	40	#	40	#	40	160				

Comments: