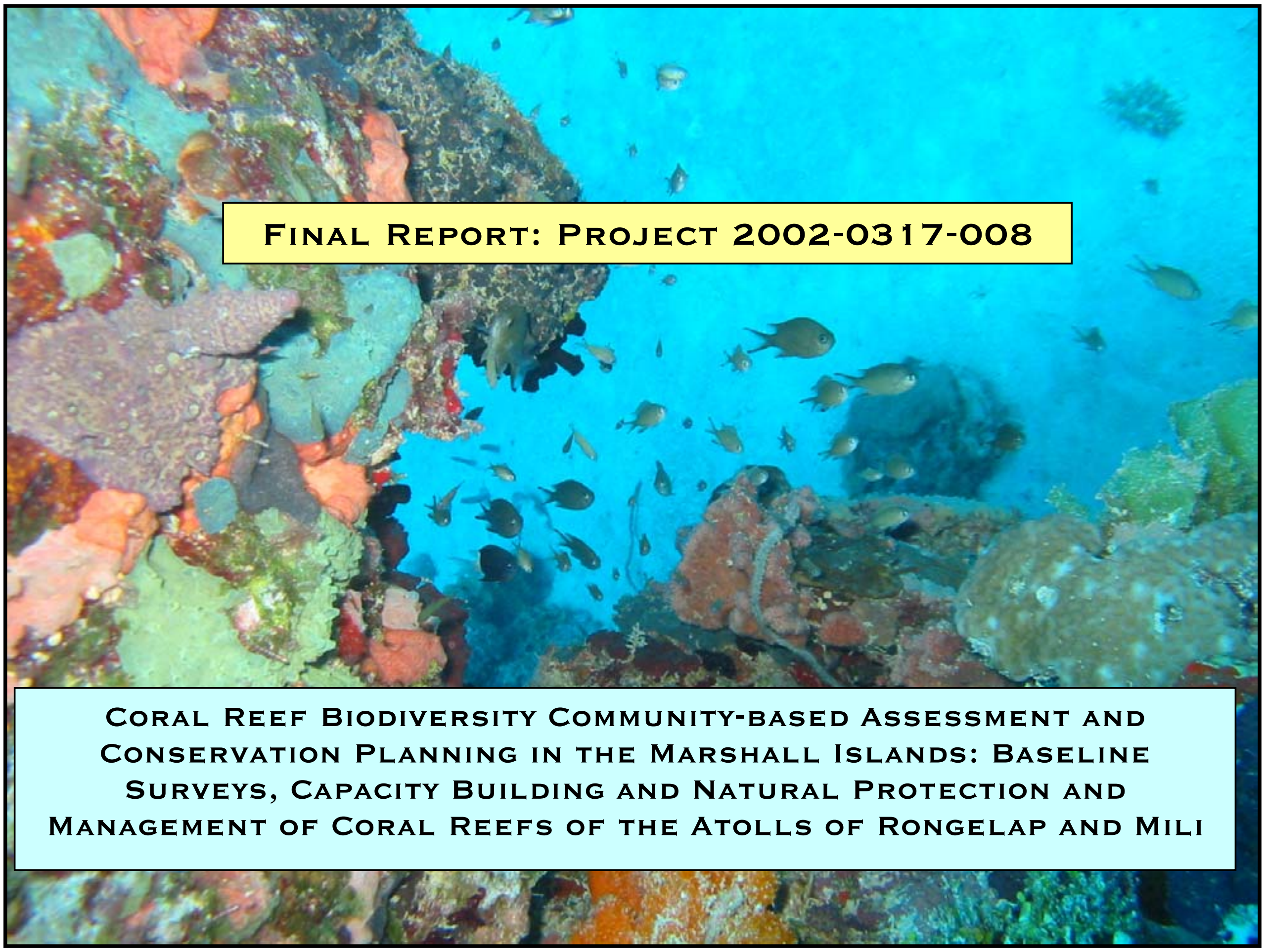
CMI - NRAS 2003

Mili and Rongelap Atolls,
Republic of the Marshall Islands



Final Report: Project 2002-0317-008

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 Atolls of Rongelap and Mili

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List of Acronyms

AIMS	Australian Institute of Marine Science
CB-MPA	Community-based Marine Protected Area
CMI	College of the Marshall Islands
CNMI	Commonwealth of the Northern Mariana Islands
FMP	Fisheries Management Plan
FSM	Federated States of Micronesia
GCRMN	Global Coral Reef Management Network
JCU	James Cook University, Australia
LIT	Line Intercept Transect
MEIC	MIMRA, RMI-EPA, IA, CMI
MIMRA	Marshall Islands Marine Resources Authority
MPA	Marine Protected Area
MSP	Marine Science Program
NRAS	Natural Resource Assessment Surveys
PhD	Doctor of Philosophy
RalGov	Rongelap Government
RMI	Republic of the Marshall Islands
RMI-EPA	Environmental Protection Authority - Marshall Islands
UH	University of Hawaii, US
UN	United Nations
UQ	The University of Queensland, Australia
US	United States of America

1. Introduction

During June and July 2003, a team of local students from the College of the Marshall Islands, local volunteers and local and international scientists conducted assessments of the coral reefs of Mili and Rongelap Atolls. There were 12 participants at the Mili Atoll surveys, and 15 participants at the Rongelap Atoll surveys. Participants came from the Marshall Islands and eight other countries (USA, Philippines, Brazil, UK, Australia, New Zealand, Italy, and Germany). The multicultural environment of this project emphasized the international interest for reef conservation in the Marshall Islands.

The research has been done in order to assist local agencies and governments to select sites for conservation and sustainable development of coral reefs and to assess the richness and status of resources in the country. In Mili, this work will be directly used for the establishment of marine reserves. In Rongelap, recommendations for reserve sites will be put forward, with the local government being very supportive of this idea.

2. Methods

The NRAS surveys included recording the fish, coral, invertebrate and seaweed data on a series of 4 transects; 2 divers were working on each of the four transects that were located at predetermined depths. The diagram 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 1). Each diver would swim the transect four times, accomplishing different duties at a time.

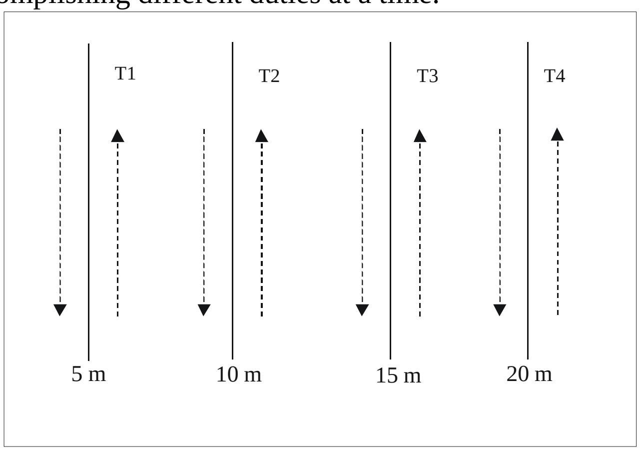


Figure 1. Layout of four transects at each survey site (Transects T1, T2, T3 and T4).

A 50 m tape measure was used as a marker so the same transect would be covered on return swims from one end of the transect to the other. 20 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 two scuba divers collected the information. Each diver had two jobs, accomplished by two separate transect swims (Table 1).

Table 1. Task allocation to survey divers.

"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

2.1 Fish data

Fish counts were undertaken by one scuba diver, swimming along the 50 m length measuring tape. 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 2). The target fish were recorded at family and species level. The fish species recorded were 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.

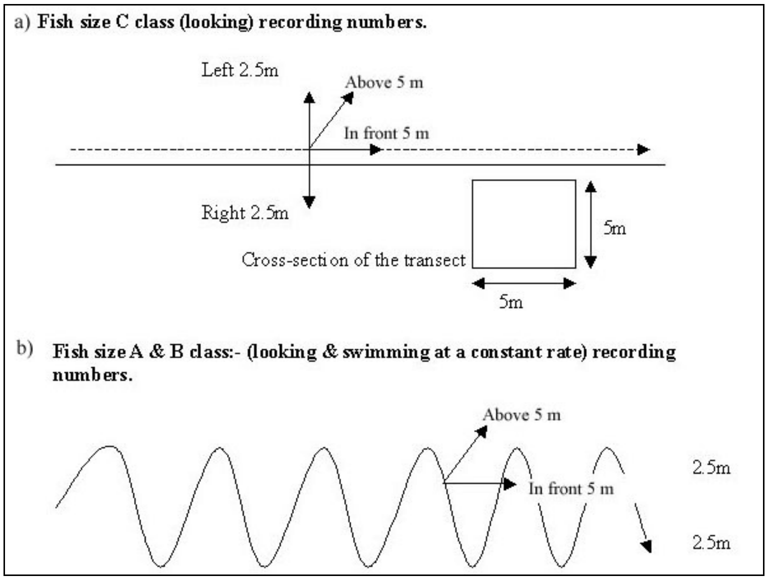


Figure 2. Patterns of swimming and observation radius for (a) large fishes and (b) small fishes.

2.2 Invertebrate data

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 as for fish (Figure 2b), counting the target species. The purpose of criss-crossing the transect was to record the smaller species and the sedentary species.

2.3 Benthic Line Intercept Transect (LIT)

LITs were carried out according to AIMS-ASEAN methodology with minor adjustments (English et al. 1997). Recorders noted all features at two levels, AIMS-ASEAM life-forms and target coral genera or species. 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.

2.4 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. Samples of seaweeds were taken for preservation and cataloguing at the library of the College of the Marshall Islands.

2.5 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 clove oil, which stuns small fish. This technique was used for smaller or cryptic fishes that are difficult to visually identify . Underwater photos also aided with identification in a few cases.

All fish species were given a semi-quantitative rating, following the DAFOR scale (Table 1). 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 1. 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 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.

2.6 Coral diversity

Corals were surveyed by Zoe Richards. Each of the sites was sampled once. 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 Zoe Richards, Dr Carden Wallace ( ) and Dr Douglas Fenner (non-). Voucher specimens have been deposited in the Museum of Tropical Queensland (Townsville, Australia) and are available for viewing upon request.

Coral species were given a semi-quantitative abundance rating following the DAFOR scale (Table 1). An estimate of percentage cover of coral was given for each site along with recording the three most dominant species.

3. Results

3.1 Summary of Outcomes

		SUCCESSES		
	OUTCOME PROPOSED	**OUTCOME ACHIEVED**	**ADDITIONAL OUTCOME**	**DETAILS**
CAPACITY BUILDING	Establishment of skills and knowledge basis	• Local students trained as surveillors; • 4 trained Marshallese CMI graduates are now interns at the Marshall Islands Marine Resources Authority (MIMRA) and two are accepted into BSc program at James Cook University in Australia; • an US volunteer trained during the project is now a PhD student at University of Hawaii on a coral conservation project	Request from local government and national agencies for training of more people in immediate future	
AWARENESS	• Heightened awareness of coral reefs issues with students, fishermen and local governments. • Education of people on coral reefs and conservation	Training (students), public presentations, posters and articles both in the Country and internationally	• More interest by more students from CMI; • More interests from local government from other atolls	**Articles:** • three in Journal of the Marshall Islands (local newspaper) • two on Vancouver Aquarium web site*[1] • one in Newsletter of the Ecological Society of Australia. • Article submitted to the journal of SPC, Women in Fisheries **Presentations**: • MIMRA (August 6th, 2003), RalGov (Sept 2003) • Women group in Majuro (Sept 2003) • Nitijela and Rongelap Senator (Oct 2003) • UH (Oct 3, 2003) • Australian Coral Reef Society 80th Annual Conference (September 2003); • UN Conventions work-shop (Oct 10th, 2003, Townsville) • Coral Reef Taskforce Meeting (Guam, Oct 4th, 2003)
*[1]Marshall Islands: Scientists Return from Coral Reef Surveys posted on 08/15/03 http://www.vanaqua.org/aquanew/archive.php?show=month&month=August&year=2003				

SCIENTIFIC ACHIEVEMENTS	Creation of national data base	Data submitted to National Biodiversity Data Base (RMI-EPA)	Four PhD projects (based at UH, UQ and JCU) are conducted in the area from participants of the projects	
	Presentation at international science meetings	• Internat. Tropical Marine Ecosystems Management Symposium, March 2003: poster and talk by S.Pinca on RMI surveys • Minisymposium organized and abstracts submitted at 10th Internat. Coral Reef Symposium, Okinawa, June 2004	Additional data collection: • Genetic fish population analysis • Measurement of currents at passes and survey sites • Bathymetric mapping • Shoreline mapping • Tidal measurements	
	Potential new species	Probably one species of damselfish ( )		Will be described with international expert on damselfishes
MANAGEMENT ACHIEVEMENTS	• Work towards establishment of MPAs • Formal meetings with local governments	• Issuing of recommendations to RalGov, MIMRA, local landowners and Council in Mili • Presentation of results to RalGov	More interest from other atolls to establish MPAs and conduct baseline reef resource surveys	
INTEGRATION and PARTNERSHIP WITH NATIONAL, REGIONAL AND INTERNATIONAL EFFORTS	Data sharing with international data banks	Data submitted to FishBase and ReefBase	**National**: • CMI as part of Working Group: MEIC through intervention of SPC; • Interest stimulated in other atolls for similar program: request of surveys in Namu atoll **Regional**: • Awareness of national program to neighboring countries and agencies; request for assistance with similar programs: Kiribati, Niue, New Caledonia **International:** • Request to CMI and its data to be part of GCRMN • Partnership established with Tacoma Aquarium, Seattle: support for future surveys • Partnership established with the Aquarium of Genova, Italy: special exhibit and presentation will be developed in January 2004 by S. Pinca and L. Castellano • Partnership with Vancouver Aquarium through M. Hengeveld: future collaborations is planned; a presentation is scheduled for Dec 2003.	

FUTURE	Monitoring planned for the next 10 years Long-term resource management and conservation planning and implementation consolidated in the RMI	• Proposal of training and monitoring plan for the next 10 years; • Trainees will become trainers and assistant trainers and surveyors for monitoring program • Establish monitoring programs across the RMI • Develop a plan for a national marine reserve network (NMRM) • Implement the NMRM	• Certificate Program in Marine Conservation at CMI • Summer short course at CMI for government officials and outer island interest parties	

3.2 Training

The first educational phase took place during the two weeks preceding the fieldwork. Six Marshallese students and six foreign volunteers and students 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 with books and computers.
- Practical training in survey operations by diving in Majuro Atoll: underwater species identification, transects, snorkeling for fish size estimation using wooden dummies of fish.
- Practical training in diving-for-science procedures.

The team acquired 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). Team members' knowledge was assessed through a series of identification tests on the computer and in the water.

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.

Photo: Wooden fish for size test

The second part of the education/awareness phase took place in Majuro through participation at public presentations at different meetings (MIMRA officials, local government officials, traditional articraft women group, women group at the Nitijela - central government), newspaper articles and lectures at the College. International awareness is still ongoing and will be expanded through presentations at the Vancouver Aquarium, Tacoma Aquarium and Aquarium of Genova between December 2003 and January 2004.

4. Data

Data for both Mili and Rongelap Atolls were collected on biodiversity of corals and fishes during timed swims by the two specialists Zoe Richards (Museum of Tropical Queensland) and Maria Beger (University of Queensland). Data on abundance, coverage and size of target species of corals, fishes, seaweeds and invertebrates along replicate 50 m transects at four different depths were collected by students and scientists under the leadership of Dr Silvia Pinca.

4.1 Mili Atoll – 24th June to 7th July 2003.

4.1.1 General summary for Mili:

A total of 20 sites were sampled during the two weeks: 9 on the ocean side of the atoll, 1 pass, and 9 lagoon and pinnacle sites (Figure 3). The reefs surveyed were found in mostly pristine conditions, with a large number of fish, coral, algae and other species present and abundant. The team found abundant and large size fisheries target fishes, and recorded abundant mega fauna such as sea turtles, whales, and rays. Sharks were not very abundant, and there was local anecdotal evidence of illegal shark fishing by foreign large-scale fishing operations.

Mili surveys followed a call from local landowners and the Mayor of the atoll (pers. communication, landowner Ben Chutaro and Mayor Lenn Lenga) who propose to establish a Marine Sanctuary and a Marine Science Station in the North East of the atoll, corresponding to Rheier's pass and Bue pass. They requested assistance from CMI and NRAS to collect baseline data in this part of the atoll. These data will form the base for future monitoring programs and facilitaste a comparison with the reefs in other parts of the atoll. The surveys also served to evaluate the choice of site for the proposed marine reserve based on scientific data. The resource assessment confirmed the choice of the local initiative. However, sites outside the currently proposed marine reserve area also showed high biodiversity and health values and would be suitable as other marine reserves as part of a reserve network in Mili Atoll.

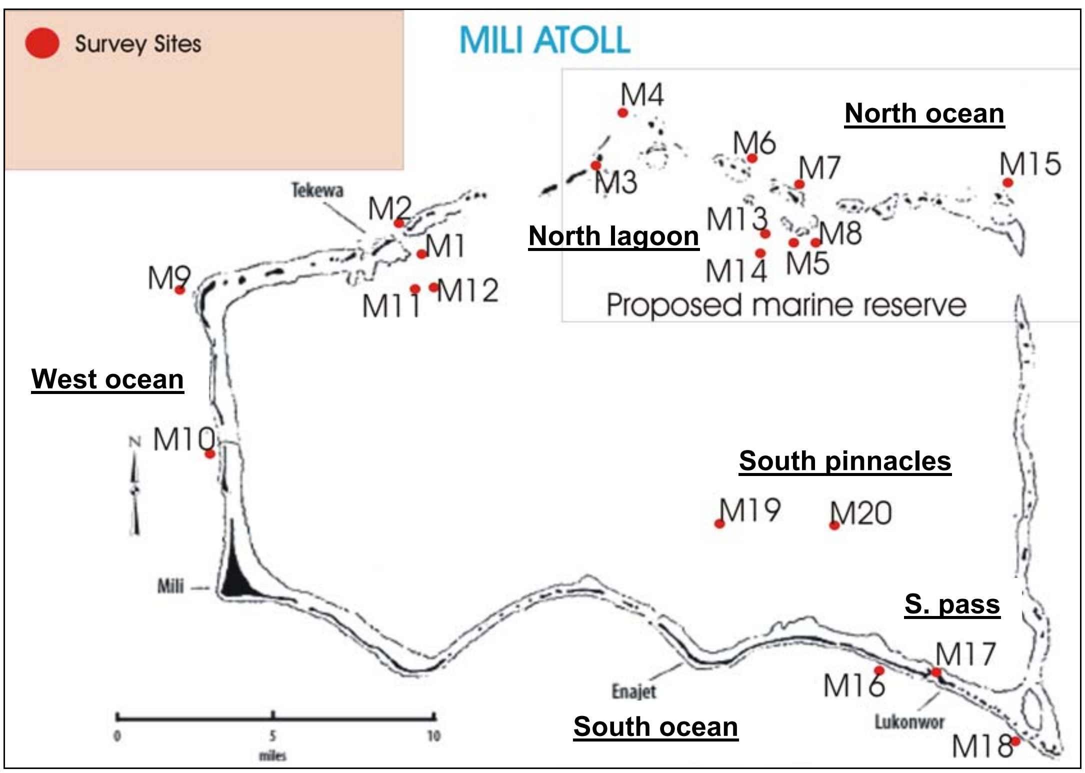


Figure 3. Map of survey sites in Mili Atoll.

4.1.2 Regional descriptions

We divided the atoll in subregions or habitat areas to describe variations that are mostly related to geographical location and exposure to prevalent wind and wave directions. Six of these subregions are described for Mili: north ocean, west ocean, south ocean, south pass, south pinnacles and north lagoon areas.

4.1.2.a Substrate and corals

The highest coral coverage are found at the north, west and southern ocean regions (Figure 4). The southern pinnacles and the other lagoon sites show a very high coverage of sand.

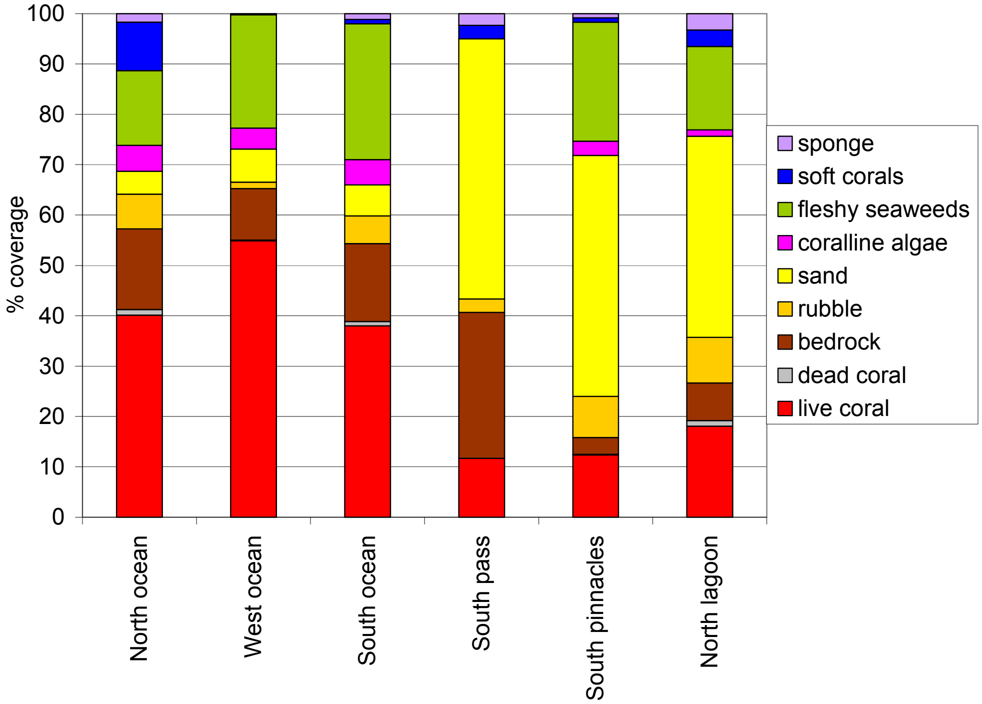


Figure 4. Substrate caterogries and their variation among the subregions in Mili.

branching was represented with the highest relative coverage in the lagoon and central pinnacle areas while non encrusting life form was more representative of the ocean sites. The pass environment was characterized by large coverage in non massive corals and tabulate (Figure 5). The most recurrent coral was , presenting the highest percent cover for total live coral (Figure 6). Its percent cover was highest at the west and south ocean zones. was also a typical ocean coral while Faviids were mostly recorded at lagoonal sites.

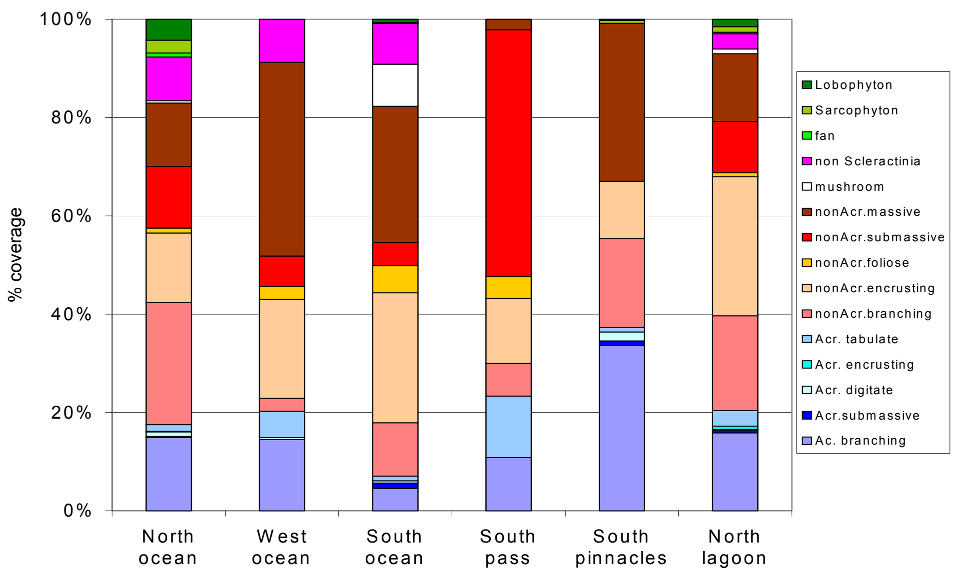


Figure 5. Life forms of coral in Mili atoll by geographic areas.

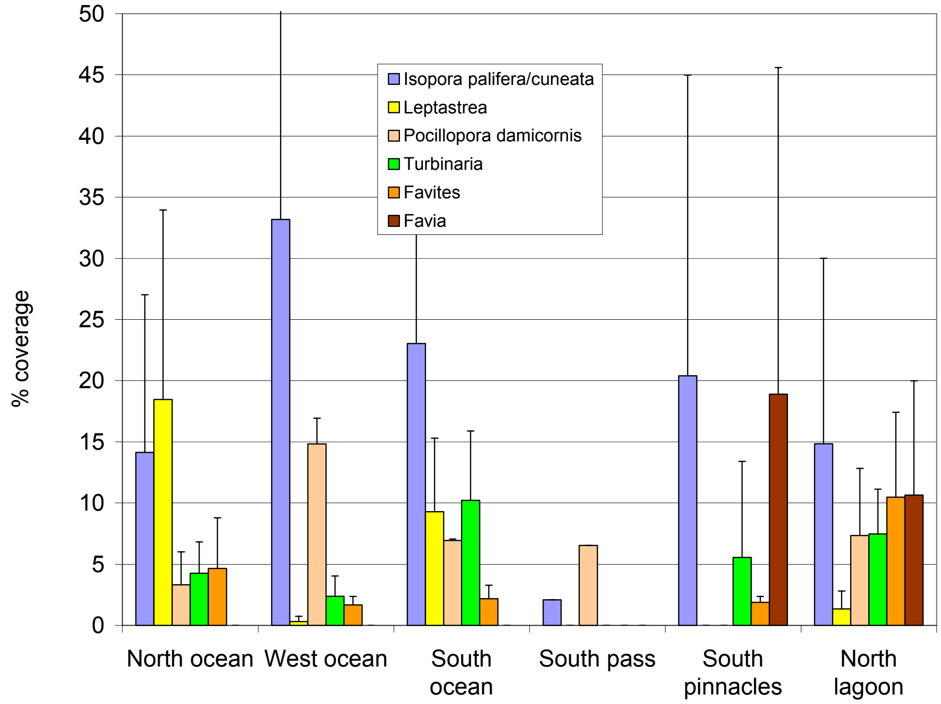


Figure 6. Variation in coral composition among the six subregions in Mili Atoll.

4.1.2.b Fish

Total abundance of fish did not change dramatically among the habitat regions (Figure 7). Highest values were found at the south and north ocean regions.

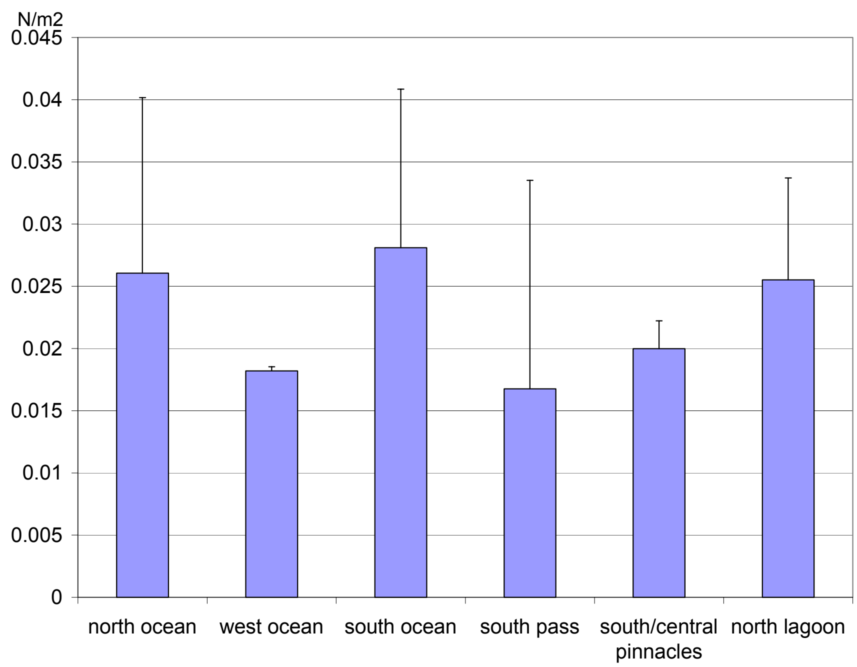


Figure 7. Variation of total fish abundance among the 6 subregions at Mili Atoll. Abundance is in total number of fish per square meters of water surveyed.

The most important commercial fish families (those with highest total number of counted fish) were the surgeonfish, wrasse, fusilier, parrotfish, snapper and grouper families (Figure 8). Surgeonfishes were most abundant at the north lagoon and at the southern ocean regions. Wrasses have the highest relative abundance and are mostly found at the south pinnacles. Snappers were mostly found at the west and north ocean areas.

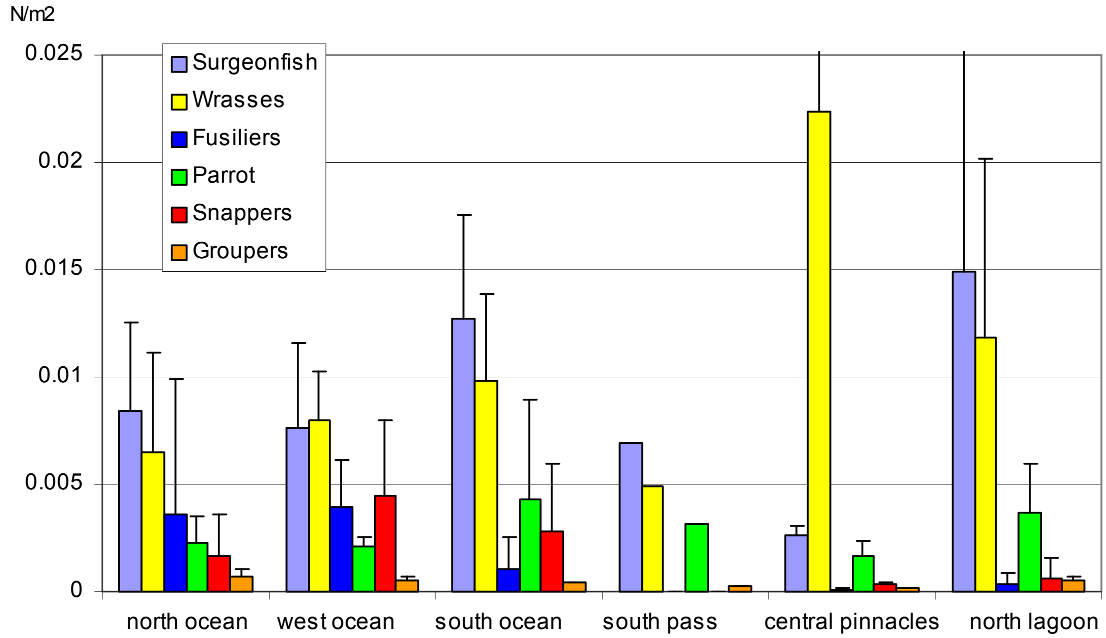


Figure 8. Most abundant fish families (food fish) and their variation among the 6 regions in Mili Atoll.

4.1.2.c Giant clams

Four species of giant clams were found in Mili (Figure 9). The highest total number was recorded at the south pass where was present with 8 individuals. The second most important clam was .

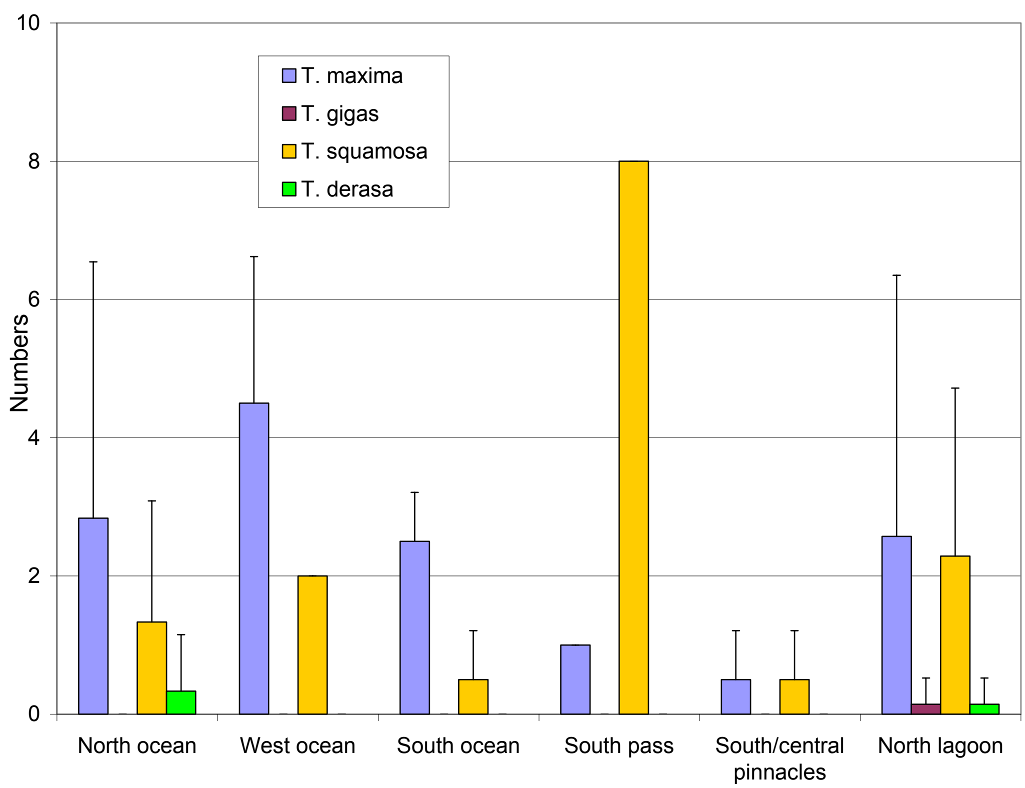


Figure 9. Giant clams recorded in Mili and their distribution among the regions.

4.1.3 Status of the reef

We considered the following criteria to give an image of the health of the reefs: live hard coral coverage, seaweed coverage, and presence of diseases and pests (bleaching, COTS, coral diseases, human impacts).

4.1.3.a Live coral coverage

Coral cover was listed for six bio-geographical zones in Table 2. It shows maximum, minimum and average values and standard deviation of live coral coverage.

Table 2 Percentage of live corals in total substrate; other substrate classes were: dead coral, bedrock, sand, rubble, coralline and fleshy algae, soft corals and sponges.

	Maximum % cover	Minimum % cover	Average % cover	Standard deviation
North ocean	51.50	23.33	40.13	10.02
West ocean	56.74	53.00	54.87	2.64
South ocean	40.33	35.67	38.00	3.30
South pass	11.67	-	11.67	0
South pinnacles	16.00	8.67	12.33	5.19
North lagoon	30.00	5.00	18.08	8.74

The highest coral covers (53 and 57 %) were recorded at site M9 and M10 (west lagoon sites) (Figure 10). Both sites were located on the leeward side with respect the prevalent winds. The lowest (14%) coverage in fleshy seaweeds is found at the western ocean sites as well, where the highest coverage of coralline algae is recorded (Figure 4). The lowest coral coverage was recorded at site M2, on the leeward ocean side (North of the atoll).

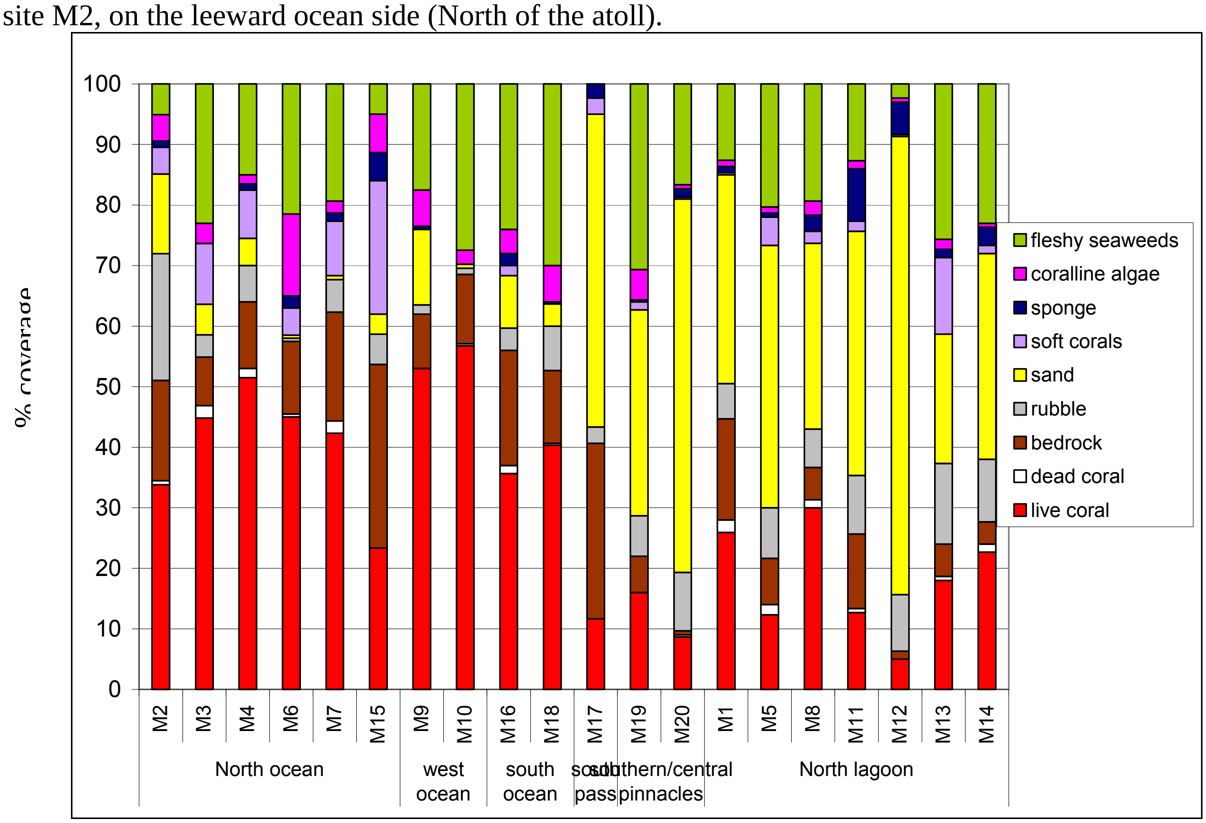


Figure 10. Live coral and other substrate coverage in Mili atoll at each site.

<u>4.1.3.b Presence of diseases and pests</u>

No sign of coral bleaching was recorded for the atoll of Mili. There was a series of bleaching incidents in the Pacific area during El Nino and La Nina events in 1998, 2000, and 2002. Approximately 16% of the world's ocean reefs were damaged during these events, especially in the northern Indian Ocean, Southeast and East Asia and western Pacific (Wilkinson 2002). During the last bleaching Fiji recorded a coral death of 40% (with bleaching extent from 64 to 80% of colonies bleached) and Palau suffered extensive damage in 1998. The GBR suffered from severe bleaching as well. However, no bleaching has been recorded for the Marshall Islands, with the only exception of an incident in September 2001 where some of the very shallow flat reefs on the lagoon side of Majuro atoll bleached during a time of particularly elevated temperatures and no wind conditions, coincident with the period of spring tide. Local knowledge does not recall that any similar events ever happened in RMI. No sign of coral bleaching was recorded for the atoll of Mili. No coral diseases have been recorded and only 4 COTS were found.

<u>4.1.3.c Human impacts</u>

No anthropogenic impacts were recorded in Mili.

4.1.4 Fish Biodiversity

A total of 373 fish species were recorded from Mili atoll in 2003. The 373 species were observed on dives at 20 sites, additional dives and snorkels undertaken in the area. 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 11). At Mili we were approaching the plateau, however we were still adding species per dive.

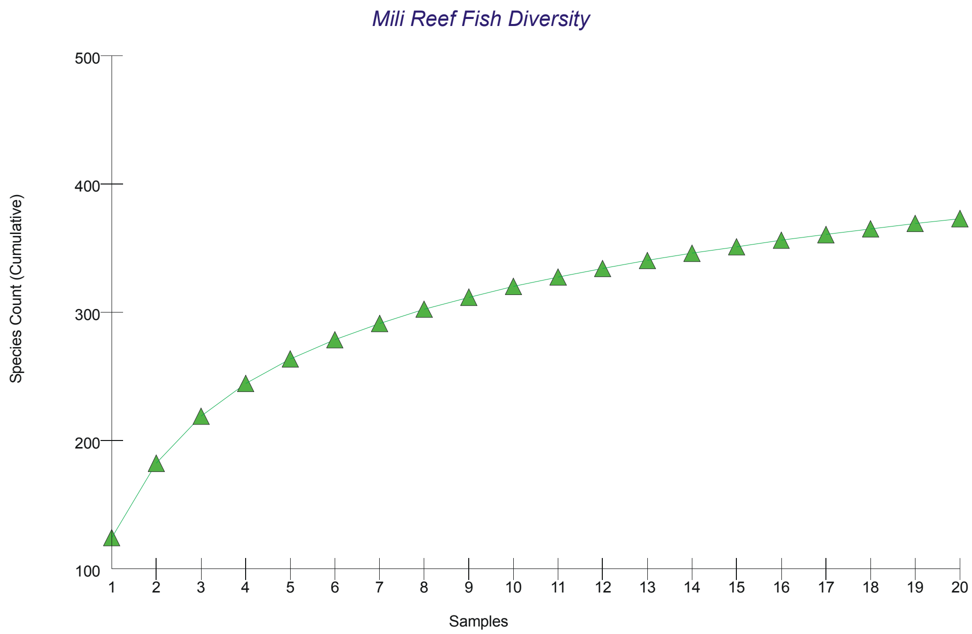


Figure 11. Species-area curve for fish diversity in Mili Atoll.

The number of fish species at each site varied from 95 to 162 with an average of 124 (±15.9) fishes. Sheltered sites in the lagoon tended to support less fishes in total, but they harboured many unusual species, and site variation within the lagoon was greater than in outside areas. The richest areas were the central pinnacles in the southern lagoon and the ocean area in the region of the proposed marine protected area (Figure 12).

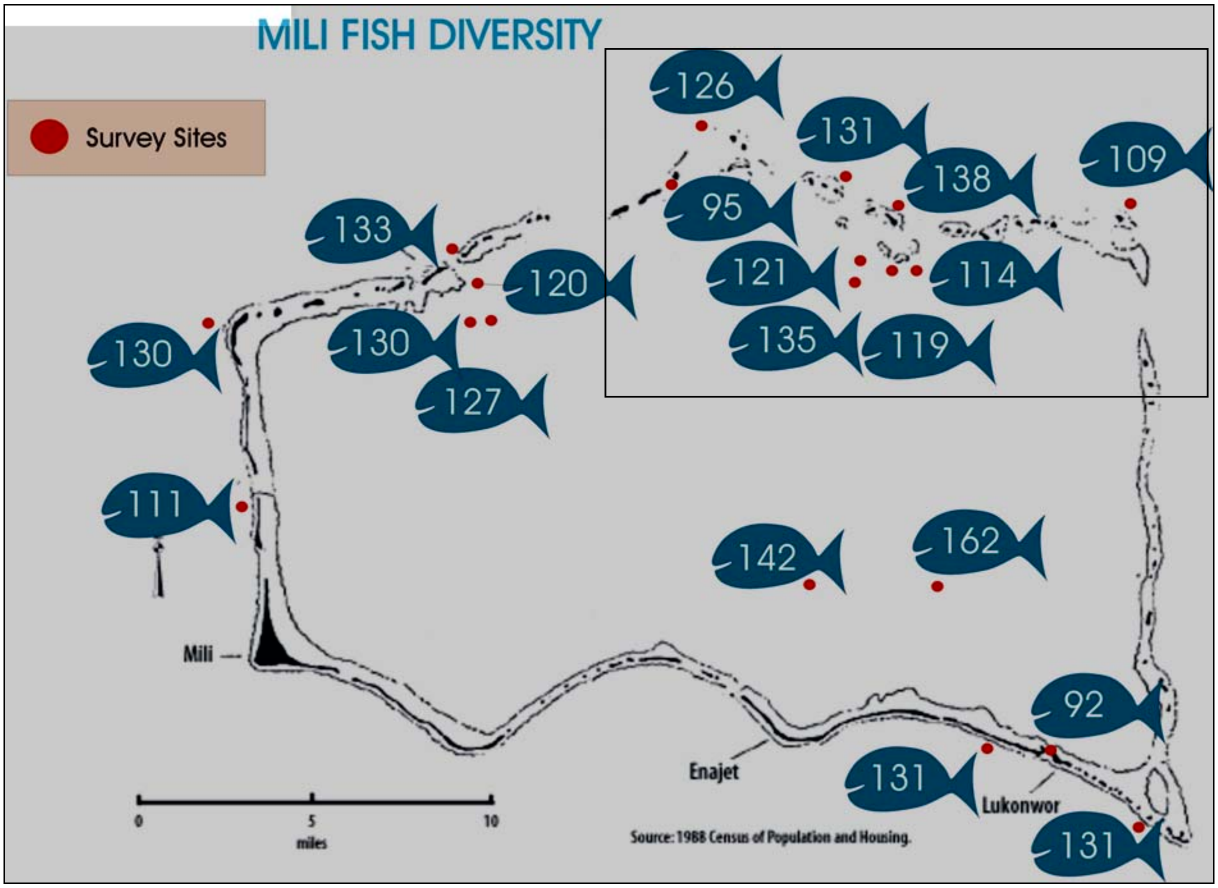


Figure 12. Mili reef fish diversity map. Square marks the proposed marine protected area (Figure 13).

Since the main aim of the Mili expedition was to assess the reef health and diversity in the area of the proposed marine reserve, we show this area in more detail in Figure 13. This area features lagoonal pinnacles rich in fish life.

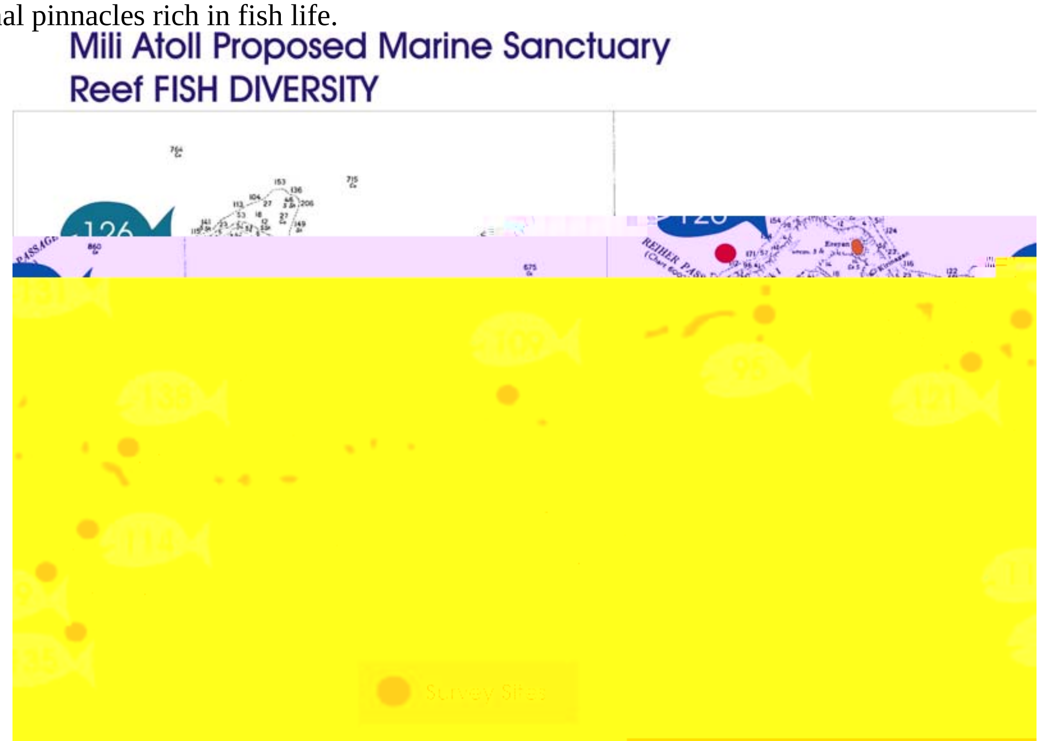


Figure 13. Mili atoll proposed marine sanctuary reef fish diversity map.

4.1.5 Coral Biodiversity

The number of coral species at each site varied from 44 to 72 with an average of 50 (±10.3) corals. Sheltered sites in the lagoon tended to support more corals in total, and they harbored many unusual species (Table 3). The northern ocean areas also supported a high number of coral species, whereas in the southern ocean sites fewer coral species were recorded. The richest areas were the lagoon and ocean sites in the region of the proposed marine protected area.

Table 3. Average number of coral species in the zones at Mili Atoll.

Zone	Mean number of Corals	St Dev
North Ocean	53	± 12.0
North Lagoon	56	± 8.8
West Ocean	45	± 2.1
South Ocean	40	± 5.7
South Pass	36	± 0.0
South Central Pinnacles	48	± 7.8

4.1.6 Megafauna

Megafauna in Mili Atoll included giant clams, manta rays, eagle rays, sharks, marine turtles, dolphins and beaked whales (Figure 14).

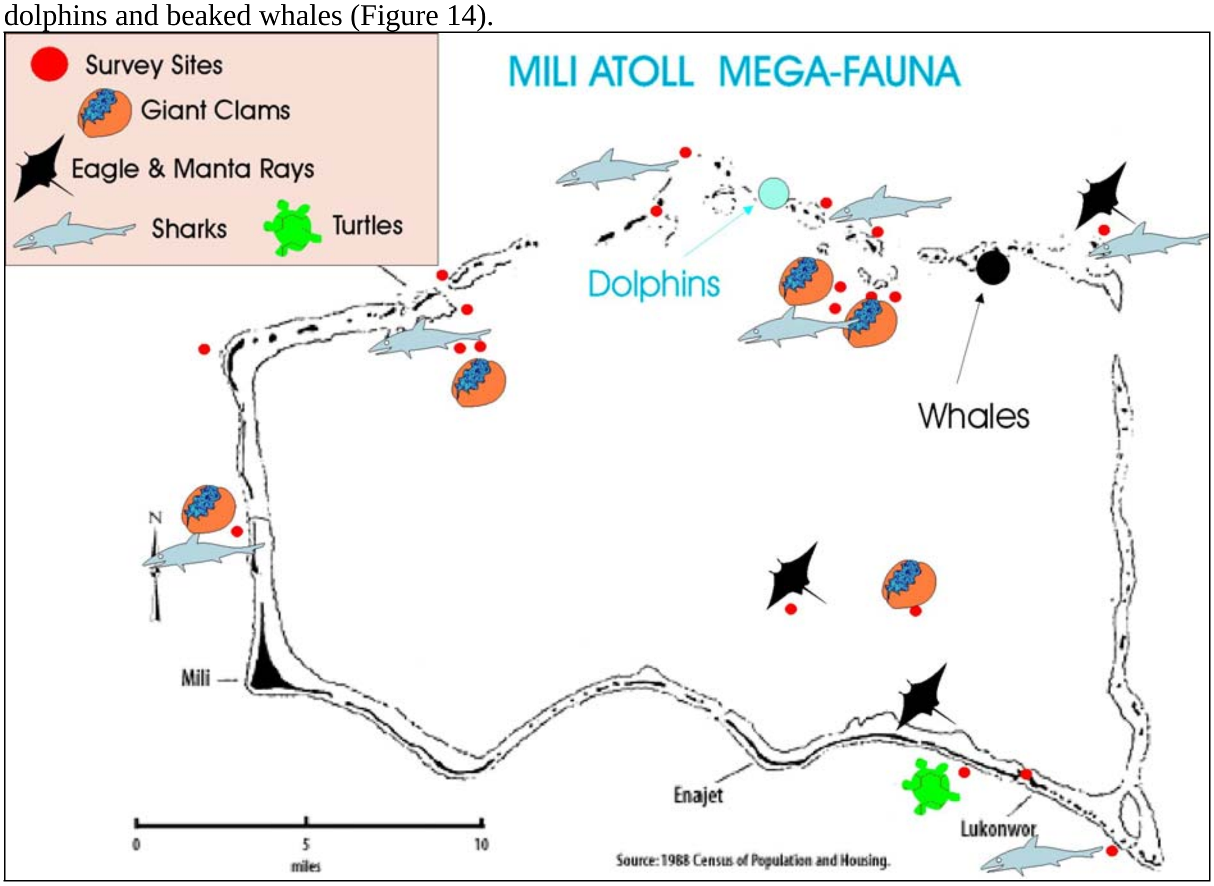


Figure 14. Survey sites at Mili Atoll and observed megafauna.

<u>4.1.6.a Sharks</u>

All shark species were recorded on timed swims by the fish diversity expert. Sharks were counted and the depth at which they were first seen was noted. In Mili Atoll, all shark species were relatively seldom encountered, which was in sharp contrast with some of the Northern Atoll such as Rongelap (see 4.2.5.a) or Bikini Atoll (Beger, unpublished data).

Table 4 shows that the mean abundances of reef sharks varied between species and locations in Mili Atoll. Grey reef sharks ( ), silvertip sharks ( ) and whitetip reef sharks ( ) were seen on most dives in all ocean zones, and their abundance varied between these habitats. Blacktip reef sharks ( ) were observed in the northern ocean zone and on the central southern pinnacles. Nurse sharks ( ) were not seen in Mili Atoll but are included in Table 4 for easier comparison with Rongelap Atoll.

Table 4. Abundance of sharks in six habitat zones at Mili Atoll.

	Grey reef shark		Blacktip reef shark		Whitetip reef shark		Silvertip shark		Nurse shark	
	Mean Abundance	St Dev	Mean Abundance	St Dev	Mean Abundance	St Dev	Mean Abundance	St Dev	Mean Abundance	St Dev
North Ocean	1.5	± 2.3	0.3	± 0.5	0.5	± 0.5	1.2	± 1.5	0	± 0
North Lagoon	0.1	± 0.4	0	± 0	0.6	± 0.8	0	± 0	0	± 0
West Ocean	0	± 0	0	± 0	0.5	± 0.7	1.5	± 2.1	0	± 0
South Ocean	1.5	± 0.7	0	± 0	1	± 1.4	0.5	± 0.7	0	± 0
South Pass	2	± 0	0	± 0	3	± 0	0	± 0	0	± 0
South Central Pinnacles	0	±0	1.5	± 0.7	0.5	± 0.7	0	± 0	0	± 0

Some shark species showed obvious preferences to certain depths. For example, blacktip reef sharks were almost exclusively found in shallow areas above 2 m in depth (Figure 15). Grey and whitetip reef sharks showed no preference of depth. Silvertip sharks were always observed at 15 m of depth and below, they usually swam below the divers. These data describe where these sharks were first seen when the observer first entered the water. At this point, sharks would often change depth as they were curious about the divers and usually came to the same depth as the diver.

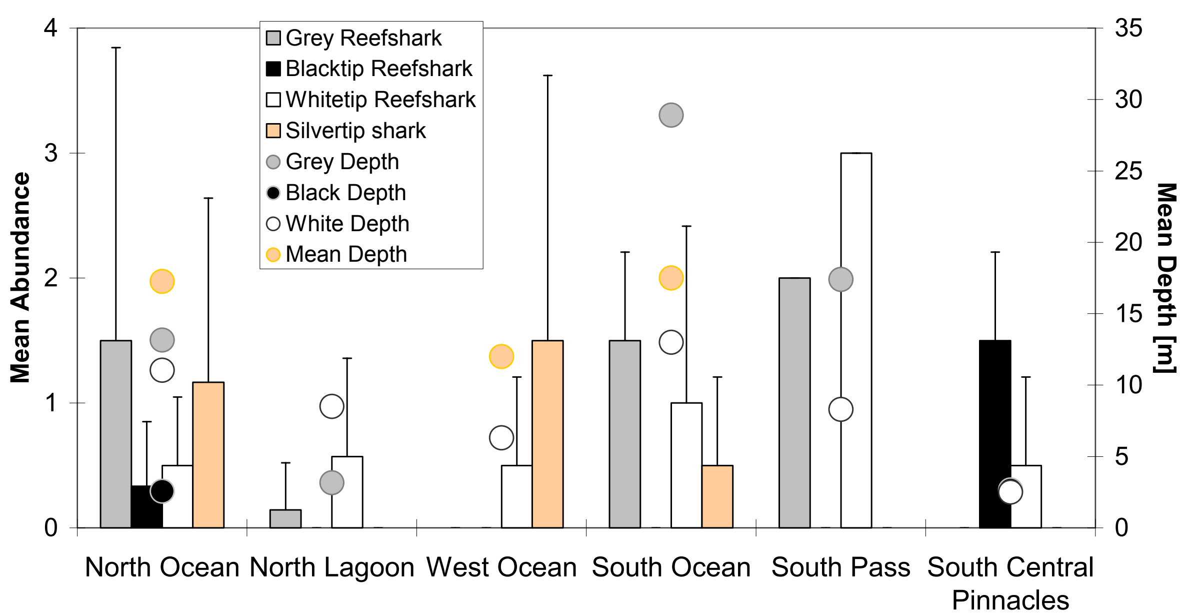


Figure 15. Mean abundance and preferred mean depth of sharks in seven zones at Mili Atoll.

4.1.6.b Turtles and Rays

Turtles and rays have been grouped together since they were seldom encountered. Their occurrences were listed in Table 5.

Table 5. Presence and abundance of marine turtles and large rays in Mili Atoll.

Species		North Ocean	North Lagoon	West Ocean	South Ocean	South Pass	South Central Pinnacles
Green turtle	*Chelonia mydas*	0	0	0	1	0	0
Hawksbill turtle	*Eretmochelys imbricata*	0	0	0	0	0	0
Manta ray	*Manta birostris*	0	0	0	0	0	0
Eagle ray	*Aetobatus narinari*	2	0	0	0	0	0
Number of Sites in Zone		**6**	**7**	**2**	**2**	**1**	**2**

4.1.6.c Humphead Wrasse

Humphead wrasses ( ) were counted during each dive by the fish diversity expert. Additionally, all other team members reported these fishes to the megafauna database. In Mili Atoll, fewer Humphead wrasses were observed than in Rongelap Atoll. Most were seen in the northern part, where they were found at the edge of the drop-off and near passes (Figure 16).

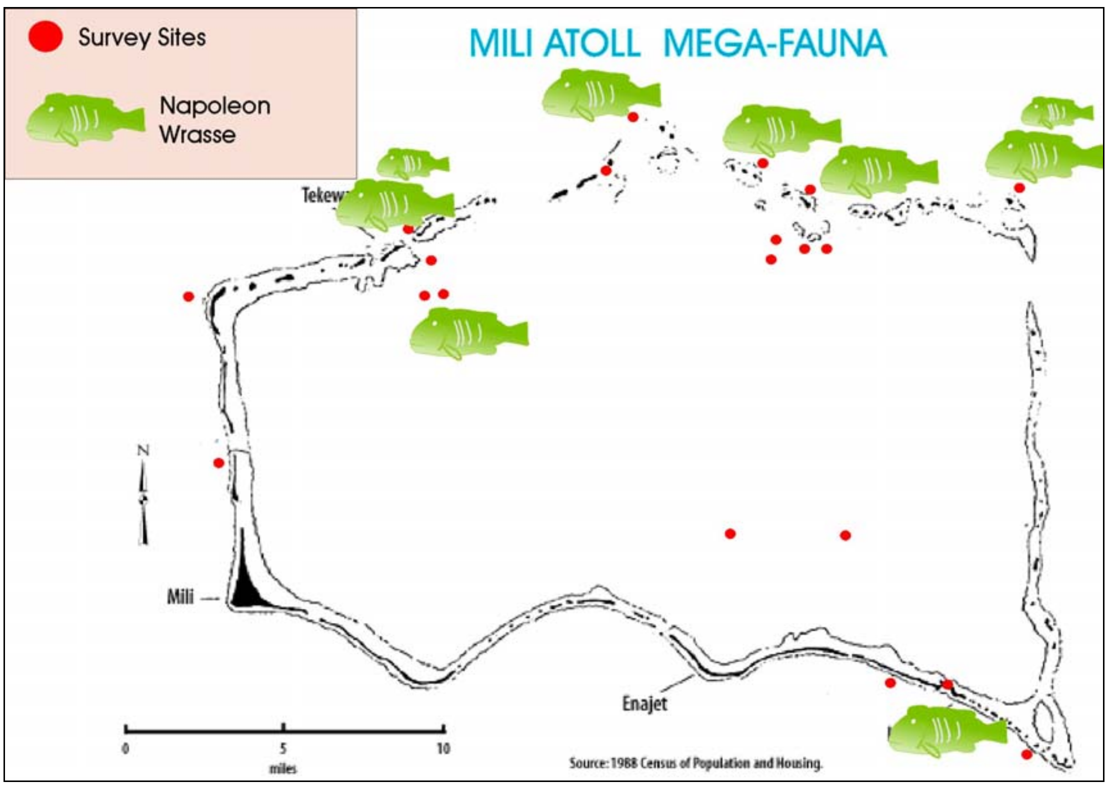


Figure 16. Occurrences of Humphead wrasses at Mili Atoll. Smaller icons signify locations where juveniles were seen.

4.2 Rongelap Atoll, 9th July to 30th July 2003

4.2.1 General summary for Rongelap

A total of 30 sites were surveyed in Rongelap Atoll (Figure 17). 11 sites at pinnacles and patch reefs inside the lagoon, and 19 ocean and pass sites. The reefs surveyed were found in extremely pristine conditions, with a large number of fish, coral, algae and other species present and abundant. The team found large numbers and sizes of fisheries target fishes, and recorded abundant mega fauna such as sea turtles, rays and napoleon wrasses. Sharks were overall also abundant, but the team found some survey sites contaminated by thick fishing lines, buoys and hooks that may stem from large-scale shark or tuna fishing operations.

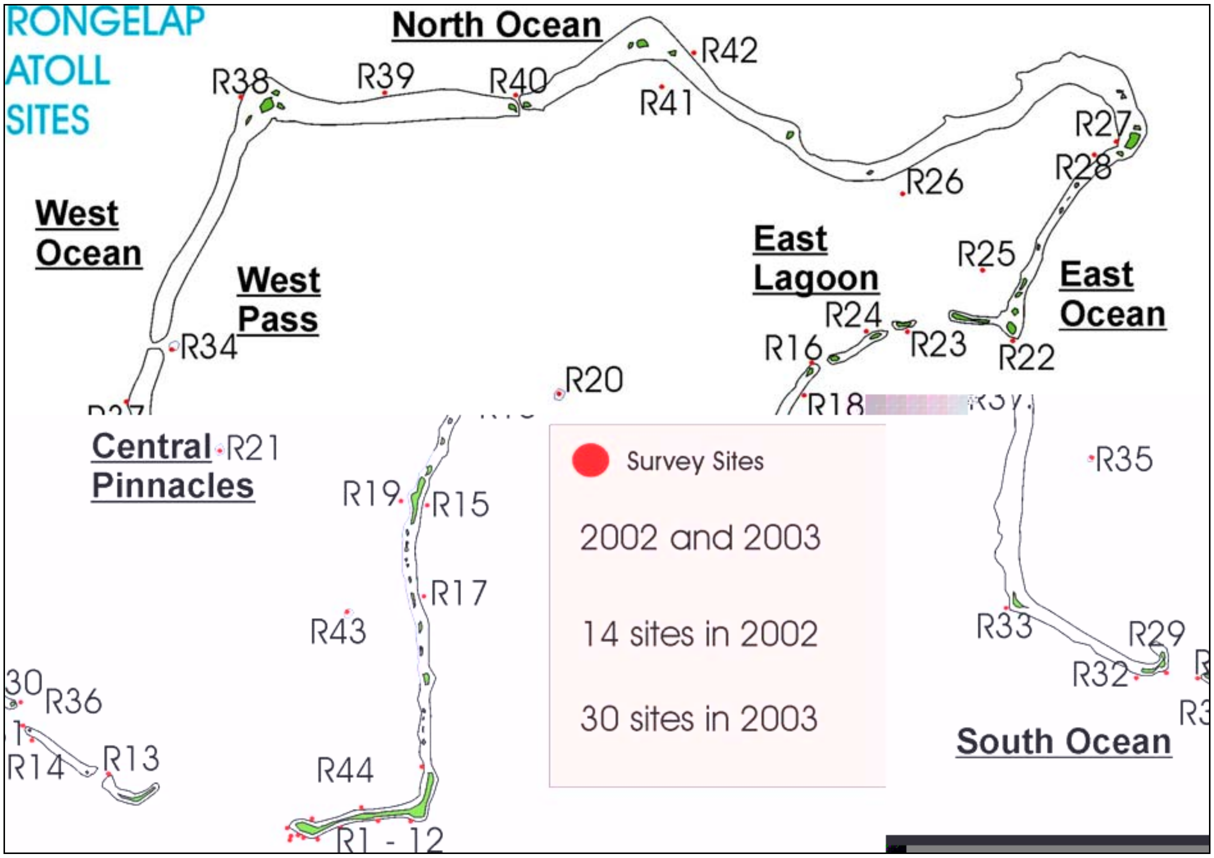


Figure 17. Map of survey sites in Rongelap Atoll.

4.2.2 Regional descriptions

Similarly to how it was done for Mili Atoll, Rongelap was divided in seven sub-regions: east ocean, south ocean, west ocean, north ocean, east lagoon, central pinnacles and west pass.

4.2.2.a <u>Substrate and corals</u>

Highest coral coverage was at the west ocean and west pass sites that also showed the lowest values of seaweed coverage. The west ocean sites had the highest cocerage of coralline algae (Figure 18). branching were represented with the highest relative coverage in the lagoon and central pinnacle areas while encrusting life form was more representative of the ocean sites. The pass environment was characterized by a large cover in non massive and tabulate (Figure 19). The most abundant coral species group as highest percentage of relative coverage among live coral was massive (Figure 20). It was highest at the pass and at the ocean areas. was highest at the south ocean area. The west ocean showed highest values of relative coverage of .

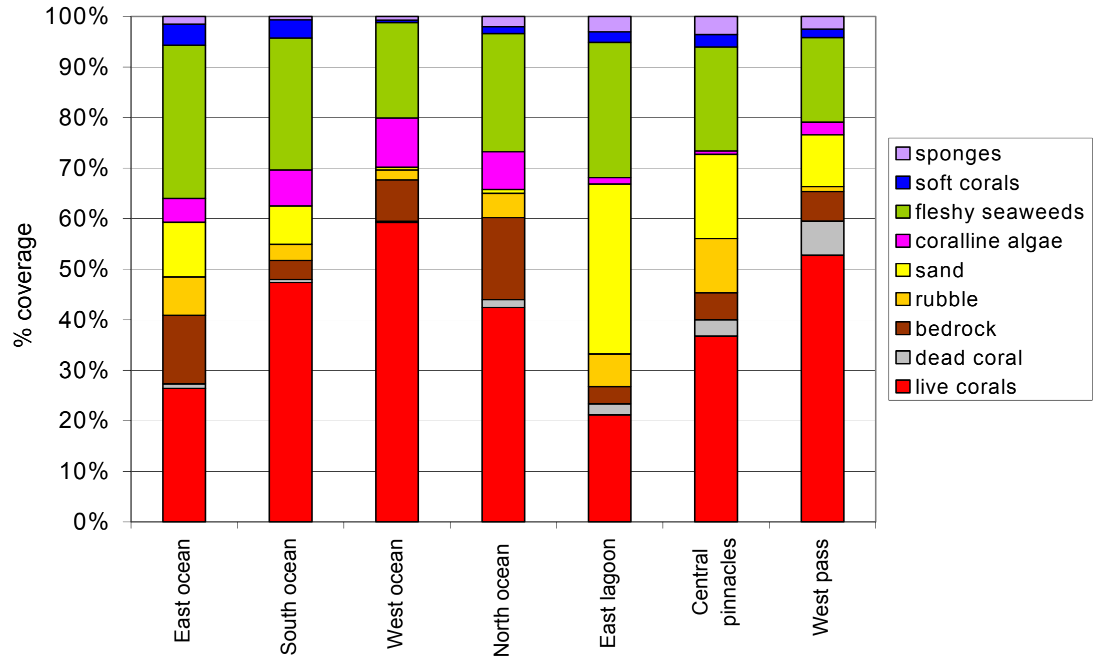
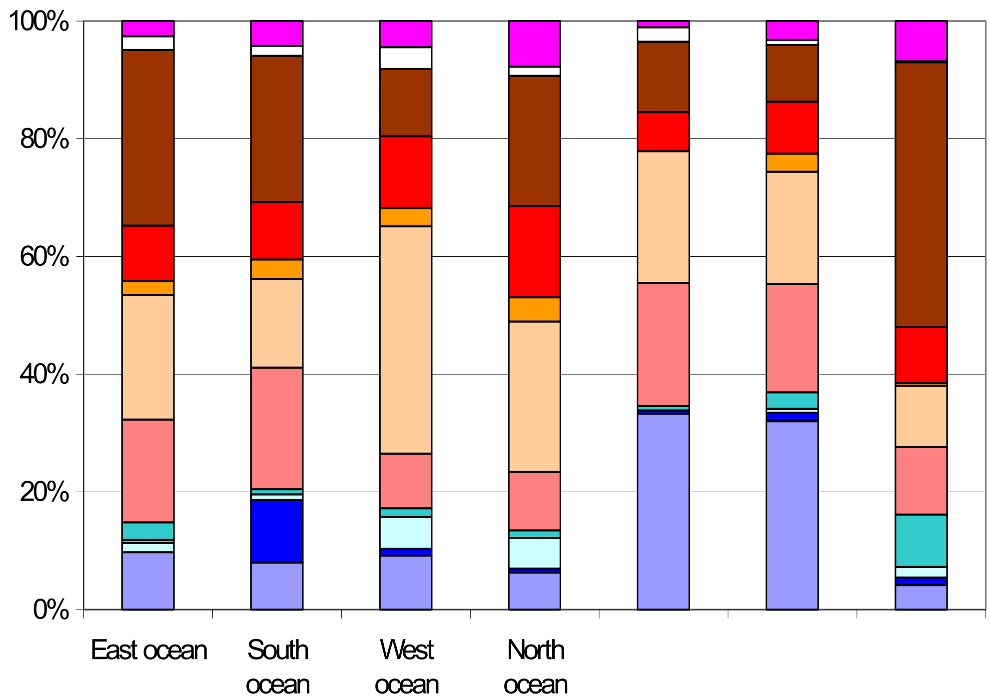


Figure 18. Substrate types and variation among different subregions.



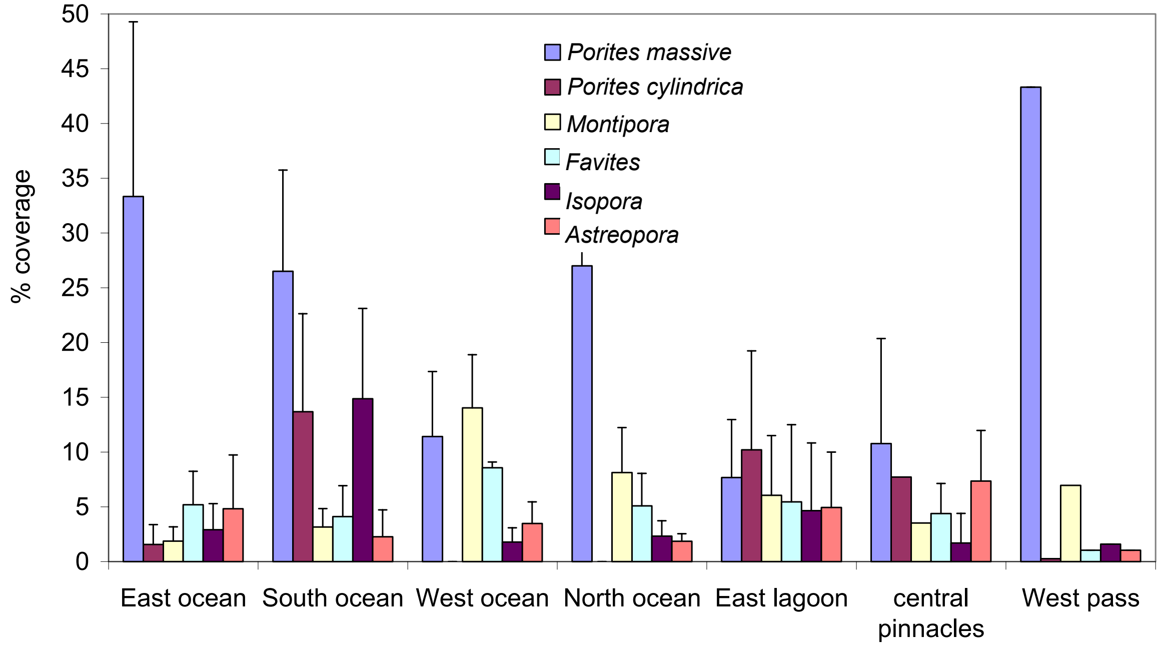


Figure 20. Most abundant coral species and their variation among the sub-regions in Rongelap.

4.2.2.b Fish

Total abundance of fish was recorded at the east lagoon region (Figure 21).

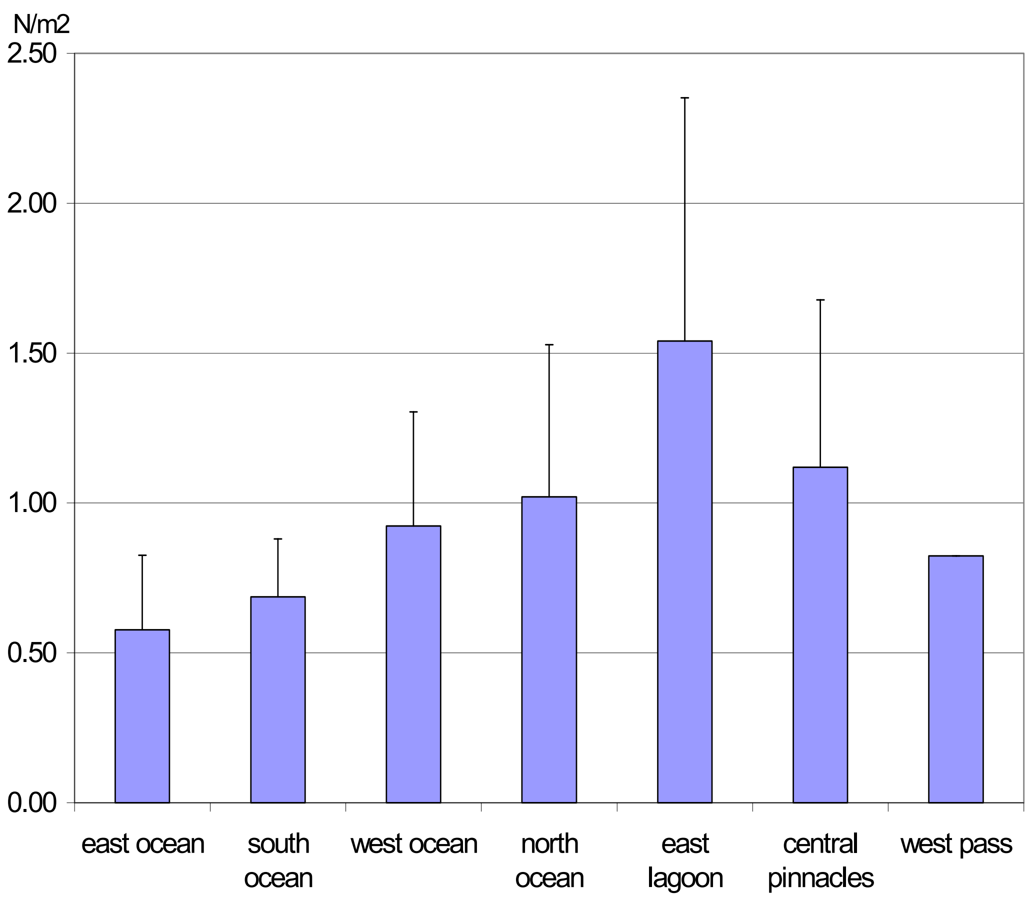


Figure 21. Total abundance of fish in number per square meter and variation among sub-regions in Rongelap.

Among the most abundant food-fish families, Surgeonfish were the most important in number per square meter (Figure 22). Snappers were most abundant in the west ocean region.

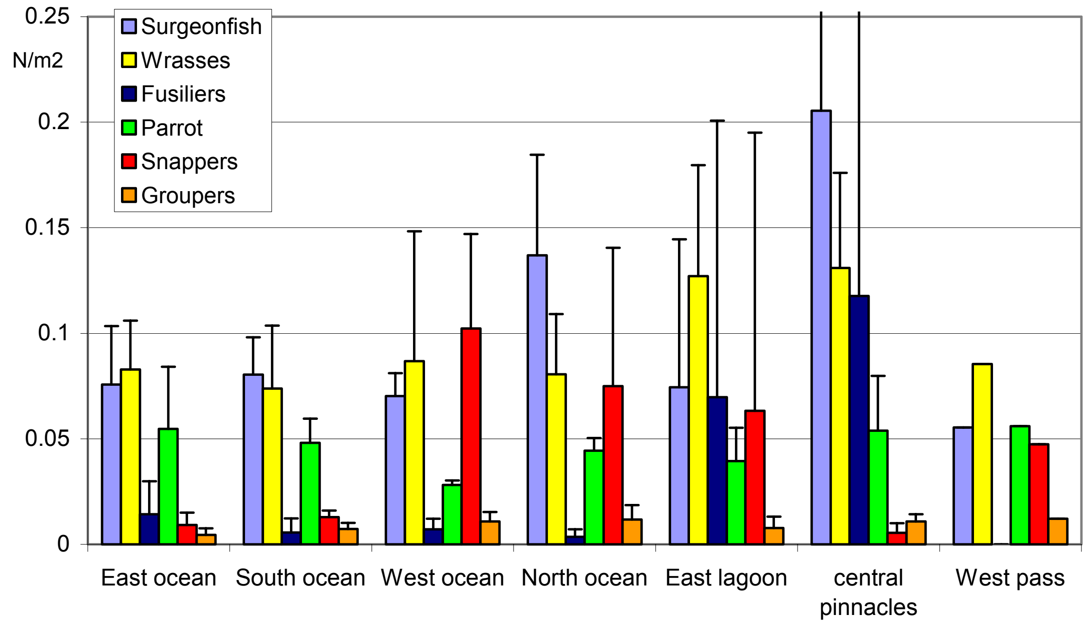


Figure 22. Variation of main food-fish families among the subregions in Rongelap.

4.2.2.c Giant Clams

Five species of giant clams were found in Rongelap atoll. The highest numbers were recorded for at the west pass. (Figure 23). At the central pinnacles all the five species were recorded.

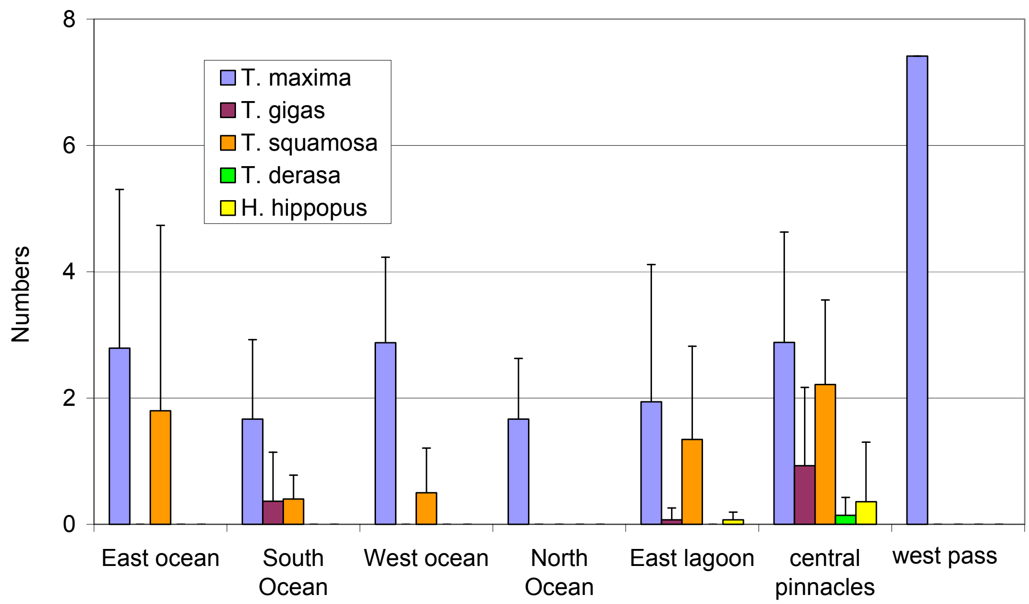


Figure 23. Five species of giant clams found in Rongelap and their variation among the seven sub-regions.

4.2.3 Status of the reef

4.2.3.a Live coral coverage

Coral cover was listed for the seven bio-geographical zones in Table 6. It shows maximum, minimum and average values and standard deviation for live coral coverage.

Table 6. Percentage of live corals in total substrate; other substrate classes were: dead coral, bedrock, sand, rubble, coralline and fleshy algae, soft corals and sponges.

	Maximum % cover	Minimum % cover	Average % cover	Standard deviation
East ocean	38.08	8.75	26.4	11.52
South ocean	54.92	37.17	47.3	7.64
West ocean	63.25	55.08	59.2	5.77
North ocean	46.08	37.50	42.4	4.43
East lagoon	34.83	5	21.1	10.13
Central pinnacles	65.00	23.75	36.7	13.49
West pass	52.75	-	52.8	-

The highest coral covers (65 and 63 %) were recorded at site R19 (pinnacle in front of Eneaetok island) and site R38 (on the north west corner of Rongelap Atoll) (Figure 24). Both sites were located on the leeward side with respect the prevalent winds. At site 19 the highest coverage by transect (70%) was recorded at the shallow depth (5 m), while at site 38 the 10 m transect was the one with the highest coverage (79%). The lowest coral coverage was recorded at site 24, on the leeward lagoon side, in front of Mellu Island (North east of the atoll), where the general topography is a steep sand slope with sparse coral bommies. Sites 19 and 38 showed also the lowest percentage coverage of fleshy seaweeds (16 and 14% respectively).

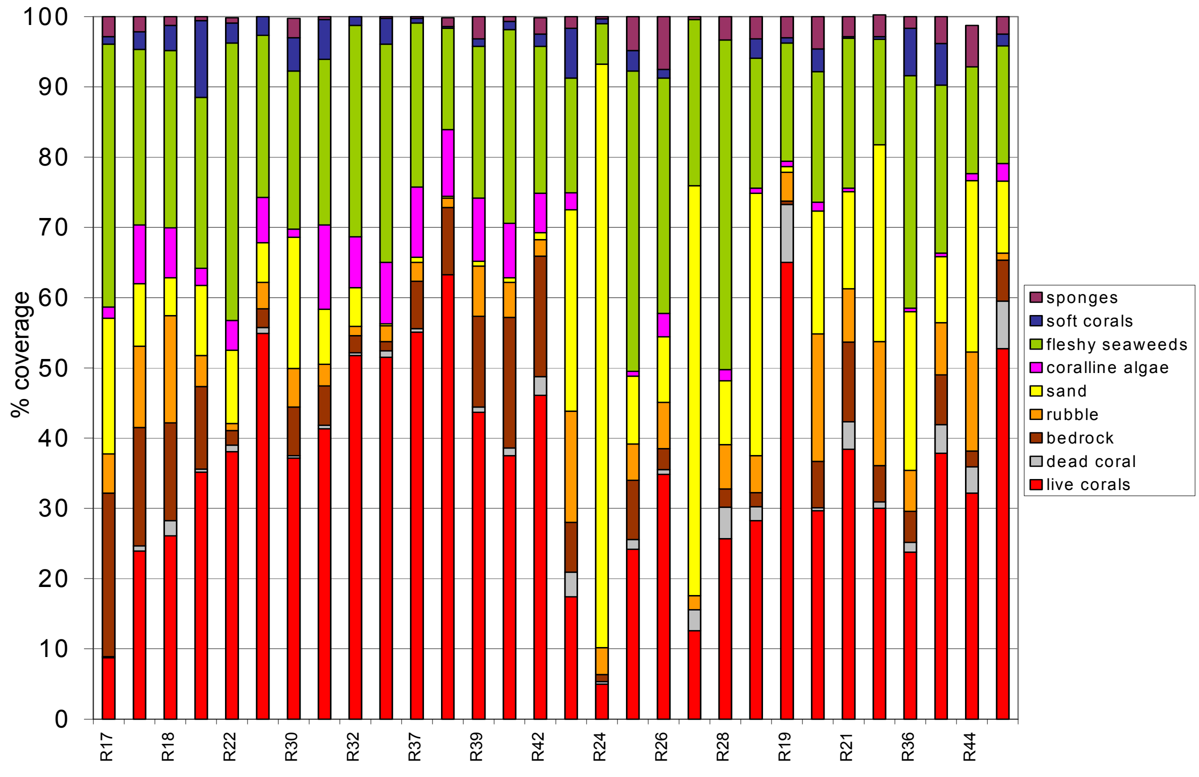


Figure 24. Live coral and other substrate types coverage in Rongelap atoll by sites.

4.2.3.b Presence of diseases and pests

No sign of coral bleaching was recorded for the atoll of Rongelap. No coral diseases have been recorded and only very few COTS (9 were recorded in Rongelap) have been found.

4.2.2.c Human impacts

Human impacts were recorded in the form of occasional illegal fishing evidence: long-lines were found entangled on corals at four sites in Rongelap, on outer reefs on the leeward site of the atoll (south and southwest) at a depth of 25-30 m. At one site some floater buoys were seen with attached lines that were entrapped on the bottom. These sightings were at the south and south-west coast of Rongelap Atoll. It seems improbable that the long-lines drifted by accident from the boat of origin from far away (at least 5 miles off shore, according to the law) since they were found at the lee of the atoll. The lines appeared to be fairly recently entrapped in the corals, since no biofouling encrusted them.

4.2.4 Fish Biodiversity

A total of 397 fish species were recorded from Rongelap Atoll in 2003. The total known number of fishes is thereby raised from 359 to 449 fish species. The 397 species were observed on dives at 30 sites, additional dives and snorkels undertaken in the area. 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 25). At Rongelap we were approaching the plateau, however we were still adding species per dive.

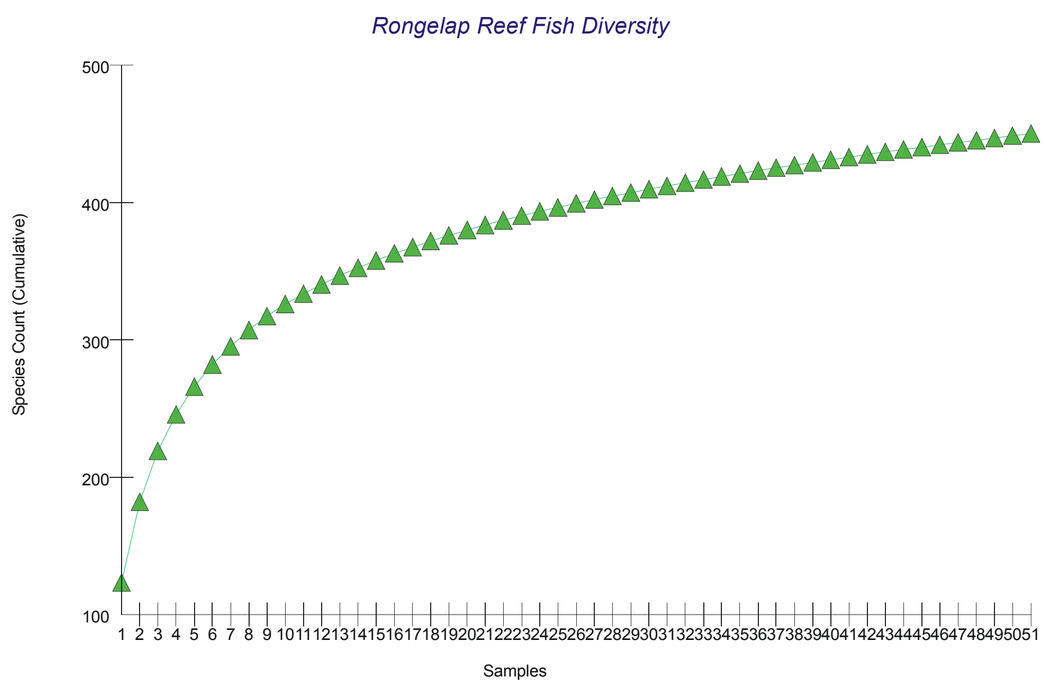


Figure 25. Species-area curve for fish diversity in Rongelap Atoll, combining 2003 and 2002 surveys.

The number of fish species at each site varied from 91 to 205. On average sites harboured 124 (±32.4) species of fish. Sheltered sites in the lagoon tended to support less fishes in total, but they harboured many unusual species, and site variation within the lagoon was greater than in outside areas. The richest area was the tip of Jaboan at Rongelap Island, where the highest fish species numbers were counted both in 2002 (179 species) and in 2003 (205 species). Passes generally supported more species of fishes, since they combined aspects of outer and lagoonal habitats, and also had high current speeds flushing the area and transporting nutrients (Figure 26).

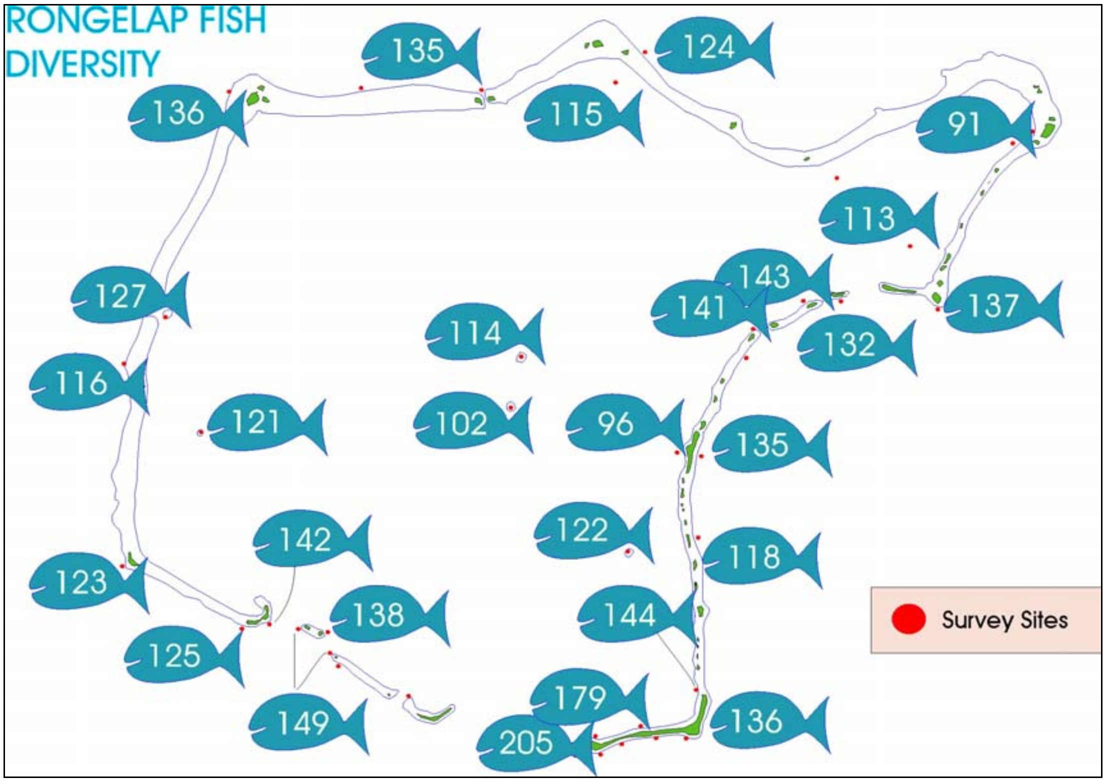


Figure 26. Rongelap reef fish diversity map.

4.2.5 Coral Biodiversity

The number of coral species at each site varied from 34 to 90 with an average of 67 (±13.6) corals. By comparison with Mili, a considerably higher mean number of corals (17 species) were found in Rongelap (Table 7). Sheltered sites in the lagoon tended to support less corals in total, but they harbored many unusual species, and site variation within the lagoon was greater than in outside areas. The richest areas were the southern and eastern ocean areas and west pass.

Table 7. Average number of coral species in the zones at Rongelap Atoll.

Zone	Mean number of Corals	St Dev
East Ocean	74	± 9.6
South Ocean	77	± 10.3
West Ocean	67	± 2.8
North Ocean	68	± 0.0
East Lagoon	57	± 13.2
Central Pinnacles	66	± 16.8
West Pass	70	± 0.0

4.2.6 Megafauna

Marine megafauna was recorded on all surveys, and during boat travel. Megafauna in Rongelap Atoll included giant clams, manta rays, eagle rays, sharks and marine turtles (Figure 27).

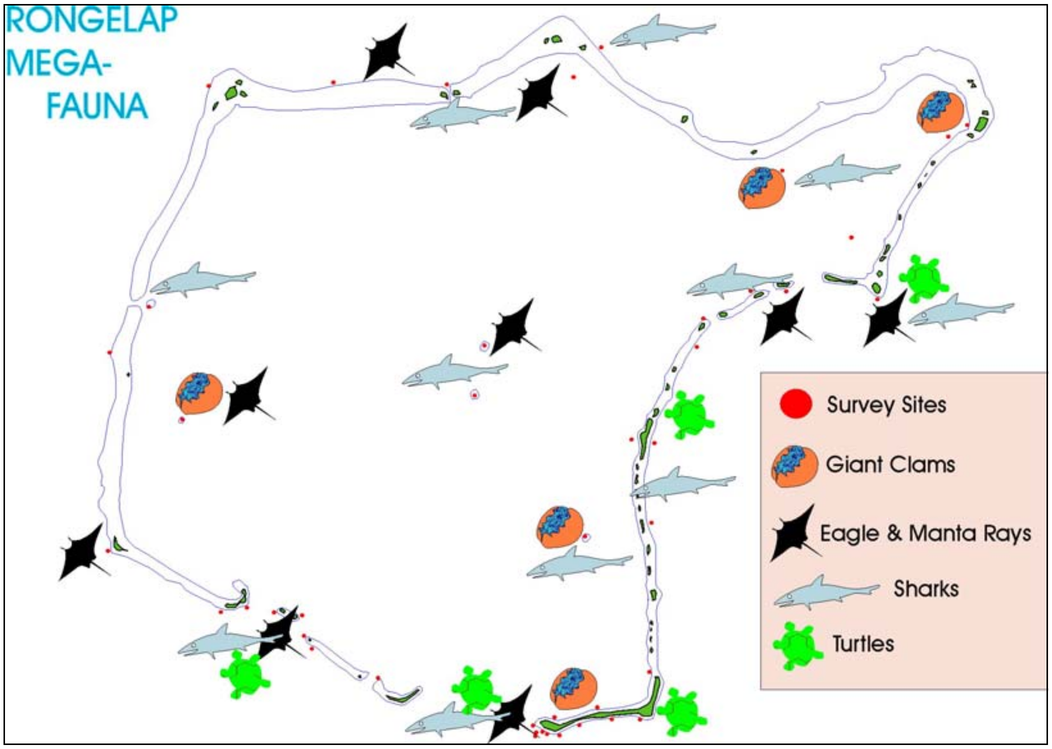


Figure 27. Survey sites at Rongelap Atoll and observed megafauna. Includes sites from 2002 preliminary surveys at Rongelap Island.

4.2.6.a Sharks

All shark species were recorded on timed swims by the fish diversity expert. Sharks were counted and the depth at which they were first seen was noted. Table 8 shows the mean abundances of reef sharks varied between species and locations in Rongelap Atoll. Grey reef sharks ( ) were the most abundant shark species observed at Rongelap Atoll. These sharks were most abundant in the northern ocean side of the atoll and least abundant at the eastern lagoon. Blacktip reef sharks ( ) and whitetip reef sharks ( ) were observed in each zone. Silvertip sharks ( ) were rarely seen, and all sightings occurred on deep drop-offs on the eastern oceanside or the central pinnacles. Nurse sharks ( ) appeared to be rare and were only seen at three sites, two central pinnacles and one western ocean site.

Table 8. Abundance of sharks in seven habitat zones at Rongelap Atoll.

	Grey reef shark		Blacktip reef shark		Whitetip reef shark		Silvertip shark		Nurse shark	
	Mean Abundance	St Dev	Mean Abundance	St Dev	Mean Abundance	St Dev	Mean Abundance	St Dev	Mean Abundance	St Dev
East Ocean	5.2	± 5.45	0.4	± 0.55	0.4	± 0.55	1.0	± 1.41	0.0	± 0.00
South Ocean	5.6	± 7.83	0.4	± 0.89	1.4	± 1.67	0.0	± 0.00	0.0	± 0.00
West Ocean	6.0	± 8.49	0.0	± 0.00	0.5	± 0.71	0.0	± 0.00	0.5	± 0.71
North Ocean	10.7	± 5.51	0.3	± 0.58	0.3	± 0.58	0.0	± 0.00	0.0	± 0.00
East Lagoon	3.0	± 2.16	0.3	± 0.49	0.9	± 0.69	0.0	± 0.00	0.0	± 0.00
Central Pinnacles	7.9	± 6.47	1.0	± 1.29	1.0	± 0.82	0.1	± 0.38	0.3	± 0.11
West Pass	6.0	± 0.00	1.0	± 0.00	1.0	± 0.00	0.0	± 0.00	0.0	± 0.00

Some shark species showed obvious preferences to certain depths. For example, blacktip reef sharks were almost exclusively found in shallow areas above 2 m in depth (Figure 28). Whitetip reef sharks showed no preference of depth. Silvertip sharks were always observed below the divers at 30 m of depth and below. Nurse sharks varied in their preferred depth. Since silvertip and nurse sharks were only seen on a few occasions, they were excluded from Figure 28. These data describe where these sharks were first seen when the observer first entered the water. At this point, sharks would often change depth as they were curious about the divers and usually came to the same depth as the diver.

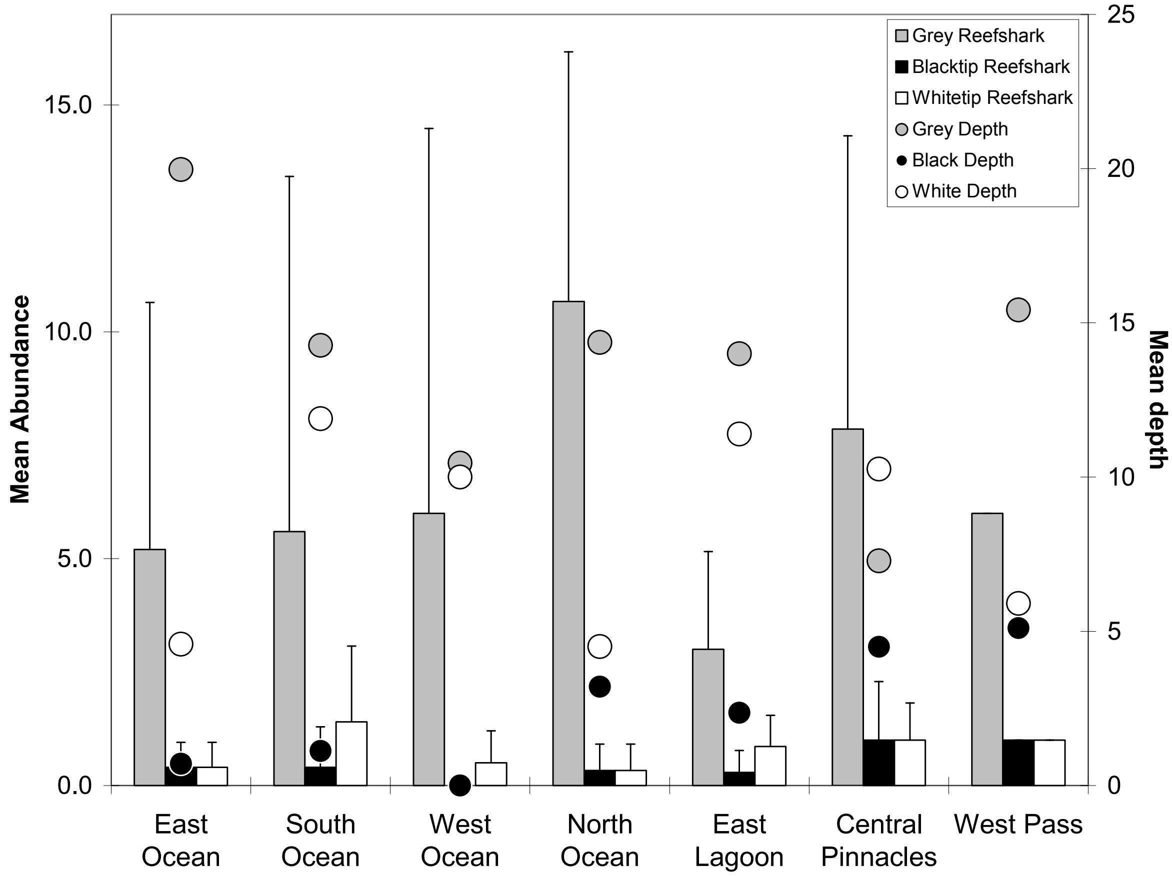


Figure 28. Mean abundance and preferred mean depth of sharks in seven zones at Rongelap Atoll.

4.2.6.b Turtles and Rays

Turtles and rays have been grouped together since they were seldom encountered. Their occurrences were listed in Table 9.

Table 9. Presence and abundance of marine turtles and large rays in Rongelap Atoll.

Species		East Ocean	South Ocean	West Ocean	North Ocean	East Lagoon	Central Pinnacles	West Pass
Green turtle	*Chelonia mydas*	1	1	0	1	0	1	1
Hawksbill turtle	*Eretmochelys imbricata*	0	0	0	0	0	0	0
Manta ray	*Manta birostris*	0	0	0	0	0	3	0
Eagle ray	*Aetobatus narinari*	1	3	0	0	0	5	0
Number of Sites in Zone		**5**	**5**	**2**	**3**	**7**	**7**	**1**

4.2.6.c Humphead Wrasse

Humphead wrasses ( ) were counted during each dive by the fish diversity expert. Additionally, all other team members reported these fishes to the megafauna database. Humphead wrasses were mainly observed in the eastern part of Rongelap Atoll (Figure 29), where they were found at the edge of the drop-off, on lagoon pinnacles near passes and in passes.

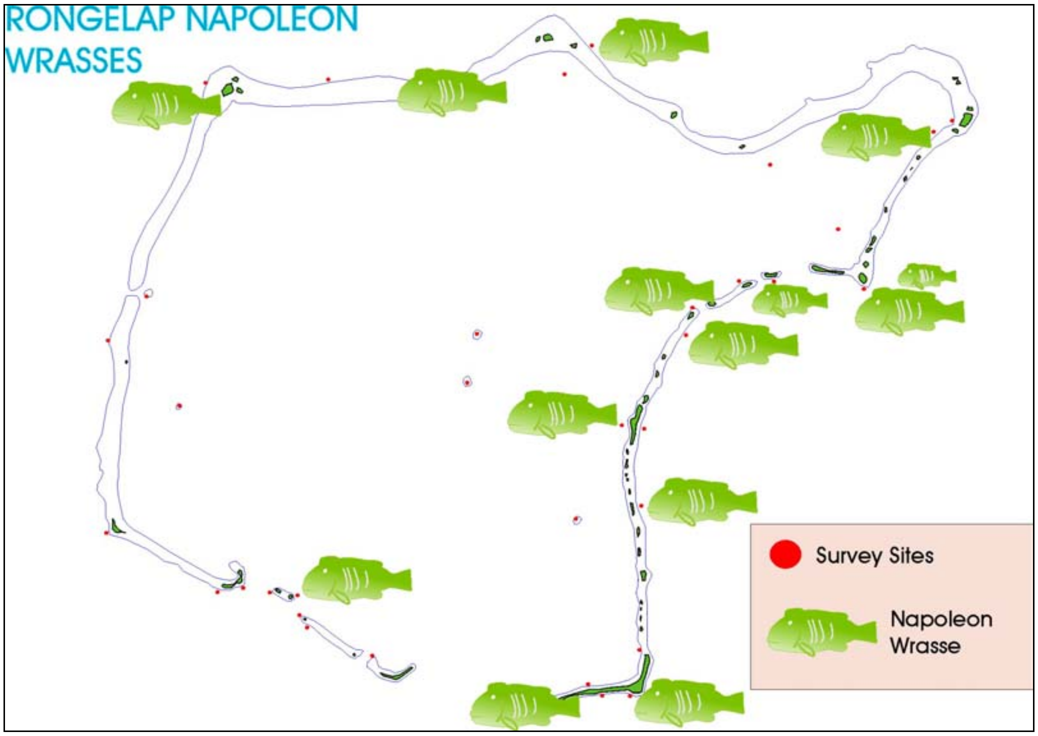


Figure 29. Occurrences of Humphead wrasses at Rongelap Atoll. Smaller icons signify locations where juveniles were seen.

5. Recommendations for coral reef conservation

The results of this study documented an outstandingly pristine and healthy coral reef ecosystem on Rongelap and Mili Atolls. This detailed resource assessment provided a baseline for future changes and impacts that might occur as a result of resettlement of Rongelap, and will serve as the baseline dataset for long-term monitoring that will be initiated at Mili Atoll's proposed marine reserve. Here we look at two separate issues for Rongelap and Mili Atolls. In Mili, local landowners and communities who live on their atoll have decided to set up a marine sanctuary. Rongelap Atoll has been largely uninhabited for over 40 years, and our data serve as pre-settlement baseline which will help to determine reef management during and after resettlement.

The most important and foremost recommendation is that all human activities that may impact the coral reef ecosystem should be carried out in a well-controlled and regulated manner. A completely intact and prosperous coral reef is a highly valuable resource and this is becoming extremely scarce on a global scale. Wisely managed uses of the resource as well as well managed land-based activities would ensure that human populations and thriving coral reefs could 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.

5.1 Marine reserves

Marine protected areas are a widely recognized means for fisheries management and the conservation of biodiversity. Several agencies are now involved in protecting coral reefs in the RMI: MIMRA and CMI, as part of the MEIC Working Group for the Fishery Management Plans multilateral cooperation group, are actively cooperating towards the establishment of MPAs in the atolls of the country. When compared to the other Micronesian countries, RMI is the only one still lacking established MPAs (Table 10).

Table 10. Number of marine reserves implemented in Micronesian countries.

Country	Number of established MPAs
CNMI	8
Guam	13
FSM	2
Palau	13

Marine reserves should be established based on several factors to ensure maximum conservation efficiency. The major selection criteria are

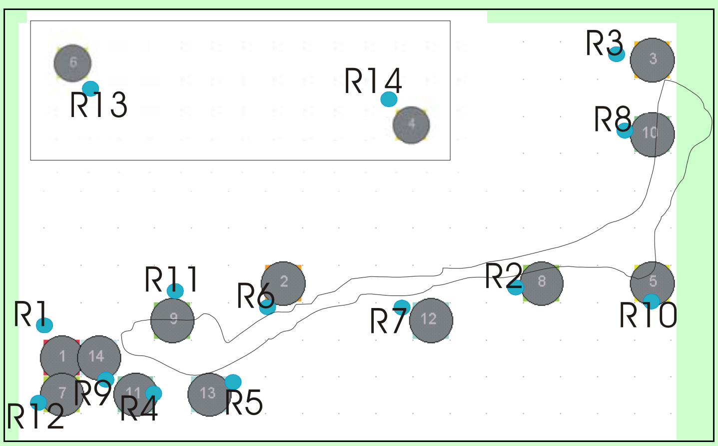
(a) biological integrity,
(b) low threats potential,
(c) social acceptance, and
(d) logistical ease.

5.1.1 Biological integrity: diversity, coral cover, and indicator species

Reef fish and coral diversity can be utilized to prioritize sites that should be protected in a marine reserve network, or other conservation measures. In this approach it is important to apply complementarity as a method to identify the best sites. An example using only Rongelap Island illustrates the utility of this method (Example 1).

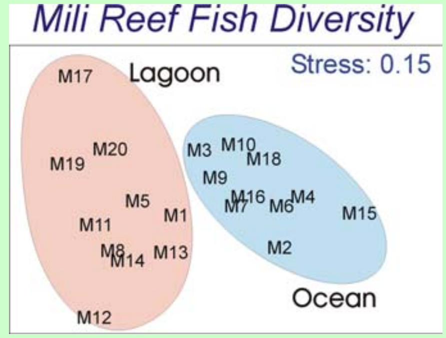
Example 1: The complementarity reserve prioritisation method was used to highlight priority sites for coral reef fish conservation on Rongelap Island. While the ocean sites support on average a higher number of fishes and more abundant species, the lagoon habitat forms an important ecosystem supporting many rare, habitat specific and cryptic species.

For the reserve prioritisation for fishes, the first site selected (R1), a ocean 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. This indicates that the importance of lagoonal sites should not be underestimated.



The maps of fish and coral diversity were used to identify biodiversity hotspots. Multivariate statistical analysis showed the differences in communities in the lagoon versus ocean reefs (Example 2). Using this split as a surrogate for complementary habitats, the first level in a series of criteria for priority sites for management areas in Mili and Rongelap were proposed. 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. They also do not consider other biological indicators. Thus, other criteria adding further information layers about conservation priority sites are described below.

Example 2: Sites were grouped according to their community structure of reef fishes. The resulting graph splits the reefs of Mili Atoll into two distinct groups of sites: lagoon reefs and ocean reefs, reflecting the different species contained on these reefs and can thus be used for a simple form of a complementarity approach.



Ecosystem function and biological diversity are interwoven in their interactions, thus it in necessary to look at more than one aspect of what makes a reef interesting for conservation. Coral cover, coral complexity and substrate composition are further indicators for reef status and biological integrity. Coral cover is a useful indicator of reef health. We selected sites with higher coral cover as better sites for conservation. The proportion of fleshy seaweed in the substrate also indicates the potential conservation value of reefs, since fleshy seaweeds are direct competitors of corals and high levels of fleshy seaweed in combination with decreasing coral cover on suitable substrate may indicate a stressed reef.

There may be species that have a higher importance in conservation. Such species can be of local commercial or traditional interest, rare or endangered, of charismatic nature, or biological indicators for reef health. Examples are listed in Table 11.

Table 11. Examples of indicator species for conservation.

Class	Example
Local commercial or traditional interest	Trochus shell, giant clams
Rare or endangered	Marine turtles, humphead wrasse
Charismatic nature	Whales, dolphins, manta rays
Biological indicators for reef health	Butterflyfish

We used the information given in the megafauna sections on charismatic and rare marine animals to add a further layer of information to our conservation model. Invertebrate data included occurrence and abundance of giant clams. Fish transect data quantified indicator fishes.

5.1.2 Low threats potential: natural and anthropogenic threats

Since coral reefs are dynamic systems that change in time our approach must reflect the potential for future changes. Major causes of reef deterioration are natural and anthropogenic adverse impacts.

In selecting a site for a marine reserve it is essential to minimize all potential threats to the reefs protected. If there is a choice of sites, which equally fulfill all other criteria, a site with a lower susceptibility to human or natural threats should preferably be chosen. Different susceptibility can be caused by position, exposure, degree of water flushing, proximity to human settlements and proximity to industrial sites.

5.1.3 Social acceptance and logistical ease

Social acceptance is an important factor in the long-term effectiveness of a MPA. It influences compliance, creates stewardship towards the reserve with local people and may interfere less with traditional activities. All sites for marine reserves should be selected in close consultation with local communities affected by the reserve.

Logistical ease implies that sites with easier access to both visitors and patrolling boats and less exposure might be preferable for establishing a marine reserve. This could minimize effort and human resources required for surveillance and therefore minimize cost.

For the atolls in the Marshall Islands, we recommend to establish marine reserves as part of a national marine reserve network plan, but also as a community-based coastal resource management effort. Such a reserve can locally apply the principles of participation, social equity, productivity and self-reliance along with environmental sustainability. At the same time the effort should not be isolated, but be part of a national dialog between local atoll governments or communities and should be co-ordinated by MIMRA.

Any reserve should be part of a coastal resource management plan that details the way the reserve and adjacent resources and areas are managed for the good of all local stakeholders. 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.

5.2 Recommendations for Mili Atoll

The area proposed by the local land-owners as a marine Sanctuary supported a highly diverse and abundant coral and fish fauna. Giant sea fans were characteristic for the sheltered area in passes in this zone. The marine environments sampled to gather information on the biodiversity and health of the location included passes, ocean walls and lagoonal pinnacles. Several pinnacles, both inside the lagoon and just at the mouth of the passes, were surveyed.

Our site recommendations for marine reserves follow from Figure 30 that shows an overlay of all biological criteria important for marine protected area selection. It illustrates that the local government and landowners already selected a suitable area in the atoll (however, increased survey effort in this zone relative to other parts of the atoll should be remembered) for their proposed marine sanctuary with respect to biological integrity. The potential for human induced impacts is relatively low owing to low population numbers and their traditional life style. The northern part is oriented towards the prevailing wind direction, subjecting the area to water movement that minimizes the threat of higher seawater temperatures (that may cause coral bleaching) due to stagnating water masses.

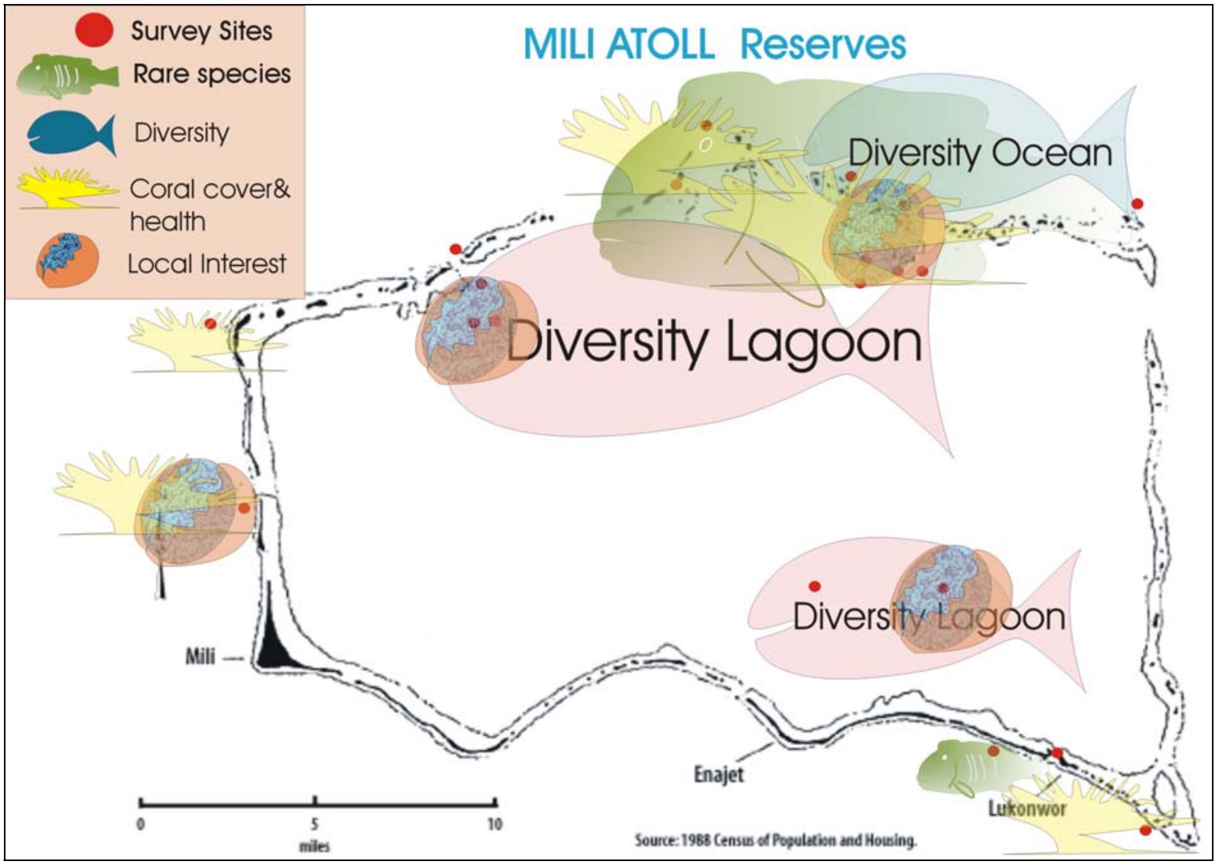


Figure 30. Map of biological integrity at Mili Atoll: Overlay of criteria relevant to reserve selection.

Based on these results we further recommend undertaking the necessary steps leading to the establishment of the proposed marine sanctuary. This will involve the delineation and zonation of management areas, the development of a management plan in collaboration with all stakeholders, and the establishment of a long-term monitoring program. This monitoring program should be based on local resources, and should initially involve the training of locals in the relevant techniques. Experts in coral reef monitoring should be consulted for the design of the monitoring program. Owing to the bias in assessing the natural resources towards the proposed reserve on the NRAS 2003 trip, it might be advisable to expand the resource assessment in the future to include yet un-surveyed areas of Mili. Initially we recommend the procurement of external funding to start the process described above. However it is important to aim for a design that can be sustainable and self-funded in the long term.

5.3 Recommendations for Rongelap Atoll

In Rongelap Atoll, the resource assessment was conducted on reefs all around the atoll, spreading the survey effort relatively evenly. As a result, a map overlaying data for all biological criteria important for marine protected area selection shows several "hotspots" where several criteria are fulfilled (Figure 31). We recommend a Rongelap reserve network that contains (but is not limited to) sites from several of these hotspots of conservation value around the atoll.

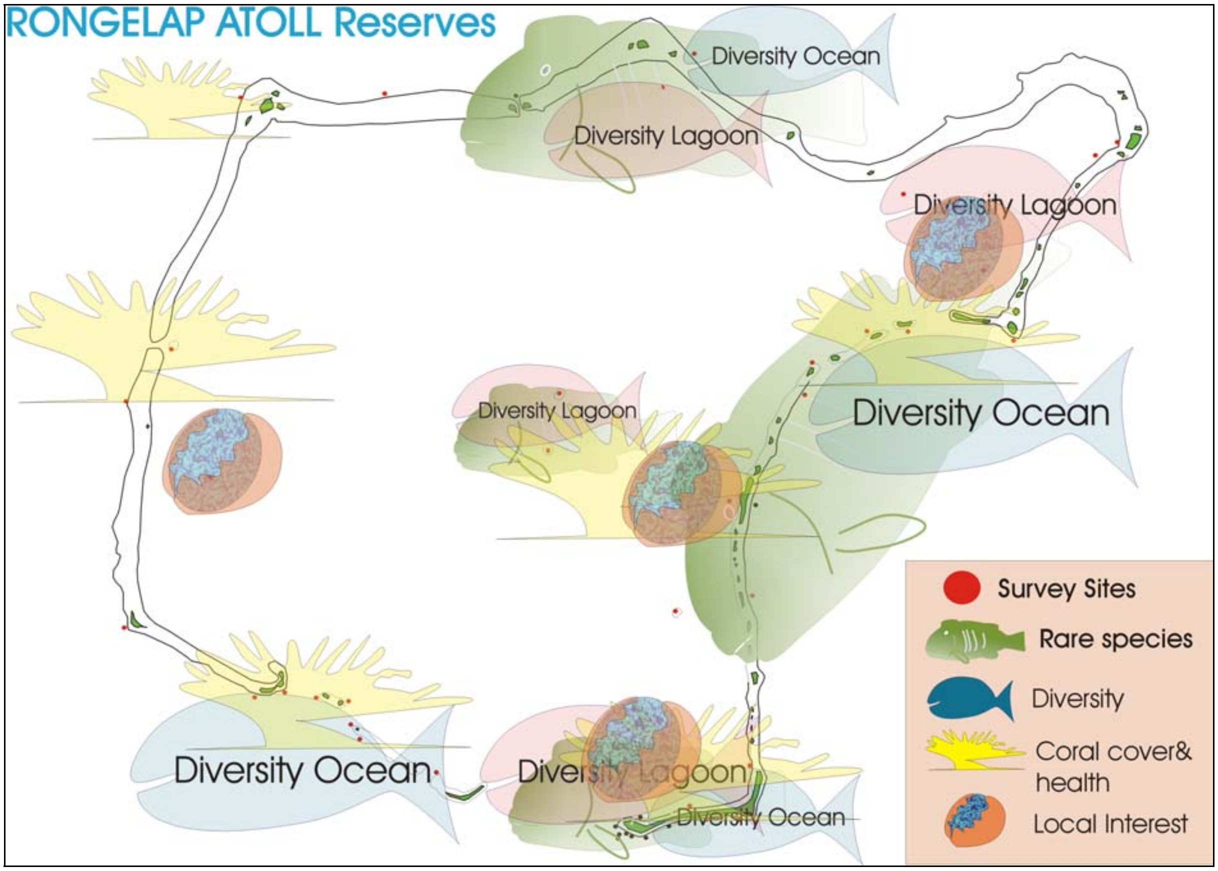


Figure 31. Map of biological integrity at Mili Atoll: Overlay of criteria relevant to reserve selection.

The reefs around Rongelap Island merit special emphasis in this report. Rongelap Island will harbor the majority of the returning population of Rongelapese people. Thus all human activities such as fishing, waste disposal and boat traffic will be more concentrated in this area. However, some of the most diverse, healthy and unique reef formations are found here. The site at Jaboan point, Southwest tip of Rongelap Island, which had already been recommended as a prime marine reserve site by the NRAS team after a pilot project in 2002, was revisited to survey the permanent transects established in 2002. This site was outstanding in reef health and diversity: for example we counted 203 fish species within 60 minutes. The lagoon adjacent to Rongelap Island harbors many small patch reefs and bommies that support an extraordinary variety and abundance of life.

We recommend special care when administering the resettlement program of Rongelap. A marine resource management plan should already be in place when the settlement commences. We also recommend to immediately undertake the necessary steps leading to the establishment of several small marine reserves around Rongelap Island, including Jaboan point and several of the lagoon patch reefs near Rongelap Island. This will involve the delineation and zonation of management areas, the development of a management plan in collaboration with all stakeholders, and the establishment of a long-term monitoring program. This monitoring program should be based on local resources, and should initially involve the training of locals in the relevant techniques. Experts in coral reef monitoring should be consulted for the design of the monitoring program. Initially we recommend the procurement of external funding to start the process described above. However it is important to aim for a design that can be sustainable and self-funded in the long term.

6. Partnerships

Cooperation with scientists from other countries resulted to be extremely beneficial to the outcome of the project. Different backgrounds and expertise were employed in data collection and discussion of logistics and selection of sites as well in adaptation of methodologies to different situations. The study conducted during this project included not only assessments of commercial food-fish and general coral reef status but also a detailed study of the health and richness of coral reefs and their associated fauna, as well as biodiversity assessments of all the species of shelf and slope reef fish and hard corals. This last effort is made possible by the presence of two taxonomy specialists from Australia.

Future collaborations have been established and interest in the area from a scientific point of view has been stimulated:

- Four PhD thesis will be based on studies done in the region and analyzed in different Universities in both Australia and the US by participants to this project. Requests of collaboration has been expressed by researchers at UH and at the Tacoma Aquarium of Seattle.
- Future partnership between this latter Institution has been built for more activities towards conservation and awareness in year 2004.
- Collaboration with researchers at James Cook University will be essential for a study on genetic differences among population of a damselfish collected during the expedition; these results will be used for future selection of conservation sites based on connectivity. The results will be submitted to peer-reviewed papers.

7. Future direction

Successes obtained during the training and capacity building session and awareness raised in the community will be used for future projects of monitoring and surveying of other atolls. The drive to concentrate on resource conservation has been developing from both the population and individual local governments in the past few years. The governments and the people have been starting to recognize the need to preserve the traditional "good and sustainable life" of the Marshall Islands and to assure livelihood for all the Marshallese people. The strategic plan or the development lays down goals for achieving sustainable use of the natural resources and protection of the environment as well as sustainable coastal fishing activities. Establishment of conservation areas throughout the nation is a recognized as an important strategy that addresses the conservation and preservation of marine resources. In this line of action, the country is committed to reinvigorate - and re-plan with the support of science - the ancient traditional ("mo").

During the years 2001 to 2003 the first efforts towards the conservation of coral reefs and the sustainable management of marine resources in RMI have started through the activities developed at the Marine Science Program (MSP) at CMI. MSP has been used as a springboard for the long term planning of conservation measures in the atolls of the country. Both MIMRA and RMI-EPA are concentrating their present efforts on resource conservation and sustainable management through different departments, committees and activities. In particular, MIMRA is working on helping individual atolls issue FMPs through both community awareness and marine environment and fishery resources stock assessments, in order to delegate responsibility for coastal resource management to the local communities and government Councils and help them manage fishing and other activities related to marine resources. The MSP at the College is collaborating with RMI-EPA and MIMRA on these actions. A Working Group (MEIC) has been established in 2002 - through the coordination of the Secretariat of the Pacific Community - between MIMRA, RMI-EPA, the Ministry of Internal Affairs and CMI. The MSP at the College has the responsibility for undertaking underwater marine resources assessments to be used as base for the FMP.

As part of this effort the MSP is also teaching and training college students – and in the immediate future government employees as well - for creating local capacities for coastal and resource management and monitoring of resource and environment status.

7.1 Mechanisms of MPAs

The protected areas suggested would serve the multiple purposes of: a. preservation of biodiversity and resources from global and local threats and research, b. education, c. aquaculture and d. tourist attractions.

a. Preservation of resources of biodiversity and research:

Global Threats: Global change and destructive fishing practices are as serious. Global changes threatens RMI through sea level increases and bleaching. Sea level change is a serious direct danger to the settlement of people, being the average altitude in the country of 3 m over the present sea level. The threat is aggravated by the increasing shoreline degradation and erosion, especially in the capital Majuro. Bleaching has not been a major threat to the corals of RMI: the corals did not suffer from major bleaching responses to temperature increase events of the past 20 years, contrary to other tropical coastal areas in the world. There is no local memory of similar incidents in previous times. A possible resistance from local strains or species could be an important focus of research of global interest in RMI.

Local threats: Destructive (cyanide or overfishing from foreign live fish industry) and illegal fishing activities (in-shore shark fishing) threaten the sustainability of the use of marine resources and the health of the coral reef community as a whole, as well as the preservation of local biodiversity. Protected areas are ways to control and patrol the coastal regions where such threats are impoverishing and threatening coral reefs.

b. Education and outreach: more local and foreign people need to be educated in the need of conservation of coral reefs. Future monitoring and survey projects will have a strong emphasis on education. More relationships have been established with international institutions that are willing to support the RMI effort in local education. Both the Vancouver Aquarium and the Tacoma Aquarium will be involved in future projects in RMI.

c. Aquaculture. Preservation of reproductive and growing grounds of species that are targeted in the aquarium industry (giant clams, corals, black-lips pearl oysters) would also have an advantage from the institution of MPAs. Plans for aquaculture ventures in the countries are being set and a large project on education and demonstration is in place at the College through collaborations with the University of Hawaii. Aquaculture is seen as the best partner in conservation activities and sustainable development of pristine or semi-pristine atolls.

d. Tourism, if managed in a sustainable manner, can be a secure source of income for local populations, if the environment is protected as healthy and diverse as it is still in the outer islands. Tourism and aquaculture are being looked at as the best hope for future sustainable income. New projects are developing in Rongelap and these come along with conservation plans.

One of the difficulties in this process will be the legal action for the institutionalization of such protected areas, considering that all land and coastal areas in the Marshall Islands are privately owned. The first step to be undertaken in the process will be for the communities to obtain the approval of traditional (landowners) on the use of their land for both universal interest (conservation of biodiversity, study site for resistance to bleaching and ecological responses from coral reef communities to sea level rise) as well as national and local interest (conservation of resources and preservation of sources of fishing stock that can spill-out into neighboring fishing or farming areas).

The community-based marine protected areas (CB-MPA) or reserves will be adopted as the modernized version of the traditional Marshallese 'mo' or taboo area. When such small reserves are established in RMI, local people will be engaged in the patrolling of the protected areas, become tour guides for nature visitors, be in charge of monitoring the condition and health of the ecosystem, as well as manage research stations that will be based around such protected sites.

MIMRA and the local governments will plan the conservation resolutions based on the scientific and management recommendations together with the opinions and desires of local communities. The request for implementation of MPAs comes directly from the communities. In this way, the establishment of marine protected areas will be the results of community consultations, expectations and requests, as well as of the outcome of the research conducted by local and external scientists. MIMRA will be the agency in charge of coordinating these inputs.

7.2 Funding of MPAs

MPAs will be funded through community-managed activities based on tourism and aquaculture. The management plans will have to include programs for economic exploitation of the MPAs, such as tourist entrance fees to the park for snorkeling access, anchoring fees at mooring buoys, interpretative material and souvenir sales at the park and guided tours. New aquaculture enterprises (giant clams, corals, pearls) using MPAs as sources of seedlings and as protection of the farming site, could support the program through the dedication of part of the profit (sales to aquaria and souvenir shops) to the park management expenses. Such aquaculture enterprises in the vicinity of MPAs must be limited to extensive culture of filter-feeders that do not require additional feeding. The income generated by such kind of activities would sponsor the park rangers salaries and the patrolling expenses.

7.3 Training and capacity building

Training to prepare local personnel for management and monitoring is essential to the success of any community-based solution to conservation and sustainable development. Some occasional assistance from external institutions has been given to CMI in the past for matters related to management and conservation. The University of Rhode Island – Coastal Resource Center for community-based management, the University of Hawaii-Hilo for locally-based aquaculture, the University of Alaska for market and economic studies on aquaculture and fisheries have conducted workshops and trainings with students and government officials at CMI in the past. More specific plans for training of local people are being developed at CMI, a specialization 2-month educational and training course on MPAs management and monitoring will start in June 2004, and will include workshops on specific subjects. In the long term, this short course will be expanded to include training of more people through a Certificate Program in Marine Conservation at CMI. This certificate program has already been approved by the curriculum board. Both programs will be offered to Government officials (from MIMRA, RMI-EPA, local governments) and other interested parties.

An additional focal goal for the future is the education of local and foreign people about the importance of preservation and community-based management and sustainable use of coastal resources. In RMI this will be achieved through more presentations and exhibits and through the participation to survey programs.

7.4 Surveys of new atolls to assist MIMRA in resource assessments

Plans for surveys new atolls in the country are being made. The following atolls will be the first to be studied, following a direct request from MIMRA and from local governments:

- Majuro (capital atoll with highest population density)
- Arno (closest atoll to capital and base of a reef-fishing project)
- Namu (desire from local community to have resource assessments)
- Rongerik (same jurisdiction as Rongelap and Ailinginae)

The research will be undertaken when funding is secured. Local financial assistance has been assured as a small donation to CMI. Matching funds are needed to proceed.

7.5 Annual monitoring of atolls

Financial support is needed and searched for to accomplish education, survey and monitoring plans for the next three years as a beginning of the long-term planning.

7.6 Challenges for the future

Major challenges will still have to be tackled under different frameworks. These challenges include: expenses to be faced for more surveys and monitoring activities; fees for training workshops - that include invitation of specific experts for taxonomy and management training; enforcement tools (patrolling boats, legal assistance), etc. All these necessary tools need external financial and technical assistance. However, these preliminary expenses will secure the long-term character of the national initiative for conservation and alternative livelihood resources (tourism and aquaculture associated to CB-MPAs).

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