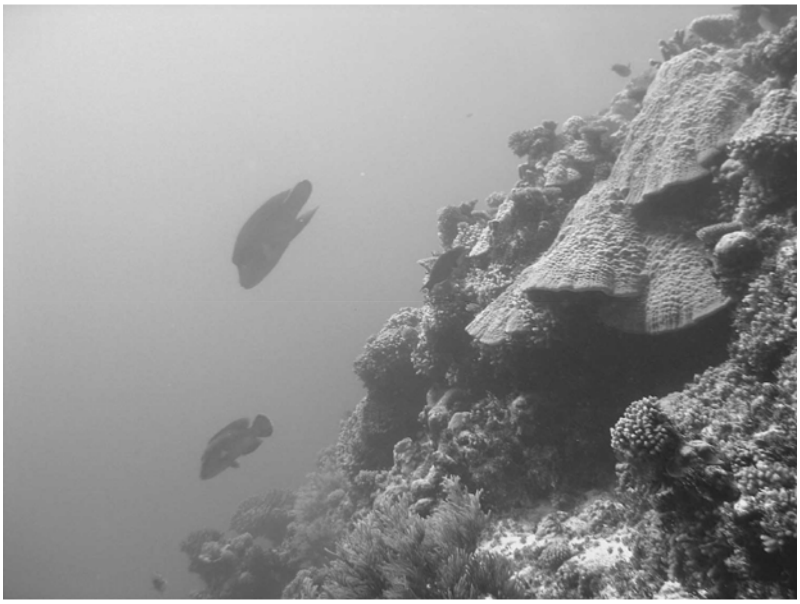
Finding Napo: Conservation of napoleon wrasse and rare corals 2006



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Funders:

RalGOV, CMI, Bp, MIMRA, UQ, JCU, VU, NOAA, NRAS

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Executive summary and Future prospects

"Finding Napo" aimed to survey the rare coral reef fish and corals of Rongelap and Rongerik Atolls in the northern Marshall Islands. The project was completed in December 2006 and funded by a bp-conservation programme grant to Maria Beger, and complemented by a Coral Reef Conservation grant to CMI, an International Society of Reef Studies Fellowship to Zoe Richards (JCU), a Victoria University research grant to Eric Peterson (VU), and in-kind contributions of RalGov, Marshall Islands Marine Resource Authority (MIMRA), CMI, UQ, VU and NRAS. "Finding Napo" forms part of a larger goal to establish a long-term monitoring initiative at Rongelap Atoll. Former baseline surveys have revealed a significant proportion of unique fauna with small populations inhabiting the atoll reef communities, particularly within the protected lagoons and this warranted further investigation in this project because rare species have high conservation priority due to their inherent vulnerability to natural and anthropogenic threats.

A team of 5 scientists was based on Rongelap Atoll for 3 weeks from 29th November till 21 December 2006 and completed the "Finding Napo" project in conjunction with Phase I of the long-term monitoring project. Seven long-term monitoring sites were established around Rongelap Rongelap Island. In a multidisciplinary approach fish, benthic and invertebrate data was collected along with oceanographic and climate data. Maria Beger (UQ) led the 2006 survey and conducted fish surveys, Emma Kabua (MIMRA) conducted benthic surveys and invertebrate transects, Reinhard Beger developed the monitoring database, and refined it during the trip, Andre Seale was the trip photographer and also did large fish surveys, and Eric Peterson (VU) collected climate and oceanographic data.

Unavoidable logistical difficulties with Air Marshall Islands resulted in Zoe Richards, Brent Matters and Glenn Dunshea surveying rare corals at Arno Atoll in the southern Marshall Islands. The coral biodiversity portion of the current project will be conducted in conjunction with Phase II of the monitoring project. Phase II of the project will be conducted in September 2007 whereby control sites in the northern part of Rongelap Atoll and nearby Rongerik Atoll will be established. Phase II of the project will be led by the same people and also involve participants from the College of the Marshall Islands and Marshall Island Marine Resource Authority. Funding for Phase II of the project has been secured from the Winifred Violett Scott Estate and additional funding is pending from the National Fish and Wildlife Foundation. Once long-term monitoring sites are established monitoring surveys are planned every two years.

Rongelap has an extremely high fish diversity, with abundant apex predators such as large groupers and sharks. Rongelap also supports the endemic *Amphiprion tricinctus* (Three-band anemonefish). These species were recorded as part of the monitoring transects. Several *Cheilinus undulatus* ("Napo") were observed, on one occasion we observed a breeding pair. In the lagoon, we recorded the rare *Cirrhilabrus balteatus* (Girdled wrasse), which is endemic to the Marshall Islands, *C. luteovittatus* (Yellowstripe wrasse), which only occurs in the Caroline Islands and the Marshall Islands. For the first time we encountered *C. johnsoni* (Johnson's wrasse), which is also endemic to the Marshall Islands.

Acropora rongelapensis, described from Rongelap Atoll in 2004 is an exceedingly rare coral and was the focus of targeted surveys during the "Finding Napo" project. Formally, only 4 colonies were known from a single location. After extensive searching, an additional 8 colonies were located during the "Finding Napo" project. Molecular specimens of these corals were collected during the trip and subsequent phylogenetic analyses support that this is indeed a new species with novel sequence data (Richards, pers comm.). With such a small population size, this species is of critical conservation interest and will be presented to the IUCN as a candidate for the Red List of Threatened Species during the Global Marine Species Assessment to be conducted in the Philippines in July 2007.

Snorkel surveys in Rongelap Atoll lagoon.

Team

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L to R: Andre Seale, Emma Kabua, Maria Beger, Ailuk the "baby", Reinhard Beger and Eric Peterson.

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Emma Kabua is measuring a *Tridacna gigas* (Giant clam) in the lagoon.

Background

The Republic of the Marshall Islands (RMI) in the northwest equatorial Pacific, encompasses a total land area of as little as 134 km^2, and a total reef area of 6,110 km^2 (Spalding et al. 2001) with extremely rich marine resources. A local interest in coral reef management and conservation has recently arisen. The RMI have committed to: 1. activate conservation sites, 2. train local people in knowledge and skills to conserve marine resources, and 3. improved understanding of marine ecosystems to achieve sustainable development and resource use, environmental protection, and an improvement of income opportunities (RMI 2001). Several local and short-term projects contributing to reef conservation have been initiated in the past three years, including College of the Marshall Islands (CMI)-led data collection at Mili, Bikini, Likiep, Ailinginiae and Rongelap Atoll. The Marshall Islands Marine Resource Authority (MIMRA) is aiming to take the leadership in coordinating all efforts towards conservation and management, but lacks personnel specifically trained in marine ecology and conservation. The scientific support for these tasks is offered by the Marine Science Program at CMI who have established a marine resource management and assessment short training course for summer 2004. Namu Atoll was identified as one of the priority atolls for resource assessment and the establishment of marine reserves. Additionally, the local government is extremely interested to designate marine reserves. Our project links with and complements these efforts by providing data, educational opportunities, recommendations for conservation planning to MIMRA, and a platform for the graduates from the CMI training course to consolidate their skills during their first survey project.

Rongerik Atoll is under the jurisdiction of the Rongelap Atoll Local Government (RalGov) which administers the Rongelap Atoll Complex of the three Atolls of Rongerik, Rongelap and Ailinginae. The Rongelap Atoll Complex, South-East of Bikini Atoll, has been virtually untouched by recent human impacts for 5 decades, since people were evacuated after the H-bomb experiment at Bikini and consequent fall-out in 1954. People of Rongelap are now attempting to once again inhabit their native islands. The Rongelapese plan to set up marine conservation areas in their jurisdiction before the resettlement begins. They are also searching for sustainable sources of income for the Rongelapese, and are dependent on expert input to advise on reserve site selection, conservation of enigmatic rare species and management of marine resources.

In previous years, RalGov has supported various data collection efforts to obtain the basis for the use of systematic conservation decision support tools. Ailinginae Atoll was surveyed in 2002 by a group from University of Hawaii (UH). Rongelap Rongelap Island, the main island of Rongelap Atoll was surveyed by a NRAS (Natural Resource Assessment Survey) team in 2002. In 2003, a full atoll survey was conducted. The team found an extremely rich reef fauna and flora, including many sightings of Napo's in high abundances. Our coral expert, Zoe Richards, discovered and described a new Acropora coral from this trip, *Acropora rongelapensis* (Richards & Wallace 2004). However, the team also found that illegal shark fishing had taken place, as indicated by large shark fishing longlines on the Western Wall reefs, and a significantly lower abundance of reef sharks in 2003 than in 2002. On one occasion, we also sighted a mature Napo with a fishing hook still in its mouth. Reports are available on http://www.nras-conservation.org/publications.htm. RalGov is now moving into the next phase for resettlement, where housing has been built and they develop projects that can create employment. A piggery has been established and a small tourist resort is being built. Another development idea is an aquaculture venture http://www.splash.net.au/-sustainable2.html. There is no data from Rongerik Atoll yet. Rongerik is the most easterly of the Rongelap Atoll Complex and is likely to be a source of larvae to Rongelap as the prevailing winds are north easterly winds, causing currents to flow from Rongerik toward Rongelap and Ailinginae. To address this lack of data, and fill the last data gap for a conservation plan for the Rongelap Atoll Complex, RalGov asked us to conduct reef surveys at Rongerik.

Logistical constraints and safety considerations forced the team in 2006 to change the project objectives. Rongerik Atoll proved inaccessible due to bad weather and contaminated fuel stores at Rongelap Atoll. Hence the 2006 surveys were focussed on developing the long-term monitoring programme at Rongelap Atoll.

Logistical challenges

Unavoidable and unforeseeable logistical challenges were presented to our project in 2006. The domestic airline Air Marshall Islands experienced severe difficulties with aircraft maintenance and personnel in November and December 2006. Therefore, only five team members flew to Rongelap on the planned date, with plans for other team members to follow on later flights. However all subsequent flights were cancelled so that no other team members were able to travel to Rongelap. The remaining team members either remained in Majuro (the capital of the RMI) or collected data on Arno Atoll (the coral expert team).

The Deborah K, a supply barge servicing Rongelap monthly broke down on her way from Majuro to Rongelap, and consequently, our equipment, food and fuel were delayed on Rongelap. The fuel on island was blended with contaminated coconut oil. Although we were able to use one of the two remaining working vehicles for snorkelling surveys, we could not use this fuel in our dive boat, the Bravo. Consequently, the team members on Rongelap could not go to Rongerik to conduct surveys there.

People in Rongelap	Maria Beger Emma Kabua Andre Seale Reinhard Beger Eric Peterson
People in Majuro	Dean Jacobson Harieta Safeti Elai XX Don Hess
People in Arno	Zoe Richards Glenn Dunshea Brent Matters

Owing to these challenges, the project team conducted four activities:

1. Surveys for rare species – Finding Napo,
2. Development and implementation of Phase I of a long-term monitoring programme on Rongelap Atoll,
3. Sampling of wind, tides, and flow velocities for ocean modelling, and
4. Sampling for genetic analysis of rare corals.

***Spondylus varius* (Thorny oyster) on a lagoonal bommie.**

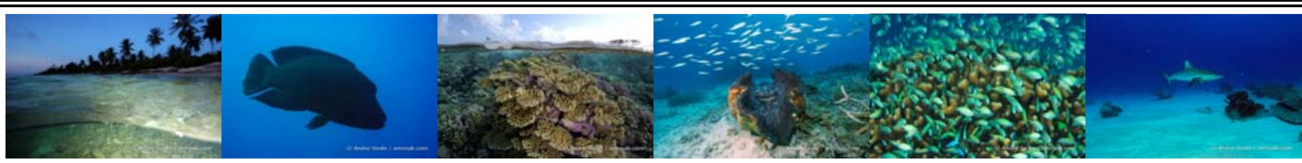
Activities: Finding Napo

Due to unforeseeable circumstances, we were unable to go to Rongerik Atoll in December 2006. Instead we concentrated our efforts in the neighbouring Rongelap Atoll. Rongelap has an extremely high fish diversity, with abundant apex predators such as large groupers and sharks. Healthy populations of lagoonal groupers, such as *Epinephelus maculatus* were observed, highly abundant parrotfishes and other herbivores were present. Rongelap also supports the endemic *Amphiprion tricinctus* (Three-band anemonefish). This species was encountered once during our surveys, as most sites were in the lagoon, and this species prefers outer reef habitats. Several *Cheilinus undulatus* ("Napo") were observed, on one occasion we observed a breeding pair. In the lagoon, we recorded the rare *Cirrhilabrus balteatus* (Girdled wrasse), which is endemic to the Marshall Islands, *C. luteovittatus* (Yellowstripe wrasse), which only occurs in the Caroline Islands and the Marshall Islands. For the first time on Rongelap, we encountered *C. johnsoni* (Johnson's wrasse), which is also endemic to the Marshall Islands.

Although the coral experts were not on Rongelap, the team extensively searched for *Acropora rongelapensis*, collected coral specimens and extensively photographed coral colonies. *Acropora rongelapensis*, described from Rongelap Atoll in 2004 is an exceedingly rare coral and was the focus of targeted surveys during the "Finding Napo" project. Formally, only 4 colonies were known from a single location. After extensive searching, an additional 8 colonies were located during the "Finding Napo" project. Molecular specimens of these corals were collected during the trip and subsequent phylogenetic analyses support that this is indeed a new species with novel sequence data (ZR, unpublished data 2007). With such a small population size, this species is of critical conservation interest and will be presented to the IUCN as a candidate for the Red List of Threatened Species during the Global Marine Species Assessment to be conducted in the Philippines in July 2007.

Maria Beger sampling *Acropora rongelapensis,* a rare coral described in 2004 from its type locality: Rongelap Atoll.

Throughout the surveys, Andre Seale, our photographer, documented the organisms and project activities on Rongelap. This material has high educational value, documenting what healthy coral reefs look like http://www.artesub.com/gallery/2351041#125170594.



Justification for a monitoring programme

The Rongelap Atoll Complex in the northern Marshall Islands is comprised of Rongelap, Rongerik and Ailinginae Atolls. The northern atolls are unique because they have been virtually uninhabited or subjected to commercial or subsistence fishing since 1954 when local inhabitants were first evacuated after radioactive fallout from atomic tests at Bikini Atoll. As a proactive conservation measure, we have initiated a long-term monitoring programme of coral reef resources at Rongelap Atoll. This long-term monitoring program is unique because the seemingly pristine resources of the northern Marshall Islands will be placed under increasing threat in the foreseeable future because the Rongelapese people are preparing to repatriate their native islands, and the local government is working towards establishing a sustainable community. Several avenues for economic development have been proposed, including a piggery, aquaculture, tourism and fishing ventures. There is a high likelihood of degradation to the marine environment from such developments.

As a consequence of its unusual history, Rongelap has effectively been protected from exploitation for over 50 years. On a global scale, Rongelap represents one of the few pristine reefs left in the world. However, the government and the people themselves need to adaptively manage the exploitation of the natural resources that will take place when the imminent relocation starts. Because practically all reefs elsewhere have suffered recent and ongoing impact (Jackson et al. 2001), very little is known how a reef in a state of pristine, natural equilibrium will be affected by human impacts. We also do not know at what stage of potential reef health decline that intervention (various management measures) will be needed. A monitoring program is crucial to quantify shifts in reef health due to the exploitation and management, but also to increase our knowledge about ecosystem function and decline processes. This project will play a vital role in addressing the region's critical coral reef conservation needs by establishing a long-term monitoring programme before resettlement begins. This is an extraordinary opportunity to examine the impacts of both human pressure on reef resources and the success of marine reserves. The monitoring programme was designed in accordance with globally accepted marine survey techniques that are standardised and easily replicable.

Objective	Details
Develop monitoring initiative at Rongelap Island to document possible ecosystem changes with resettlement	Monitoring program with nested sites and 5 replicates: - high-settlement island outer reef, lagoon and pass, and, - controls of remote island outer reef, lagoon and pass
Collect baseline data for long-term monitoring program	- Add monitoring data of fine resolution to existing dataset of Rongelap Reef status (Pinca et al. 2004) - Target sites adjacent to likely sources of impacts, such as main settlements, airport, port, resort, proposed aquaculture venture, piggery
Involve local surveyors trained in CMI's Marine Science Program	- People with previous survey experience refresh their skills - Recently trained people can obtain practical skills - Locals from RalGov, MIMRA, EPA and CMI
Create database for monitoring to be housed jointly by CMI and MIMRA	- Database is accessible and easy to query for future reference - Database is capable to also house future data

During Phase I of the project, we created a methodology and implemented 7 monitoring sites for a suite of methods near the main island, Rongelap Rongelap. During Phase II (which will take place in June/ July 2008), biodiversity and hard coral abundance data will be collected at these existing sites and control sites will be established in the northern parts of Rongelap and in Rongerik. After completion of Phase II, the long-term monitoring methodology will be formalised into a "long-term monitoring guide", enabling future comparisons between impact and non-impact and reserve and non-reserve sites to be made using the exact methodology established here. The specialist methods that we use are developed according to internationally accredited monitoring strategies.

As the monitoring programme develops, we will produce DVDs containing data, results, scientific publications, reports, videoed presentations and educational resources on an ongoing basis and distribute this DVD widely to effectively communicate with RalGov, CMI students, MIMRA, CMAC and other stakeholders.

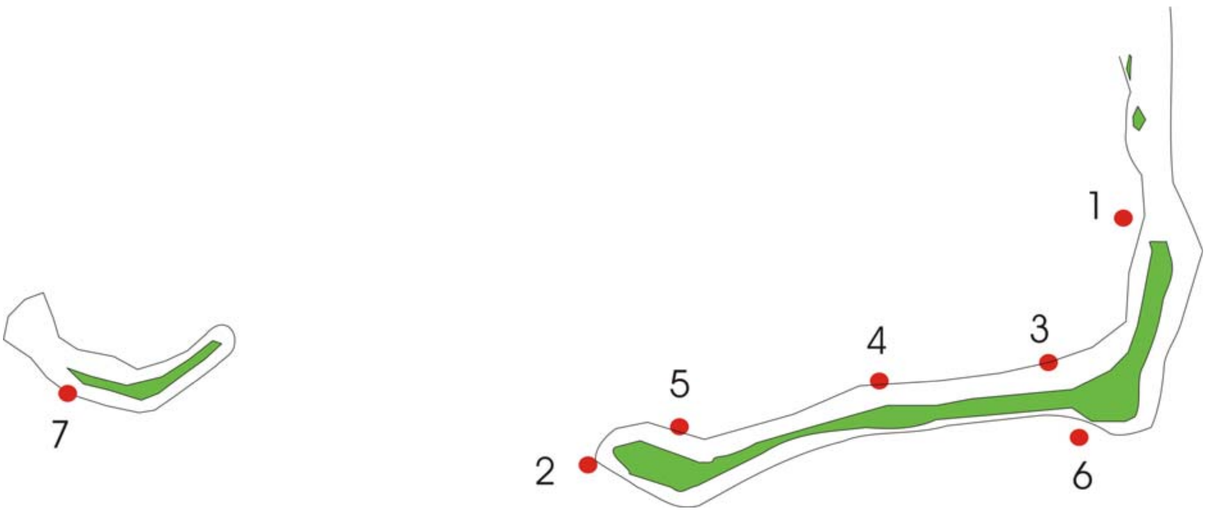
Activities: Monitoring Phase I

Objective 1. Develop monitoring initiative at Rongelap Island to document possible ecosystem changes with resettlement

We developed the monitoring programme as outlined below, following standard methodologies. The location of monitoring sites were determined based on the following information:

- Previous data collection sites/ outcomes,
- Locations of planned developments,
- Representative habitat information for control sites at remote islands,
- Logistics and safety considerations.

Each monitoring site was surveyed with 5 replicate transects at two depths, 3 m and 10 m. These levels of replication were required to provide sufficient statistical power to detect an effect of the magnitude typical of reef community response to environmental degradation. Specifically, given the spatial variability in habitat structure and fish distribution at these scales, we aimed for at least 5 replicate, independent censuses at each depth in each of the sites on each sampling cycle, however completed one site with only 3 replicates.



7 monitoring sites were completed (red).

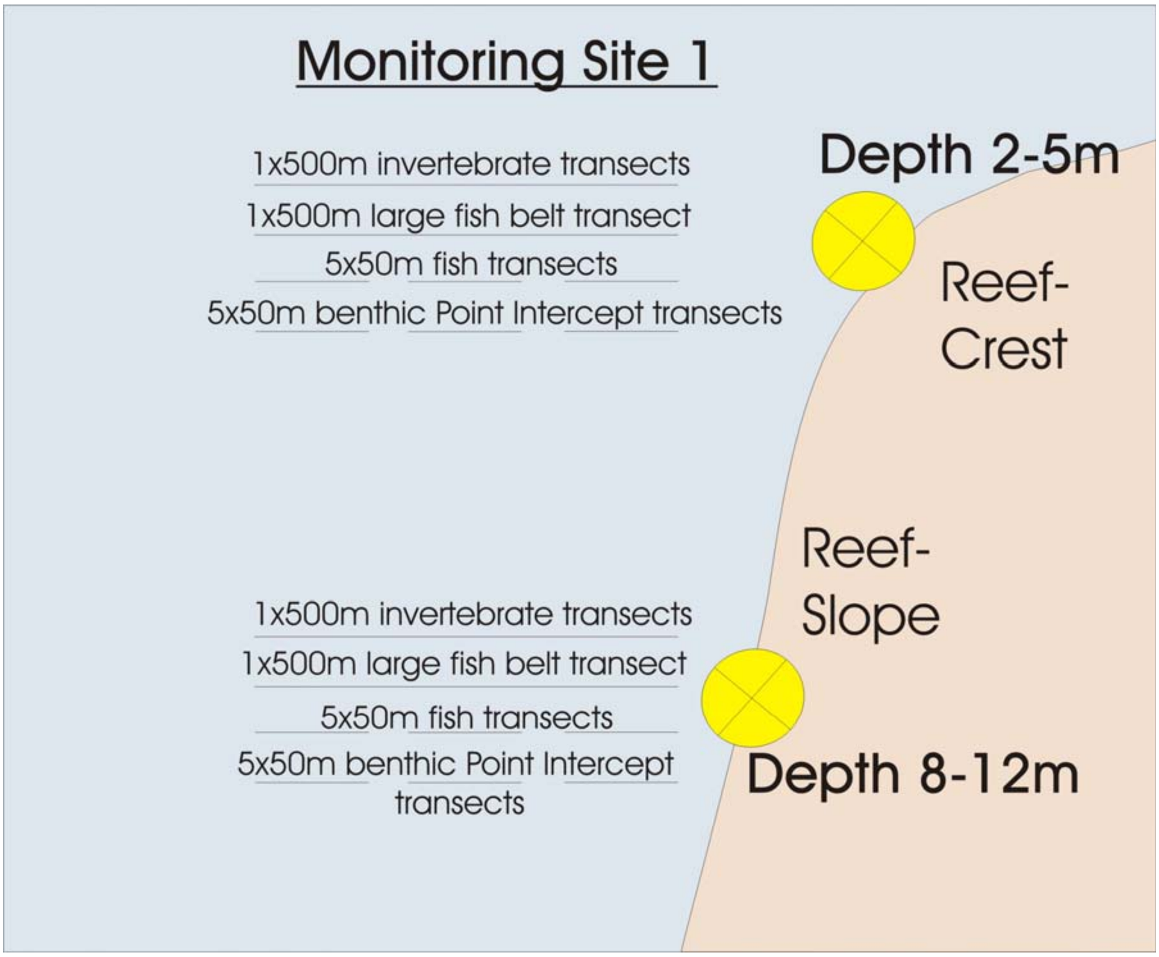
Although this project re-visited the two existing permanent transects from the previous project (2002), the use of permanent transects re-sampled through time is problematic in the experimental design and the interpretation of the data. This is called a “repeated measures” design. It greatly limits the power of statistical tests of differences among zones because the samples in different years are not independent (what you see in one year is partial function of permanent attributes specific to that site, rather than entirely a function of changes in the zone). Instead, we randomly sampled the transects in a “box” of GPS co-ordinates. The central concept here is that by sampling randomly within a habitat-depth strata in each sample cycle, we derived an independent estimate of the reef community that applies to the entire area of that habitat-depth within the zone, not just of a single site that we come back to again and again (that could be, or could become unrepresentative of the zone in general).

Objective 2. Collect baseline data for long-term monitoring programme.

The four main survey components of the programme were the monitoring of fish species, macro-invertebrates, algae and corals/ benthic life forms. We completed several components to the methodology at 7 sites (both deep - shallow reef) in Phase I as listed below (schematic drawing below).

1. Fish visual transects – 5 replicate 50m belt transects at each site with size estimates, for robust abundance and density estimates. Fish were counted in varying belt widths as follows:
    - Large, mobile fishes: 5m belt width
    - Smaller territorial fishes: 2m belt width
2. Benthic Point Intercept transects – 5 replicate 50m transects at each site, for robust benthic cover and coral abundance estimates.

3. Target invertebrate transects – 500m straight-line swims at each site. Invertebrate transects of varying swath width as follows:
   - Holothurians, *Trochus*, giant clams (Tridacnidae): 5m belt
   - COTS, other pests such as the coral-eating snail *Drupella*, disease, bleaching: 2m belt
4. Fish large belt transects – at each site one 500m-long transect were swum. The observer recorded all the abundance and size estimates of all species of large fish.
   - 10m belt width
   - Large fish recorded according to selected species list including large fish, commercially important species, and sharks.
   - Shark sexes were noted.
5. Installation of tide measurement gauges, temperature probes, and an anemometer.



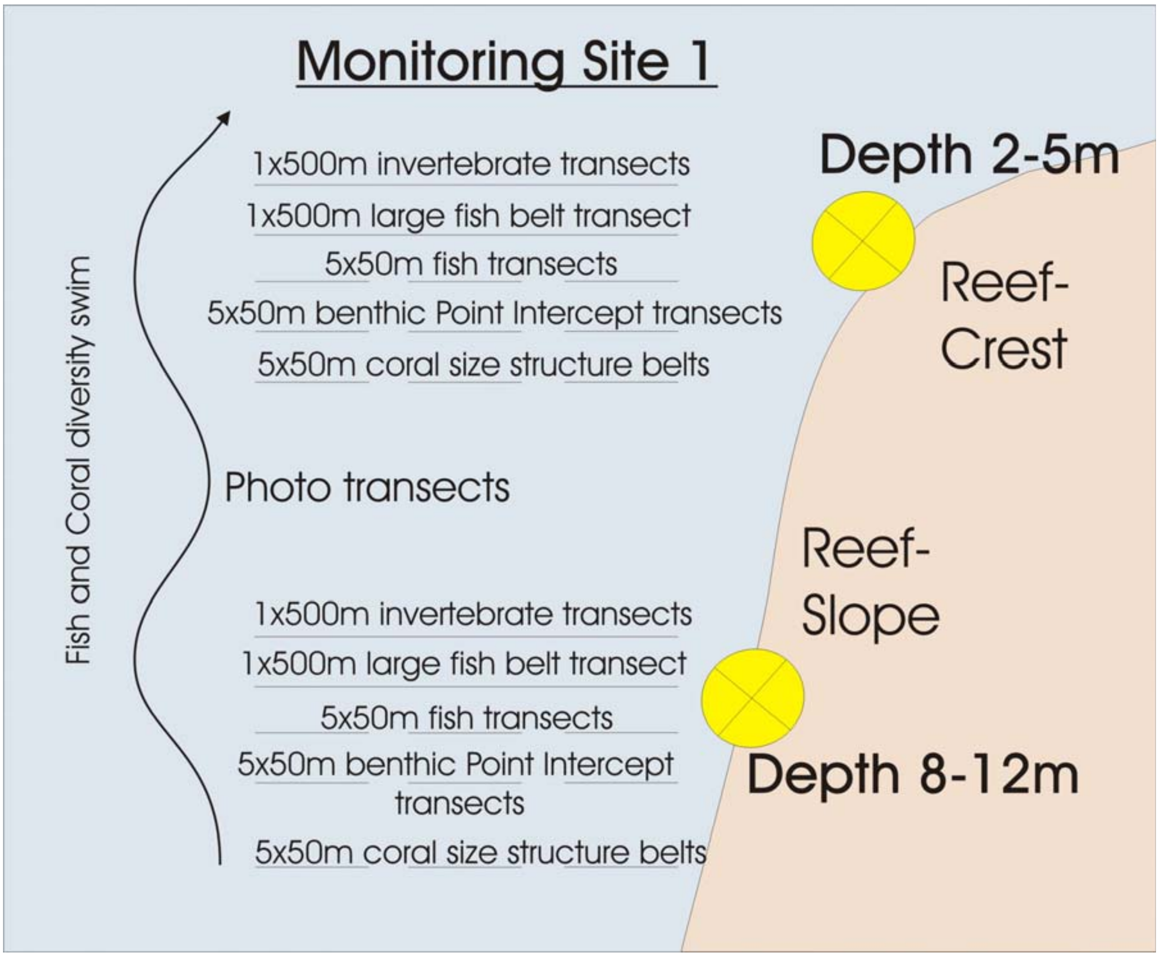
Design of monitoring methods at each site for Phase I.

The following other methods were also identified as part of a monitoring programme, but still need to be completed at these sites in the future (schematic drawing below):

6. Diversity and abundance of hard and soft corals and giant clams (Tridacnidae), abundance of coral-eating pests (including the crown-of-thorns starfish *Acanthaster planci*, or COTS, and the snail *Drupella*) and incidence of coral diseases and bleaching: timed swim of 60 minutes, maximum depth 20m.
   - Record presence and abundance of all hard coral species and soft coral genera
   - Estimate size classes of hard corals
   - Record presence and abundance of giant clams
   - Record presence and abundance of crown-of-thorns starfish, *Drupella*, coral bleaching, coral diseases and other disturbances
7. Coral size structure transects
8. Algae Quadrates along benthic transects – 4 replicate quadrats of 25cm x 25cm per 50m transect at each site, recording algae genera and species, for more robust benthic cover and coral abundance estimates.
9. Time series photographic (size-calibrated) transects of coral health – the combination of accurate GPS data and a series of conspicuous underwater features (i.e. large or unusual coral structures) allow the

rapid relocation of a previously photographed area without the need to install permanent markers. This strategy worked well during a coral disease study on Majuro, and has the potential to reveal subtle colony—specific changes in coral health, as well as changes in algae and coral composition that would be overlooked by random transect data. Coral area can be digitally traced and quantified. Time series comparisons are facilitated by rectifying and stitching images from each time point into a single photomosaic, allowing comprehensive side-by-side analysis.

10. Socio-economic monitoring: as people arrive, their numbers, activities, income, and opinions should be monitored.



Full monitoring methods.

Objective 3. Involve local surveyors trained in CMI's Marine Science Program

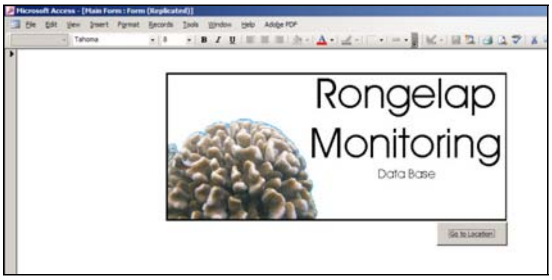
There is a great scope for local surveyors to be trained and involved by the programme. During Phase I this was not a priority, our local surveyor was a fully qualified scientist, and other local surveyors were unable to get on the flight to Rongelap. In the future, the intention is to provide an assessment of how data of appropriately trained locals (students and graduates of the CMI Marine Science program, trained non-expert locals) compare to those of the specialist scientists. This then enables RalGov and CMI to carry out more frequent, low-cost monitoring activities by using local trained people and have specialists only when funds allow or when we are alerted to a specific event such as coral bleaching.

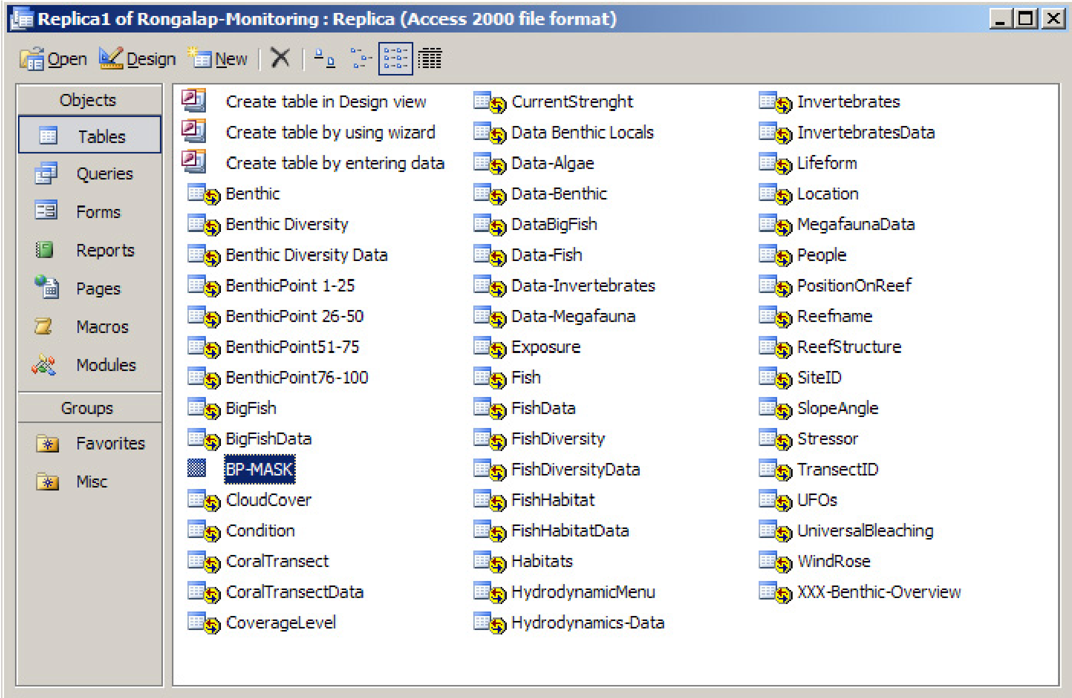
A detailed training methodology for local surveyors with different skill bases should be developed. For example, some local surveyors already have a high skill level, while others may need to be trained in the use of SCUBA and basic marine ID skills. All local surveyors should undergo a training and validation programme prior to surveying. They should have undergone the CMI Marine Science Programme science training. The initial training then comprises of familiarisation and revision of 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 for the CMI training course were chosen from information on past studies done in the RMI and published literature on the Marshall Islands (Pinca 2001). These species will also be adopted for the monitoring for surveyors who Laminated "cheat sheets" for invertebrates, and main benthic categories should be prepared ahead of time to aid in underwater identifications (Appendices).

Objective 4. Create database for monitoring to be housed jointly by CMI and MIMRA

In the lead-up to the fieldwork for this project, one team member (Reinhard Beger) created a database in MS ACCESS™. This database was then refined during the fieldwork, as data needed to be entered and bugs were identified (Appendices).

The data entry was conducted in the field by all project participants, each responsible for their collected data. Copies of the database are stored at RalGOV, CMI, and MIMRA.





Data tables in the Rongelap Atoll Monitoring Database.

Future needs

Phase II of collecting the baseline data for the Rongelap Monitoring project will complete the sites by collecting the missing data for coral sizes, diversity data and phototransects. On Rongelap, all monitoring sites at present are on the main island, where the development will occur. Therefore we need to establish control sites at more remote islands and reefs of Rongelap.

Figure 4. Monitoring sites completed (red) and potential additional monitoring sites as controls (blue).

In addition, Rongerik has still not been surveyed and future research projects should conduct a resource assessment there. The focus on rare fishes and corals was not possible during Phase I, mostly because habitats where the rare target species occur were unsafe to visit. Future projects should focus on rare species during general assessments, and manta-tow assessments should be conducted to cover a large area for rare fishes. Monitoring sites should also be established in Rongerik.

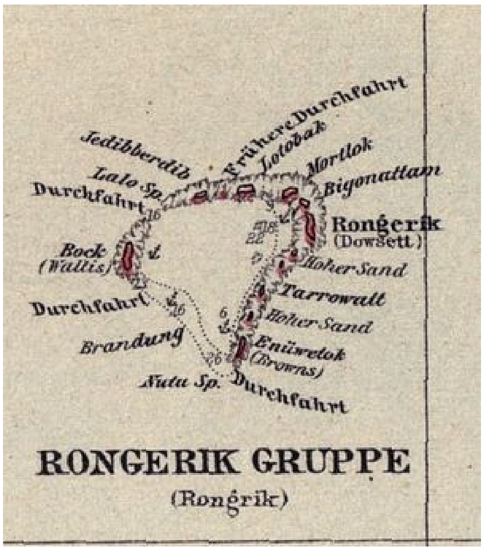


Figure 5. Map of Rongerik Atoll, taken from the 1893 map 'Schutzgebiet der Marshall Inseln', published in 1897, from WIKIPEDIA.

Activities: Ocean modelling of bathymetry and flows

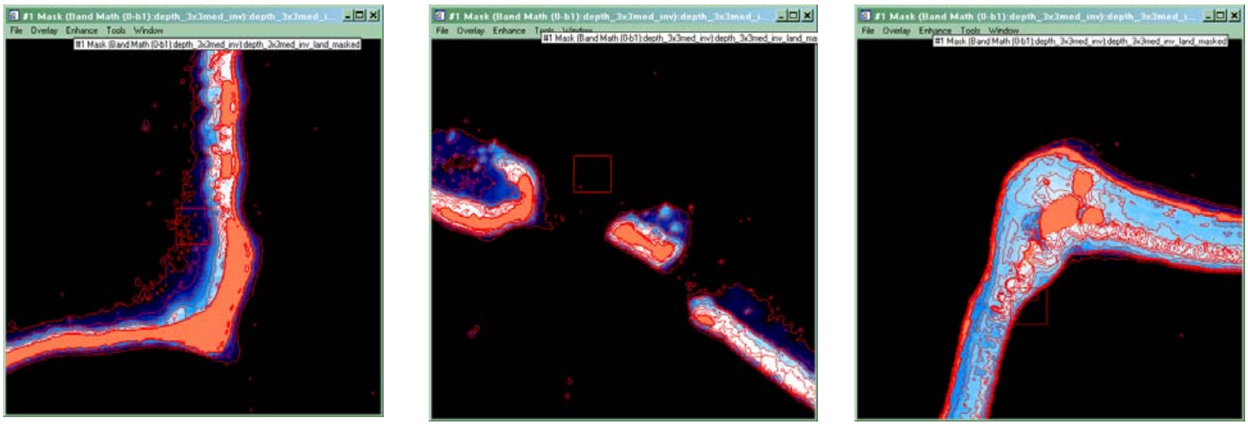
Coral reef animal life history involves distinctive sedentary and pelagic phases. The pelagic phase is important for dispersal of marine species on local, regional and global scales and influences community structures and patterns (Armsworth 2002). One team member, Eric Peterson, was leading the collection of climatic and oceanographic data to enable a realistic circulation model for Rongelap Atoll. He plans to develop such a model to simulate larval transport in clusters of atolls that are spatially isolated from continental influences. This model is based on CFD finite element depth dependent modelling with three-dimensional simulations of turbulent advection and diffusion. This model can then be ground-truthed with site-specific observations of fish and corals collected by the monitoring team, and potential changes can also be simulated by changing the boundary parameters.

The finite element modelling approach builds on actual topographic details which may also create eddies important to larval migration trajectories. Water flow in the benthic boundary layer is also important for growth of coral (Hearn et al. 2001) and transport of sand; these affect habitat structure and suitability of substratum for settlement of larvae. Benthic shear stress can be quantified and interpreted as a surrogate for sediment quality (Peterson 1999), and so this parameter should be a good index of the suitability of any particular patch of substrate as coral community habitat.

Such models require several input data, including accurate local tidal information, wind speed information, land height and water levels, water flow velocity and volume across the reef flats, water flow through passes, and accurate bathymetry. Wind speed was measured by installing an anemometer on the Rongelap pier for the duration of the field trip. Local tidal information was obtained by placing tide measurement probes both on the pier and on the ocean-wards side of the atoll (to also obtain data on height differences between in- and outside the atoll). Flow across the reef flat was obtained by following a drifter (balloon filled with fresh water) with a GPS and a depth sounder simultaneously logging data. Local land height was surveyed using land surveying equipment.

Eric Peterson measuring physical data: a) land height surveying, b) drifting across reef flats with instruments in a dry-bag, c) wind speed logging.

Bathymetry was determined using remotely sensed imagery. Contemporary techniques for bathymetric calculations typically utilise a variety of statistical processing techniques of visible green and blue wavelengths. The more successful algorithms utilise ratios and/or regression models of both blue and green channels of data. The data provided for this study was sourced from the ASTER sensor (Visible red, green & Near IR), which lacks visible blue data. Visible green only was therefore used for bathymetric calculation. A linear regression model was constructed using sub-samples of validation data derived from GPS tracked echo soundings, and historic nautical charts to predict depth from the calibrated ASTER data (with assistance from Marcus Reston, VPAC, marcus(at)vpac.org).



Bathymetry maps for parts of Rongelap Atoll from ASTER imagery.

Alternate Activity: Rare coral at Arno Atoll

When faced with the logistical problems with flying to Rongelap Atoll, our coral biodiversity specialist, Zoe Richards decided to survey Arno Atoll for rare corals and collect samples for phylogenetic analysis. Whilst the majority of the coral assemblage at Arno atoll was found to be similar to that of other RMI atoll communities there was one notable exception. Zoe discovered a population of Elkhorn coral. The classic Elkhorn coral (*Acropora palmata*) is one of the most distinctive of all *Acropora* corals (Veron & Stafford-Smith 2000). Since its discovery in 1816, it has only been known only from the Atlantic Ocean (Lamarck, 1816; (Wallace 1999; Veron & Stafford-Smith 2000). However, Pacific Elkhorn coral was discovered for the first time in this project. This coral is not widely distributed in the Marshall Islands' as it has never been previously reported. It is however locally common in shallow reef top and groove habitats at Arno Atoll. This finding led us to question the relationship between the newly found rare Pacific Elkhorn coral population and the highly endangered Atlantic Elkhorn species *Acropora palmata.* Is the Pacific Elkhorn a remnant or ancestor of the Atlantic population? Or is this simply a case of morphological plasticity within an already described species (such as *A. abrotanoides*) or is the Pacific Elkhorn a new species?

If the Pacific Elkhorn coral populations are closely related to the Atlantic population, these populations may be remnants of a Miocene population that was distributed throughout global oceans before the closing of the Caribbean Tethys Sea. The alternative explanation is that the Indo-Pacific populations represent range expansions however the likelihood of this is low considering the isolation of modern Pacific and Atlantic reefs. Considering the Atlantic population was recently added to the endangered species list, the potential existence of Indo-Pacific populations is of great interest to conservation.

It is now widely accepted that morphology conceals cryptic evolutionary relationships (Richards et al., in press) hence the identity of the Marshall Island Elkhorn population must be determined using genetic techniques. A large number of nuclear and mitochondrial sequences of the Atlantic coral occur in Genebank to facilitate comparison with the Pacific Elkhorn population and other related species. As a follow-up to this project, sequences have been obtained from 7 individuals of *A. palmata*, 2 individuals of *A. robusta*, 3 individuals of *A. abrotanoides* and 7 individuals of the Pacific Elkhorn for the mitochondrial control region. Results indicate the Pacific Elkhorn is not closely related to the Atlantic Elkhorn because it falls within the large Indo-Pacific clade however Pacific Elkhorns do not fall within the boundaries of other species that are predicted to be close relatives. Hence the Pacific Elkhorn appears to be a new species (Phylogenetic results or more details are available from Zoe Richards upon request). We intent to test this hypothesis further using 2 nuclear introns (Pax-C & cnox) and another mitochondrial region (cytochrome oxidase). The combination of genetic markers will provide an unambiguous determination of the identity of the Indo-Pacific Elkhorn populations.

Pacific Elkhorn coral – locally abundant and geographically rare. Photo: Dean Jacobson.

Post-project Follow-up / Outputs

Although the team was not able to work in Rongerik, some outputs listed in the original proposal were achieved, or achieved in a modified way. This section refers to the original proposal and provides details relevant to each output.

Key project deliverables

Technical report: provided here to bp-conservation programme

Technical and methodological presentation to MIMRA representatives: completed in April 2007 by MB

Poster of results: not yet completed – to be completed for the Australian Coral Reef Society Conference in Fremantle, Western Australia, October 2007.

Data to be incorporated in the national database: completed, data with RalGov, CMI and MIMRA.

Metadata to be incorporated in international databases such as Reefbase and Fishbase: not completed – awaiting coral data to be collected in Phase II.

Coral collections of rare corals are to be kept, and made accessible to the public at the Museum of Tropical Queensland. Specimens have been registered into the Worldwide *Acropora* collection and are available upon request from Zoe Richards.

Publication of results in peer-reviewed international journals: not yet completed.

Skills consolidation and training for local participants: Completed with one local participant, Emma Kabua. Emma significantly enhanced her surveying skills for benthos, her diving skills, and her coral ID skills.

Equipment given to local collaborating organisations: Some equipment such as compressor spares were given to CMI, and the book: Reef and Shore Fishes of the South Pacific, New Caledonia to Tahiti and the Pitcairn Islands, by John E Randall. A coral identification manual to Scleractinian corals of the Marshall Islands was created specifically for use by students in the project.

Dissemination of results

Technical report disseminated to MIMRA, local government, stakeholders and funders. Partially completed (this report, website update).

Technical presentation to MIMRA will be organised after the completion of fieldwork: Completed in April 2007 by MB, presentations also given prior and after fieldwork to RalGOV representatives.

Poster of results will be disseminated to MIMRA, local government, CMI, funders, participants institutions, local communities, other interested local parties: In prep for ACRS Conference, 2007.

Data to be incorporated in national database managed by MIMRA: Data given to MIMRA, and in the process of being incorporated into the national conservation GIS.

Metadata will be available via ReefBase and FishBase: Not yet completed.

The coral collection, and peer-reviewed publications will be accessable through library and database resources. Coral data and specimens registered in WWW Acropora collection.

Evaluation – How will success be measured?

Successes will be measured in milestones:

1. *Team members arrive in Majuro:* Completed.
2. *Logistics are organised:* Completed.
3. *Article in RMI Journal is written and published:* Completed.

4. *Fieldwork is conducted and successfully completed:* Fieldwork was conducted but not in Rongarik.
5. *Data are entered, and formatted:* Completed.
6. *Deliverables are delivered (presentation, report, poster etc):* Presentations to RalGOV, MIMRA, and the Coastal and Marine Advisory Council.
7. *Data are sent to National database:* Completed.
8. *Metadata are compiled and sent to international databases:* To be completed.

Accounts

Item	**specs**	**Days**	**cost**	**amount**	**total**	**NOAA**	**bp grant**	**MIMRA**	**RalGov**	**CMI**	**ISRS**	**other**
Pre project expenses												
Admin												
Communications	phone etc		100	1	100	50				50		
Insurance DAN	locals only covered		70	12	840	420						420
freight	domestic, international return		400	1	400	400						
freight	international		400	1	400							400
Living costs 1	Majuro	3	100	6	1800					1800		
Travel												
Int Flight 1	Australia		2000	4	8000	2000	2000				1300	1300
Int Flight 2	Australia		2000	1	2000		**2000**					
Int Flight 2	Canada		2000	1	2000	2000						
Domestic flights	Majuro- Rongelap RT		450	12	5400	4050				900	450	
Boat travel	(fuel only)		700	1	700	500	200		50			
Gear												
Boat	MIMRA/CMI/ RalGov				5000	3000			2000			
Medical/ drugs			200	1	200		200					
O2 equipment							700					
Satellite phone	hire and use		500	1	500	500						
Underwater paper	100 sheets		70	2	140		200				40	
GPS			300	1	300					300		
Underwater camera			1200	2	2400					1200		1200

Monitoring markers, tapes etc			150	1	150		150					
Field expenses												
Diving equipment use/ hire		1	500	12	6000	2500		500		3000		
Food+ water		16	25	12	4800	2640	1660				500	
Accomodation		16	30	12	5760				5760			
Compressor	spares, oil, fuel		200	2	400					400		200
Compressor	compressing at Rongelap		3000	1	3000	2000			1000			
Post trip expenses												
Administration	photocopy, postage		100	1	100	100						
Website fee and admin	subcontracted		500	1	500	400	**100**					
Foreign currency conversion fees			200	1	200							
Report	printing		400	1	400	250	**150**					
Report dissemination			100	1	100		**150**					
Presentations	in country		100	1	100					100		
			US$	**51190**		**20810**	**7510**	**500**	**8810**	**7750**	**2290**	**3520**
				Grand Total		**NOAA**	**bp grant**	**MIMRA**	**RalGov**	**CMI**	**ISRS**	**other**
							30380			**total matching**		

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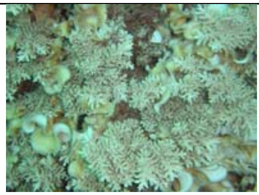
Appendices

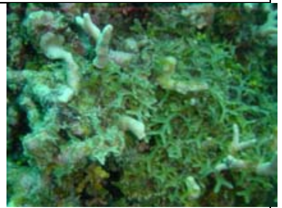
Algae cheat sheet

Brown algae BA

sargassum



Padina - like pencil shavings, high nutrient conditions



Dictyota -

Bluegreen algae BG

Filamentous brown FA

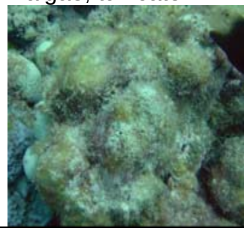
Green algae GA

Caulerpa

Codium – spongy stuff

Halimeda HA

Turf algae TU
short turf, hydroids, algae, tunicate mix



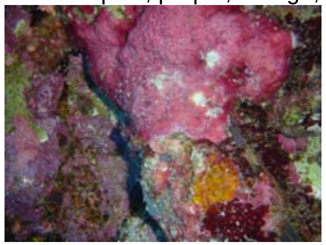
Filamentous green FA

Red algae RA

Peyssonellia – red leafy algae

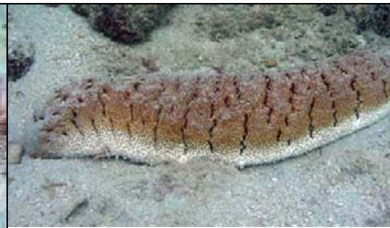
Galaxaura – bushy with stiff branches

Coralline algae CA - red encrusting algae looks like lichen in pink, purple, orange, red



Filamentous red FA

Invertebrate cheat sheet

 ***H. nobilis*** – thicker body wall All habs but esp. shallow reef bottoms, lateral & anal papillae	 ***S. chloronotus*** – dark green. Smaller morphs in shallow; larger morphs deeper	 ***T. anax*** – cream w/ orange/pink blotches & warty. Crest & deep H^{2}0. Can get to <1m long	 ***H. fuscopunctata*** – transverse folds. Pale undersurface. All habs but mostly deep water.	 ***A. lecanora*** – short bulbous red or red/brown mottled. Mostly hard substrata on crest. Anal teeth.
 ***P. graeffei*** – mottled w/ dark spots & white-tip pap., w/ long black tents, crest & deep water.	 ***T. ananas*** - All habitats but esp. deep water	 ***A. mauritiana*** – red w/ dimpling, white blotches. Hard substrata in exposed habitat. Anal teeth.	 ***B. marmorata*** – black/ orange w/ small black spots. Deep, on sand	 ***H. atra* -** Thinner body wall cf. nobilis Shoter than *leucospilota*, sandy with bare patches. ***H. fuscorubra*** – similat to *H. leuco* but less elongate, + denser, small pap. & orange tips

H. fuscogilva – whitish w/ dark brown or black dorsal mottling. 3 titties. Mostly crest & deep water

H. edulis – mostly reef crest & deep water.

B. argus – leopard spot mottling (can be variable). All reef habs but prefer lagoon

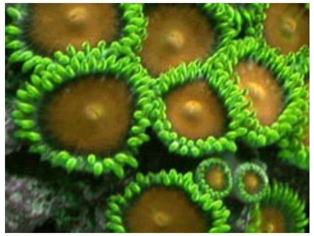
S. hermannii (both photos) - brown/orange w/ darker low tubercules. All habitats, but esp. reef flat & lagoon.

H. leucospilota - small pointy papillae & elongate oral tentacles. lagoons & reef flat. Beware *H. Atra* & *Fuscorubra*

Soft coral - dendronephtyia

Flower/ pulsing soft coral - Xenia

Stylaster – under overhangs & caves

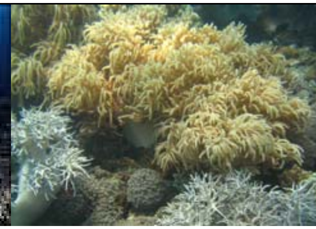


Zoanthid, polyps contract if waved at.

Leather coral sinularia

Leather coral - Sarcophyton

Leather coral - Lobophyton



Sinularia flexibilis



Tridacna maxima / Tridacna squamosa


Tridacna derasa


Tridacna gigas


Hippopus hippopus
On shallow reef flat


COTS

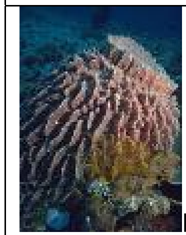



Drupella


Triton shell


Firecoral - Millepora


Blue coral Heliopora


Barrel an d

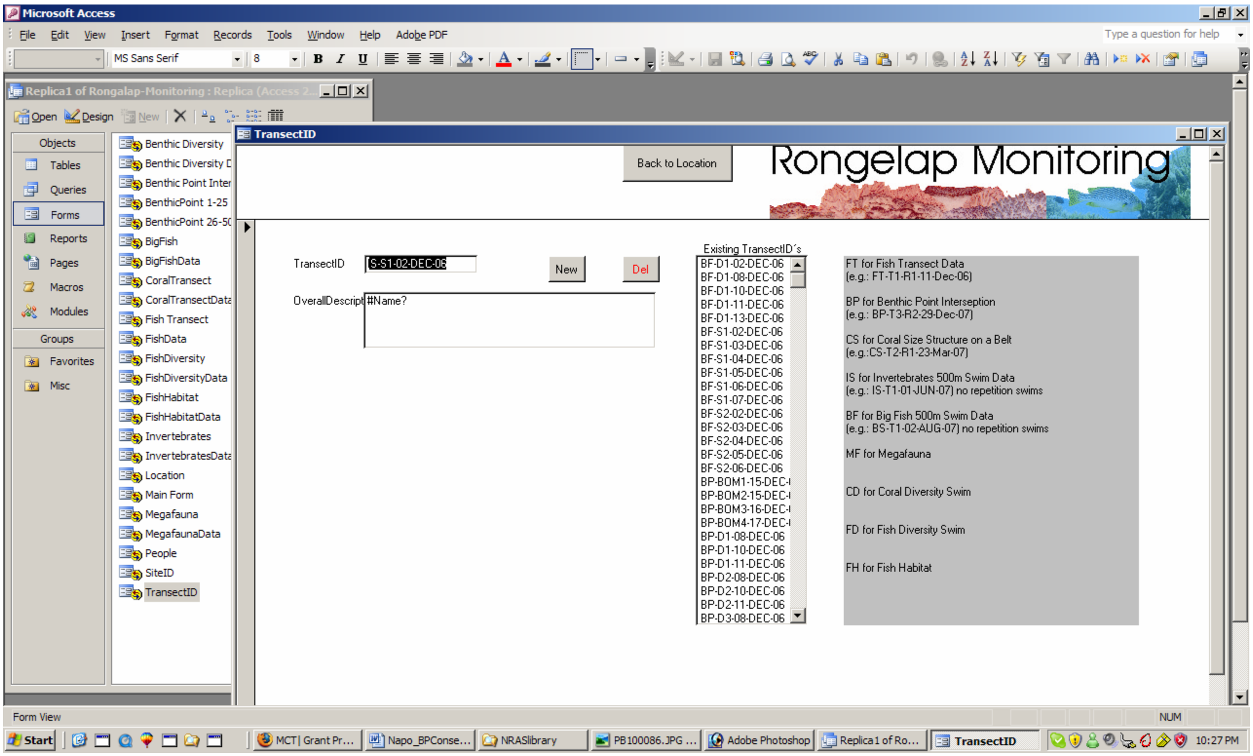

tube sponges


Branching sponge

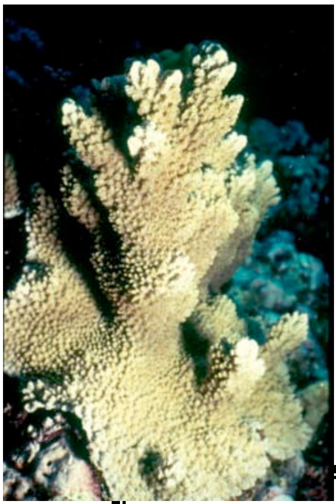

Lumpy sponge


Encrusting sponge

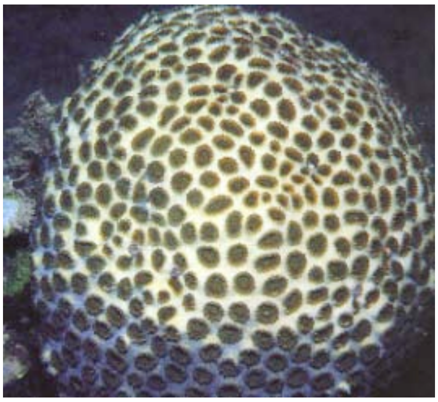
Database presentation sheet



Hydnophora

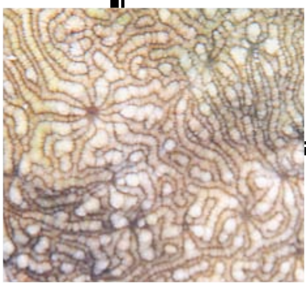


Favia

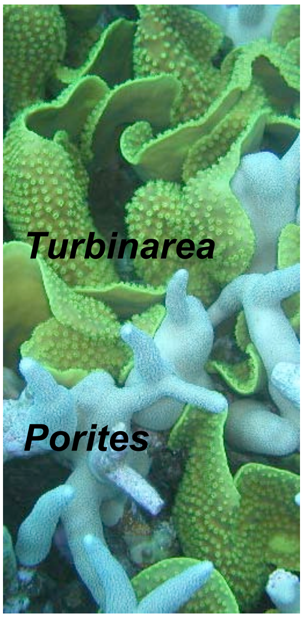


Acropora

HARD CORAL GENERA OF THE MARSHALL ISLANDS



Psammocora



Cynaria

Rongelap Atoll
Coral Reef
Monitoring
Initiative

ZOE RICHARDS

Family Acroporidae

Genus Acropora

branching, plates, digitate, encrusting - **axial polyp** on tip of branch - many radial corallites



Subgenus Isopora

Many axial polyps, chunky club branches

Genus Astreopora

massive, encrusting, large **open polyps - "jet engines"** bumpy coenosteum

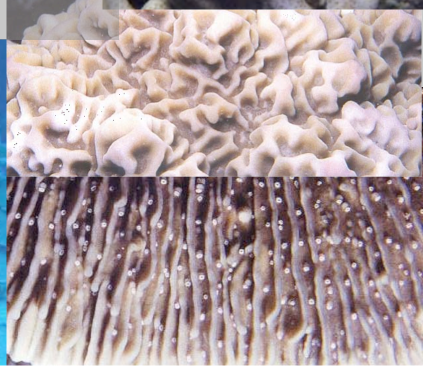
Genus Anacropora

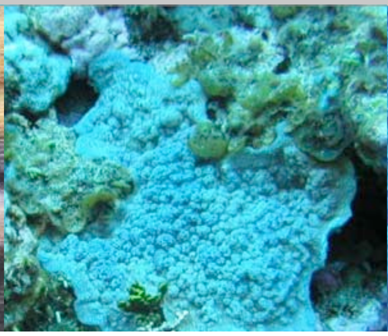
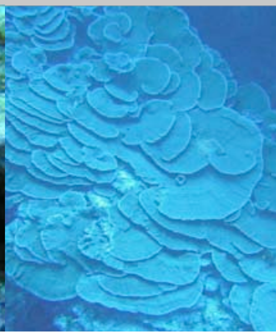
slender irregular branching colonies, branches less than 10mm thick with blunt ends - no axial polyp - soft substrates

Genus Montipora

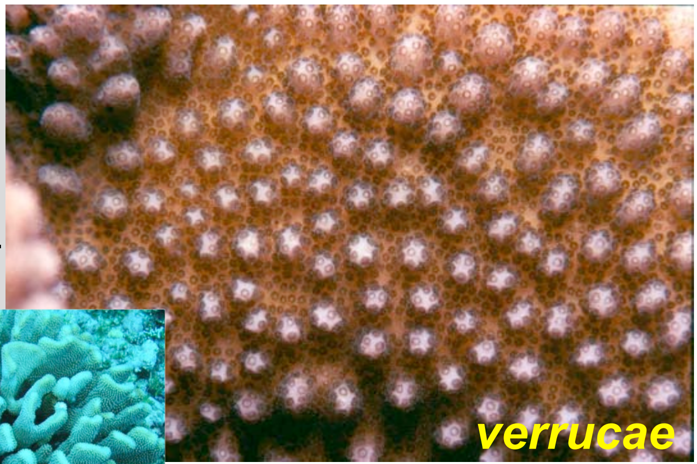
encrusting, foliose or knobby branches

polyps tiny <1mm - surface covered in spines, spines may be fused into ridges



Family Pocilloporidae



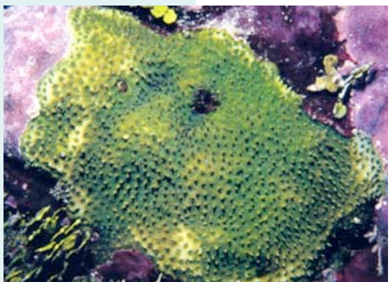
Genus Pocillopora
Branching colony surface lumpy – *verrucae*- small corallites on and between verrucae

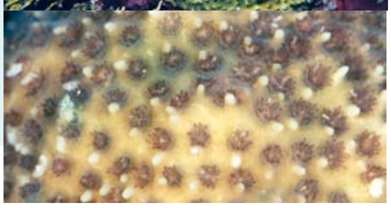
Genus Seriatopora
thin branches with pointy or rounded tips
corallites in rows down branch
upper corallite wall developed as a hood
branches may be highly fused

Genus Stylophora
thick branches, wide at the tip, Rod in centre of corallite. **spiny hood - upper wall of corallite wall more developed**

Family Astrocoeniidae

Genus Stylocoeniella
thick branches, wide at the tip, Rod in centre of corallite.
spiny hood - upper wall of corallite wall more developed





Family Poritidae

Genus Porites
massive, branching or foliose
corallites small
colony surface smooth
-plates can resemble *montipora*

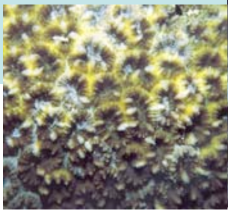
Genus Goniopora
columnar or massive
corallites polygonal
24 tentacles with long stalks
tentacles extended during the day

Genus Alveopora
columnar or massive
corallites polygonal
12 tentacles with long stalks
tentacles extended during the day

Family Faviidae

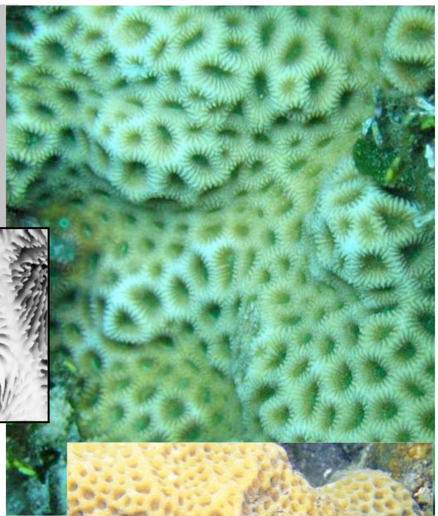
Genus Favia

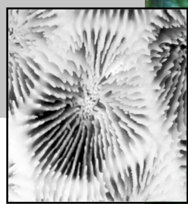
colonies massive or encrusting
rounded corallites 3-20mm diameter
corallites have single mouth and **own wall**
septa have fine teeth
paliform crown
budding intratentacular



Genus Favites

massive or encrusting
polygonal corallites 6-20mm diameter
corallites monocentric and **share walls**
paliform lobe poorly developed
septal teeth can be large
budding largely intratentacular



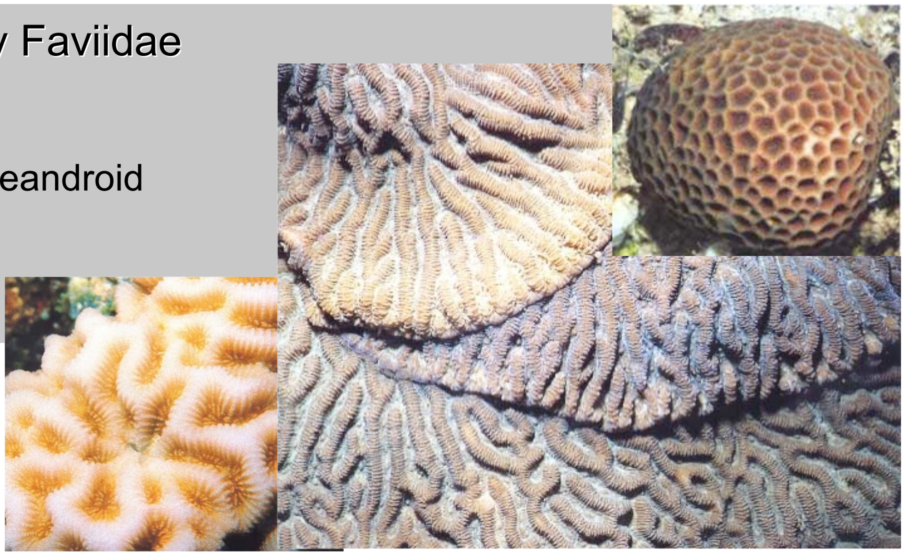


Favid key

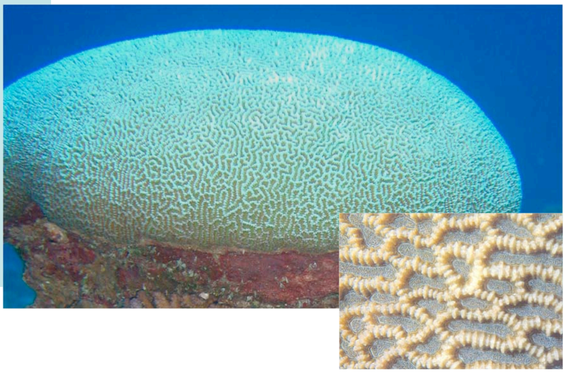
- Colonies phaceloid – **Genus Caulastrea**
- Colonies massive
  - Budding intratentacular or meandroid
    - Colonies plocoid
      - Corallites not exsert – **Genus Favia**
    - Colonies ceroid
      - Paliform crown not obvious – **Genus Fav ites**
      - Paliform crown obvious – **Genus Goniastrea**
    - Colonies tending towards meandroid
      - Valleys wide and deep – **Genus Oulophyllia**
    - Colonies meandroid
      - Columellae absent or mesh -like – **Genus Platygyra**
      - Columellae plate -like – **Genus Leptoria**
  - Budding extratentacular
    - Colonies plocoid
      - Corallites small (<4mm diameter)
        - Corallites crowded – **Genus Cyphastrea**
        - Corallites well spaced – **Genus Plesiastrea**
      - Corallites medium
        - Septa do not alternate – **Genus Montastrea**
      - Corallites large - **Genus Diploastrea**
    - Colonies ceroid
      - Corallites small (<4mm) – **Genus Leptastrea**
- Colonies plates or branching, monocentric corallites – **Genus Echinopora**

Family Faviidae

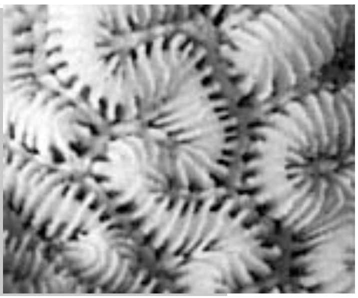
Genus Goniastrea
massive, encrusting
corallites are neatly ceroid or meandroid
septa have fine teeth
obvious paliform lobes
Budding intratentacular



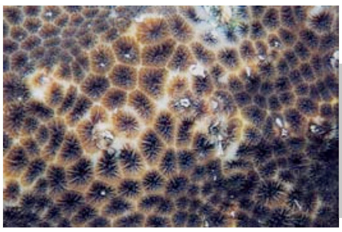
Genus Platygyra
massive
corallites in rows
(**meandroid**)
thin valley walls
columellae continuous
tangle along valley floor



Genus Leptoria
massive, meandroid
columella a series of **vertical plates**
valley walls thick
septa neat



Genus Ouphyllia
massive
corallites in rows
(**meandroid**)
Large deep valleys -
disctinctive colonies



Genus Leptastrea
Encrusting,
corallites shallow

Genus Montastrea
Massive, corallites have own walls
paliform lobes may be developed
septa have fine teeth
budding is **extratentacular**

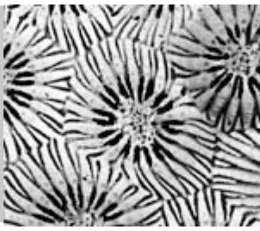
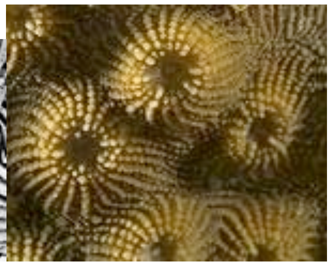
Family Faviidae

Genus Plesiastrea

colonies massive or encrusting usually cryptic
corallites **small**, round and exsert, distinct
paliform lobe. Coenesteum costate
extratentacular budding


Genus Diploastrea

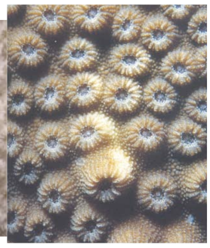
massive to encrusting, often very **large** colonies
large polyps tightly packed into raised domes
thick septa
extratentacular budding

Genus Caulastrea

Genus Cyphastrea

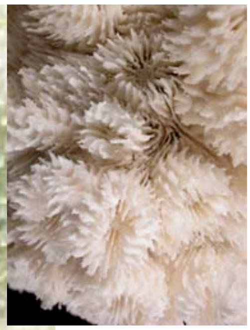
massive, encrusting or branching
corallites small, round, own walls
surface bumpy paliform lobes
poorly developed

Genus Echinopora

massive, laminar or branching
corallites have own walls
septa exsert
spines on septa and coenosteum





Family Mussidae

Genus Acanthastrea

Massive, often
multicoloured
large fleshy corallites
spiky due to large septal
teeth

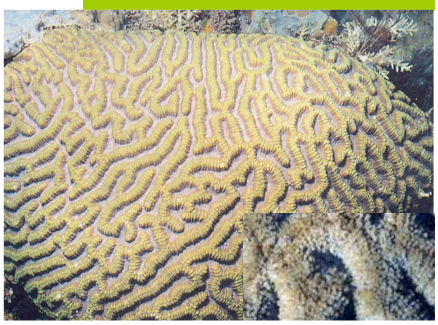


Genus Symphyllia

massive
polyps within
meandering
valleys
valley walls are
thick, no gaps
spiky due to large
septal teeth

Genus Lobophyllia

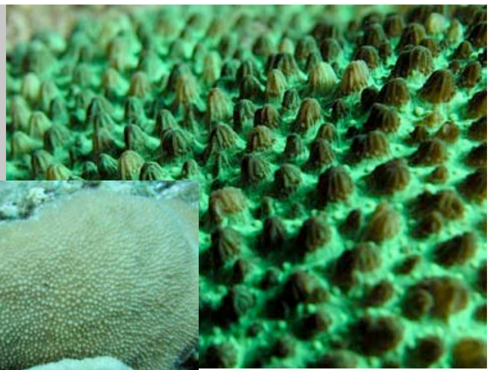
colonies
meandering
with
gaps between
valleys
spiky due to
large septal
teeth



Family Merulinidae

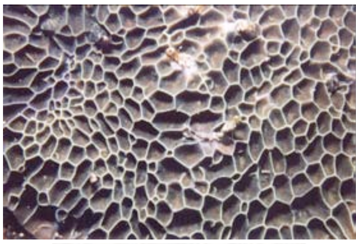
Genus Hydnophora

massive, encrusting or branching
pyramid structures between corallites (**hydnophores**)
septa converge on top of pyramid
may be hidden by tentacles



Genus Merulina

Laminar with uprightbranches valleys spread like a fan



Genus Gardinoseris

Acute ridges between corallites

Genus Coeloseris

Granule on top of wall

Family Agariciidae

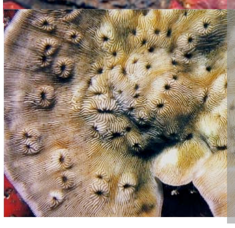
Genus Pachyseris

laminar to encrusting
no distinct corallites
ridges parallel to the colony edge

Family Dendrophylliidae

Genus Turbinarea

plates, foliose or encrusting,
corallites are 1-5mm diameter
corallites immersed or exsert
coenosteum is smooth well develoed columellae



Genus Leptoseris

Encrusting, plates widely spaced inclined corallites

Genus Pavona

massive or foliaceous
bifacialy and leafy fronds
corallites compact and small - no walls

Family Siderastreidae

Genus Psammocora

massive, columnar, branching, laminar or encrusting
corallites small forming a **flower** coenosteum is granular

Pseudosiderastrea

Family Fungiidae

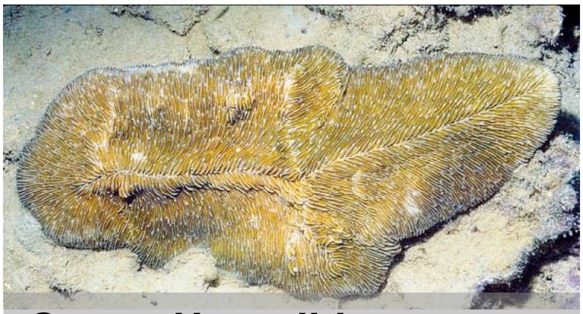

Genus Fungia
corolla solitary, circular or elongate
free-living
septal teeth pointed

Genus Cycloseris
small circular
polyps, may have
raised mouth



Genus Ctenactis
round ends, neat
appearance

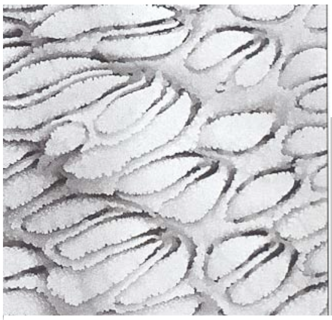
Genus Halomitra
dome shaped
mouths scattered over surface
septa have teeth



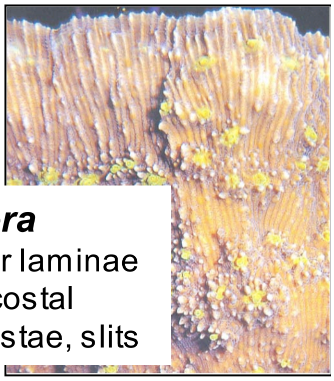
Genus Herpolitha
Elongate, rounded or
pointed ends - x,y, or t
shaped. Mouths within or
outside axial furrow

Genus Podobacia
Attached,
encrusting or
laminae. Large
exsert
corallites inclined
towards
colony margin.

Genus diaseris
small
free-living



Genus Polyphyllia
corolla elongate or round
mouth all over the surface
septa forming petal

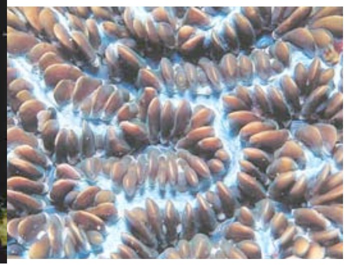


Genus Oxypora
thin encrusting or laminae
colonies, slight costal
ridge, toothed costae, slits

Family Oculinidae
Genus Galaxea
encrusting, massive or columnar
corallites exsert, very exsert septa
coenosteum **blistered**



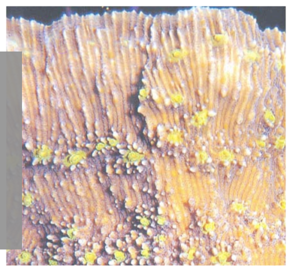
Family Carophylliidae
Genus Physogyra
meandroid
septa very exsert
corallite walls blistered
bubble-like **vesicles** cover septa
long tentacles can cover vesicles

Genus Euphyllia
colonies meadroid with small gaps betw
septa exsert. Polyps have long tentacles
extended day and night

Genus Plerogyra
colonies flabello-meadroid with small gaps
between septa exsert. Polyps have long
tentacles extended day and night

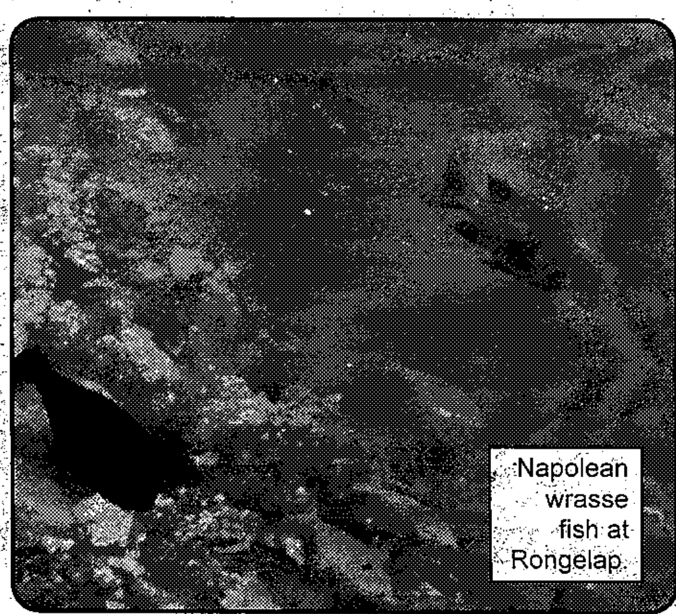
Genus Oxypora
Thin laminar or encrusting colonies with
Ridges on surface, corallites inclined
Towards margin, slits



Group focuses on our marine wonders

Four of the marine scientists who are taking part in the survey at Rongelap and Rongedrik Atolls, pictured from left to right: Eric Peterson, Zoe Richards, Glenn Dunshea, and CMI's Dean Jacobson.

Rongelap under the microscope



Napolean wrasse fish at Rongelap.

A group of international marine scientists are spending three weeks at Rongelap and Rongerik Atolls to monitor the health of the coral reefs and inspect rare species discovered on previous marine surveys.

Three College of the Marshall Islands students — Emma Kabua, Elai Isaiah, and Harietta Sefeti — are accompanying the scientists along with the college's Dean Jacobson.

According to participating scientists Maria Beger of the University of Queensland, Zoe Richards of Townsville's James Cook University, and Eric Peterson of Melbourne's Victoria University, "the coral reefs at the northern outer atolls are amongst the most pristine and healthy in the world."

This status has led to ongoing surveys of the atolls, which are all done with the blessing and help of the Rongelap Atoll Local Government.

This month's team of surveyors, which also includes MIMRA staff, is being supported by a grant from the British Petroleum Conservation Program and will concentrate on Rongerik Atoll.

Because the atolls under RalGov jurisdiction — Alinginae, Rongelap, and Rongerik — have been largely uninhabited for at least 50 years, the fish, coral and invertebrate populations are of special interest in the international marine science world.

'Our monitoring program will establish permanent sites close to future human impacts where the health and diversity of coral reef creatures will be closely monitored.'

As well, Alinginae and Rongerik are both being proposed for world heritage site designation, highlighting the importance of finding out more about the atolls' marine life. According to a statement from the scientists: "We will particularly focus on rare and commercially important corals and fishes, such as Napoleon wrasses, groupers, and sharks, because these species are depleted and even endangered in parts of the RMI and elsewhere in the Pacific and Asia."

The team's efforts will also start a monitoring program funded by the US National Oceanic and Atmospheric Administration and designed to detect "before and after" changes during the resettlement of Rongelap.

"RALGov is making good progress in constructing necessary infrastructure, including the airport, pier, housing, the pig farm, and tourist accommodation," the scientists said. "Our monitoring program will establish permanent sites close to future human impacts where the health and diversity of coral reef creatures will be closely monitored.

"The current survey will be followed by a series of follow-up surveys over many years to come." This is because Rongelap's reefs are amongst the best in the world for natural and intact coral reef ecosystems, with abundant large fish, excellent coral cover and diversity and a lots of special reef features, and the monitoring program represents a unique opportunity to document the earliest changes caused by humans.

"With this detailed information, damage can be detected and ideally lead to better management," the scientists said. "For example, anchoring in a favorite dive spot could cause damage to corals, but this is easily prevented by constructing mooring buoys."