Helen Reef Marine Resources in the Year 2000

The State of Marine Resources of Helen Reef in the Year 2000: Results of Scientific and Community Monitoring Surveys, April 24 to May 3, 2000

Helen Reef Marine Resource Management Program, Hatohobei State, Republic of Palau

Final Report

Produced by:

Charles Birkeland, Hawaii Cooperative Fishery Research Unit, University of Hawaii - Manoa
Alison Green, Great Barrier Reef Marine Park Authority, Townsville, Australia
Michael Guilbeaux, Community Conservation Network, Honolulu, Hawaii
Terry Donaldson, International Marinelife Alliance, University of Guam Marine Lab, Guam
Dominic Emilio, Hatohobei State Representative, Republic of Palau
Lisa Kirkendale, University of Guam Marine Lab, Guam
Jeff Mangel, Wildlife Consultant, Hawaii
Rob Myers, Coral Graphics, Guam
Kevin Weng, Stanford University, Palo Alto, California
Rob van Woesik, University of Ryukyus, Okinawa, Japan

Acknowledgments

We wish to thank the former Governor Crispin Emilio and the State of Hatohobei for their kind invitation to join this resource monitoring expedition to one of Hatohobei's greatest treasures, Helen Reef. We are also grateful to the captain, crew, and boat drivers of the M/V *Atoll Way* for their able assistance, as well as the Community Conservation Network their efforts in organizing the logistics of the expedition. The Bureau of Lands and Surveys provided assistance and support in mapping. Special thanks are offered to the Hatohobeian people and those others who accompanied our expedition for their assistance and the many kindnesses we experienced during our visit to Palau and Hatohobei. Their contributions made for a truly unique and enjoyable experience. Support for the coordination and implementation of these surveys was provided in part by the Environmental Defense Fund's Minigrant Program; the Palau National Congress, the Olbiil Era Kelulau (OEK) and Palau's Capital Improvement Program (CIP); and the Hatohobei State Government.

The Helen Reef Resource Management Program
Hatohobei State Government Office
PO Box 1017, Koror
Republic of Palau, PW 96940
Phone: +680 488-8044
Email: helenreef@palaunet.com

Cover Photo: Diver with Giant Clam, Helen Reef, Palau 2000. By Michael Guilbeaux.

HELEN REEF RESOURCE MANAGEMENT PROGRAM
P.O. BOX 1017
Koror, PW 96940
Phone: 488-8044 Fax: 488-2218
Email: helenreef@palaunet.org

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Dear Friends,

We am pleased to release the report “Helen Reef Marine Resources in the Year 2000: The State of Marine Resources of Helen Reef in the Year 2000: Results of Scientific and Community Monitoring Surveys, April 24 to May 3, 2000”. Supported by funds from the Republic of Palau’s Capital Improvement Program (CIP), the expedition has assisted the State in many ways, including laying a foundation for the current protection and management activities now present at Helen Reef.

The editing and release of the report rested in the hands of Michael Guilbeaux, and while the process has taken somewhat longer than we all expected, we recognize the constraints and other competing, productive activities Mike that has been engaged in over this period. Despite the delay in the report’s final release, the Hatohobei State Government, officials, project staff, and community members have always had access to the information included within – from the moment the expedition returned to Koror until today.

We wish to thank the Community Conservation Network, the many scientists, their home institutions, our state employees, and community members that have participated in this effort and strengthened our management program in many ways.

Please contact the Helen Reef Resource Management Program or the Hatohobei State Government should you have any questions concerning Helen Reef Conservation Area.

Sincerely,

Huan Hosei, Chairperson
Helen Reef Resource Management Program

and

Sabino Sakarias, Governor,
Hatohobei State Government

HAFATITIN PEPAYER (EXECUTIVE SUMMARY)

HAFATITIN MEYAH MAKAWE SCIENTIST FITEHI IWORI HOTSARIHIE RETIPERI ME HUHEIH MA FABONGURI HAFAUWERI MAHAM ESA TOHONGARI HARIMOBONGURI HARIMOUWERI MAHAM RETIPERI MASIRAPAYE HUHAHANGAS (APRIL 24 –MAY 5, 2000).

Ifiri fitehiye yefauhuyehi nga maka scientist hasoh ba Hotsarihie ra yerap sewa nifar iyohoih tsori Hatohobei ba yepipie sewa manu wori hotsor (major resources). Makaye yehatufanganie manu reteti ma manu worufaruh. Iyaka manu reteti ra hie (giant clam), summum (trochus), periperi (sea cucumber), woru (sea turtle), ma ieh (fish). Iyak manu worufaruh ra habang, hataf, kaingaow, menerihots, saiwesaow, ma maruwa.

Ifiri yah meyemei nga hasohu ba Hotsarihie yeweriroh sewa banatsahu ma hamotori faruharaye (location). Maka iheri wori hotsor ma manu wor yefauhu Hotsarihie ba ebe wahawah sewa tipats ireng. Bara sew ra Hotsarihie yetaw sewa ma ifiri Panou (Palau) ngaye sabar hahapa Indonesia. Iyer ma tsapir ma yesa hamatahi sewa ma sibe materahie maifih heihatowasi.

Maka tsori Hatohobei yehamatahi sewa tipeh (are concerned) ifiri tawasikara yemouri fauhuyehi iwori hotsori Hotsarihie. Iyer ma tsapir ma State Government yesa tihongoh Community Conservation Network (CCN) ba yebe tapangihits ifiri yerari hawerewereri Hotsarihie. Meihara CCN yesa hasihoto maka scientisteri pipiyeri foruh ba habe meyahi nga ha kauh fauhuri ma hotsori Hotsarihie retiperi meyah sai (April 24 –May 5, 2000), ba ebetsuh ba:

1. Ebewoh kaur meyameyari hots. Bara sew ra maka scientist habe meyahin manu worihots ma mohor ma towasir hots ma rengit.

2. Ebewoh tsori Hatohobei ra habe kau fauhuri meyameyari manu wori hots ma rengit. Bara sew ra habe kau fauhuri fitehiyer.

2. Maka scientist habe hangerihits fauhur yerar hawerewereri maka erap nifar ma iwori hotsori Hotsarihie.

HAFATITIN MEYAH SCIENTIST FITEHI (SCIENTIFIC SURVEY):

Maka scientist hafauhu yah fitehi (conducted scientific survey) hasa mayahin iheri hots ma bara pahur fauhumir ra erap nihohor. Hasabara meyahi ma fauhur mohor ma towasir maka hotsokara ha tutu ireng. Hotsoka hemour tufin ra yerau miretuh ba niyiyeri fitehi ma kau masirapaka imowats. Maka scientist hamengi nga State Government etsuh ma ebe ihatsahuh habe fauhu fitehiye (survey) hamour hanahangarihits ye titin meyameyari ieh ma hots, hasa hura mohor ma towasir. Fitehiye hafauhu ra meyameyari manu wori hotsokara hamour yapaharin ba niniyeri kau, hasa hahoyani haye fitemaru ieh mahahekene ifir sew tutu.

HIE (GIANT CLAM):

Banatsahu ma yepipi heihatowasi iwori Hotsarihie, maka scientist yemoh tot tipeh ba etuhuriwoh hasamaru hie ma toh ra hawehin. Maka hawehin ra pasung, ma pahur kimeri wori hots. Ngaira hie ma harafitamaru ma hawehin. Hara Hapusuhur ma yepipi sewa ba yetoh yahamat yeha hatawasin.

SUMMUM MA PERIPERI (TROCHUS and SEA CUCUMBER):

Maka scientist hamangi nga summum ma erap sewa towasir ba retiperi meyah tutu nga harafitemarutsohu me hehokeneni. Bara sew ra tsori foruhomo nga hangutahei ba yehaitena. Ira Periperi ra etsuhuriwoh ngaira etaipipi sewa.

IHERI HOTS RA YENANAP (LARGE REEF FISH):

Ira pohow ma hariyenap, ma matirai ra harafitemaru. Ifiri yah mengimeng nga ha taihatosuh ma yebe harafitamarutohu ba Hotsarihie yerap sewa hotsor. Ihakayer ma hamengi nga etawasi ifiri sairoh uruteri hari (overfishing). Ira mami ma yetuhuri who. Ngaiaka masuh ma wororum, ma metesa, ma moru, ma bara paur iheri hots ra yepatsihitsih ra etuhuri pipi.

WORU (SEA TURTLE):

Ira woru ra etsuhur habito tsahai iwor piyeri Hotsarihie. Ififri saiye nga maka scientist hahekene morori teheri seih ma rimaru (15) woru ra ebita tsahai. Ifiriyah meyamei nga hamengimeng nga worukaye hebita tsahai retiperi ma seihetuh bong (10 days period). Bara sew ra ifiri meyah tutu nga hasohu ba yewoh hasamaru haye huhemar woru ma hatsab ma hahekene retiperi sew tsikang yaheyaf.

HOHOR MA FASARI HOTS (GENERAL CORAL REEF HEALTH):

Ifir yah meyamei nga maka scientist hasohu ba yewoh ma hanahari meseri hots ra yetowasi ifiri betsitetiwe yefauhuyehi retiperi masirapawe sahangas ma tiwebuhuh ma tiweih ma fisu esara tohongari sahangasi ma tiwebuhuh ma tiweih ma waru (1997-98). Me titn towasiri tet ra yebuhou titin iran reportawe yefauhuyehi ifiri fitehiwe yefauhuyehi retiperi haworouweri mahamri sahangasi ma tiwebuhuh ma tiweih ma tiwou (August, 1999). Ifiri yah meyamei nga iyaka rengit ma hotsopohung ma hotsobehih ma yemeseraho ifiri taemeye yewoh betsi teti. Nga iyakara hotsonap ma hotsofaruh yetaitowasi nga yenah ba yetsuhuri fas. Ifiri yah meyamei nga yewoh hanahari ma yemouri barafas tafari hots. Mere hehakene ma ifiri hotsori matariparaparari hara iyouh ra yefas sewa rengitir ma hotsopohung ma hotsobahih. Maka scientist hamengimeng nga ira ma tsapir ma harafitemar ihe meihara maifiriwe sahangasi ma tiwebuhuh ma tiweih ma huwou (1992), ra banatsahu ba betsitetiwe yefauhuyehi yeriyaroh hots esa tohoroh imar ma hani ihe.

YAH TSORI FORUH MENGIMENGIR PIHEIMAR (COMMUNITY BASED MONITORING PROGRAM):

Tsori foruh hangutahei ba habe piheimaruh Hotsaihie. Nga saira tsori Hatohobei maka habe meyahini yereri fitehiye (monitoring program). Maka sibe piheimaruh ra hie, summum, periperi, woru, hatsab, ma ihenap. Fitehiye (monitoring program) yetsuh ma yebe tapangihits tsori foruh ba ebetsuh ma sibe meyahi nga sihura fauhuri maka si piheimarun uruteri hari (over time).

HASUBUTAHERI GIS (MAPPING AND GEOGRAPHIC INFORMATION SYSTEM [GIS]):

Ifiri fitehiye nga ewoh tsori tsitsiri motsoh (Palau Bureau of Lands and Survey) ra hapuhuhotuh maka scientist hasa yapaharin hotsori Hotsarihie ba ira ma yeraumir ba neniyeri kau ma fitehir piheimar. Maka tsori tsitsir motsoh ma tsori State ma tsori foruh hatapatap fengani ifiri fitehiyer. Meihara hotsoka hamour tsirin yerau miretuh ba meni haburataheri marine-focused GIS ra yabe tapangihits ifiri yerari pihemanu Hotsarihie. Me fauhur titin fitehiye (report) ra yebe bira iyohoih tsori foruh ma maka scientist ma maka hei meyameyari hots, ma yebe miretuh iran yari State fael.

YAH SCIENTIST MENGIMENG NIHATAINGEHIR PIHEIMAR (MANAGEMENT RECOMMENDATION):

Maka scientist ha mengimeng nga yats State Government yebetabei maka huwou fauhumir:

1. State Government yebe hasubu mengimengir piheimar ra yebetsuh ma yebe hatoharoh maka hei hatowasi ma maka hei seiroh; yesa fauhu faraur hohor Hotsarihie ra yebemoh iyohoih tsori Hatohobei. Bar sew ra hasoh ba ma yerar ma yebesub fauhur piheimar iwori Hotsarihie ra yebe pou titin meterahi.

2. Yebarawoh scientist ra yebara bituh retiperi soruw haye rimouw masirap (3 –5 years) hasabara yapie fitehiye yemouru fauhuyehi meihara. Nga iyaka tsori foruh hapoupori ma habe tsepiyatsahu yah meyahi ma ha metarahi (monitor) Hotsarihie meihara esaraho. Lyer me yetoh maiareng hafatitini pepaye ma maka yah scientist fitehi.

Translated by Marcus Hangaripaii

EXECUTIVE SUMMARY

Helen Reef is a major resource for the Hatohobei (Tobi) people of Palau due to its abundant marine life (particularly giant clams, trochus, sea cucumbers, turtles, seabirds, and large reef fishes). It is internationally renowned because of its unique geographic location, high number of species, and relatively pristine condition. This atoll is isolated from the rest of Palau, and is closer to other countries (e.g., Indonesia, 160 kms) than it is to the capital, Koror (600 kms). Therefore, it is difficult to protect and has been heavily poached by foreign fishing boats.

The Hatohobeian people, the Hatohobei State Government, and others are concerned with the loss of the valuable marine resources at Helen Reef. Therefore, the State assembled an international team of scientific experts to visit the area from April 24 to May 3, 2000, in order to:

1. Establish a baseline monitoring program and conduct a scientific survey to assess the current status of the marine resources and the health of the coral reefs;

2. Test the piloting of a community monitoring program for these resources; and

3. Provide recommendations on the future management of this important reef.

Scientific Survey

We, the scientists that traveled to Helen Reef from April 24 to May 3, 2000, conducted a survey of key resources and the general health of the reef at permanent study sites. These sites can be surveyed by the State in the future to examine possible changes over time. Our survey was conducted by counting animals during timed swims or within measured areas at a number of sites throughout the atoll.

Giant Clams

Given past reports of poaching of clams at Helen Reef, we were pleasantly surprised to find relatively high numbers of some target species of giant clams (*Tridacna derasa, Hippopus hippopus* - "*pasung*", and *T. maxima/squamosa*). Unfortunately, we found very few of the largest species (*T. gigas* - "*hie*"). The smallest species (*T. crocea* - "*haputsuhur*"), which is not generally harvested, was common at all sites surveyed.

Trochus and Sea Cucumbers

Trochus species have been seriously depleted at all sites surveyed, including traditional harvesting grounds. Only a few individuals were found during many hours of searching by both scientists and members of the Hatohobeian community. Large species of sea cucumbers of commercial value were present, but in low numbers.

Large, Economically Valuable Reef Fishes

Sharks and groupers were present only in relatively low numbers, which would not be expected in such a remote location, unless harvest pressures were present sometime in the past. In contrast, napoleon wrasse and bumphead parrotfish were relatively abundant. All of these species are vulnerable to rapid depletion through overfishing. Populations of herbivorous fishes (especially parrotfish and surgeonfish) and some carnivores (e.g., snappers) were large.

Sea Turtles

Green sea turtles are still use Helen Island as a nesting site in relatively high numbers. Over a 10 day period, there was evidence of 15 nesting turtles. Rats were noted on the islands. Roughly two to three sea turtles, of both green and hawksbill species, were seen on almost every one-hour dive.

Biodiversity List Updates and General Reef Health

Updates of fish and coral species lists occurred as a result of this survey. The number of fish species now reported for Helen Reef is currently 530, including an undescribed *Epibulus* species, contributing to an increase of 42 species from the 1992 surveys. Fewer species of fish were seen than in the 1992 survey, possibly because the death of corals during the bleaching event led to a decrease in available food and shelter.

Helen’s hard coral species list has increased to 272 species, including two previously undescribed *Psammocora* (Siderastreidae) species. There were some obvious effects of the 1997-98 coral-bleaching event, first reported in the August 1999 survey (Weng and Guilbeaux, 2000). Most of the large staghorn, table and soft corals died in this event; furthermore, there was a complete absence of nine (9) *Acropora* corals that were relatively common in 1992. However, many of the large, slow growing massive corals survived, and areas of the lagoon were not as conspicuously affected by the bleaching event. Generally, the western outer slopes supported the highest number of *Acropora* recruits and indicates that these slopes will recover their *Acropora* density and coverage relatively rapidly. In contrast, the outer eastern slopes supported fewer *Acropora* recruits, but abundant *Pocillopora* recruits.

In terms of other concerns, shipwrecks on the atoll continue to add iron nutrients to the water column, promoting smothering alga growth in limited, down-current areas; and rats were present on the islands, which may be having an adverse affect on sea bird populations.

Community-Based Monitoring Program

Components of a community-based monitoring program were piloted in coordination with the scientific monitoring program. The purpose of such a community based program would be to allow the Hatohobeian people to monitor the resources of principle concern to them using useful, but non-technical methods. Species of concern that have been identified by the community include giant clams, trochus, sea cucumbers, turtles, large fishes, and sea birds. This program when fully developed can assist the Hatohobei community keep track of key valued marine resources in a systematic, standardized way over time using methods that are not overly difficult.

Mapping and Geographic Information System (GIS) Development

In order to map survey features of the reef and establish a data base that can store monitoring information about Helen Reef over time, team of surveyors and GIS specialists begin collecting information related to monitoring stations and geographic features of Helen Reef. This information will be used to produce computerized maps of the monitoring activities and be incorporated the development of a marine GIS system for Helen Reef.

Management Recommendations

The scientific team has the following suggestions for the Hatohobei State Government:

1. That the State, with its partners, strive to develop and implement an effective management strategy that will prevent poaching impacts and ensure the sustainable use of Helen Reef by the Hatohobeian people. The success of this management plan will depend largely on effective enforcement and inter-agency cooperation, as well as community support and involvement. Different levels of protection within a locally managed marine area framework were discussed with community leaders.

2. That a scientific survey of Helen Reef should be conducted every 3-5 years based on similar methods developed in this expedition. Scientific investigation of reef organisms, communities, and processes should be promoted as resources allow. Invitations for the Palau International Coral Reef Center and other scientists to join or initiate scientific monitoring at Helen Reef should continue.

3. On-going project and community-based monitoring and review of marine resources, organized and coordinated by the Hatohobei State Government, should be conducted on an one (1) to two (2) year basis or when opportunities allow. These community-oriented activities should include general surveys of the species or variables of concern.

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1 INTRODUCTION

Helen Reef in the Southwest Islands of Palau is the one of the greatest marine assets of the Hatohobei (Tobi) People and of the Republic of Palau. Helen Reef is known as one of the most biologically diverse coral reef atolls in the Pacific and historically one of the most biologically abundant reefs in Palau, including acclaimed populations of plentiful marine resources including, trochus, turtles, sea cucumbers, seabirds, and many large reef fish. Reflected in its traditional Hatohobeian name *Hotsarihie*, which signifies "Reef of the Giant Clam", Helen Reef is perhaps most famous in the region for its once ubiquitous giant clams, and unfortunately the unchecked foreign poaching that has occurred there over the past decades. The richness and abundance of the atoll's resources are factors of its location, being remote from human populations and bordering the biodiverse marine eco-regions of Melanesia and SE Asia. The cumulative characteristics of the atoll have attracted many users over time including subsistence fishers from Hatohobei and neighboring islands, sea-faring traders, local businesses interests, and foreign commercial resource operations. The remoteness of Helen Reef which contributes to its historical levels of resource abundance is also a underlying cause for recent resource declines, as the atoll is usually uninhabited and has been notably vulnerable to poaching for the last half century by foreign fishermen from Asian countries. Over time, it is suspected that these combined uses and threats have effected many of the reefs resources, including depleting commercially valuable stocks, removing or reducing top predators (large fish and sharks), reducing in number many threatened populations, and using destructive fishing methods (such as blast and cyanide fishing). These apparent impacts, along with recent coral bleaching episodes occurring in 1997-98 in the region, has raised concerns among community members, resource managers, conservationists, and scientists about the status and condition of marine resources at Helen Reef.

To address these concerns, the Hatohobei State Government is considering strategies and options for protecting this important area in the future including establishing a special managed area (e.g., Marine Protected Area [MPA]) or using alternative resource management strategies (e.g., replenishment of clam populations through restocking from cultured stocks). In order to obtain a more informed basis for decisions, the Hatohobei State Government, the Community Conservation Network, and other supporting agencies (such as the Palau International Coral Reef Center, the Palau Division of Marine Resources) are assisting with the development of a scientific and community marine resource monitoring program at Helen Reef and in Palau. This monitoring effort and successive versions that evolve, it is hoped, will provide information to the State and other National programs concerning the status of marine resources and influence of some of its management activities. The Hatohobei State Government obtained funding from the Palau National Congress (OEK) and other sources to conduct the monitoring baseline presented in this report. The specific objectives were identified:

- To produce recommendations on the design of a comprehensive, long-term monitoring program for Hatohobei State that includes both scientific level and community oriented monitoring methods and protocols appropriate for the logistical, biological, and social contexts of Helen Reef and the State.
- To provide the State with a report on the status of key biological elements of particular concern and of the general ecosystem condition at Helen Reef.

- To build the capacity of the State and community through appropriate exposure to, education of, and training in monitoring techniques that can enhance community resource monitoring activities at Helen Reef.
- To furnish the State with general and specific management recommendations, procedures, or actions that may serve to improve the management, use, and conservation of marine resources at Helen Reef, especially as related to Marine Protected Area development.

In order to accomplish these specific objectives, the Hatohobeian State Government assembled a team of scientists and conservation practitioners to design and implement a monitoring program for Helen Reef. A first step in this process was a meeting between the scientists and representatives of the community (held April 23th, 2000) to identify their concerns regarding Helen Reef and how the scientists may be able to help them address these concerns. The meeting was facilitated and translated by Governor Crispin Emilio. The advice and concerns of the community were recorded so they could be used as the basis for designing the first phases of the monitoring program.

The primary concern of the community was that they had lost most of the marine resources of Helen Reef through poaching and that they are asking for assistance to find a way to protect these resources. The resources identified as of particular concern were:

- Trochus
- Sea turtles
- Giant clams
- Sea Cucumbers
- Large Fish, especially Napoleon Wrasse, Grouper, and Parrot Fish
- Seabirds.

With respect to each of these resources, the Hatohobei community wished to know:

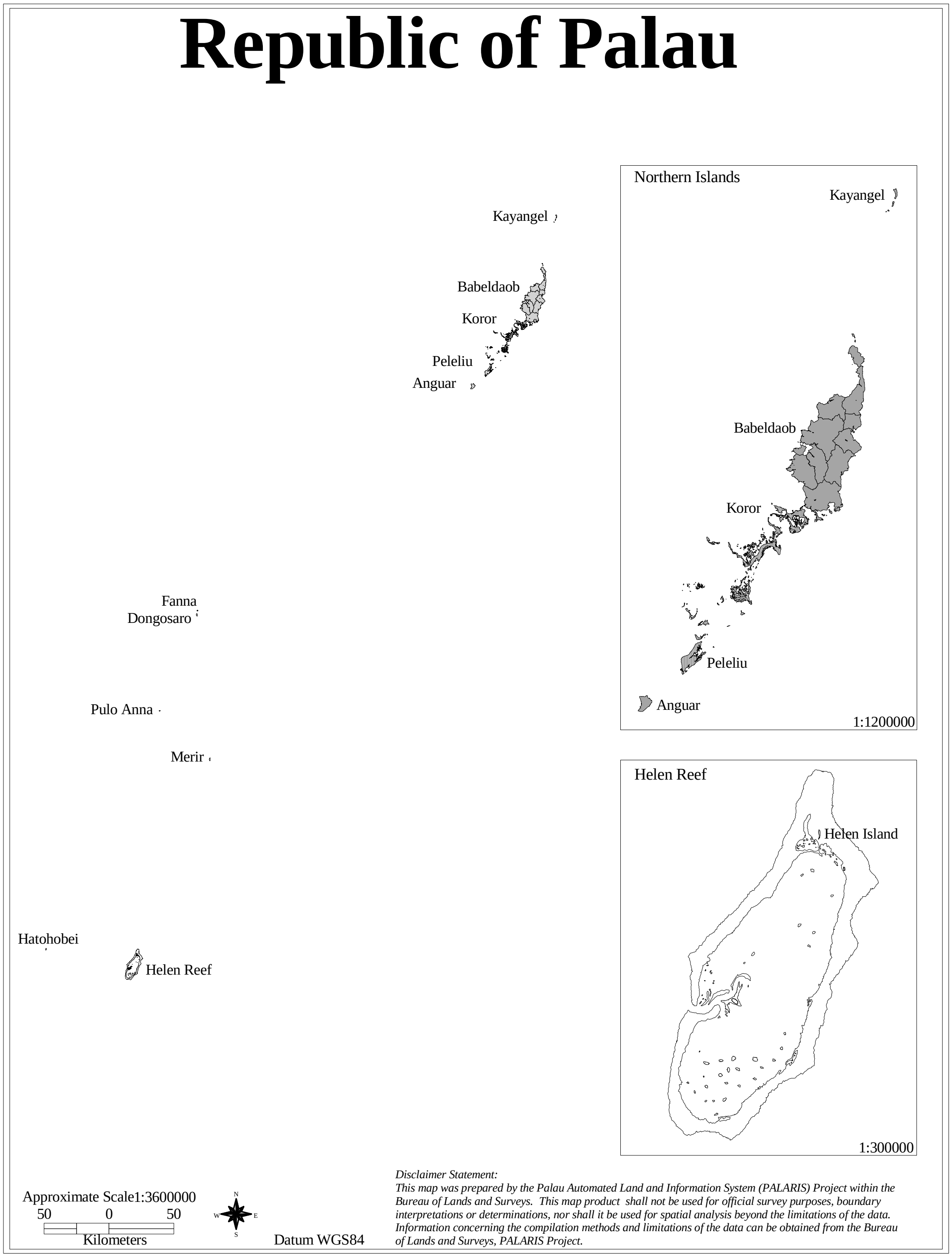
- How much do they have left?
- Where are they?
- How vulnerable are they? And how can they be better managed?

2 METHODS

2.1 Description of Study Area

Helen Reef is located in the Southwest Islands of Palau (Map 1: 3^{o}N 131^{o}E), which are closer to the islands of Indonesia and the Philippines than the capital in Koror. Helen Reef is a large atoll, approx. 24 kms long and 10 kms wide, and 162km^2 in area. The atoll's long axis extends north-south. Indications from the Hatohobei community are that prevailing wind conditions tend to originate from the southeast, making the eastern side windward and the western side leeward.

Map 1. Map of the Republic of Palau (prepared by the Palau Bureau of Lands and Surveys) showing the location of Helen Reef.



2.2 Description of Habitat Types

The reef profile at Helen Reef can be divided into six easily recognized habitat types, which vary in terms of their geophysical characteristics. The *outer reef slope* is located on the seaward side of the reef, and consists of an irregular and often steep slope. Above the outer reef slope, the *reef crest* is a sharp (or in some places gradual) break in slope at seaward margin or edge of a reef flat. The *reef flat* is unconsolidated substratum that is exposed during spring tides. The *lagoon* is almost entirely enclosed by the reef flat (Map 2), except for a deep, wide *channel* on the western side which permanently connects the lagoon to the open ocean. The *inner reef slope* extends from the reef flat down to the lagoon floor. Several *patch reefs* are located in the lagoon, mostly in the south. Wave exposure is low in lagoonal habitats, and high on the outer reef slope and reef flat, particularly on the windward side. A small coral cay with vegetation is located proximate to the northern reef flat area.

2.3 Overall Design of Monitoring Program

En route to Helen Reef aboard the Atoll Way, the scientific team and Hatohobei representatives consulted with each other to plan for the design of a monitoring program that would:

- Focus on monitoring both the marine resources identified as of particular importance to the community, as well as more general measures of ecosystem condition identified by scientific experts;
- Provide a scientifically rigorous baseline database for the long term monitoring of the marine resources at Helen Reef;
- Provide an overall sampling design that would incorporate factors likely to be of importance sources of variation around the atoll (habitat type and exposure), as well as allow for including previously studied sites and monitoring methods that could be used by community members in future surveys;
- Where possible, providing an historical perspective by repeating surveys previously conducted at Helen Reef; and
- To the degree possible, assist with the development a community monitoring program that is complimentary to a scientific monitoring program.

The survey team was then divided into four sub-teams who were responsible for the design and implementation of the monitoring programs for each of the major resources (Table 1).

Table 1. Summary of Survey Design and Teams.

Taxa/Focus	Team	Major Objectives
Invertebrates	L. Kirkendale	Repeat historic giant clam (Hester and Jones 1974, Bryan and McConnell 1976, Hirschberger 1980) and trochus (Maragos *et al*. 1994) surveys with adapted methodology
	R. van Woesik	Repeat of 1992 coral community survey (Maragos 1994) & updated species list
	C. Birkeland, R. van Woesik, L. Kirkendale	Establish new quantitative baseline surveys of giant clams, trochus, sea cucumbers and coral communities
	L. Kirkendale	Comparison of community survey methods for giant clams, trochus, and sea cucumbers with stratified scientific survey
Reef Fishes	T. Donaldson, R. Myers	Repeat of 1992 reef fish diversity survey (Donaldson 1993) & update of species list
	A. Green	Establish new quantitative baseline survey of reef fish communities, including large, vulnerable species
	T. Donaldson, A. Green	Monitor grouper spawning aggregations
Sea Turtles	J. Mangel, D. Emilio	Repeat Geermans (1993) census of turtle nesting activity on island Collect information on and recommend methods for swimming turtles observed throughout the atoll.
Community Monitoring Program Pilot	K. Weng, D. Emilio, and M. Guilbeaux.	Develop practical, repeatable community monitoring methods that may compliment a scientific monitoring program
Resource and Station Mapping	Kelly Raleigh-Otobed and other staff of the Palau Bureau of Lands and Survey	Establish and maintain a GPS Base Station on Helen Island. Support monitoring teams in the field with roving GPS units.

2.4 Location of Marine Survey Sites

2.4.1 Quantitative Baseline Survey Sites for Fishes, Corals, and Macroinvertebrates

The study sites for the quantitative sampling program were selected with three goals in mind:

- to include sites identified as important to the Hatohobei people,
- to encompass the variety of exposures around the island (northeast, northwest, southeast, and southwest sides), and
- to overlap as much as possible with the sites used in the 1992 Rapid Ecological Assessment (REA) by the Division of Marine Resources and The Nature Conservancy (see Maragos *et al*. 1994) and other previous surveys on trochus, giant clams, and sea cucumbers (see invertebrate surveys for methodology and additional sites).

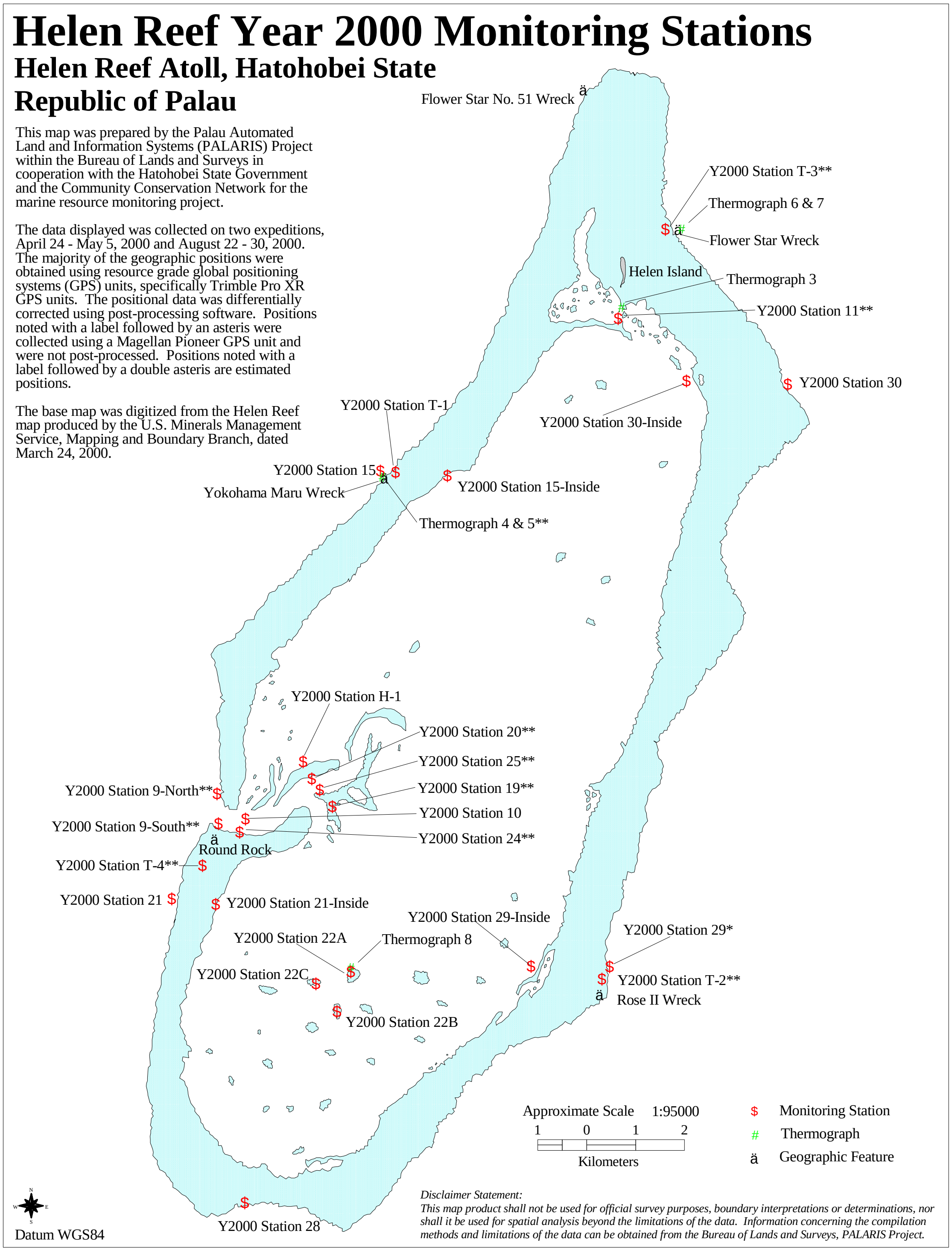
For consistency, sites selected for the 2000 quantitative survey that were in the general vicinity of the Maragos *et al*. (1994) sites were crossed referenced to those site numbers (Table 2). In some cases existing site names were modified and/or their area of coverage broadened for simplicity sake and to reflect the expanded spatial coverage and the balanced nature of the quantitative survey's coverage (*e.g*. 1992 sites “15” and “16” became identified in 2000 as site “15/16” and, more precisely, “15 outside”, “15 reef flat”, and “15 inside”). The location of each 2000 study site, the corresponding 1992 site number (from Maragos *et al*. 1994), the description of the site, and its GPS recordings[1] are summarized in Table 2 and represented as “Stations” in Map 2.

[1] GPS readings during this expedition were taken with two classes of GPS receivers: the Palau Bureau of Lands and Surveys (BLS) team used Trimble “resource grade” receivers, while the marine resource monitoring team operated a Magellan consumer grade unit, in this case the Magellan "Pioneer" GPS model. All GPS coordinates cited in this report originate from the consumer handheld GPS unit; the coordinates recorded by the BLS will be reported on elsewhere.

Table 2. Location of Study Sites for Quantitative Survey Design Combined for Fishes, Corals, and Macroinvertebrates.

Location	Site #	General Description	Standard Handheld GPS Reading
Northeast	30(/18)	(a) Transects on the outer reef slope started approximately 250 m north of the point were Site 30 was located and ran in a southerly direction. (c) Transects on the inner reef slope commenced at approximately the same latitude (in the vicinity of 1992 Site 18) and ran in a southerly direction.	2° 57.13' N; 131° 50.54' E 2° 57.17' N; 131° 49.44' E
Southeast	29	(a) Transects on the outer reef slope started approximately 250 m north of the point were 1992 Site 29 was located and ran in a southerly direction. (c) Transects on the inner reef slope were done on the lagoon side of a bar reef parallel to the inner reef slope north of 1992 Site 23 and ran in a southerly direction.	2° 50.72' N; 131° 48.58' E 2° 50.70' N; 131° 47.72' E
Northwest	15(/16)	(a) Transects on the outer reef slope started directly adjacent to the stern of the big shipwreck on the NW side and ran in a northerly direction. (b) Transects on the reef flat started approx 150m from the wreck where the two upright stern masts lined up forming a line perpendicular to the long axis of the ship and ran in a northerly direction. (c) Transects on the inner reef slope also commenced where the two upright stern masts lined up forming a line perpendicular to the long axis of the ship and ran in a southerly direction.	2° 56.17' N; 131° 46.05' E 2° 56.20' N; 131° 46.24' E 2° 56.12' N; 131° 46.79' E
Southwest	21	(a) There were no obvious reef features at this site. Transects on the outer reef slope commenced at the GPS location and proceeded in a northerly direction. (b) Transects on the reef flat were located approximately 150m from the outer reef slope site. To avoid large expanses of sand flat, one transect ran in a northerly direction and the remaining four ran in a southerly direction. An additional macroinvertebrate survey was conducted nearer to the outer reef slope from this area in a depth of 2m. (c) Transects on the inner reef slope commenced directly across from the outer reef slope site.	2° 51.46' N; 131° 43.75' E n/a 2° 51.40' N; 131° 44.24' E
Patch reefs	22	Three patch reefs were surveyed on the reef slope for both fish, corals and macroinvertebrates: (a) Site 22a (P22 in figures) – 1 transect on east side (b) Site 22b (P2 in figures) – 2 transects on east side (c) Site 22c (P3 in figures) – 2 transects on east side	 2° 50.66' N; 131° 45.73' E 2° 50.22' N; 131° 45.57' E 2° 50.53' N; 131° 45.35' E

Map 2. Year 2000 Helen Reef Monitoring Stations. Prepared by the Palau Bureau of Lands and Surveys.



2.4.2 Study Sites for Repeat of 1992 Survey

Many of the study sites surveyed by Maragos *et al*. (1994) in 1992 were resurveyed, although some were not because they were incompatible with the present baseline survey and there was insufficient time (8 field days) to do them all (Table 3). Some additional surveys were added to compliment the baseline survey (*i.e.*, to include areas where no quantitative data was available). For future reference, their geographical location was recorded using a handheld GPS.

Table 3. Summary of 1992 Southwest Island Rapid Ecological Assessment Survey Sites (from Maragos *et al*. 1994) Repeated in 2000.

2000 Site Name	1992 Site Name	Fish	Macro-invertebrates	Benthic Videos	Coral Recruitment	2000 Handheld GPS Reading
9 North	9	X	X	X	X	2^o 50.53' N; 131^o 45.35' E
10	10	X	-	-	-	-
11	Near 11[2]	X	-	-	X	2^o 58.11' N; 131^o 48.75' E
	12	-	-	-	-	-
	13	-	-	-	-	-
	14	-	-	-	-	-
15 inside	15/16[3]	X	X	X	X	2^o 56.12' N; 131^o 46.79' E
	17	-	-	-	-	-
19	19	X	-	-	-	-
20	20	X	-	-	-	-
21 inside	21	X	X	X	-	2^o 51.40' N; 131^o 44.24' E
21 (outside)	-	X	X	X	X	2^o 51.46' N; 131^o 43.75' E
22a 22b 22c[4]	22 (expanded to include 3 patch reefs)	X	X	X	-	22a: 2^o 50.66' N;131^o 45.73' E 22b: 2^o 50.22' N;131^o 45.57' E 22c: 2^o 50.53' N;131^o 45.35' E
	23	-	-	-	-	-
24	24	X	-	-	-	-
25	25	X	-	X	-	-
	26[2]	-	-	-	-	-
	27	-	-	-	-	-
28	28	X	-	-	-	2^o 48.08' N; 131^o 44.56' E
29 (outside)	29	X	X	X	X	2^o 50.72' N; 131^o 48.58' E
29 inside	-	X	X	X	X	2^o 50.70' N; 131^o 47.72' E
30 (outside)	30	X	X	X	X	2^o 57.13' N; 131^o 50.54' E
30 inside	18	X	X	X	-	2^o 57.17' N; 131^o 49.44' E

[2] The survey team believes that Site 26 was incorrectly marked on the 1992 map (Maragos 1994), and was actually slightly east of the 1992 Site 11.
[3] For the 2000 surveys, the 1992 sites of 15 and 16 (Maragos 1994) were lumped together and the cross reef area collectively identified as site 15, site 15/16, and site "15 inside", "15 reef flat", and "15 outside".
[4] In Figures 1-5, Sites 22a, 22b, and 22c are reported as P22, P2, and P3 respectively.

2.5 Scientific Survey Methods

2.5.1 Marine Invertebrates

Charles Birkeland, Rob van Woesik, and Lisa Kirkendale

A number of methods were used to assess invertebrates on Helen Reef, including qualitative and quantitative protocols.

2.5.1.1 Repeat of the 1992 REA Coral Survey

In order to obtain some estimates of change to the coral communities between 1992 and 2000, slight modifications were made to techniques used in the 1992 Southwest Islands REA coral survey technique (Maragos 1993). While the 1992 REA made estimates of relative coral abundance between the reef crest and 20 m, using 30-minute SCUBA swims, the 2000 survey made attempts to stratify the data using quantitative recording techniques. In 1992, in order to estimate relative-coral abundance, Maragos's DACOR method was used (DACOR is an acronym defining the categorization of each coral observed as dominant, abundant, common, occasional or rare). Maragos (1992) also recorded a 2-10 minute underwater video, and estimated the percentage-live-coral cover at each site. In 2000, however, we attempted to quantitatively estimate these variables using digital video and the point-intercept method, which are outlined below.

2.5.1.2 Year 2000 Quantitative Baseline Survey (Corals and Other Macro-invertebrates)

Corals were quantitatively surveyed using two techniques, the "point-quarter" method and video transects using a point-intercept method, to estimate living coral cover, abundance, diversity, size distribution, frequency, and dominance.

Coral communities at 5 sites (9 north, 15 outside, 21 outside, 29 outside, 30 outside) were quantitatively surveyed using the plotless point-quarter method at 3 m depths consistently, and at 8 meter depths as logistics allowed. The method is described in detail in Brower and Zar 1984, UNESCO 1984, and Birkeland and Lucas 1990. Abundance was assessed by measuring the average distance from random points to the center of the nearest colonies.

Digital-video transects were also taken to obtain a permanent record of the quantitative study sites (Table 2) along each of five (5) replicate 50 m transects at 3 and 10 m depths at outer and inner reef slopes, and when practical on reef flats (e.g., H-1,) and other locations (e.g., 9 South and 25). The 3 m transects were the same as those used for the invertebrate surveys and the 10 m transects were those used for the fish surveys (see below). The video images were taken, consistently, following the contour of the substrate at approximately 0.6 to 0.8 m above the bottom. Preliminary quantitative video sampling was undertaken at 11 sites (presented in pairs where applicable): Sites 9 South; 15 inside lagoon and 15 outside; 21 inside lagoon and 21 outside; 22 (lagoon patch reefs); 25; 29 inside lagoon and 29 outside; and, 30 inside lagoon and 30 outside. Copies of these videos were provided to the Palau International Coral Reef Center in Koror, Palau and it is recommended that additional copies be given to the Hatohobei State Government. In order to obtain some preliminary approximate estimates of coral cover, the video images were skimmed and not systematically analyzed; more thorough analyses are recommended for future comparisons (see Carlton and Done 1995 or GCRMN for possible methods of systematic analysis).

Macroinvertebrates, including giant clams, *Trochus* spp. and holothurians (sea cucumbers), were surveyed using two methods: transects in general, and in some instances, timed swims. Macroinvertebrates were recorded along five replicate 50 m x 2 m belt transects on the inner and outer reef slopes at 3 m, and on the reef flat at <1 m at all quantitative monitoring sites (15, 21, 29, 30). For recording purposes, each belt was partitioned into 10-m intervals. Patch reefs (Sites 22b and 22c) and some reef flat habitats (Sites T-1[15] and T-3) were surveyed using timed swims and transects. Timed swims, as reported here and in the community monitoring section, involved an individual counting macroinvertebrates on either side of the field of vision for 3-4 replicate 10 minute swims at patch reef flats (<1 m depth; 4 m width of vision) and patch reef slopes (10 – 15 m depth, 10 m width of vision). Each taxa was identified to the finest taxonomic level possible, and allocated to a size class, which varied depending on the group surveyed (e.g., 1-5, 6-10, 11-15, 16-20 and >20 cm for giant clams). Other invertebrate taxa encountered were also recorded.

2.5.1.3 Repeat of Historic Macroinvertebrate Surveys and Additional Sites

Additional sites were surveyed with transects for macroinvertebrates and at some sites, corals, in an attempt to 1) revisit previously surveyed areas, and/or 2) to assess areas important to the community (Table 4).

Table 4. Additional Transects Sites for Quantitative Invertebrate Survey.

Location	**Site number**	**Taxa surveyed**	**General Description**	**Handheld GPS Reading**
Northwest	Site H-1 (Hester & Jones 1972)	Macroinvertebrates and corals (video, description)	Channel patch reef flat, <1 m	2° 53.36’ N; 131° 52.57’ E
Northwest	Site 9 North (Maragos *et al*. 1994)	Macroinvertebrates and corals (point-quarter)	Outer reef slope, 3 m	2° 50.53’ N; 131° 45.35’ E
Northeast	T-3, Adjacent to Flower Star Wreck, *Trochus* harvesting grounds	Macroinvertebrates	Reef flat, <1 m	2° 58.77’ N; 131° 49.23’ E
Southwest	Site 21 (Maragos *et al*. 1994)	Macroinvertebrates	Shallow outer reef slope, 2 m	2° 51.46’ N; 131° 43.75’ E
Southeast	T-2 (Rose II wreck), Trochus harvesting ground	Macroinvertebrates	<1-0 m, walking	n/a[5]

[5] GPS unit unavailable.

2.5.1.4 Updating Species List

All species of macroinvertebrates and corals observed were recorded to the lowest taxa possible. This information was used to update existing species list for the atoll *(e.g.*, corals, Maragos 1993).

2.5.2 Reef Fishes

2.5.2.1 Repeat of 1992 Reef Fish Diversity Survey and Update of Species List

Terry Donaldson and Rob Myers

Assessment of reef fish biodiversity was made at each site by use of timed (15 minute intervals) visual censuses along depth gradients. Survey depths, depending upon habitat type, ranged between 1-35m. Each species observed 5m either side of an imaginary line in front of the first diver was counted once. This provided presence-absence data for each site. The second diver photographed species and made notes of species within the general area. Species were identified to the lowest possible taxon following Myers (1999) and Kuiter (1992). This information was used to update the most current fish species list for the atoll (Donaldson 1993).

Quantitative assessment of significant groups was also made. All individuals of species of significant interest were counted. These species included groupers (Serranidae: Epinephelinae), some wrasses (Labridae: *Cheilinus, Epibulus,* and *Oxycheilinus* spp.), bumphead parrotfishes, (Scaridae: *Bolbometapon muricatum*), sharks and rays, butterflyfishes (Chaetodontidae), angelfishes (Pomacanthidae), etc. Data of number of individuals observed per minute provided an estimate of relative abundance.

2.5.2.2 Quantitative Baseline Survey

Alison Green

A quantitative visual census survey was conducted using a stratified sampling design, which would provide a rigorous baseline for measuring changes in the reef fish communities at Helen Reef over time. The survey was designed to incorporate the variation in reef fishes assemblages associated with different habitat types and exposures around the atoll.

The variation associated with habitat type was examined at each of two sites on the leeward side of the island: one site north of the channel near the big shipwreck[6] (Site 15) and one site south of the channel (Site 21). At each site, reef fish were surveyed at four habitat types: outer reef slope (at 10 m depth); outer reef crest (3 m depth); reef flat (depth < 1 m); and inner reef slope (10 m depth). Other habitat types and depths were not systematically surveyed due to time constraints, although lagoon patch reefs were surveyed to a limited degree. Reef fishes were surveyed along five replicate transects in each habitat type at each site using the methods described below.

[6] Noting there may be some anomalies in comparisons of the reef habitat and communities in this area due to iron nutrients released by rusting ship metal.

Variation in reef fish communities were compared among the windward and leeward sides based on surveys of two habitat types, outer reef slope (10 m) and inner reef slope (10 m), at each of two sites on leeward, western (Site 15 and 21) and windward, eastern sides (Sites 29 and 30). These habitat types were selected for this comparison because species richness and abundance are high in both, but the species that comprise those assemblages differ (see Results).

2.5.2.2.1 Quantitative Survey Methods for Reef Fish Communities

A restricted family list was used which comprised only those families that are amenable to visual census techniques, because they are relatively large, diurnally active and conspicuous in coloration and behavior (Table 5). This method excludes species that are not amenable to the technique because they are nocturnal, very small or cryptic in behavior.

Table 5. Reef Fish Families Included in Quantitative Baseline Survey.

Sharks & Rays:
Carcharinidae (whaler or requiem sharks)
Ginglymostomatidae (nurse sharks)
Hemigaleidae (weasel sharks)
Myliobatidae (eagle rays)
Bony fishes:
Acanthuridae (surgeonfishes & unicornfishes)
Aulostomidae (trumpetfishes)
Balistidae (triggerfishes)
Caesionidae (fusiliers)
Carangidae (trevallies)
Chaetodontidae (butterflyfishes)
Diodontidae (porcupinefishes)
Ephippidae (batfishes)
Fistularidae (flutemouths)
Haemulidae (sweetlips)
Kyphosidae (drummers)
Labridae (wrasses)
Lethrinidae (emperors)
Lutjanidae (snappers)
Malacanthidae (sand tilefishes)
Monacanthidae (leatherjackets)
Mugilidae (mullets)
Mullidae (goatfishes)
Nemipteridae (coral breams)
Ostracidae (boxfishes)
Pinguipedidae (sandperches)
Pomacanthidae (angelfishes)
Pomacentridae (damselfishes)
Scaridae (parrotfishes)
Scomberidae (mackerels)
Scorpaenidae (scorpionfishes)
Serranidae (groupers)
Siganidae (rabbitfishes)
Sphyraenidae (barracudas)
Synodontidae (lizardfishes)
Tetraodontidae (puffers)
Zanclidae (moorish idol)

Reef fishes were surveyed using visual census techniques along five replicate 50 m transects within each habitat at each site. Reef flat surveys were performed when tides allowed. Transect width was 3 m for most species, with two exceptions. Damselfishes were counted along a 1 m wide belt, since they are small, very abundant and most remain closer to the substratum, so narrower transects provide more precise estimates of their abundance. Several very large species (Napoleon wrasse, bumphead parrotfish and sharks) were counted along most of the width of the reef slope (20 m wide), since they tend to be wary of divers and move away from the transect. They also tend to be less abundant, so a larger area is required to provide reasonable estimates of their abundance. Transect lengths were measured using 50 m tapes, and transect widths were measured using known body proportions for narrower transects (1-3 m) or estimated for wider distances (20 m).

Fishes were surveyed by making three passes along the transects counting different groups of families in each pass. The first count was of large, highly mobile species, which are most likely to be disturbed by the passage of a diver (such as large parrotfishes, wrasses, snappers, and emperors). This was done while an assistant followed behind laying out the tapes so that tape deployment would not disturb fish or the observer during the initial count. The tapes then remained *in situ* until all of the fish and invertebrate (see above) surveys were completed at that site. The second count was of medium sized mobile families (including most surgeonfishes, butterflyfishes and wrasses), and the third count was of small, site-attached species least disturbed by the passage of a diver (mostly damselfishes). The size of each fish (total length in cm) was estimated visually and recorded directly onto underwater paper.

Fishes were compared among locations on the basis of fish species richness and density where: fish species richness was the total number of species recorded on transects and fish density was converted to the number individuals per hectare (ha). These comparisons were made based on adult fishes only to avoid the possible influence of annual fluctuations in recruitment rates on subsequent comparisons through time. Adult fishes were defined as individuals that were more than one third of the maximum total length of each species (as recorded in Myers 1991 or Randall *et al*. 1990).

2.5.2.2.2 Quantitative Survey Methods for Large Fish Species

Some large species of reef fish that are of particular importance to the Hatohobeian people are also targeted by fishermen. These species are particularly vulnerable to overexploitation and include napoleon wrasse (*Cheilinus undulatus*), and the bumphead parrotfish *(Bolbometapon muricatum*). Previous interviews with resident Hatohobeians and others indicated that *C. undulatus* was known to be very common and tame at Helen Reef until the late 80’s and early 90s (Hatohobeian people and N. Idechong, pers. comm.). However this species is known to be targeted by the live reef fish trade which has been active in the area during the late 1980s, and low numbers were observed during recent manta tow surveys by Weng and Guilbeaux (2000). A targeted program was designed to survey napoleon wrasse and bumphead parrotfish using a more appropriate methodology, using visual surveys that employ long (timed-swim) transects covering as much reef area as possible.

These species along with another large parrotfish vulnerable to overexploitation (Pacific Steephead Parrotfish: *Chlorurus microrhinos*) were counted during the first pass of the quantitative fish baseline survey on the outer reef slopes (depth = 10 m; see above) which covered a distance of 250 m (five 50-m transects) using a width of 20m. In order to increase the area surveyed for large fish, these species were also counted during 15 minute timed swims using a width of 20 m on outer reef slopes and channel pass areas at other study sites where quantitative surveys were not conducted (depth = 6 - 10 m; n = 20). The distance covered in these timed swims had been recently calibrated as mean = 224.3 m, se = 7.29 (A. Green, unpublished data).

The counts for both techniques were then converted to a standard density (per 8,000 m^2) for comparison with densities recently recorded for these species elsewhere in the Western Pacific (Australia and Papua New Guinea).

2.5.2.3 Monitoring Grouper Spawning Aggregations

Terry Donaldson and Alison Green

Grouper spawning aggregations around the new moon have been reported on the south side of the main channel entrance (Hatohobeian people, pers. comm.). Despite the fact that these aggregations have been targeted by the live reef fish trade since the 1980s, Weng and Guilbeaux (2000) observed sizeable spawning aggregations of *Plectropomus* and *Epinephalus* species in the channel just prior to the new moon in August 1999. However, their abundance compared to historical levels is unknown (Weng and Guilbeaux 2000).

During this survey, drift dives were conducted in the channel entrance in the late afternoon/dusk on several days (5-6pm: 30 April to 2 May 2000) leading up to the new moon (4 May 2000) in order to determine if spawning aggregations were present at that time.

2.5.3 Sea Turtles

Jeff Mangel and Dominic Emilio

2.5.3.1 Turtle Nesting Monitoring Program

To monitor nesting activity of green turtles (*Chelonia mydas*) on Helen Island, hourly walks around the perimeter of the island were conducted between sunset and sunrise to survey for nesting turtles. Activities and monitoring at Helen Island followed similar procedures identified in Geermans 1994 and Guilbeaux 1996. Particular effort focused around 2 hours before and after high tide based on local information that this was the time that turtles were most likely to nest on Helen Island (Dominic Emilio, pers. comm.).

When a track was observed, the nesting turtle was located by slowly moving up the track until it was seen or heard. To minimize disturbance turtles were always approached from behind and using flashlights with red filters. Use of any lights was kept to a minimum. Examination of the turtle was begun only after the turtle had laid approximately 10 eggs or had finished nesting. In general, the examination of the turtles and turtle crawls consisted of:

2.5.3.1.1 Tagging

Turtles were tagged using monel metal flipper tags issued by the SPREP Marine Turtle Research and Conservation Program (Apia, Samoa). Each tag contains a unique identifying number and an address to which tags may be sent if recovered (tag return address: SPREP, Noumea, New Caledonia). Each turtles was tagged twice. The tag site is on the trailing edge of the front flipper directly adjacent to and inside of the large scale closest to the turtle's body. Each turtles was tagged twice, with one tag applied to each of the front flippers.

2.5.3.1.2 Size Measurements (Carapace Length)

To provide a measure of size, Curved Carapace Length (CCL) Minimum (in cm) of each turtle was measured. This was done by placing a flexible measuring tape at the front center notch of the carapace and then stretching it along the midline to the rear center notch.

2.5.3.1.3 Nesting Information

When nesting turtles were encountered, the time of nesting and location of the nest were noted. Nest location was classified as (a) open - in direct sunlight, (b) border - receiving some shade over the course of the day or (c) vegetation – not receiving direct sunlight.

2.5.3.1.4 Identifying Marks

Any features that may be useful in identifying individual turtles were also noted. These may consist of scars or injuries on the carapace or body or patterns of barnacles on the carapace.

2.5.3.1.5 Interpretation of Tracks

Not all turtles that nested on the island during the course of the trip were encountered during the nightly patrols. For those turtles not seen, track width was measure to provide an estimate of the size of the turtle. The track was also examined to determine if and where the turtle nested.

2.5.3.2 Monitoring Program for Swimming Turtles

All turtles encountered in water during the "Quantitative Baseline Survey of Reef Fish Communities" (see above) were recorded to provide some insight into the distribution and abundance of green and hawksbill turtles around the atoll. Observations of turtles by other scientists were also noted and compiled.

2.6 Community Monitoring Program

Dominic Emilio, Kevin Weng, and Michael Guilbeaux

The purpose of a community resource monitoring program is to give members of the Hatohobei community, including the Hatohobei State Government, skills and training needed to determine for themselves the levels of key resources or the condition of the habitat at Helen Reef (or other area under State management). A community monitoring program is one that is planned, designed, and undertaken largely by members of the community. In the design of such a program, it is important that the community identifies what animals and habitats it decides are important to monitor, determines the methods to be used (with assistance from outside practitioners, if so desired), and develops an overall monitoring strategy to detect change in those features, conditions, or the long-term success of a project (see Margoluis and Salafsky

1998). Through this process, the community determines which of its members are to be involved (through the creation of a local monitoring team), and can get reports directly from this team once the monitoring has been conducted. A community monitoring program allows the community to gather relevant information about their resources and project without relying exclusively on outside experts, at more frequent intervals, and with perhaps better communication of results (e.g., communication of results occurs in local languages and other forms determined by the community).

During this survey, members of the scientific team worked with members of the Hatohobei community to develop and carry out components of a pilot community monitoring program, which is presented here. It is envisioned that community monitoring activities can build and improve upon this program overtime. In this pilot program, the community members and the monitoring team decided to survey clams and trochus, two of the marine resources at Helen Reef that are of greatest concern to the Hatohobeian people. In the future, as members of the community become more familiar with monitoring approaches, activities may be expanded to cover fishes, sea cucumbers, turtles, or other resources or factors of interest to their project.

In order to sample for the number of non-moving animals (e.g., clams and trochus) there are on the reef, we used timed swims, a technique similar to the swimming or walking searches Hatohobeians use to collect trochus. Once a site with the appropriate habitat has been chosen, the observers form a line, with about 10 meters (30 feet) between each person. Then the group swims (or, on some occasions, walks) along the reef counting trochus or clams. Each person estimates the zone scanned based on visibility (mostly a factor of the persons height above the substrate) a search zone about 10 meters wide (5 meters or 15 feet to either side); because the people are 10 meters (30 feet) apart, theoretically there is no possibility for overlap between the areas that each one sees. After ten minutes, each person writes down the number of animals he has seen. After the survey is complete, the counts and area from each persons' survey are combined together, analyzed[7], summarized, and presented as results.

In order to get an idea of historical levels of resources (e.g., trochus) previously present at different times and areas at Helen Reef, members of the Hatohobei community were interviewed to provide examples of past harvesting results and effort and other anecdotal information for the estimation of densities. Trial community timed swims for trochus were conducted at Site T-1(15) on the reef flat and Site T-3 on the Northeast reef flat. Timed swims for clams were conducted at <1 m depth on the reef flats at Sites 22b and 22c. Additionally, a timed walk for surveying trochus, consisting of 8 community members and using similar methods, was conducted on the reef flat at low tide in the rubble zone,T-4, north of Site 21.

[7] To help understand how to calculate the number of trochus in an area (density) for community monitoring, the following explanation is presented. Though our tests, it has been estimated that in ten minutes, at a slow swimming speed scanning for trochus, each person covers a distance of about 100 m. Because one person searches a band about 10 m wide, the area surveyed is about 10 m x 100 m (or 1000 m2). For comparison sake, this area is slightly bigger than the size of about two (2) basketball courts (a basketball court is equivalent to 437 m2). If a person found five trochus in one ten-minute swim, the density of trochus at that spot is about five (5) trochus per 1000m2, or 5 trochus / 1000 m2, or 0.005 trochus per 1 m2. Using the basketball court example, this is the same density of five (5) trochus per three (2) basketball courts, or (by doing simple division, 5 trochus / 2 basket ball court areas) 2.5 trochus per one (1) basketball court.

3 RESULTS AND DISCUSSION

3.1 Macroinvertebrates

Lisa A. Kirkendale

3.1.1 General Remarks

Quantitative surveys, including timed swims and belt transects, were conducted at various sites at Helen Reef for invertebrate groups that are of interest to the community of Hatohobei State. These include: *Trochus niloticus*, *Tridacna* and *Hippopus* spp. of giant clams, and holothurians. Timed swims, done in 10-min intervals or replicates, were conducted to compare with transects for giant clams and topshells (e.g., trochus). If comparable to transect results, timed swims may considered as a option for an on-going community monitoring program in the future.

These three groups of macroinvertebrates (trochus, clams, and sea cucumbers), and certain species within each group, did not always overlap in habitat requirements. Every effort was made to visit areas where each group had been found in the past. As well, permanent sites for long-term monitoring were also surveyed to establish baseline estimates for these groups. This resulted in a total of four main baseline areas (30, 29, 15, 21) which were common to both the fish and coral studies, and formed the permanent, quantitative component of the study. Several additional sites were included that were recognized as 1) important to the community because they were areas that traditionally yielded high numbers of a target species (listed as Site T-x) or 2) had been surveyed at some time in the past (see methods).

Nine different sites were surveyed for giant clams, trochus, and sea cucumbers, with a total of 19 belt transects surveyed, ranging from one to four per site. At sites 30, 15, and 29, three transect areas were surveyed and they were: 1) an outer reef slope site (3 m), 2) an inner reef slope site (3 m) and 3) a reef flat site (~1-2 m). Site 21 had three transects, as outlined above, as well as an additional reef flat site (~1-2 m), which was closer to the edge of the outer reef slope than the first reef flat site. Only one transect area was surveyed at: 1) H-1 (channel reef flat site at ~1-2 m); 2) Site 9 North (3 m on the outer reef slope); 3) each of the three patch reef sites (inner reef slope-type habitats at 22a, 22b, and 22c[8] at 3 m); and the northeast reef flat site T-3 (a trochus harvesting ground at ~1-2 m). Of the 19 transects surveyed, 16 were 500 m^2 each, and those at the three (3) patch reefs at the southern end of the lagoon were 100 m^2 each. A list of other invertebrate taxa encountered during these surveys is provided in Appendix 1, Table A1.

3.1.2 Topshells-*Trochus Tectus* spp.

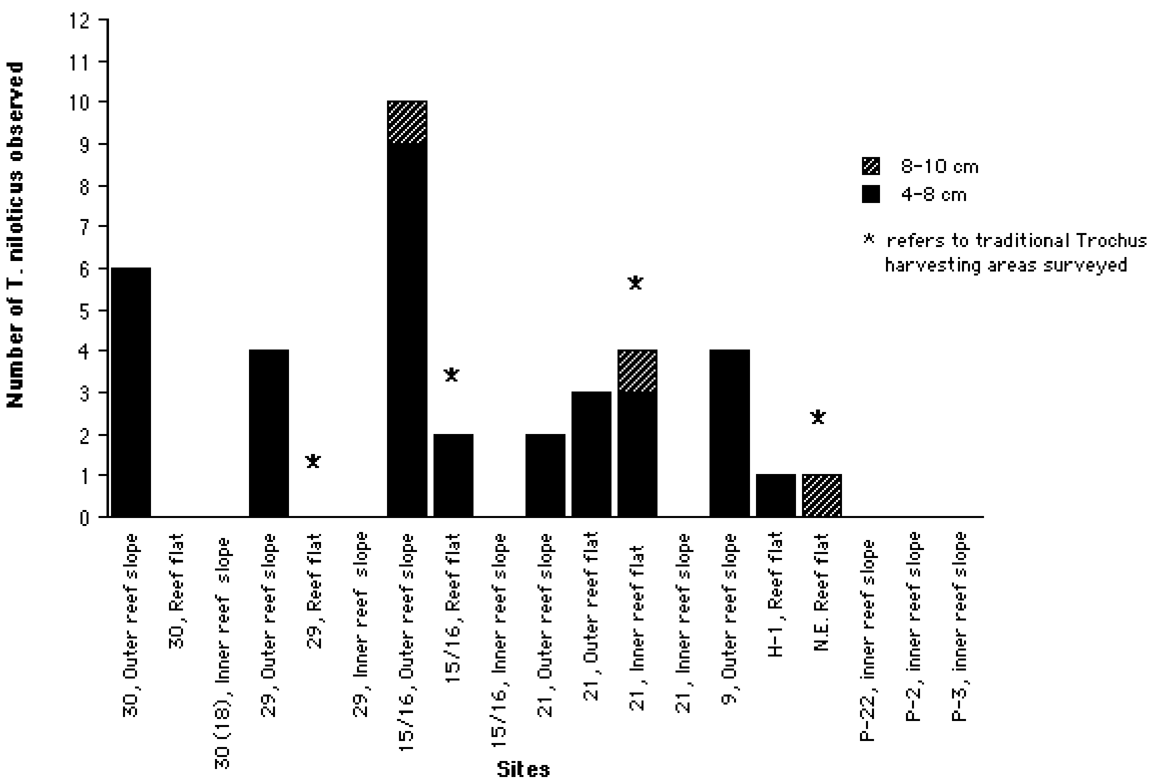
Trochus spp. were primarily surveyed by belt transects; however two timed swims – as part of the community monitoring effort – were also performed at Site T-1(15) and T-3 reef flats. (see Methods). Five species of topshells, or close relatives, were commonly observed on Helen Reef in overlapping habitats and were recorded in all surveys. These were: 1) *Trochus niloticus*, the

[8] Listed in Figures 1-5 as P22, P2, and P3 respectively.

species harvested by, and of interest to, the Hatohabeian community 2) *Tectus spp.* (both *T. pyramis* and *T. triserialis*, which are known as "false *Trochus*"), which superficially resemble *T. niloticus* but are not harvested by the community, 3) *T. maculatus*, which may be confused with juvenile *T. niloticus* but will never attain a large size, and 4) *Astralium rhodostoma*, which also may be mistaken for a juvenile of *T. niloticus*, but is a member of a different family (Turbanidae), and is not harvested by the community.

Two size classes of topshells were recorded for *Tectus pyramis* and *Trochus niloticus*. These were: 1) 4-8 cm (<3 inches), which is generally considered too small for harvesting and 2) 8-10 cm (3-4 inches), which is the approximate harvestable size (Curren 1993). Four of five indicated traditional *Trochus* harvesting grounds were surveyed with transects (surveys at Sites 15 [near T-1], 29 [T-2], by the northeast wreck [T-3], 21 [south of T-4]) and results indicate very low numbers of large *T. niloticus* (Figure 1). At one of the traditional harvesting grounds, T-2 (Site 29), no *T. niloticus* were observed. During these transects, only three (3) large individuals (> 8cm) were observed (Figure 1) at Site15 outer reef slope, Site 21 inner reef flat (south of T-4), and by the northeast wreck reef flat, T-3. Therefore, in 2000 m^2 of traditionally harvested reef flat area surveyed, only two large *T. niloticus* were observed (Figure 1).

Fig. 1. Cumulative bar graph of counts of Trochus niloticus observed on 500 m2 transects (100-m2 for P22, P2 and P3) surveyed from Apr. 26- May 02, 2000 at Helen's Reef.



The highest abundance of all species of topshells was observed at transects on the eastern side of the atoll at ~3 m (Sites 29 and 30). However, these were all small animals (~5 cm) and were primarily *T. maculatus*, a topshell that is not harvested by the community, as it never attains a large size. More large *Tectus pyramis* (the false *Trochus*, a species not utilized by the community), were observed than large *T. niloticus* (targetted species), at all sites surveyed.

It is clear that Helen Reef *Trochus niloticus* populations are extremely low at this time. Timed swim and walk data from outer reef flats at Sites T-1, T-3, and T-4 reported in the community monitoring section (see Section 3.5.1.1) also indicated very low numbers of large *T. niloticus*. Unfortunately, it is difficult to draw comparisons between timed swim and transect data, because of the extremely low number of harvestable *T. niloticus* observed. However, for estimations of large *T. niloticus* only (as juveniles of this species are more cryptic – they often live deep within the reef matrix and can often be confused with other related species) timed swims with a constant swimming speed are probably a good method for community monitoring.

Although localized extinctions have been reported in the literature (Borsa and Benzie 1996), communication with members of the community suggests that the low numbers of *T. niloticus* observed during this study are probably due, in part, to overharvesting. The highest rates of fertilization take place among dense groups of individuals, likely because high gamete concentrations are necessary for external fertilization (Borsa and Benzie 1996). No dense aggregations of adult *T. niloticus* were observed during the course of these surveys, which may affect the recovery ability of *T. niloticus*. It has also been reported that *T. niloticus* can exhibit highly variable, and localized levels of larval recruitment (Borsa and Benzie 1996).

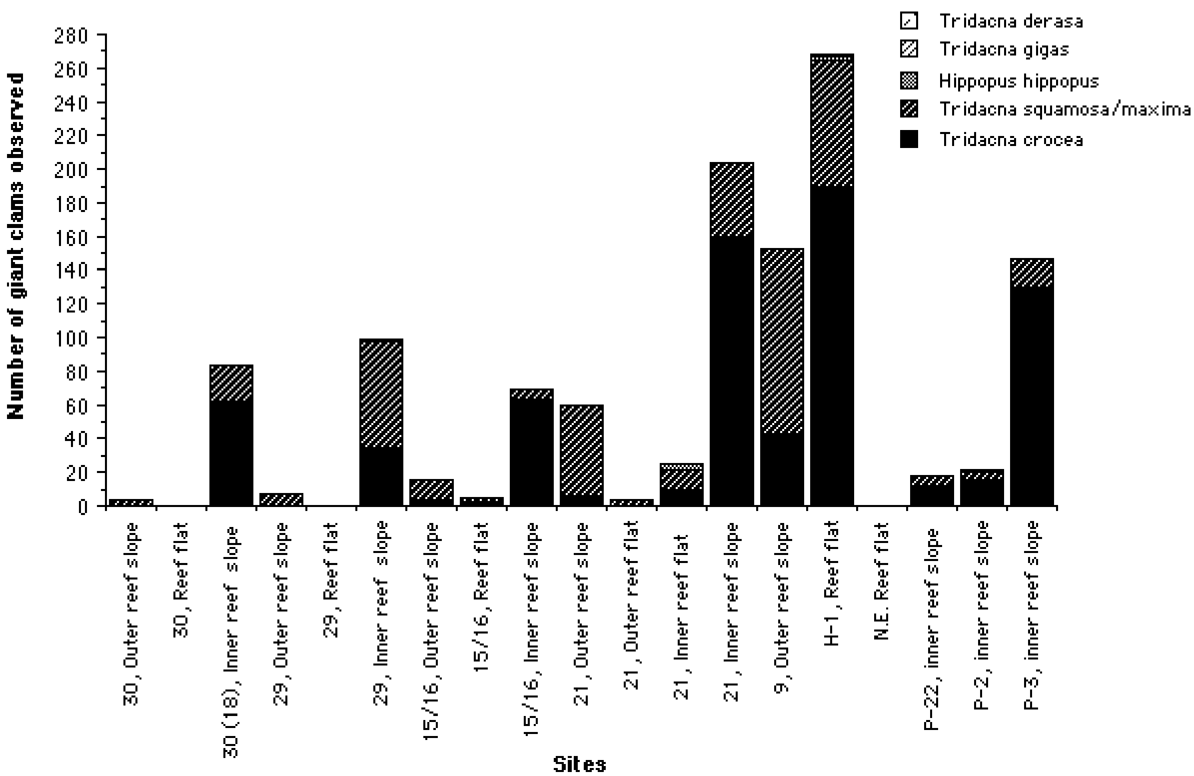
Encouragingly, it has also been found that once harvesting pressure is released, *T. niloticus* can recover relatively quickly (McGowan 1956, 1958). Their life-history, which includes a short duration in the water column (approximately 3-days), can result in patchy distributions and localized recruitment, as reported earlier, but also enables them to rapidly reseed an area. This is perhaps best documented by their remarkable proliferation following introduction throughout most of insular Polynesia and Micronesia (Smith 1987). Interestingly, the populations of *Trochus niloticus* at Helen are indigenous, which means they are native to Helen Reef (McGowan 1956). This occurs on only two other island groups in Micronesia: Yap and the Palau Islands (McGowan 1956).

3.1.3 Giant Clams (*Tridacna* and *Hippopus* species)

Six species of giant clams were surveyed, using timed swim and depth-stratified sampling methodologies, at Helen reef. These were: *Tridacna crocea*, *T. maxima*, *T. squamosa*, *Hippopus hippopus*, *T. derasa* and *T. gigas*. Because there was some question as to the identity of *T. squamosa* and *T. maxima* among smaller size classes, these two species were lumped together in this study. However, *T. squamosa* was present and in greater numbers based on counts in certain areas, compared with estimates in previous studies conducted at Helen reef (Hester and Jones 1974, Bryan and McConnell 1976, Hirschberger 1980). Problems with the transect survey technique were encountered due to patchy distributions of some large clam species of interest (especially*T. derasa*, *H. hippopus* and *T. gigas*). Therefore, in certain areas, timed swims were also conducted to better estimate these populations.

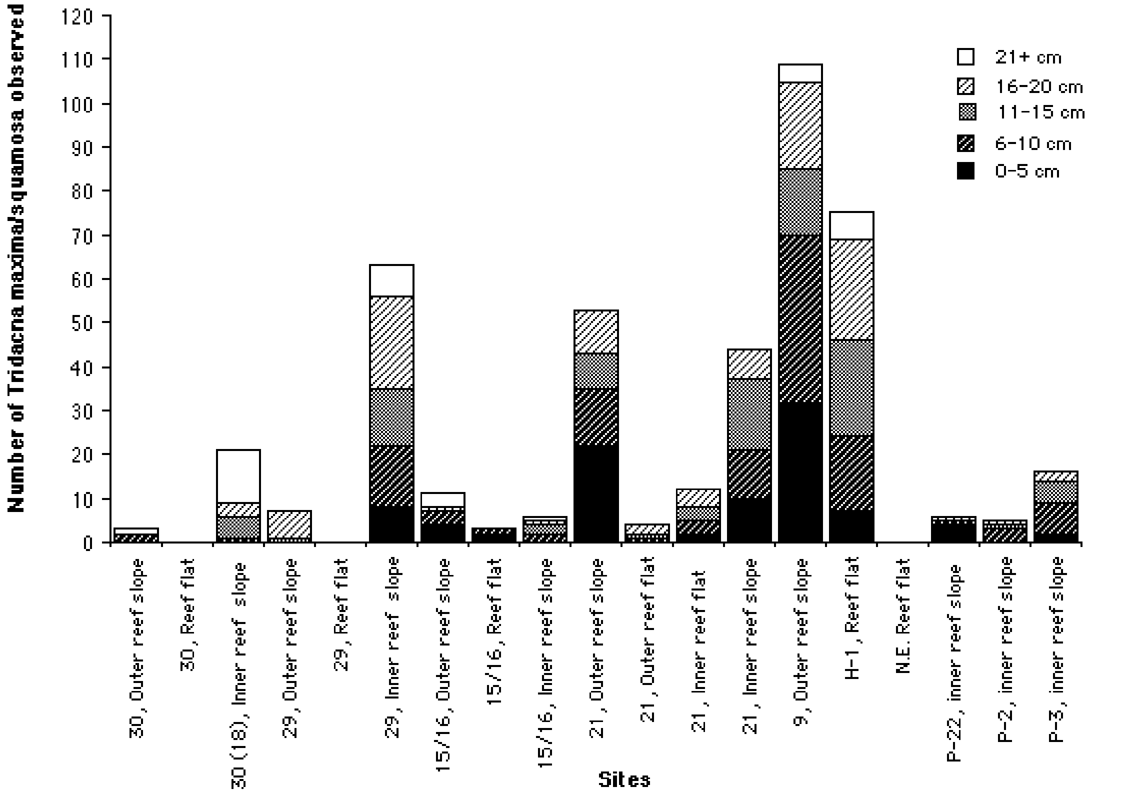
Baseline monitoring sites, which only employed transect methodologies, had high numbers of *Tridacna crocea*, and*T. maxima/squamosa* (Figure 2). The highest numbers of clams were found on the inner reef slope of all sites surveyed (Figure 2). The fewest clams were found on the reef flat, except for at Site H-1, where *T. crocea* and *T. squamosa/maxima* were found in high numbers. The results for *T. crocea* confirm other published findings, which reported that *T. crocea* was ubiquitous (Bryan and McConnell 1976 and Hirschberger 1980). However, *T. crocea* was ubiquitous only in certain habitats, for example, it was largely absent on all reef flats surveyed in this study (Figure 2).

Fig. 2 Cumulative bar graphs of counts of giant clam species on 500 m2 transects (100-m2 for P22, P2 and P3) surveyed from Apr. 26- May 02, 2000 at Helen's Reef.



Size classes were recorded for *T. squamosa/maxima* to determine recruitment levels. When observed in high numbers, generally all size classes of these two species were represented (Figure 3). This may indicate that juveniles preferentially settle and/or recruit to areas where other clams live at Helen, as juveniles were often found on the shells of live adults, for certain species (L. Kirkendale, pers. obs.). This suggests that adult populations, and perhaps aggregations, may foster reseeding. Given their mode of reproduction, which is broadcast spawning, aggregated or clumped populations could definitely result in higher levels of fertilization, compared with a more evenly distributed population. The highest number of large clams was observed on the inner reef slope at Site 30, with 11 large (>21 cm) *T. maxima/squa mosa* recorded in 500 m^2. At baseline monitoring sites in general, few large clams were observed relative to other size classes, which may indicate that the former are harvested (Figure 3).

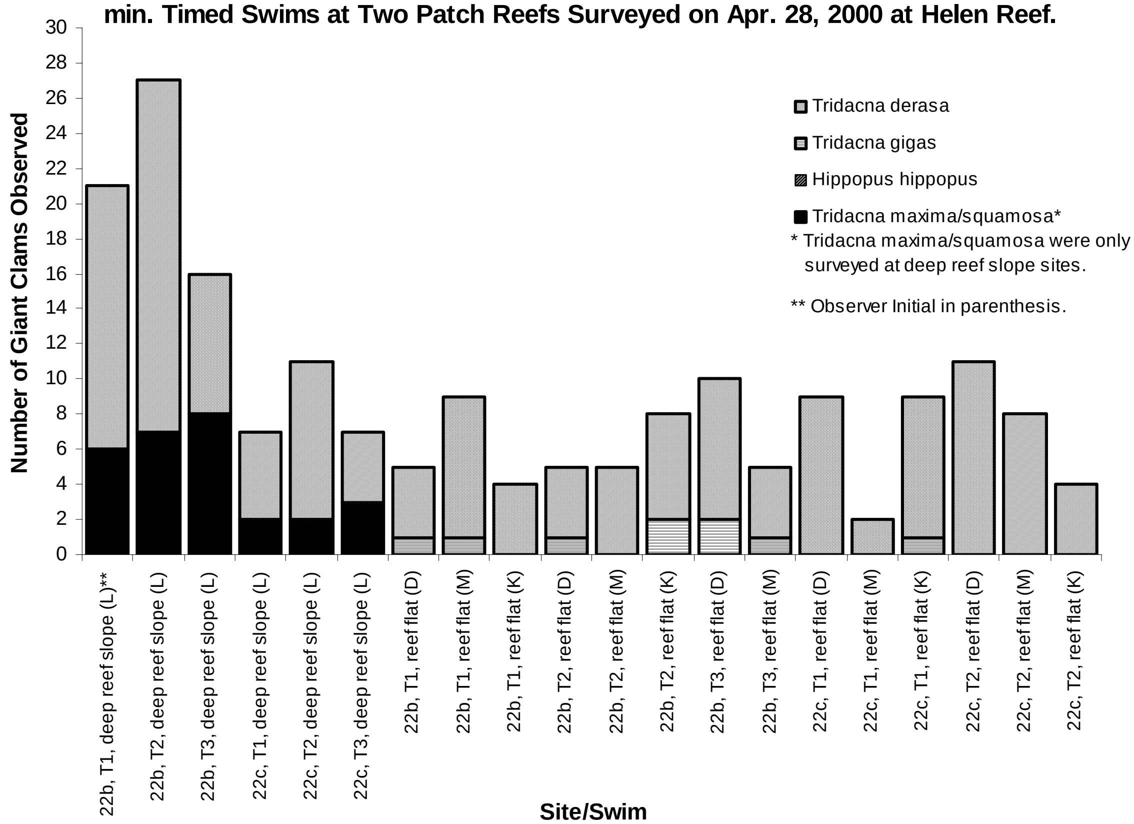
Fig. 3 Cumulative bar graph of counts by size class of Tridacna squamosa/maxima on 500 m2 transects (100 m2 for P22, P2 and P3) surveyed from Apr. 26-May 02, 2000 at Helen's Reef.



Depth-stratified belt transects were surveyed to estimate giant clam populations on the patch reefs, as reported previously. One 100 m^2 transect was surveyed at 3-m depth at each of three patch reefs (22a, 22b and 22c) (Figure 2), and of the four largest giant clam species (*Tridacna squamosa*, *T. derasa*, *Hippopus hippopus* and *T. gigas*), one (1) *T. derasa* (38 cm) was observed. Timed swims were also conducted on the reef slope (~10-15 m), as well as across the reef flat (~1-2 m) for two southern lagoonal patch reefs (22b and 22c). A greater area was surveyed in reef slope swims (estimated range of 5 m on either side of the surveyor), as the surveyor was higher above the bottom and could thus scan a greater area, compared with reef flat surveyors (estimated range of 2 m on either side of the surveyor). Multiple 10-min. timed swims were conducted by one surveyor on the reef slope at each of the two patch reefs, 22b and 22c. This resulted in an area of approximately 15000 m^2 (5000 m^2/10 min.) covered at each of these sites. For reef flat surveys on these patch reefs, a three surveyor team swam eight (8) 10-min. intervals at 22b and six (6) 10-min intervals at 22c, covering an estimated total area of 8000 m^2 (1000 m^2/10 min.) and 6000 m m^2 (1000 m^2/10 min.) at each site respectively.

The most viable populations of both of the largest species of *Tridacna*; *T. gigas* and *T. derasa*, were found on patch reefs located in the southern half of the lagoon. Nine (9) *T. gigas* (>50 cm) were observed in reef flat habitats on two (2) patch reefs (22b and 22c) surveyed during timed swims (~1-2 m depth) (Figure 4; Appendix 4, Table A4), compared with only one or two observed elsewhere at Helen (from random visual counts). Most encouragingly, 142 *T. derasa* (> 20 cm) were counted during timed swims at the two patch reefs surveyed, in both reef slope and reef flat environments (Figure 4). This is in comparison to three (3) *T. derasa* observed on transects at all other locations surveyed (Figure 2).

Fig. 4. Cumulative Bar Graph of Counts of Giant Clams (>20 cm) From Twenty, 10-min. Timed Swims at Two Patch Reefs Surveyed on Apr. 28, 2000 at Helen Reef.



The data from timed swims for the two patch reefs yielded higher estimates of the four giant clam species surveyed (*T. squamosa, T. gigas, T. derasa* and *H. hippopus* greater than 20 cm), which better estimated population levels, than did the transects (Figure 2 compared with Figure 4). The timed swims were able to cover more area compared to the transects, and better accounted for the patchy distributions of the larger giant clam species. Higher numbers of giant clam species, in general, were found on 10 min. swims on the reef slope compared with the reef flat. Although, this was in part due inclusion of large *T. squamosa* in reef slope surveys, which were not surveyed on the reef flat, the surveyor on the reef slope, as mentioned earlier, scanned a much larger area (4 m width on the surface compared to 20 m width at depth).

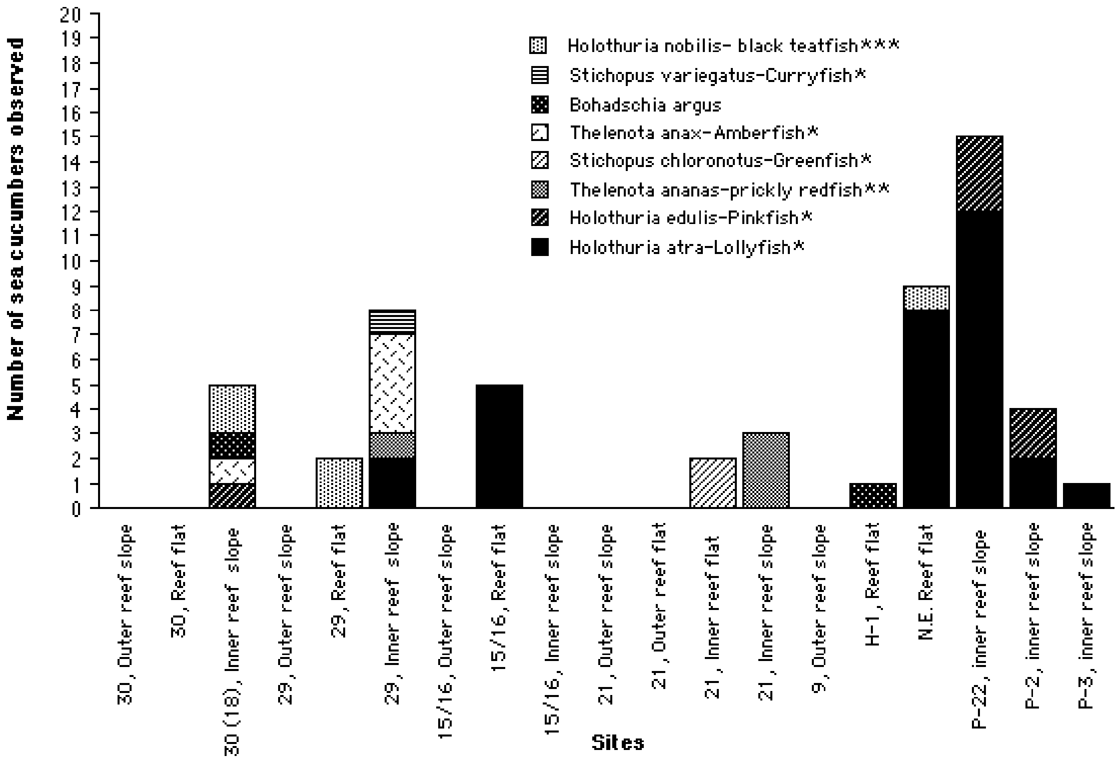
Hippopus hippopus, one of the larger giant clam species that seemed to predominantly occur on reef flats at Helen, was relatively rare based on quick visual surveys, as well as transect and timed swim data (Figures 2 and 4). Previous studies reported that 91% of the *H. hippopus* observed were in the north, which suggests that populations may have been missed, due to the few surveys conducted in this area (Hirschberger 1980). Interestingly, while returning from the northeastern reef flat site T-3 (one of the traditional harvest grounds of *T. niloticus*), we passed over an *H. hippopus* "belt", where in a narrow strip along the top of the reef flat, many *H. hippopus* were observed (L. Kirkendale, pers. obs.). As mentioned previously, *H. hippopus* may not have been encountered, as they are very patchily distributed. Also, this species is difficult to see (cryptic, due to mantle coloration which matches the substrate), which may have led to an underestimation of their population numbers (Hirschberger 1980). This is somewhat encouraging, as what makes them difficult to survey, should also make them difficult to poach. Therefore, patchy distributions, cryptic coloration and high populations in the northern part of Helen, as well as overharvesting are all factors that may contribute to low numbers of *H. hippopus* observed during this study.

The giant clam populations on the reef slope and reef flat of the southern, lagoonal patch reefs, offer the best opportunity for maintenance and recovery, as 1) they are more numerous, and occur in greater proximity to one another than at other areas surveyed at Helen, and 2) they are somewhat protected from poachers at these locations, compared with the much more accessible reef flat and outer reef slope habitats. Unfortunately, comparisons of giant clam estimates from previous studies are difficult due to differences in sampling methodologies. In the past timed swims, areal tows and non-depth stratified transects were used, however, in this study timed swims and depth-stratified techniques were employed. Based on gross comparisons with previous studies, it is obvious that populations of giant clams have not recovered to the levels observed in 1972 (Hester and Jones 1974). During previous studies, many dead shells were observed on Helen (Bryan and McConnell 1976). In this study, few dead shells were observed, and the only significant mounds of dead shells found, were those in front of octopus dens. Regarding the baseline monitoring sites and methodologies employed in this study, future surveys can easily replicate the methods employed in this study (especially given that all sites were surveyed by GPS) and now have a good grounds for comparison.

3.1.4 Sea Cucumbers

A total of eight different species of sea cucumbers, or holothurians, were observed during transect surveys at Helen Reef; *Holothuria nobilis*, *H. edulis*, *H. atra*,*Stichopus variegatus*, *S. chloronotus*, *Bohadschia argus*, *Thelenota anax* and *T. ananas*, (Figure 5). The most abundant species' encountered was *Holothuria atra*, also known as a lollyfish, however, no more than 15 of this species was ever encountered on any individual transect surveyed. No total species' count at any site exceeded 20 individuals, and the most diverse sites, each with four different species, were two inner reef slopes; Sites 30 (18) and 29 (Figure 5).

Fig. 5 Cumulative bar graph of counts of sea cucumbers on 500 m2 transects (100 m2 for P22, P2 and P3) surveyed from Apr. 26- May 02, 2000 at Helen's Reef. Stars indicate high, medium and low value (3 highest, 0 lowest).



Commercially important species were ranked and reported, however, only one high value species, *Holothuria nobilis*, also known as the teatfish, was observed at Helen Reef (Figure 5) (South Pacific Commission, 1994). It was found at three sites: the inner reef slope at Site 30, the reef flat at Site 29 and the reef flat at the northeast site (one of the additional sites, a traditional *Trochus* harvesting ground). However, no more than two individuals were recorded from each site. One medium value species was recorded during the survey, *Thelenota ananas,* commonly referred to as the prickly redfish. This species was found at two inner reef slope sites; at Site 21 and 29, but never exceeded 5 individuals at either site. All other species observed at Helen Reef, which were often more abundant than either *H. nobilis* or *T. ananas*, such as *H. atra*, are considered of low commercial value. This is excluding *Bohadschia argus* (the leopard sea cucumber), which is not commercially valuable at all.

Quick visual surveys indicated that sea cucumbers, like some species of giant clams, were patchily distributed. Individuals were often located outside the boundaries of the survey area, however, these "local abundances" were only of low value species. In general, it does not appear that high numbers of commercially-viable sea cucumber species occur at Helen Reef. This may be due to many factors including previous and ongoing harvesting and/or poor estimates of populations due to biased sampling methodologies.

3.1.5 Soft Corals

In the survey conducted in 1992, it was noted that soft corals, large lobey animals that can resemble toadstools, were a dominant component of the fauna, and at some locations occupied up to 80% of the available substrate (B. Smith, pers. comm.). This invertebrate group was surveyed during this study, because like hard or scleractinian corals which are the main reef builders, certain species of soft corals are also important components of the reef community, and are sensitive to bleaching. Large, rounded mounds, which were found at all sites surveyed on Helen Reef from 1-10 m, are likely the remains of either *Lobophytum* or *Sinularia* spp. (J. Starmer, pers. comm.)(see video footage). The bleaching event that occurred in 1997-98 was thought to have contributed to the death of these animals, and resulted in the formation of these structures. In contrast, other soft corals, most notably a zooxanthellate nephtheid, as well as *Rumphella* sp., which is a gorgonian, seemed relatively unaffected by the bleaching and occurred in many sites surveyed, including very shallow habitats (1-3 m).

In total, forty-three species of soft coral were found on Helen Reef and most of these were found along the walls of the channel and at Site 28, a drop-off at the southern end of the atoll. Although measuring soft coral diversity during this survey used a very “shotgun” sampling effort, it is thought that the soft coral diversity at Helen Reef is basically a subset of that found in Palau or Indonesia. This is thought to be a result of the greater habitat diversity in Palau and Indonesia, compared with Helen Reef (J. Starmer, pers. comm).

3.1.6 Macroinvertebrate Conclusions

It is clear from the results of this preliminary study that past and present overharvesting has resulted in the depletion of previously abundant populations of targeted invertebrate groups, including *Trochus niloticus* and some species of giant clams at Helen Reef. Although this is unfortunate, and needs to be addressed, it is important to note that the habitat remains relatively intact, such that subsequent human-facilitated or natural repopulation could be fairly successful, if protection and monitoring occurs.

It is less clear whether or not overharvesting of sea cucumbers has resulted in the low numbers observed, because of the lack of earlier population or historical harvest estimates. However, overharvesting of sea cucumbers by foreign fishing vessels is likely, given the large amounts of suitable habitat observed during the course of this study (L. Kirkendale, pers. obs.), and historical populations estimates, and reports of frequent poaching (– as was evidenced by the two Indonesian fishing vessels and their smaller associated gleaning boats that were collecting resources when the scientific team arrived at Helen Reef).

Bleaching of both soft and hard coral species is evident at Helen Reef (see results below). Soft corals, specifically, have been hit hard and appear to be recovering much more slowly than hard corals. This is especially evident by the slow regrowth and recruitment of *Sinularia* and *Lobophytum* spp., which are the two species previously reported to have occupied ~80% of the substrate, in certain areas of Helen Reef.

3.2 Reef-Building Corals

Robert van Woesik

3.2.1 Overview

A baseline was established for the coral communities of Helen Reef in April-May 2000 using digital-video images. Systematic records were taken using the protocol outlined in the methods. As mentioned in the methods, in order to obtain preliminary approximate estimates of coral cover, the video images were skimmed and not systematically analyzed (Table 6). Additionally, coral communities are described at the surveyed sites and a coral species list for Helen Reef is provided (for 8 diving days; Appendix 2, Table A2). In 2000, we recorded 272 coral species, which includes 2 previously undescribed *Psammocora* (Siderastreidae) species.

Table 6. Estimates of Percent Coral Cover by Preliminary Video Analysis.

Site	9	15 outside	15 inside	22a,b,c	25	29outside	29 inside	30 outside	30 outside
3m depth	12-18%	10-14%	3-5%	18-20%	12-15%	10-15%	18-25%	10-15%	10-12%
10m depth	10-14%	12-16%	1-2%	5-7%	15-18%	15-18%	8-10%	15-18%	12-15%

3.2.2 A Comparison Between 1992-2000

3.2.2.1 Staghorn corals

One obvious problem when undertaking a survey in a location for which no quantitative data exists is to overcome the time barrier and attempt to understand historical events that may have structured the contemporary communities. The highest sea surface temperatures on record were evident in 1997-98 (Source: NOAA National Weather Service Climate Prediction Center, http://www.cpc.ncep.noaa.gov/data/indices/index.html) and these surely led to the death of a great majority of the *Acropora* (i.e., staghorn and table coral) colonies on Helen Reef, as it did in Palau and in most of the western Pacific. Indeed, the primary difference between the coral communities in 1992 (through a qualitative assessment, Maragos *et al*. 1992) and 2000 was the conspicuous absence of *Acropora* in 2000. Notably in 2000, there was a complete absence (i.e., local extinction) of nine *Acropora* corals that were relatively common in 1992. These corals were *Acropora acuminata, A. clathrata, A. florida, A. nana, A. palmerae, A. paniculata, A. pulchra, A. secale, A. valenciennesi*, and *Anacropora forbesi*.

3.2.2.2 Soft corals

Another historical clue was the 'footprints' left by soft corals. Soft corals, especially *Sinularia* and *Lobophytum* species, the dominant coral reef soft corals, which can often take up 20-30% of the space on a coral reef, suffered heavy losses in 1998 in the western Pacific. Having observed the gradual decay of hundreds of tagged soft-coral colonies, on western Pacific reefs in the 1998 summer, I found telltale 'footprints' that are useful. These 'footprints' are smooth slightly elevated mounds, whose outer periphery traces the former outline of the soft-coral colonies. These mounds remain 'bare' for at least 2 years because invertebrates rarely recruit onto them.

Verification of a soft-coral foundation, or 'footprint', is met by lightly scarping the epilithic-turf algae off the mound and looking for aggregations of club-like (2-3 mm) soft-coral spicules. These 'footprints' allowed at least an approximation of the pre-bleaching (1998), soft-coral distribution. Estimates for each site are given below in order to aid researchers in the future when assessing reef recovery and community dynamics.

3.2.3 Reef Recovery

The recovery of the reef, in terms of coverage and frequency of *Acropora,* appears dependent on the location of the site. Generally, the western outer slopes (Sites 15 and 21) supported the highest number of *Acropora* recruits. This high number of recruits indicates that these slopes will recover their *Acropora* density and coverage relatively rapidly, and high-coral coverage may again occur within 3-4 years (because of rapid growth of these corals). In contrast, the outer eastern slopes (Sites 29 and 30) supported fewer *Acropora* recruits, but abundant *Pocillopora* recruits. The lagoon was not as conspicuously affected by the 1998-bleaching event and change will be less noticeable.

Site descriptions:

Site 9 (south channel mouth)

The 3-m slope supported abundant colonies of *Pocillopora* spp., *Millepora dichotoma*, *Goniastrea pectinata*, *Favia stelligera*, *Coeloseris mayeri*, *Astreopora* spp., *Acropora palifera*, *Leptastrea* spp., and Platygyra daedalea. There was evidence of a recovering *Acropora* community by the presence of *Acropora hyacinthus*, *A. nasuta* and *A. latistella* recruits. Preliminary video analyses showed approximately 12-18% coral coverage. 'Footprint' traces of soft corals showed approximately 10% soft coral coverage before the 1998-bleaching event, while in 2000 coverage of soft corals was 2-3%.

The gorgonian *Rumphella* sp. and the hydrozoan *Millepora* spp. were dominant at 6-8 m, while at 10-12 m the most conspicuous invertebrate was the sponge *Katiba milnei*, covering approximately 25-28% of the substrate. Many large *Diploastrea heliopora* colonies had died within the last 2 years, mostly likely in 1998. Other common corals at 10 m were *Symphyllia* spp. and faviids. Large *Junceella* spp. (gorgonians) and some large *Lobophytum* spp. soft-coral colonies were also present. Preliminary video analyses showed approximately 10-14 % coral coverage at 10 m.

Site 11 (lagoonal, south of the island)

This reef was dominated by *Echinopora gemmacea*, *Porites rus*, *P. cylindrica*, *Ctenactis echinata*, *Heliofungia actiniformis*, *Fungia fungites*, *Acropora elseyi*, *A. formosa*, *A. austera*, *A. donei*, *A. tenuis*, *A. subglabra*, *A. digitifera*, *Pavona varians*, *Pocillopora damicornis* and *Goniopora* species.

An interesting observation was made at Site 11. This site was adjacent to the coral island, and the sea surface temperatures were obviously influenced by the island's proximity (i.e., convection through the water by solar radiation heating the island's shoreline sand and adjacent water). Water temperatures while diving most sites on Helen Reef in April-May (2000) were generally 30-30.6°C (86-87°F), even at 20 m. But the temperature at Site 11 was 32.8°C (91°F). Interestingly, and judging by the size of the coral colonies at Site 11, all the corals at Site 11 appeared to have survived through the 1998-bleaching event, even *Pocillopora damicornis* colonies, the first coral to normally bleach and die when subjected to high sea surface temperatures. These colonies were found in abundance on the shallow reef. It appears that the corals at this site may have been pre-conditioned to regularly high sea surface temperatures. A regional increase in sea surface temperatures in 1998 appeared to have little affect on the corals at this site.

Site 15 outside (outer reef slope, close to shipwreck)

Slight spurs and grooves were evident at 3 m. *Favia stelligera* was the dominant coral along with *Millepora platyphylla* and *M. exaesa*. Other common corals were *Pocillopora verrucosa, P. eydouxi, Montastrea* spp., *Pavona varians,* and *Favites* species. The coverage of cyanobacteria (blue-green algae) was particularly high; which was initially thought to be associated with the wreck, although another dive 1.5 km south of Site 15 also showed high cyanobacteria coverage. Preliminary video analyses showed approximately 10-14% coral cover. There were abundant *Acropora* recruits at this site. Five 1 x 50 m belt transects measured on average 20 *Acropora* recruits, between 1-10 cm in size, for each transect.

There were more coral species at 10 m than at 3 m although dominance varied little; again *Favia stelligera* and *Millepora exaesa* were most common. Common corals included large *Diploastrea heliopora* colonies, mussids (i.e., *Symphyllia* spp. and *Lobophyllia* spp.), *Acropora palifera, Goniastrea pectinata, Porites rus*, *Leptastrea* spp. and some *Cladiella* (soft corals) colonies. Some small *Acropora* were seen but were not as common as they were at 3 m. Preliminary video analyses showed approximately 12-16% coral cover.

Site 15 inside (lagoon slope)

At 3 m, the habitat was primarily sand with sparse carbonate patches supporting corals. Coral aggregations were dominated by *Acropora tenuis, A. nasuta, A. nobilis* (1-2 m stands), *Favites chinensis, Montastrea curta,* and *Goniastrea aspera*. *Halimeda* (the macroalgae) was common. Preliminary video analyses showed approximately 3-5% coral coverage at 3 m. At 10 m, *Acropora longicyanthus, Porites cylindrica, Coscinaraea columna, Lobophyllia hemprichii, Acropora aculeus, Echinopora lamellosa* and *Porites rus* were prevalent. Preliminary video analyses showed approximately 1-2% coral cover, 7-10% carbonate and 85% sand at 10 m.

Site 19 (inner pass reef)

The habitat from 1 to 3 m was dominated by *Porites lutea* and *P. cylindrica*. The deeper 4-5 m colonies *of P. cylindrica* were partially dead on the tips of the branches but the base of the colonies had survived. In contrast, *P. cylindrica* colonies below 5 m had suffered complete mortality. (Notably, many partially dead *P. cylindrica* colonies were recovering by the following process: the basal portions had extended toward the tips of the branches. This does not happen with *Acropora* colonies because they do not appear to be able to initially extend laterally, which is necessary in this recovery process, before extending distally [to the tips of the colonies]. Therefore, once an *Acropora* colony is damaged at the tips of its branches the rest of the colony will die.)

The habitat at 4 to 6 m was occupied mainly by dead colonies of *Porites cylindrica,* live colonies of *Ctenactis* spp. and *Herpolitha weberi,* and some small *Acropora* colonies. At 10 to 12 m, the corals were primarily massive *Porites lutea*, faviids (especially *Echinopora gemmacea), Millepora tenella* and *A. formosa* stands.

Sites 22a, 22b, 22c (three lagoonal patch reefs)

Porites lutea and *Porites cylindrica* dominated the lagoon patches at 3 m. The *Acropora* colonies (on the lagoonal patches) had survived the 1998-bleaching event well compared to the outer and inner-reef slopes. Indeed, there were large stands of *Acropora* at most depths, especially *A. longicyathus*. Other common shallow-dwelling *Acropora* included *A. latistella, A. subulata, A. samoensis, A. carduus, A. millepora, A. selago, A. donei, A. humilis, A. verweyi, A. elseyi, A. vaughani, A. gemmifera, A. nasuta,* and *A. cerealis*). A variety of faviids were also common on the shallow reef, particularly *Goniastrea* and *Favia* species. Preliminary video analyses showed that the upper reef supported 18-20% coral cover, while the deep slope supported 5-7% coverage.

The most common corals on the deeper slopes (> 6 m) were *Acropora grandis, A. abrolhosensis, A. granulosa, A. valida, A. subglabra, A. vaughani, A. kirstyae, A. brueggemanni* (and large stands of *A. pichoni* at 30 m, Birkeland pers. obs.). Large dead stands of *Echinopora lamellosa* were evident at 10 m. Live corals included large polyped faviids, *Acanthastrea* spp, some large *Ctenactis* spp. and *Herpolitha* spp. (fungiids), and large stands of two (2) undescribed species of *Psammocora*.

Site 20 (inner channel, northern edge)

This site was sandier than the south side but also dominated by *Millepora tenella*, *Diploastrea heliopora* and *Rumphella* (gorgonian). The site did previously support 2-3 m stands of *A. valenciennesi* and *A. florida*, and large 1.5-2.5 m plates of *A. clathrata* and *A. latistella*. These species, excluding the last, were not found on Helen Reef during the 2000 survey. Abundant stands of *Goniopora columna* and massive *Porites* were found along the mid-slope, many of which suffered partial mortality in 1998. Interestingly, the shaded parts of the colonies survived as did shaded parts underlying *Nephthea* (soft coral) colonies. The reef at 10-12 m supported mainly *Diploastrea heliopora, Goniopora* spp., *Oxypora lacera*, *Pachyseris speciosa, Leptastrea* spp., *Halimeda* and *Tydemania expedialis* (the latter two being green algae).

Site 24 (inner channel, southern edge)

Most common at 3 m were the corals *Millepora tenella*, massive *Porites lutea, Heliopora coerulea, Astreopora* spp., *Pocillopora* spp.. The shallow reef also supported abundant *Rumphella* (gorgonian) and *Sinularia* (soft coral) 'footprints'. The reef appeared to be recovering well, as evidenced by the prolific number of small and diverse *Acropora* recruits, which had an average size of 12-15 cm diameter (i.e., approximately 3 years old).

Corals were sparse at 8 to 10 m, mainly *Diploastrea heliopora, Symphyllia* spp., *Pachyseris speciosa, Pavona minuta, Plerogyra sinuosa* and *Goniopora* spp.. At > 12 m large gorgonians (*Subergorgia* spp.) and sponges were most conspicuous.

Site 25 (inner pass reef)

The reef flat supported remnants of *Acropora formosa* and *Sinularia* (soft coral) colonies, although the coral diversity was relatively high. Most common corals were faviids, *Porites lutea, Acropora longicyanthus, Millepora tenella, Montastrea spp.,* and *Sandalolitha robusta.* At 3 m *Rumphella, Echinopora gemmacea, Echinopora horrida, Ctenactis* spp.*,* and *Porites cylindrica* dominated.

There were exceptionally large colonies of *Echinopora gemmacea* (5-6 m)*, Pavona clavus* (5 m diameter, 3-4 m high), and *Ctenactis* spp*.* (60-80 cm) at 10 m. Common colonies included *Leptoseris papyraceae, Psammocora contigua, Porites rus,* and *Pavona cactus.* Preliminary video analyses showed the upper reef supported 12-15% coral cover, while the deep slope supported 15-18% cover.

Site 28 (outer reef slope, southern edge)

The community at this site were on a steep wall. Coralline algae cover was particularly high and *Pocillopora* recruits were common. The sticky-sponge *Katiba milnei* was very common at 8 m, as were faviids, especially *Favia stelligera.* 'Footprints' of *Sinularia* (soft corals) were common at 6 m. Large gorgonians (*Subergorgia* spp.), *Porites rus, Leptastrea* spp. and *Mycedium* spp. were most abundant at 10-12 m.

Site 29 outside and Site 30 outside

These two exposed, outer reef, sites were very similar in coral composition. Encrusting coralline algae, the coral *Favia stelligera* and the macroalgae *Halimeda* dominated the slope. Preliminary analyses of the digital videos showed coral cover at 3 m at ~10-15 % and 15-18 % at 10 m.

Dominant corals at 3 m were *Millepora exaesa, Montipora foveolata, Platygyra* spp., *Heliopora coerulea, Favia* spp., *Leptastrea* spp., and *Goniastrea* spp.. There was a considerable number of large *Pocillopora eydouxi* colonies, and judging by their size they had survived the 1998-bleaching event. *Pocillopora* recruits were common.

The primary corals at 10 m were *Favia stelligera* and *Millepora exaesa*. Corals abundant at this depth were *Porites nigrescens, Heliopora coerulea, Millepora dichotoma,* and *Montipora informis,* with occasional but large *Diploastrea heliopora* colonies. Notably, post-1998 survivorship of the latter species appeared to increase with depth. It appears that the reef at these sites was covered with approximately 12-20% soft corals before 1998, yet in 2000 soft coral cover on the shallow reef was <1% (although *Nephthea* spp., was common at 10 m).

Site 29 inside (lagoon slope)

Most common corals at 3 m included *Porites cylindrica, Millepora tenella, Favia* spp., *Hydnophora rigida, Echinopora horrida, Asteropora explanata, Acropora brueggemanni,* and *Montastrea magnistellata.* The gorgonian *Rumphella* and the green algae *Caulerpa* (including several species) were also common. Soft coral 'footprints' appeared to cover up to 15% of the substrate. Preliminary analyses of the digital videos showed approximately 18-25% coral coverage.

The deep slope at 10 m was dominated by *Echinopora gemmacea* and *Astreopora explanata.* Black and orange (*Stylotella aurantium)* sponges were common. The most common corals included *Physogyra lichtensteini, Euphyllia spp., Echinopora horrida, Pectinia alcicornis, Merulina scabricula, Goniopora cellulosa, Acropora elseyi,* and *A. brueggemanni.* The ascidian *Didemnum molle* was also abundant. Approximately 40-50% of the slope supported dead-standing coral. Preliminary analyses of the digital videos showed approximately 8-10% live coral coverage.

Site 30 inside (lagoon slope)

Four *Acanthaster planci* (Crown-of-thorns starfish) were observed at 3 m. Here, as opposed to Site 19 (described above), most *Porites cylindrica* colonies were dead at shallow, while at Site 19 the deep *P. cylindrica* colonies were dead and the shallow colonies were alive. Except for some large *Acropora brueggemanni* colonies, all *Acropora* colonies were small. They were either new recruits or, judging by their size, survivors, while small recruits, of the 1997-98 bleaching event. Other common corals were *Montastrea magnestillata, Mycedium robakakai,* faviids*, Goniopora columna* and *Millepora tenella. Halimeda* algae was common.

At 10 m, the deep slope supported large *Acanthastrea* spp., *Porites cylindrica* colonies, and considerable *Halimeda*. This environment appeared to be primarily a depositional habitat (of suspended particulate matter), evident by the nature of the community which included numerous and large-elongate black and orange (*Stylotella aurantium*) sponges. Common corals included *Astreopora* spp. two undescribed *Psammocora* species, fungiids, and *Favia* spp*.* (*F. danai, F. maxima, F. maritima* and *F. rotundata*). Preliminary video analyses showed approximately 10-12% coral coverage at 3 m and 12-15% at 10 m.

3.2.4 Quantitative Coral Cover

Charles Birkeland

Coral communities were quantitatively surveyed using the plotless point-quarter method. Abundance was assessed by measuring the average distance from random points to the center of the nearest colonies. By this method, the coral communities on the outer coasts did not differ in average abundance (number per m^2) among sites, except for Site 15 which was close to the large grounded ship on the northwest coast. The average abundance of corals in the first 7 site-depth samples (Table 7) did not differ significantly among themselves ($F_{s[6,153]} = 0.214$), but the community at Site 15 had over twice the abundance of coral colonies (9.54 /m^2) as did the other 7 sites (4.26 / m^2, ($t_{s[190]} = 5.88$). The average abundance of corals on the east (windward, 4.45 /m^2) and west (leeward, 4.02 / m^2) sides of the atoll did not differ significantly (($t_{s[120]} = 0.47$). The greatest density of coral colonies (11.81 / m^2) was found in the lagoon on the inside of Site 29.

Table 7. Measurements of Distance Between Corals, Abundances of Corals, and Percent Cover of Living Coral on the Open Coast and Lagoon, and at 3 and 8 m Depths, on Helen Reef in April/May 2000.

Site	**30**	**30**	**29**	**29**	**21**	**21**	**9 North**	**15**	**29 Inside**	**29 Inside**
Depth (m)	3	8	3	8	3	8	3	3	3	8
N	23	17	24	19	30	19	28	32	35	33
Mean Distance (cm)	44	50	50	47	53.5	49	46	32.4	28	30.3
Se	5.2	7.7	12.4	10.5	5.9	9.2	4.4	3.3	2.4	3.1
Abundance (no./ m^2)	5.2	4	4	4.5	3.5	4.2	4.7	9.5	12.8	10.9
Mean Colony Dia. (cm)	11.6	15.9	12.5	13.1	11.8	14.1	9.9	12.4	5.5	6.1
Se	1.73	3.61	1.92	2.66	2.03	2.84	1.90	2.12	0.58	0.70
Living coral cover (%)	18	13	20	17	26	15	28	9	33	31

Although there was no difference in abundance, corals averaged larger in colony size at 8 m than at 3m. The colonies at 3 m depth averaged 12 cm in diameter while those at 8 m depth averaged 14 cm ($t_{s[130]} = 11.32$).

The living coral cover was substantially less, but the abundance of corals was significantly greater at Site 15 than at the other open coast sites. This was probably because there was an especially abundant recruitment of corals at Site 15.

In general, living coral overall was relatively low, about 10 to 30 %, largely because of a recent die-off of most of the acroporids. Nevertheless, the reef system appeared healthy because there was generally abundant recruitment despite the mortality of adults.

3.3 Reef Fishes

3.3.1 Repeat of 1992 Reef Fish Diversity Survey and Update of Species List

Terry J. Donaldson and Robert F. Myers

The fishes of Helen Reef Atoll, Southwest Palau Islands, were studied previously in 1992 during the Southwest Palau Islands Expedition (Donaldson 1993; 1996). This survey provided a checklist of species, and comparisons of species richness, species diversity and evenness, levels of similarity between sites, and differences in habitat utilization (Donaldson 1996; unpublished data). The 1992 REA surveys were hampered however by logistical limitations that limited survey effort to daylight hours only, made the use of transect lines impractical, prevented collecting, and restricted opportunities for extensive underwater photography. Still, this survey did provide a basis for comparison with subsequent efforts that utilized the same survey methods.

As reported by Weng and Guilbeaux (2000), Helen Reef experienced a bleaching event during 1997-98. Observations made during the present survey indicated widespread loss of corals at virtually all of the localities surveyed. Most of these localities had also been surveyed during the 1992 expedition, and thus provided a basis for comparison.

As part of this survey, we attempted to describe species richness and biodiversity of fishes in different habitats at Helen Reef. We also wished to augment the 1992 checklist of fishes (Donaldson 1996) with observations of additional species. Since coral bleaching was likely to have a profound effect upon species dependent upon corals for food and shelter, we attempted to detect possible changes in fish communities as a result of bleaching. Further, we sought to describe the condition of populations of species significant to the Hatohobeian people as food or of relative importance to reef system of the atoll. We also attempted to detect and characterize the presence of grouper spawning aggregations in areas where they been observed previously (Weng and Guilbeaux, 2000).

3.3.1.1 General Biodiversity

Species richness, the number of fish species observed at Helen Reef sites, was 530 (Appendix 3; Table A3-1). Previously, 488 species of fishes had been reported (Donaldson 1996). The difference likely reflects increased survey effort (three divers instead of one previously; extensive use of underwater photography) despite fewer sites sampled. Fifty-four families of fishes were recorded (Appendix 3, Table A3-2) versus 63 observed in 1992 (Donaldson 1996). The ten most speciose families of fishes were the damselfishes, wrasses, gobies, groupers and their allies, butterflyfishes, parrotfishes, surgeonfishes and tangs, squirrelfishes and soldierfishes, snappers, and cardinalfishes (Table 8). Differences in this order are compared to that of 1992 are few, with snappers replacing emperors (*Lethrinidae*) on the list (Table 8). Angelfishes, triggerfishes, emperors, blennies, rabbitfishes, fusiliers and puffers were reasonably represented. Relatively few sharks and moray eels were observed. Additional information (including comparisons of species richness, species diversity and evenness, similarities in assemblage structure between sites, and patterns of habitat utilization by selected species) is provided in further analysis by Donaldson, T.J. and Myers R.F (2000).

Table 8. Ten Most Speciose Families of Fishes Observed at Helen Reef in April-May, 2000.

Family	**Common name**	**No. spp.**	**Rank**	**Rank 1992**
Pomacentridae	Damselfishes	77	1	1
Labridae	Wrasses	69	2	2
Gobiidae	Gobies	48	3	3
Serranidae	Groupers and allies	38	4	4
Chaetodontidae	Butterflyfishes	33 H	5	5
Scaridae	Parrotfishes	30	6	6
Acanthuridae	Surgeonfishes and Tangs	26	7	7
Holocentridae	Squirrelfishes and Soldierfishes	21	8	9
Lutjanidae	Snappers	17	9	NR
Apogonidae	Cardinalfishes	15	10	8

H denotes inclusion of a hybrid.
NR denotes not ranked in top ten of 1992.

3.3.1.2 Specific Species Groups of Interest

The following represents general accounts of the ten most speciose families of fishes, in order, plus additional families of special interest because of their value for food and aquarium harvests or as indicators of general reef fish community health.

Damselfishes (*Pomacentridae*) were highly diverse and many species were relatively abundant. We found a new record for Micronesia, *Chrysiptera sinclairi*, to be remarkably common within the lagoon. Previously (Donaldson 1996), this species was mistakenly identified as female *Chrysiptera cyanea,* which also occurs at Helen Reef.

Sixty-nine species of wrasses (Labridae) were observed. Many species were relatively common, especially members of the genera *Chelinus, Epibulus* (including an undescribed species), *Oxychelinus*, *Halichoeres,* and *Thalasoma*. Species of interest to the aquarium trade, including the cleaner wrasses *Labroides dimidiatus* and *L. bicolor*, and the bird wrasse, *Gomphosus varius*, were not uncommon. While the Napoleon (humphead) wrasse, *Cheilinus undulatus*, was not uncommon either, and population levels may be comparable to those measured elsewhere (see Section 3.3.2. Quantitative Baseline Survey), too little is known of their ecology, especially patterns of distribution on atolls, to make further comment about its status.

Gobies (*Gobiidae*) were quite diverse (48 spp.), although we believe the nature of our survey method grossly underestimated the number of species actually present. Shrimp-associated gobies were especially common (16 spp.). These species have value in the aquarium trade. Little is known about their population biology and so any attempts to harvest them commercially should be made with caution.

Twenty-eight species of groupers (*Serranidae*: *Epinephelinae*) were observed but most appeared to be rare. Commonly seen species included two coral trouts (*Plectropomus areolatus* and *P. laevis*, especially the latter species), the peacock grouper (*Cepholopholis argus*), and a honeycomb grouper (*Epinephelus merra*). Three other related species, *Epinephelus maculatus, E. polyphekadion*, and *E. spilotoceps* were also seen but in far lesser numbers. Fairy basslets (*Serranidae*: *Anthiinae*) were far fewer in number of species (8) and individuals. We suspect that recruitment failure as a consequence of coral bleaching may be the reason since juvenile fairy basslets may feed upon coral mucous directly after recruitment and before they adopt a planktivorous feeding strategy. This hypothesis remains to be tested. One species of soapfishes, *Diploprion bifasciatum*, reported previously as a new record to Micronesia (Donaldson 1996), was observed again in lagoon habitats at Helen Reef.

Butterflyfishes (*Chaetodontidae*), a highly-visible group indicative of coral reef fishes and, since many feed in part or exclusively upon corals, an indicator of what coral reefs are capable of supporting, were surprisingly diverse in spite of the effects of coral bleaching. We counted 32 species and one hybrid. Species known to maintain strong monogamous pair bonds, such as *Chaetodon lunulata*, were both common and in apparently stable pairs. Few individuals were seen alone, and these were usually sub-adults or juveniles.

Parrotfishes (*Scaridae*) were quite common. We observed 30 species, and a number of species were quite abundant (see Green, this report). We suspect that parrotfishes, which are herbivores, are benefiting from an apparent increase in benthic algae following the loss of many corals from bleaching. The bumphead parrotfish (*Bolbometapon muricatum*) was observed in herds, sometimes as large as 32 individuals, at a number of relatively shallow reef front and slope habitats on the outer reef and in the outer passes. While we do not have a firm estimate of the population density of adults at Helen Reef, it does appear that this species has escaped high levels of exploitation from poachers thus far.

Surgeonfishes (*Acanthuridae*) were also diverse (26 species) and numerous. Both algae and plankton-feeding species were quite common in virtually all habitats surveyed. Again, herbivorous species such as surgeonfishes have likely benefited from apparent increased levels of benthic algae as a consequence of coral bleaching.

Squirrelfishes and soldierfishes (*Holocentridae*) were quite diverse (21 species) and relatively common at many localities. These fishes are largely nocturnal but may be observed during daylight hours in crevices, holes, caves, and under corals. They may be important as food fishes or, to a lesser extent, as aquarium fishes.

We observed 17 species of snappers. The most commonly seen species were *Lutjanus gibbus, Macolor macularis*, and *M. niger*, all of which formed schools, sometimes quite large in size, on outer reef slopes and in the outer passes. These species appear to maintain healthy populations in spite of the relative loss of habitat and prey items that likely resulted from coral bleaching. The reasons for their success remain unknown and warrant further study.

We observed 15 species of cardinalfishes (*Apogonidae*). Their numbers, however, appeared to be far less than observed previously (Donaldson 1996), perhaps as a consequence of habitat loss from coral bleaching.

Some species of another highly-visible group, the angelfishes (*Pomacanthidae*: 14 spp.), were reasonably common. For example, *Pygoplites diacanthus* was found at virtually all of the sites surveyed, regardless of habitat type. The pygmy angelfish *Centropyge vrolickii* was also ubiquitous and not uncommon.

Trevallys and jacks (*Carangidae*) were somewhat diverse (9 spp.) but not nearly as so as in 1992 (Donaldson 1996). *Caranx lugubris, C. melampygus,* and *C. sexfasciatus* were common, as was the rainbow runner, *Elagatis bipinnulata*. These fishes are easily caught on hook-and-line or by spearing (personal observation) and, as such, are highly vulnerable to over-exploitation.

Only six species of sharks were observed. The most commonly seen species was the grey shark (*Carcharhinus amblyrhynchos*). Most individuals seen were relatively small, less than 1.8 m in total length, and, like the silvertip shark (*C. albimarginatus*) were not as numerous as in 1992 (Donaldson, personal observation).

3.3.2 Quantitative Baseline Fish Survey

Alison Green

3.3.2.1 Reef Fish Communities

A total of 17,899 individuals of fish belonging to 27 families and 245 species were recorded during this survey. This was 46% of the total number of species (50% of families) recorded for the atoll on this trip (see Update of Species List above) since only species amenable to visual census techniques were surveyed in habitats <10m. Of these, only 14,515 individuals (239 species) were recorded as adults and used for further analysis (see Methods).

Species richness was highest on the outer reef slopes, followed by the inner reef slopes, patch reefs and crests (Table 9). Species richness was lowest on the reef flats. These patterns were relatively consistent among sites, except for the relatively low species richness recorded on the inner reef flat at Site 21. This was due to the low cover of coral bommies at that site ie most of the survey area was dominated by sand flats.

Fish density in each habitat type was highly variable among sites (Table 9), and did not show a clear pattern among habitat types, although density was lower on the reef flats than in any of the other habitat types.

Table 9. Mean Density (± se) and Species Richness (± se) of Reef Fishes in Each of the Major Habitat Types at Helen Reef, Where n = Five Transects.

Habitat	Site	Density		Mean Species Richness		Total # of	Total #
		mean	(se)	Mean	(se)	Species	Families
outer reef	30	43796.1	6005.61	40.6	2.25	89	
outer reef	29	34368.1	2445.50	43.2	1.83	90	
outer reef	21	23413.4	2102.13	44.8	1.66	95	
outer reef	15	17364.1	2414.65	39.0	2.30	84	
Total						**145**	**21**
inner reef	30	38240.1	3071.85	30.0	1.52	63	
inner reef	29	32200.1	2616.44	30.0	2.41	66	
inner reef	21	17173.4	5434.24	18.6	3.92	50	
inner reef	15	34280.1	5109.36	33.8	2.48	73	
Total						**129**	**19**
Crest	21	28224.0	2821.99	24.6	1.72	48	
Crest	15	33436.7	2460.38	28.2	0.66	66	
Total						**81**	**20**
reef flat	21	5375.3	671.11	13.6	1.29	30	
reef flat	15	9484.0	617.09	15.0	0.45	32	
Total						**44**	**14**
patch reef	22	25632.7	4973.80	28.6	2.09	69	
Total						**69**	**17**

The relative abundance of fish families varied among habitat types (Table 10). While many of the same families tended to dominated different habitat types, each habitat was characterized by different species (Table 11; Appendix 3, Table A3-3).

Table 10. Relative Abundance (% density) of Each Fish Family in Each Habitat Type.

Family	**Outer reef slopes**	**Inner reef slopes**	**Crests**	**Reef flats**	**Patch reefs**
Acanthuridae	11.3	2.9	44.6	17.0	4.5
Balistidae	0.5	0.3	0.3	0.3	0.1
Caesionidae	8.0	0.7	0.0	0.0	0.4
Carangidae	0.2	0.1	0.5	0.0	0.1
Carcharhinidae	0.0	0.0	0.0	0.0	0.0
Chaetodontidae	6.9	0.5	0.8	2.1	0.4
Cirrhitidae	0.0	0.0	0.2	0.1	0.0
Kyphosidae	0.5	0.0	0.0	0.0	0.0
Labridae	2.2	2.8	5.6	11.8	2.4
Lethrinidae	2.1	0.2	0.2	0.0	0.1
Lutjanidae	2.7	1.9	0.3	0.2	0.5
Monacanthidae	0.0	0.0	0.0	0.0	0.0
Mullidae	0.2	0.4	0.2	0.4	0.5
Myliobatidae	0.4	0.0	0.0	0.0	0.0
Nemipteridae	0.0	0.3	0.0	0.0	0.4
Ostraciidae	0.0	0.0	0.0	0.0	0.0
Pinguipedidae	0.0	0.0	0.0	0.2	0.0
Pomacanthidae	0.0	0.7	0.2	0.7	1.1
Pomacentridae	58.0	82.3	44.1	57.3	79.0
Scaridae	5.6	6.0	2.5	9.7	8.2
Scombridae	0.0	0.1	0.0	0.0	0.0
Serranidae	0.3	0.6	0.1	0.1	1.5
Siganidae	0.4	0.2	0.0	0.0	0.6
Sphyraenidae	0.1	0.0	0.0	0.0	0.0
Synodontidae	0.0	0.0	0.0	0.0	0.0
Tetraodontidae	0.0	0.0	0.0	0.0	0.0
Zanclidae	0.4	0.0	0.2	0.1	0.2
Total	100.0	100.0	100.0	100.0	100.0

Table 11. Most Abundant Fish Families and Species Per Each Habitat Type.

Outer Reef Slope	pomacentrids (*Chromis margaritifer, Pomacentrus philippinus, Chromis atripes, Chromis xanthura, Amblyglyphidodon aureus*) acanthurids *(Ctenochaetus striatus, Zebrasoma scopas, Naso unicornis, Acanthurus nigricans*) caesionids (*Pterocaesio tile, Caesio lunaris*) chaetodontids (*Hemitaurichthys polylepis*) scarids (*Chlorurus sordidus, C. microrhinos, Scarus prasiognathus*)
Inner Reef Slope	pomacentrids (*Pomacentrus nigromanus, Amblyglyphidodon curacao, Pomacentrus pavo, Pomacentrus amboinensis* + others) scarids (*Scarus flavipectoralis, Scarus dimidiatus*) acanthurids & labrids (mixed species)
Crest	acanthurids (*Ctenochaetus striatus, Acanthurus lineatus, A. nigricans*) pomacentrids (*Chromis margaritifer, Stegastes fasciolatus, Plectroglyphidodon dickii*) labrids (*Thalassoma amblycephalum*) scarids (Chlorurus sordidus)
Reef Flats	pomacentrids (*Chrysiptera cyanea, Stegastes albifasciatus,Pomacentrus bankanensis*) acanthurids (*Acanthurus triostegus, A. nigrofuscus*) labrids (*Thalassoma hardwicke, Stethojulis trilineata*) scarids (*Scarus sp*.)
Patch Reefs	pomacentrids (*P. philippinus, P. pavo, Amblyglyphidodon aureus, leucogaster*) scarids (*Scarus flavipectoralis*)

The raw data for these surveys are provided in printed and electronic format an expedition data volume, Volume II.

3.3.2.2 Large, Vulnerable Species

A mean density of 7.2 Napoleon Wrasse (*Cheilinus undulatus)* per 8,000m^2 was recorded on the outer reef slope at Helen Reef (Table 12), with the maximum density recorded at 33.6 per 8000m^2. These densities were high compared to other areas of the Pacific were similar counts have been conducted to date (Table 12): outer reefs of the Great Barrier Reef (GBR) and the Bismarck Archipelago in Papua New Guinea (PNG). Lower densities were recorded in the channel (Table 12), which were also lower than those recorded for large passes or channels on the GBR (mean = 4 per 8000 m^2).

Table 12. Mean Density (± se) of Vulnerable Fish Species (per 8000m^2) at Helen Reef (Palau), Outer Reefs of the Northern Great Barrier Reef (GBR) and the Bismarck Archipelago in Papua New Guinea (PNG).

Species	Habitat	Helen Reef	GBR*	PNG*
Fish				
Cheilinus undulates	outer reef slopes	7.2 (3.9)	1.8 – 4.1	2.7 – 4.1
	channels	2.6 (1.1)	4	-
Chlorurus microrhinos	outer reef slopes	27.0 (7.8)	22.5 – 39.8	13.7 – 0.138
	channels	29.1 (9.8)	27.3	–
Bolbometapon muricatum	outer reef slopes	4.6 (2.9)	10.7 – 36.4	1.0 – 1.1
	channels	4.1 (2.9)	11	–
Sharks				
(Carcharhinus amblyrhynchos, Carcharhinus melanopterus, Triaenodon obesus)	outer reef slopes	3.2 (1.13)		
Nil	inner reef slopes	0 (0)		
(Carcharhinus melanopterus)	crest	0.8 (0.8)		
(Carcharhinus melanopterus, Negaprion acutidens)	reef flat	2.4 (0.8)		
(Carcharhinus amblyrhynchos, Triaenodon obesus)	patch reefs	4.8		

**J.H. Choat and A. Green unpubl. data*

Densities of large parrotfishes were also relatively high (Table 12). The mean densities recorded for *Chlorurus microrhinos* were moderate to high compared to the GBR, but much higher than those recorded in PNG. In contrast, the density of bumphead parrotfish (*Bolbometapon muricatum)* at Helen Reef was lower than that recorded on the GBR, but higher than in PNG.

Much lower densities of all three of these species have been recorded in the Samoan (A. Green, unpublished data) and Fijian archipelagos (N. Dulvy, pers. comm.).

The degree to which these differences are due to fishing remains unclear. The counts for Helen Reef compare favorably with areas where fishing pressure is known to be light (GBR and PNG), and very high compared to areas where fishing pressure is moderate to high (Samoa and Fiji).

However, these differences could also be due to other factors, such as bigeographic variation or differences in the types of reefs surveyed (e.g., fringing reefs vs. atolls). Further studies throughout the region will be required to address this question.

Meanwhile, the question remains whether these densities are high or low for Helen Reef. This question can only be addressed if the area is protected from fishing and this study is used as the basis for a long-term monitoring program for these important species.

Sharks were recorded in low densities during the quantitative survey of the reef communities, with the highest densities recorded on the outer reef slope, followed by the reef flat and the crest (Table 12). No sharks were recorded on the inner reef slopes. Species were (in order of relative abundance) *Carcharhinus amblyrhynchos* (40% of total), *Triaenodon obesus* (27%), *Carcharhinus melanopterus* (20%), and *Negaprion acutidens* (13%), with different species observed in different habitat types (Table 12). All individuals were small in size (2-6ft). Unfortunately no comparative data is available for sharks in different regions in the Pacific at present. However, Donaldson noted that he believed the abundance of sharks to be lower at Helen Reef during this survey than in 1992 (see above).

3.3.3 Monitoring Grouper Spawning Aggregations

Terry J. Donaldson and Alison Green

While we detected some localized increases in the numbers of individuals during sunset periods (that is, more groupers present than during daylight hours), we saw no evidence of any aggregating activity. A spawning aggregation of 4-5 species of groupers (*Plectropomus* and larger *Epinephelus* spp.) was detected in previous surveys (Weng and Guilbeaux 2000). The formation of this aggregation coincided with lunar events (new moon) in August that produced strong tides. Since we were present several days before the new moon, it is unclear if the aggregations were not forming or whether we were too early to see them. Further study of the timing, location, and species composition of grouper spawning aggregations is necessary before predictions about the frequency of reproduction in aggregating species, and the possible impacts of the live reef fish trade, can be made. The same holds true for non-aggregating harem-forming species such as the peacock grouper (*Cephalopholis argus*).

3.4 Sea Turtles

Jeff Mangel and Dominic Emilio

3.4.1 Nesting Sea Turtles

A total of 6 individual green turtles were observed nesting on Helen Island over 7 days (Table 13). Zero (0) to 2 turtles were encountered nesting each night. This level of nesting was similar to that observed at this time of the year by recent residents of the island (Dominic Emilio, pers. comm.). Turtle tracks encountered on Helen Island also indicate that as many as 9 other green turtles attempted or succeeded in nesting (Table 13) several days prior to our arrival at the island.

Table 13. Summary of Green Turtle Nesting Data for Helen Island, Palau from 26 April 2000 to 2 May 2000.

Date	Track Width (cm)[a,b]	Flipper Tag #		CCL Min. (cm.)[c]	Nest Location[d]	Egg Count	Nesting Time	Identifying Marks
		Right Front	Left Front					
4/26/2000	117				V?			
4/26/2000	90				V or B?			
4/26/2000	96				V?			
4/26/2000	n/a				V or B?			
4/27/2000	90				V?			
4/27/2000	110				V?			
4/28/2000		R8753	R8754	102.7	V	85	3:30	No
4/28/2000		R8755	R8756	96	B	No	5:00	No
4/29/2000		R8759	R8760	111.5	V	No	1:30	No
4/29/2000		R8761	R8762	103	V	No	2:30	Yes[e]
4/30/2000	97				V?			
4/30/2000	130				V?			
5/1/2000		R8763	R8764	98.4	V	No	20:30	No
5/1/2000		R8767	R8766	90.4	DNL	n/a	n/a	No
5/2/2000		R8767	R8766	90.4	V	No	20:00	No
5/2/2000	n/a				DNL			

[a] For turtles not encountered during nightly surveys track width (between tips of front flippers) was measured to give an estimate of turtle size.
[b] Tracks encountered on 4/26/00 may have been from that day or 3 to 4 previous days.
[c] Curved Carapace Length Minimum (CCL min). Measured along carapace midline from front notch to rear notch.
[d] Nest location is classified as 'V' = 'vegetation', 'B' = 'border', 'O' = 'open' or 'DNL' = 'turtle did not lay'. A '?' indicates that the turtle was not seen.
[e] Large circular barnacle cluster (15cm wide x 10cm high) in forward right side of carapace.

The six turtles encountered on Helen Island were each tagged twice with monel tags. Measurements of curved carapace length (CCL min) were recorded. The mean CCL min measurement (Table 13) was 100.3 cm (range 90.4 to 111.5 cm).

Prichard (1977) identified reef areas in the Southwest Islands of Palau (including Merir and Helen Islands) as relatively small but important nesting areas for green turtles within the Republic of Palau and Micronesia. Seasonal nesting is reported by local residents to begin in February and last until August or September, however nesting has been reported year round Hirth (1997) based on prior surveys and other information lists Helen Island as a minor nesting site with a nesting population of 100 to 500 individuals. The present study supports these lower estimates, while also confirms (despite limited nesting observations on Helen Island during the 1992 REA survey) that Helen Island currently hosts (along with the neighboring Island of Merir) some of the densest sea turtle nesting in the Republic of Palau.

3.4.2 Swimming Sea Turtles

During the course of this monitoring expedition, many turtles were observed during daily surveying and support activities. A total of 10 hawksbill and 6 green turtles were noted over a period of eight (8) days during the quantitative surveys of reef fish. The majority of turtles were encountered on the 10m-depth transects on the outer and inner reef slopes. Anecdotal reports from other researchers also indicated that either green or hawksbill turtles were seen on the majority of dives. Most turtles encountered during survey dives, based on their smaller size, appeared to be juveniles or sub-adults. A small aggregation of younger turtles (e.g., 10-15 individuals) were observed in the sand flats adjacent to Helen Island.

The presence of turtles in relative abundance at Helen Reef indicate that the atoll continues to be an important foraging habitat for juvenile and adult green and hawksbill turtles. However, numerous individuals familiar with the atoll indicate that the present numbers of turtles pales to the abundance of turtles that could be found in the atoll over past decades and that present populations have declined considerably (Dominic Emilio, pers. comm.; Sabino Sakarias, pers. comm.; Thomas Patris, pers. comm.; Bill Keldermans, pers. comm.; Dr. Minoro Ueki, pers. comm.).

3.5 Community Monitoring of Trochus and Clams

Dominic Emilio, Kevin Weng, and Michael Guilbeaux

3.5.1 Trochus

3.5.1.1 <u>Timed Swims and Walks</u>

During this survey, timed swims for trochus were conducted as a part of community monitoring activities on reef flats near Sites T-1 and T-3 (as also reported in Section 3.1.2 above). During the total of eight (8)10-min. timed swims performed by two observers at T-1 (near the reef flat transects inside of the big ship wreck at Site 15; 2° 56.20 N, 131° 46.24 E), which covered approximately 8,000 m^2 of substrate (200-m^2/2 minutes[9]), only two (2) *T. niloticus* (< 8 cm) were found (or one trochus per 40 minutes). For comparisons, the density of trochus observed at this site was about 0.00025 per m^2, or 0.11 trochus per basketball court. Timed swims by two observers at T-3 near the NE shipwreck (2° 58.77 N, 131° 49.23 E) also yielded only 2 animals (< 3") for 80 minutes of search time, in an area where high numbers of *T. niloticus* have historically been found.

Community members also conducted a collective timed walk for trochus at Site T-4 (south of the channel and north of Site 21) as a group activity. The survey at this site involved seven (7) individuals each undertaking three (3) walk intervals of 10-min. duration. The resulting effort included 210 person-minutes of searching and yielded five (5) trochus, all under 3" (or one trochus per 42 minutes)

[9] Calculated from timed swim data measured with a transect tape of Dominic Emilio, Feb. 2001, Koror.

Table 14. Summary of Timed Swims and Walks for Trochus in Traditional Harvest Areas.

Location	Method/Persons/Time	Cumulative Time / Area	No. Trochus	Trochus per min	Estimated Density	Trochus per Basketball court
T-1	8 x 10 min timed swim (2 persons)	80 min / 8000 m2	2 (< 3")	1 trochus per 40 min	0.00025 per m^2,	0.11 trochus
T-3	8 x 10 min timed swim (2 persons)	80 min / 8000 m2	2 (< 3")	1 trochus per 40 min	0.00025 per m^2,	0.11 trochus
T-4	3 x 10 min timed walk (7 persons)	210 min	5 (< 3")	1 trochus per 42 min	–	–

3.5.1.2 Estimates of How Many Trochus There Were in the Past

To compare the resources at Helen Reef now with the levels that used to be there, we consulted with knowledgeable members of the Hatohobei community about the numbers of trochus they used to be able to collect in a given area. Three separate estimates were made of the levels of trochus during the time of the collection activities in the early 1980s, as described below. Note that, in most cases, only large trochus were collected, having a diameter of 3 inches or greater.

1. By searching an area of reef crest rubble zone (or *yarang*) habitat 30 m (100 ft) wide and 36 m (120 ft) long, the collectors would be able to fill nine sacks, each fifty pounds, and holding about 40 large trochus (3 inches or more wide). This means that 360 large trochus were collected in an area of about 1080 m^2. Therefore, the density of trochus was roughly 0.33 per m^2, or 144 per basketball court.

2. One collection area used frequently was the pile of rocks near the bow of the big wreck. In an area about 200 m long and 12m wide, ten or more sacks could be filled. This means that at least 400 trochus came from an area of 2400 m^2. Therefore, the density of trochus was roughly 0.17 per m^2, or 72 per basketball court.

3. In a typical rubble zone area, large trochus were about 2 m apart. Therefore, in an area of $100m^2$ there were 25 trochus. Hence, the density of trochus was roughly 0.25 per m^2, or 109 per basketball court.

All three cases of estimation give roughly similar results, suggesting the previous densities of trochus were orders of magnitude greater than present.

Observations of past trochus levels indicate that at the traditionally harvested northeast site, Site T-3, one person could collect approximately four rice sac bags (~50 lbs) of large *T. niloticus* in roughly an hour (per com. Dominic Emilio). Although somewhat less than this estimate, a 1973 study reported an average locating time for large *T. niloticus* at 11 minutes per animal (Muller 1973). This estimate was after correcting for a large aggregation found in the S.E. portion of Helen, where 54 *T. niloticus* were documented (Muller 1973).

3.5.1.3 Trochus Summary

The present surveys and estimates of historical trochus abundance indicate that there may have been as much as a three order-of-magnitude reduction in abundance since the early 1980s. This decline is believed to be due to chronic over-harvesting. The Hatohobei community have been aware of the level trochus exploitation at Helen Reef for some time, and there is a history of foreign commercial and State endorsed harvesters engaging in collection at the atoll. Two Indonesian vessels carrying reef collectors were present at Helen Reef when our expedition arrived, providing evidence of ongoing exploitation. With trochus levels so low, the potential for successful spawning and timely repopulation is of concern.

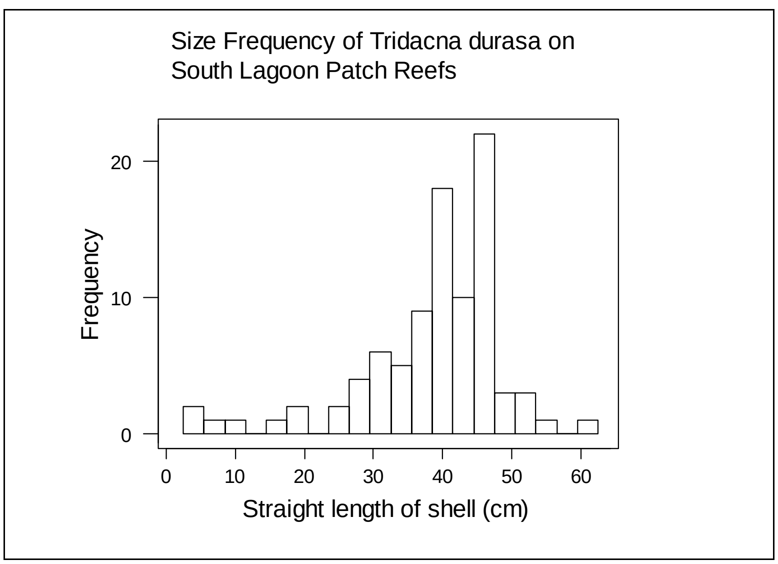
3.5.2 Clams

Timed swims for clams were conducted at two patch reefs in the southern lagoon, Site 22b and 22c (Appendix 4, Table A4) (as also reported in Section 3.1.3 and Figure 4 above). At 22b, three (3) observers conducted a total of eight (8)10-minute timed swims, counting 43 *T. durasa* and eight (8) *T.* gigas. At 22c, three (3) observers conducted a total of six (6) 10-minute timed swims, counting 42 *T. durasa* and one (1) *T. gigas*. Survey results are presented in more detail below.

3.5.2.1 Size Structure of Clam Populations

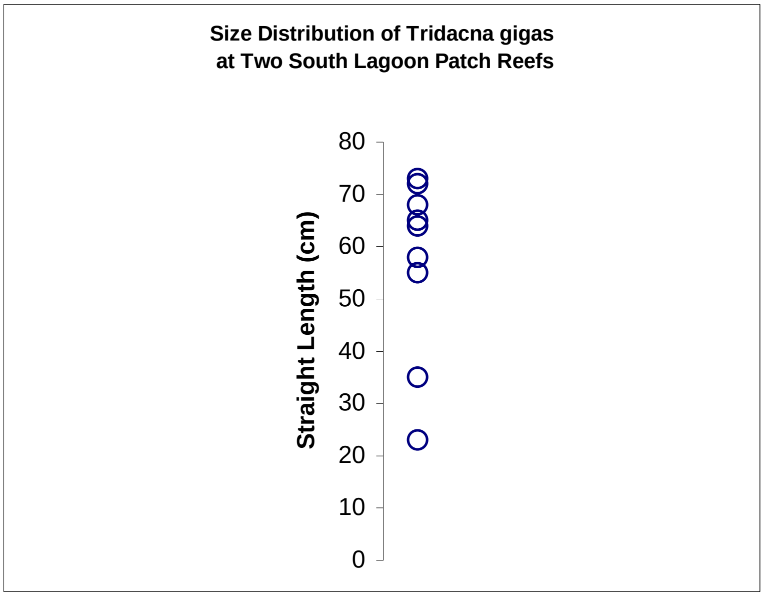
T. durasa ranged from about 60 cm straight length to less than 10 cm (Figure 8), with most individuals recorded in the 40-50 cm range.

Figure 6. Size Frequency of *Tridacna durasa* on Two South Lagoon Patch Reefs, Helen Reef, 2000.



There were too few *T. gigas* observed to present a histogram of size classes, but most individuals were in the 55-75 cm range (Figure 9).

Figure 7. Size Distribution of Tridacna gigas at Two South Lagoon Patch Reefs, Helen Reef, 2000.



3.5.2.2 Clam Summary

The population of T. durasa appears healthy, with large individuals well-represented in the population. This species is reported to lengths of 60 cm (Colin and Arneson 1995), and in our surveys, the modal size was about 45 cm with one (1) 60 cm individual recorded.

T. gigas is rare, indicating that the population has not recovered from severe over-harvesting in the past, and potential continuing harvests. This species is reported to lengths over 1 m (Colin and Arneson 1995) and our observations showed a modal size of about 60 cm, with the largest individual at 73 cm. The largest individual observed during the 1999 survey (Weng and Guilbeaux, 2000) was 105 cm. Therefore, it is apparent that individuals in the population are surviving to reproductive age and beyond. Due to their rarity, it is unclear whether successful spawning and recruitment is common.

3.5.3 Discussion of Community Monitoring

To establish and improve community monitoring at Helen Reef, a program to collect relevant information should be undertaken by the state government, and the community in general. One is to create a community monitoring program that can be undertaken during a field trip to Helen Reef, at regular intervals (such as once per year). This program can expand and improve upon the pilot program presented in this report, and cover additional resources as determined by the community.

The second program is to collect and organize information about Helen Reef, and keep careful records of research, monitoring, significant harvesting, and commercial activities. The greatest knowledge concerning Helen Reef is held in the minds of the Hatohobeian people. To enhance the usefulness of this knowledge for the sustainable management of the reef's resources, the state government should seek to record this information, as a valuable complement to other sources of information such as community monitoring activities, and reports from scientific expeditions. Community monitoring should be conducted on an annual basis.

The pilot community monitoring program focused on two species that are of direct interest to the Hatohobei community for food and economic opportunities. Further development of a community monitoring program could extend coverage to other species, such as food fishes, sea turtles, and sea cucumbers. If such a program is carried out regularly and systematically, the State will be in a better position to track changes of its resources through time, which is critical in evaluating management and conservation measures that may be implemented by the Hatohobei State Government.

4 RECOMMENDATIONS

The scientific team has the following suggestions for the Hatohobei State Government and others concerned about the management and monitoring of resources at Helen Reef:

The State should consider the development and implementation of an effective management strategy that will prevent poaching and ensure the sustainable use and management of Helen Reef by the Hatohobeian people. The success of this management strategy will depend largely on effective enforcement and local involvement and participation. Consideration of a locally managed marine protected area (or areas) may prove to be beneficial and a useful means of implementing management decisions. The consideration of special replenishment or protection zones for populations of trochus and groups may prove useful. Likewise, special consideration for nesting and habitat protection for sea birds and sea turtles will contribute to the long-term sustainable management of these populations.

Although trochus, sea cumcumbers, and giant clams are largely overfished, the habitat remains fairly intact, and so human-facilitated or natural repopulation could be fairly successful if the reef was protected and repopulation efforts monitored.

All species of groupers are highly vulnerable to exploitation, especially by hook-and-line methods. Doubtless, poachers and commercial fishers have had a far greater impact upon grouper populations at Helen Reef than basic subsistence fishing. Intensive fishing effort, such as that practiced in the Live Reef Fish Trade (LRFT), would have a highly damaging effect upon grouper populations in general. Evidence of this already exists at Helen Reef. Previously, the LRFT was allowed to operate at the atoll, and intensely in a northern side-pass of the channel pass. The LRFT targeted groupers, especially coral trouts *(Plectropomus* spp.). During the present expedition, an hour-long drift dive on a falling tide through this pass failed to detect a single grouper until the side pass joined the main pass. We had expected to see evidence of coral trout adults and juveniles, especially the latter. Since we have no reliable estimate of rates spawning and recruitment, and since poaching appears to be common in the absence of effective management and enforcement, we urge that caution be exercised in allowing further harvests of groupers until regulations can be developed and carefully implemented, with appropriate monitoring to determine effectiveness. Further, we recommend that harvests at spawning aggregations sites be prohibited since groupers and other spawning fish are especially vulnerable to over-exploitation when aggregating.

Since humphead wrasses (*Cheilinus undulatus*) are also highly vulnerable to specialized hook-and-line techniques, and humphead wrasses are highly susceptible to spearing, especially at night (International Marinelife Alliance, unpublished data), we further recommend that high levels of harvests of these species be avoided.

Sharks were far less common than in 1992, when numbers of gray and silvertip sharks were sufficient enough to be an annoyance at a number of sites where surveys were conducted (Donaldson, personal observations; unpublished data). Poachers may also be harvesting sharks for their fins (as identified by crew members of the M/V *Atoll Way*, personal communication), a practice known as finning. These fishes are also easily caught by hook-and-line and are, as such, highly vulnerable to over-exploitation. Any plan developed and implemented for the management of fishes at Helen Reef should include a component that effectively regulates the take of sharks.

Although hawksbill and green sea turtles were observed on most dives and nesting by the green sea turtle was documented on Helen Island, the populations are declining according to Hatohobeians familiar with the atoll. The taking of turtles should be reduced or eliminated until the populations recover to those perceived as stable levels.

Monitoring activities, especially by trained community members who happen to be present on site, should continue on a regular basis. It is important that the community remain involved in the selection of monitoring targets and methods, so that efforts best suit community needs and interests. There are growing regional programs that can assist with the development and support of community-based and/or scientific monitoring of marine resources (e.g., ReefCheck; the Locally Managed Marine Area [LMMA] Network, WCPA Guidebook for Evaluating MPA Management Effectiveness) which may be consulted for additional guidance and assistance. Scientific monitoring need not be necessary every year, but may be useful on a 3-5 year schedule. As community members gain experience and skills in monitoring, it may be possible to rely on local expertise to carry out some of the survey methods for some of the target species. For other methods which require extensive technical skill, the project may request the assistance of national and international scientists with those particular skills and areas of expertise.

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