Helen Reef 2008:
an Overview

by

Patrick L. Colin, Lori J. Bell and Sharon Patris

Coral Reef Research Foundation
P.O. Box 1765
Koror, Palau 96940
crrfpalau@gmail.com

Technical Report 2008

Suggested citation:
Colin, P.L., L.J. Bell and S. Patris. 2008. Helen Reef 2008: An Overview. Technical Report, Coral Reef Research Foundation, 31pp. www.coralreefpalau.org

CORAL REEF RESEARCH FOUNDATION

Report to

Helen Reef Project

SW Islands Collecting Trip, Sept 2008

INTRODUCTION

In September 2008 the Coral Reef Research Foundation (CRRF) participated in a 3 week trip to Sonsorol and Hatohobei States for the purpose of marine invertebrate collections for the US National Cancer Institute (NCI). In addition to the NCI collections we were able to make a considerable number of general observations about marine conditions as well as gather a variety of data on tides, currents and temperatures at Helen Reef. The trip was a shared charter aboard the live-aboard dive boat Pacific Explorer II, in conjunction with fish biologists Rick Winterbottom (Royal Ontario Museum, Canada) and Mark Westneat (Field Museum, Chicago), from 10 – 29 September 2008. This report is intended to summarize the observations and collections made by CRRF. Two previous small collections were made in the Southwest Islands by CRRF, July 1995 to Sonsorol State, and December 1996 to Hatohobei State. Some of those results are summarized here for continuity in data.

The Southwest Islands of Palau represent an area which is intermediate between the ultra diverse "Coral Triangle" (Indonesia, Papua New Guinea, Malaysia, Solomon Islands, Philippines) and the less (but still very high) diverse Micronesian islands. The stepping stone series of islands and atolls from western New Guinea (Indonesia) to the main Palau island group (Babeldaob, all the Rock Islands, Kayangel, Angaur) provides an interesting natural laboratory to determine dispersal from the "center of diversity" in the “Coral Triangle". For most groups of organisms for which there are suitable habitats in the southwest islands, the numbers of species present in the southwest islands are intermediate between the highly diverse New Guinea fauna and flora and the less diverse Micronesian species.

Expedition participants for CRRF:

The expedition participants for CRRF were Patrick Colin (Director), Lori Colin (Manager), Sharon Patris (Biologist), Matt Mesubed (Collector), Emilio Basilius (Collector) and Don DeMaria (Florida - Collector). Representatives from Sonsorol State, Hatohobei State and the Helen Reef project participated with us.

Four days were spent in Sonsorol state, diving off the islands of Sonsorol, Fana, Pulo Ana and Merir. Summaries presented below also include Sonsorol State collections, as these islands’ fauna are important biogeographical records relative to Hatohobei State. One day was spent on the reefs of Tobi Island, and 13 days at Helen Reef.

Schedule of Trip:

September 10 - Depart Koror.
September 11 - Arrive Sonsorol, 2 collection dives
September 12 - Collections Sonsorol, 2 dives, one dive at Fana, depart in evening
September 13 - Arrive Pulo Ana, 2 collection dives, depart in evening
September 14 - Arrive Merir, 2 collection dives, depart in evening
September 15 - Arrive Tobi, 2 collection dives, depart in evening for Helen Reef
September 16 - Arrive Helen Reef, begin collection dives, 2-4per day
September 17-27 - work at Helen Reef
September 28 - depart Helen Reef at sunset.
September 29 - Stop off Merir, one collection dive, depart for Koror mid day
September 30 - Steaming enroute Koror, arriving mid day, offload boat.

Expedition Goals:

1 - Collections of marine invertebrates and algae for the US National Cancer Institute
2 - General marine invertebrate biodiversity surveys (not intended to be comprehensive)
3 - Elucidation of tide and current regimes in the Helen Reef lagoon and channel
4 - Reef fish surveys of Humphead wrasse (*Cheilinus undulatus*) and other important food fish
5 - General observations of coral reef health and dynamics and relations to the reefs of Palau proper (Koror/Babeldaob/Peleliu etc)

An external hard drive with all data and photos will be submitted with this written report. Files referenced herein can be found on this hard drive.

NATIONAL CANCER INSTITUTE COLLECTIONS

Daily collections were made using SCUBA for NCI collections, generally making 2-3 dives per day. Appendix 1 is the dive and station log for collections and sites visited by CRRF (CRRF SW Islands Sites 2008.xls). Dive time and date is noted so that digital photographs can always be matched to the site (using photo date and time) in the event site data is ever lost for a particular photo.

Due to weather limitations, sites around the Sonsorol state islands were generally limited to the lee side. Over a period of 4 ½ days a total of 98 frozen samples were taken from these islands, broken down in the following groups by number of samples.

Phylum	**Common Name**	**# of Samples**
Annelida	Worms	1
Chlorophyta	Green Algae	1
Cnidaria	Soft Corals	10
Echinodermata	Sea Cucumbers/ Urchins	2
Porifera	Sponges	84
Total		**98**

Commonly, sponges are always the most diverse group in our NCI collections with generally the highest biomass of the soft-bodied invertebrates that we collect, followed by soft corals. A small number of other groups are also collected if they are abundant.

One day was spent at Tobi Island, and two dives were made on its NE fringing reef. 17 samples were collected at Tobi. At Helen Reef weather allowed us to visit a variety of sites in both the lagoon and on the outer reef and channel (Figure 1), with a collection of 150 frozen samples.

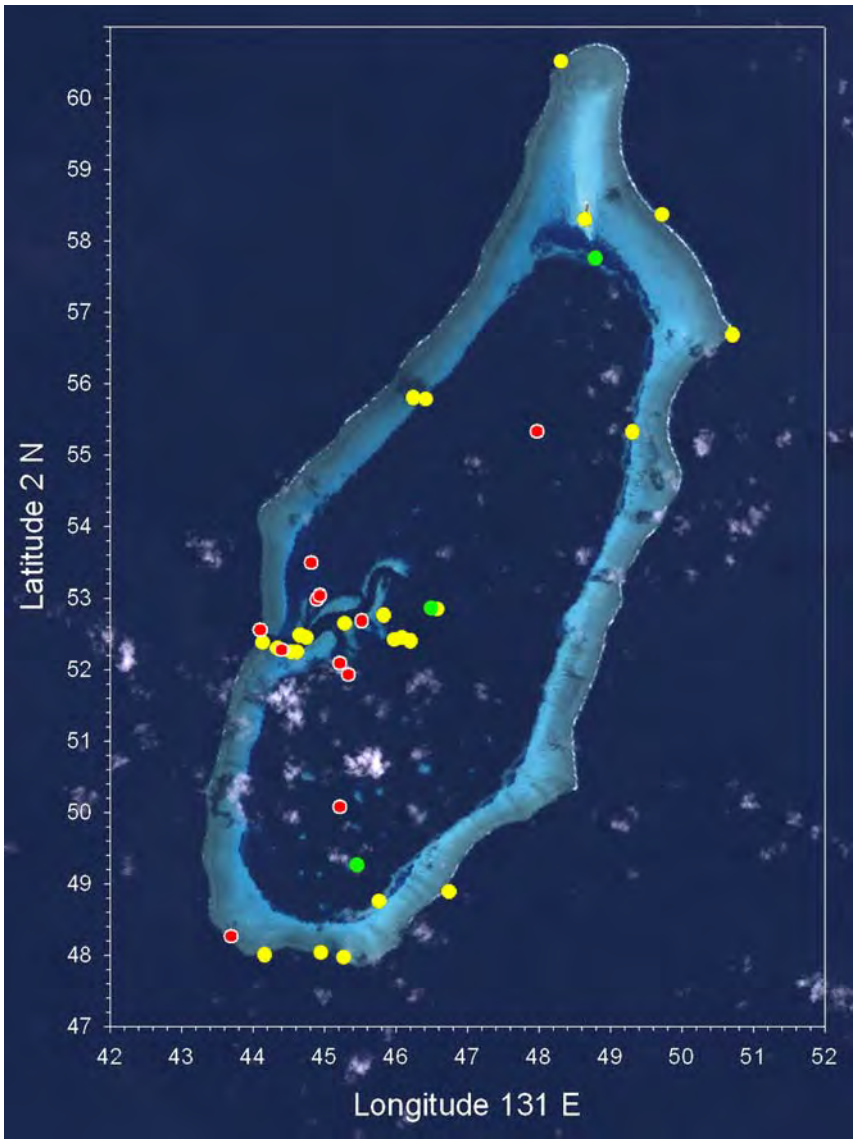

Figure 1. Map of CRRF collecting sites for NCI samples at Helen Reef. Yellow circles indicate collecting sites from 2008. Green circles are both collecting sites and represent depth logger locations. Red circles indicate sites from the collecting trip to Helen Reef in 1996.

Overall 167 NCI samples were collected in Tobi state and distributed by group as in the following table.

Phylum	Common Name	# of Samples
Chlorophyta	Green Algae	7
Chordata	Sea Squirts	11
Cnidaria	Soft Corals	54
Cyanophyta	Blue Green Algae	2
Echinodermata	Sea Cucumbers/ Urchins	6
Phaeophyceae	Brown Algae	1
Porifera	Sponges	84
Rhodophyta	Red Algae	2
Total		167

Preserved voucher specimens of each NCI sample are held at CRRF, and by contract, a duplicate specimen will be sent to the Smithsonian Institution (US National Museum) in the US. Data and photos from these collections are stored in an Access database and a copy is provided on the hard drive. Identifications of these organisms will be made by taxonomic specialists, and as ID's that come in over the coming year will be updated in the database, with annual updates provided to the Helen Reef Project. This database also includes data from previous trips to the SW Islands made by CRRF, specifically to Sonsorol in July, 1995 (42 samples collected) and Helen Reef/Tobi in December 1996 (69 samples collected).

Of special interest are collections of species from the southwest islands that are not thought to occur in the main archipelago of Palau, ie. the islands from Angaur north to Kayangel. Our baseline for comparison includes 1,407 samples collected from the main islands of Palau over the past 13 years. Listed in the table below are invertebrates not recorded from the main Palau islands, but found in the SW Islands. Included next to each name are countries where we have previously collected and recorded the same species, as a reference point. The list is comprised mostly of sponges, probably only because we concentrate on this group for NCI collections. The names themselves are not important but are listed here to simply to provide a summary record. Of interest to CRRF are two genera we have never found in the main Palau islands (*Svenzea* and *Silaquariaspongia*) and the higher diversity of three families that are not well represented (Niphatidae, Callyspongiidae and Petrosiidae), but are common in the areas of the Philippines, Indonesia and PNG.

Table 1. Species collected in the SW Islands that are unknown from the main Palau group, for Sonsorol and Hatohobei States.

Organism	Specimen ID - Other Location Records	Palau Record	0CDN Number
Sonsorol State			
Sponge	*Cribrochalina cribricutis*- Indo, Phil, Maldives	Fana	9701-F
Sponge	*Svenzea devoogdae*- Phil, Vanuatu, Malaysia	Fana	9702-G
Sponge	*Callyspongia biru* - Malaysia, Indonesia	Merir	2881-Q
Sponge	*Callyspongia* sp. 13 - Tanzania	Merir	2884-T
Sponge	*Calyx* sp. 5 (*Vagocia*) - Philippines	Merir	2879-O, 9731-M

Organism	Specimen ID - Other Location Records	Palau Record	0CDN Number
Sponge	*Epipolasis* sp. 2- Phil, Yap	Merir	2893-F, 9747-F
Sponge	*Gelliodes callista* –Chuuk, Fiji, Indonesia, Phil, PNG, Vanuatu, Pohnpei	Merir	2876-L, 9732-N
Sponge	*Siliquariaspongia mirabilis*- PNG, Phil, Chuuk, Vanuatu, Fiji, Indonesia, Malaysia	Merir	9738-T
Sponge	*Xestospongia* sp. 8 – Phil, Indonesia, PNG	Merir	9739-U
Sponge	*Cinachyrella* sp. (orange- Sonsorol) – PNG, Malaysia	Pulo Ana	9714-S
Sponge	*Cribrochalina* sp. 3- PNG, Indo	Pulo Ana	9708-M
Sponge	*Gelliodes callista* –Chuuk, Fiji, Indonesia, Phil, PNG, Vanuatu, Pohnpei	Pulo Ana	9710-O
Sponge	*Svenzea devoogdae*- Phil, Vanuatu, Malaysia	Pulo Ana	9724-F
Sponge	*Xestospongia* sp. 8 – Phil, Indonesia, PNG	Pulo Ana	9711-P, 9725-G
Sponge	*Cinachyrella* sp. (orange- Sonsorol) – PNG, Malaysia	Sonsorol	9675-Z
Sponge	*Cribrochalina cribricutis*- Indo, Phil, Maldives	Sonsorol	2866-Y
Sponge	*Cribrochalina* sp. 3- PNG, Indo	Sonsorol	2868-A, 9663-N
Sponge	*Epipolasis* sp. 2- Phil, Yap	Sonsorol	9664-O
Sponge	Petrosid New Genus 3 sp. 2	Sonsorol	2861-T
Sponge	*Siliquariaspongia mirabilis*- PNG, Phil, Chuuk, Vanuatu, Fiji, Indonesia, Malaysia	Sonsorol	2871-G, 9661-L
Sponge	*Svenzea devoogdae*- Phil, Vanuatu, Malaysia	Sonsorol	2899-L
Sponge	*Xestospongia* sp. 8 – Phil, Indonesia, PNG	Sonsorol	2860-S, 9666-Q
Sponge	*Xestospongia* sp. 9- Phil, Indonesia	Sonsorol	2898-K
Tobi State			
Gorgonian	*Isis hippuris* – PNG, Philippines, Malayisa, Indonesia	Helen Rf	9770-F
Sea Squirt	*Didemnum parau*- Philippines, PNG	Helen Rf	4409-A, 9802-O, 9914-L
Sea Squirt	*Polysyncraton cerebellum* – PNG, (Angaur)	Helen Rf	4422-Q
Soft Coral	*Sinularia* sp. H- Pohnpei, PNG, Mauritius	Helen Rf	4413-H
Sponge	"*Dysidea rhax*" - Philippines (3869-P)	Helen Rf	4447-X, 9833-W
Sponge	*Callyspongia* sp. 8- Chuuk, Fiji, PNG, Vanuatu	Helen Rf	4444-P
Sponge	*Calyx* sp. 5 (*Vagocia*) - Philippines	Helen Rf	9825-O
Sponge	*Cribrochalina cribricutis*- Indo, Phil, Maldives	Helen Rf	4429-X
Sponge	*Euryspongia* sp. 3- PNG	Helen Rf	4451-W, 9800-M
Sponge	*Gelliodes callista* –Chuuk, Fiji, Indonesia, Phil, PNG, Vanuatu, Pohnpei	Helen Rf	4452-X, 9773-I
Sponge	*Gelliodes fibulata*- PNG, Vanuatu, Malaysia	Helen Rf	4440-L, 9913-K
Sponge	*Petrosaspongia mycofijiensis*- Fiji, Tonga, Vanuatu, Malaysia	Helen Rf	9843-J
Sponge	*Siliquariaspongia mirabilis*- PNG, Phil, Chuuk, Vanuatu, Fiji, Indonesia, Malaysia	Helen Rf	4416-K, 9820-J
Sponge	*Strepsichordaia radiata* - PNG, Phil	Helen Rf	4419-N
Sponge	*Suberea verongiformis*- Vanuatu	Helen Rf	4425-T, 9777-M
Sponge	*Xestospongia* sp. 8 – Phil, Indonesia, PNG	Helen Rf	4428-W, 9767-I
Sponge	*Callyspongia biru* - Malaysia, Indonesia	Tobi	4461-J, 9752-K
Sponge	*Epipolasis* sp. 2- Phil, Yap	Tobi	9762-U
Sponge	*Gelliodes callista* –Chuuk, Fiji, Indonesia, Phil, PNG, Vanuatu, Pohnpei	Tobi	9755-N
Sponge	*Petrosaspongia mycofijiensis*- Fiji, Tonga, Vanuatu, Malaysia	Tobi	4462-K, 9766-Y
Sponge	*Xestospongia* sp. 8 – Phil, Indonesia, PNG	Tobi	9756-O

PHYSICAL MEASUREMENTS TO HELEN REEF - TIDES AND CHANNEL CURRENT

A variety of physical oceanographic instruments were installed during our stay at Helen Reef. Depth loggers (tide gauges) were placed at three locations in the Helen Reef lagoon for the duration of our stay. The locations were the northern lagoon near Helen Island, the southern lagoon on the slope of a patch reef and the central lagoon near where the ship mooring buoy is located (02° 52.785' N, 131° 46.617' E) (Figure 1). There were no appreciable differences in the tidal patterns among the three sites. A point acoustic doppler current meter was also deployed at 22 m depth in the main channel and this instrument provided a fourth tide station.

We did a comparison between the tide data for Helen Reef, using the central lagoon depth logger data with data from the CRRF depth logger located on a Malakal Harbor channel marker (Figure 2). The green line represents the daily tide in the Helen Reef lagoon, and the red line superimposed over this represents the daily tide in Malakal Harbor. The tidal phase and amplitude for Helen Reef lagoon is almost a perfect match for that of Malakal Harbor. This is interesting, but not surprising since the same amphidromal line runs directly through the main island group and Helen Reef. The tide tables for Koror can therefore be used with some confidence for Helen Reef. Data from these instruments is included on the hard drive.

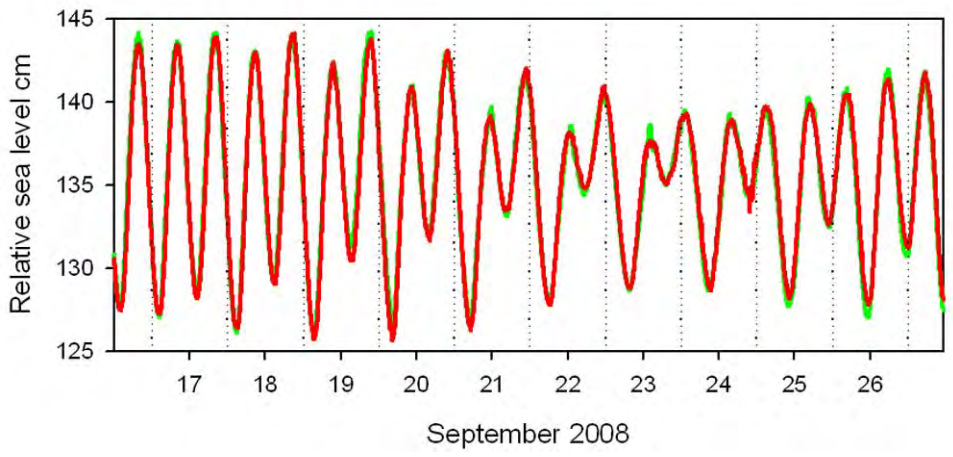

Figure 2. Tidal regime of Helen Reef Lagoon relative to Malakal Harbor in the main islands of Palau. Green line is Helen Reef, while the red line is Malakal Harbor.

Helen Reef Channel Current

A single point current meter was installed in Helen Channel at 22 m depth for 12 days starting on 16 September at 3:00 PM ending on 28 September at 8:30 AM (Figure 3). Data from this instrument is included on the hard drive. The instrument measured the current speed and direction every 5 min for the duration of the deployment. At the current meter's deployment location the axis of the channel runs southwest-northeast. Figure 3 shows the location of the current meter relative to the channel orientation as well as summarizing the current flow pattern in the channel. All measurements of current speed and direction are shown with reference to a zero point (the central yellow spot) (Fig. 3). The length of the line from the zero point represents the speed of the current, while the angle of the line relative to the compass represents the direction the current was going.

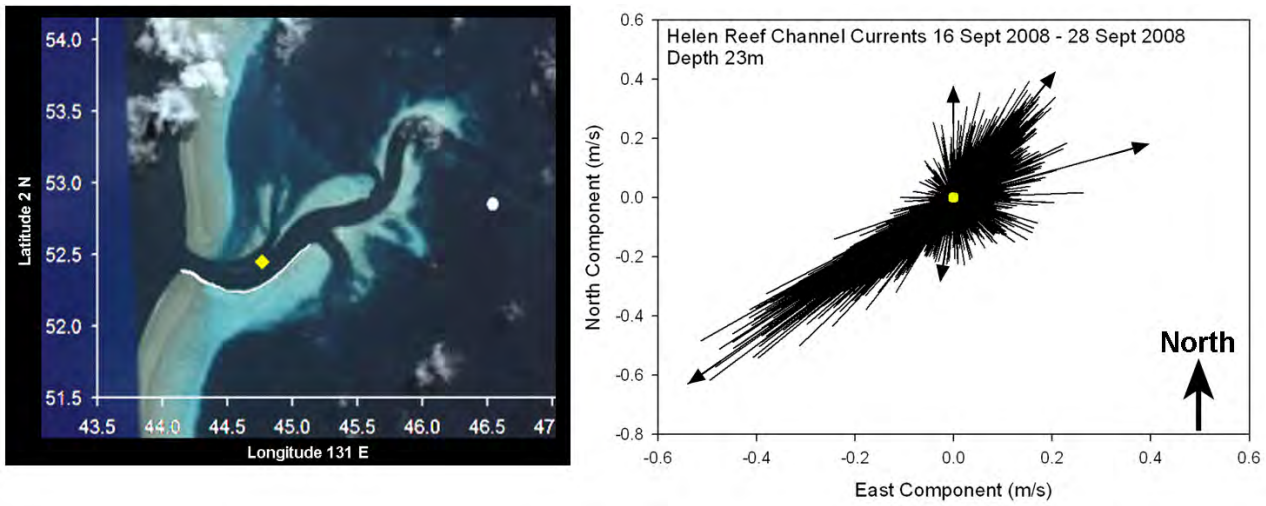

Figure 3. Left: Helen Reef Channel with yellow diamond indicating position of point current meter deployment. The white circle in the lagoon east of the channel marks the Helen Reef Mooring Buoy and site of our central lagoon depth logger for reference. Right: Current meter location is represented by the yellow circle. Graphical summary of all current flow recorded in Helen Channel for 12 days in Sept. 2008. Current speed is represented by the length of the line, and current direction flowing away from the yellow circle. The arrows provide examples of the direction of water flow, and follows the compass reference indicated.

The overall shape produced by the current measurements shows the pattern of flow on both falling and rising tides. On falling tides the flow was largely oriented along the axis of the channel as indicated by the long narrow "tail" of current vectors to the SW. On rising tides, the direction of the incoming current is less focused, probably because near the location where the meter was moored, the channel splits with a small arm oriented more to the north than the general channel axis. Overall the flow to the SW (225^{o}- outgoing from lagoon to ocean) is greater than that to the NE (45^{o}- incoming from the ocean) as evidenced by the generally greater current speeds to the SW. The highest current speeds were just over 0.6 m/sec or about 1.2 knots. There is a net OUTFLOW of water through the channel from the lagoon to the ocean. This might not be surprising if one considers the amount of water which is "wave pumped" over the barrier reef into the lagoon. This water coming across the reef adds to the water entering the lagoon via rising tides through the channel, but there is not any similar mechanism to wave pumping for removing water from the lagoon to the ocean. The net excess of water in the lagoon resulting from wave pumping has to exit the lagoon largely through the channel, hence there is a net outflow of water from the lagoon via the channel.

The currents in the Helen Reef channel respond to the normal tidal cycle; water enters the lagoon from the ocean on a rising tide while water exits the lagoon on a falling tide (Figure 4). As indicated above the outflow is generally a bit greater than the inflow. At times of either high or low tide, the current abruptly stops in the channel, and once the tide starts rising or falling, the current picks up gradually. Late in the rising or falling tide the current reaches near its maximum speed, which during the period of our observations was seldom over 0.4 m/sec at the meter site.

Weather conditions, however, can overrule this normal cycle. We were able to document one such abnormal cycle produced by a strong storm that hit Helen Reef on 19 September 2008. Starting at mid-day on September 19th, the wind came up strongly from the SW eventually reaching an estimated 40 knots, with gusts to near 50 knots. The wind caused heavy seas to break

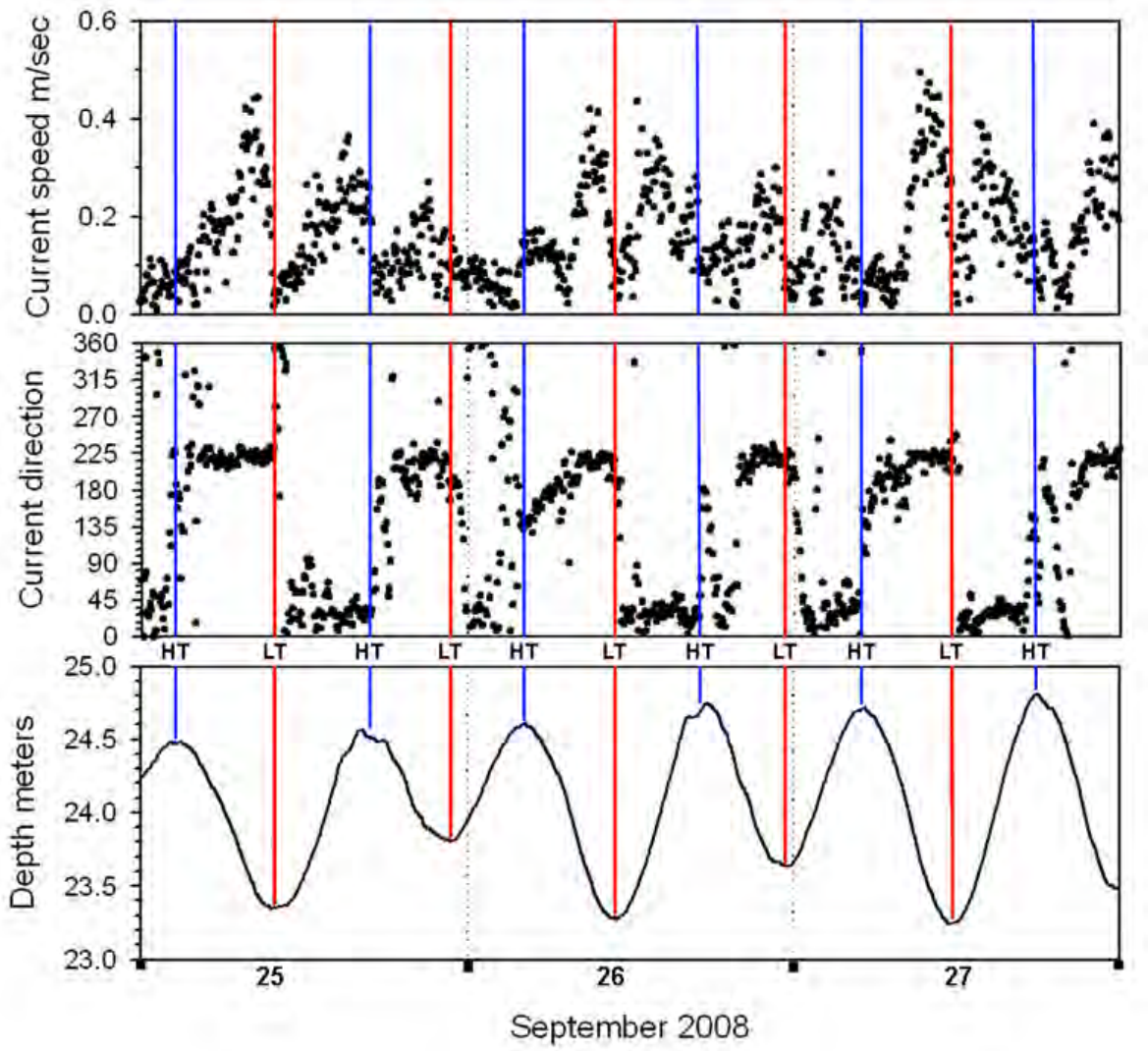

Figure 4. Normal tidal/current conditions at the Helen Reef Channel, data from 25-27 September 2008. (lower graph) Time of high tide is represented by the vertical blue line, and time of low tide by the vertical red line. (middle graph) Current direction (compass bearing) over three days, 25-27 Sept. Values near 225 degrees are outgoing (falling) tides while near 45 degrees represent incoming (rising) tides. (upper graph) Current speeds change when the tidal direction changes, but seldom are greater than 0.5 m/sec.

all along the western barrier reef. The winds abated the next morning (20 September) by about 5 AM and the tidal regime in the channel returned to normal.

During the strong SW winds while the tide was rising between 15:30 and 21:15 on 19 Sept, the current continued to flow out the channel, with speeds generally of 20-30 cm/sec (Figure 5). The entire sequence of incoming current was interrupted (stopped) by this storm event, probably due to a much larger amount of water being forced across the barrier reef by the wind causing "wave pumping". This has also been documented in the West Channel of Palau during strong westerly storms.

Following this storm a dive was made in Helen Channel on the morning of 20 Sept 08. The reef top showed significant damage from wave action, with overturned boulders and broken

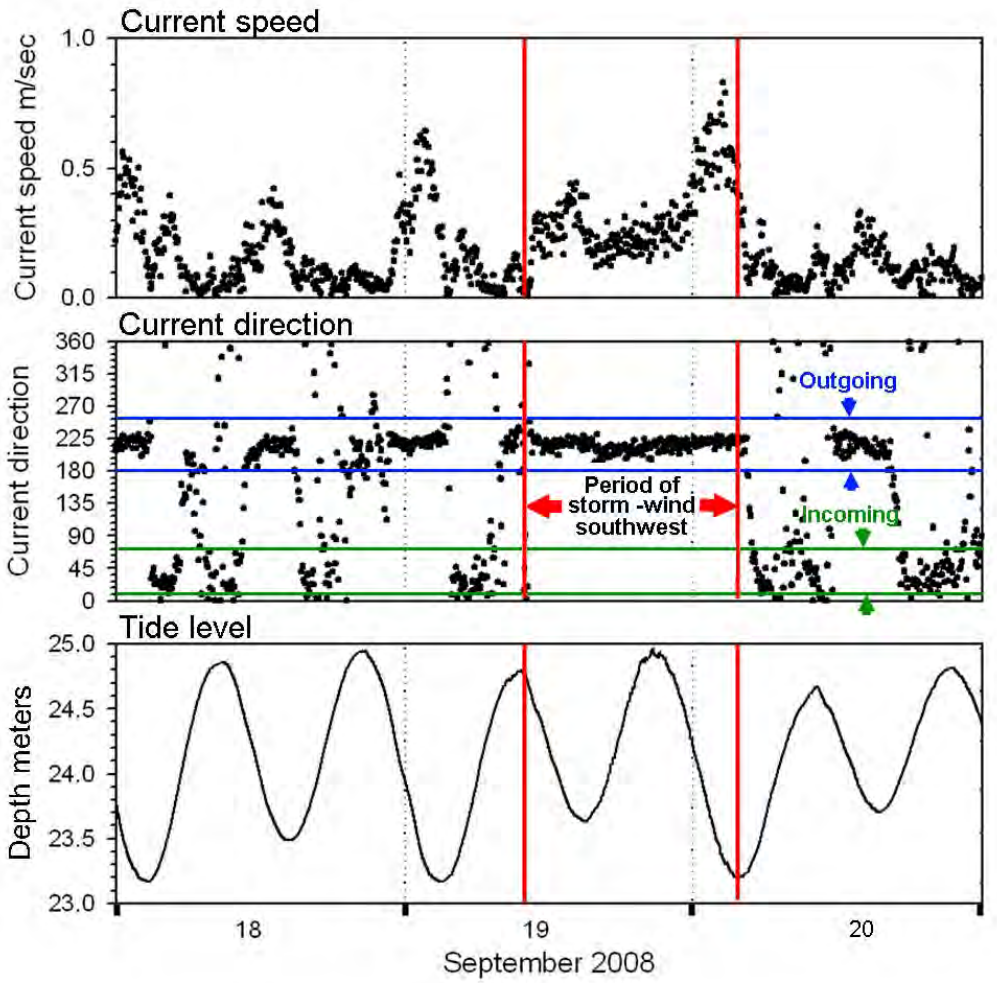

Figure 5. Tide and current data from period with strong southwesterly winds (19-20 September 2008) at Helen Reef channel. (lower graph) Tidal pattern from 18-20 September, with vertical red lines indicating the period of strong storm winds. (middle graph) Outgoing current to the SW (225 ^{o}) is between the blue lines. Data shows the current direction did not switch with the incoming tide on the afternoon of 19 Sept, remaining outgoing (near 225^{o}) through the morning of 20 Sept. (upper graph) Current speeds during the continuous outgoing current on 19 Sept varied somewhat, but did remain above 0.10-0.15 m/sec.

Figure 6. Damage from the 19 Sept 08 storm on the reef top at Helen Channel (south side) showing overturned boulders and exposed encrusting sponges typically living on the shaded underside of rocks.

branching coral (Figure 6). Many encrusting sessile invertebrates normally living on the shaded underside of these coral heads were exposed and carnivorous fish were busy feeding on them.

Currents in the Ocean around Helen Reef

While no quantitative measurements were made of currents in the ocean around Helen Reef, we did have opportunities to assess how oceanic currents are interacting with the atoll. The general oceanic current during our time there was believed to be from the southwest to the northeast. The long axis of the atoll is oriented about 20^{o}-200^{o} on the compass and parallel to the general current. The southern end of the atoll is somewhat "blunt" and possibly the current hits this blunt end and produces areas with swirling eddies as the current is cleaved by the atoll. This caused dive sites in the south to have quite variable currents. At times there was no current, but in a few minutes an eddy could sweep into the area along the reef and produce currents of 1 m/sec or more. The current at the northern end of the atoll, where the atoll geomorphology is a sharp point, was going to the north when we visited that area. There did not appear to be significant eddying of currents along the reef.

MARINE COMMUNITIES AND THEIR DISTRIBUTIONS

Based on our observations, as well as satellite and aerial photographs, we present the following tentative breakdown of the major marine habitat types at Helen Reef. Each will be briefly described below.

1. **Barrier reef**
    a. Outer slope
    b. Reef top
    c. Back reef slope
    d. Back reef mini-lagoons
2. **Barrier Reef Channel**
    a. Sides
    b. Bottom
3. **Lagoon**
    a. Patch reefs - tops
    b. Patch reefs - slopes
    c. Lagoon channel reefs
    d. Lagoon bottom - sediment
    e. Lagoon bottom - algal flat
    f. Lagoon bottom - low patch reefs

1.a. Barrier Reef - Outer Slope

The outer reef around Helen Reef is mostly a steep slope. There are only a few areas of near vertical to undercut reef; these probably due to spalling, or breaking off, of the reef. The stony coral populations on the outer slope seemed healthy and live coral was relatively abundant (Figure 7). Tabulate *Acropora* were quite common. Of interest, little *Acropora palifera* was seen. This is a coral which dominates rough water areas of many island groups, but very few were found on the outer slope of Helen Reef. Blue coral, *Heliopora coerulea*, and the calcareous green algae, *Halimeda* sp., were also abundant on outer slopes, as is typical of the oceanic islands (Figure 8).

Figure 7. Left: Outer reef slope on the northeastern portion of the atoll with young table *Acropora* corals. Right: Typical shallow outer reef slope with abundant *Halimeda* algae, as well as scattered table *Acropora* corals.

Figure 8. Left: Outer reef slope with colonies of *Heliopora coerulea* blue coral. Much of the area of the bottom is rocky with large patches of the calcareous algae *Halimeda* in depressions. Right: Looking down the outer slope with a large *Pocillopora* coral and a large amount of *Halimeda* algae dominating the bottom.

It appears that there are few areas with spur and groove features on the outer barrier reef. The only area where we encountered any spur and groove was on the northern section of the atoll on the west side (the northernmost station location on Figure 1), with some grooves on the shallow reef flat. Examination of the aerial and satellite images available also did not provide any evidence for spur and groove occurrence.

The southern barrier reef had a very sharp edge where the reef front drops away from the reef flat. On the southeast corner of Helen Reef an area of probable spalled reef had an undercut wall and ledges going down to over 90 m. Here the edge seemed particularly sharp. At the 30 m depth level, a horizontal cave was exposed that reportedly went back 30-40 m from the opening. There were a number of species of invertebrates we found here that were not found on sloping outside reefs. This is due to the vertical to overhanging walls creating a different microhabitat with more shelter from sunlight than the exposed outer reef slopes.

The suite of sponge species found on the outer reef of Helen Reef was moderately small. The orange sponge *Agelas* cf. *clathrodes* was common on the outer slope, as was the large tubular

Theonella sponge (Figure 9). The keratose bath sponge, *Spongia matamata*, was common in all habitats at Helen Reef. Soft corals are difficult to identify in the field and many collections were made. We will have a better assessment of their diversity after specialist taxonomists look at our collection. However, noticeable was the apparent low biomass of soft corals on the outer reef, compared to a similar sized atoll (Layang Layang) in Malaysia, South China Sea. Recovery of soft corals in Palau following the 1998 coral bleaching was slower than hard coral recovery, and it's possible that soft corals are still in a 'recovery' phase.

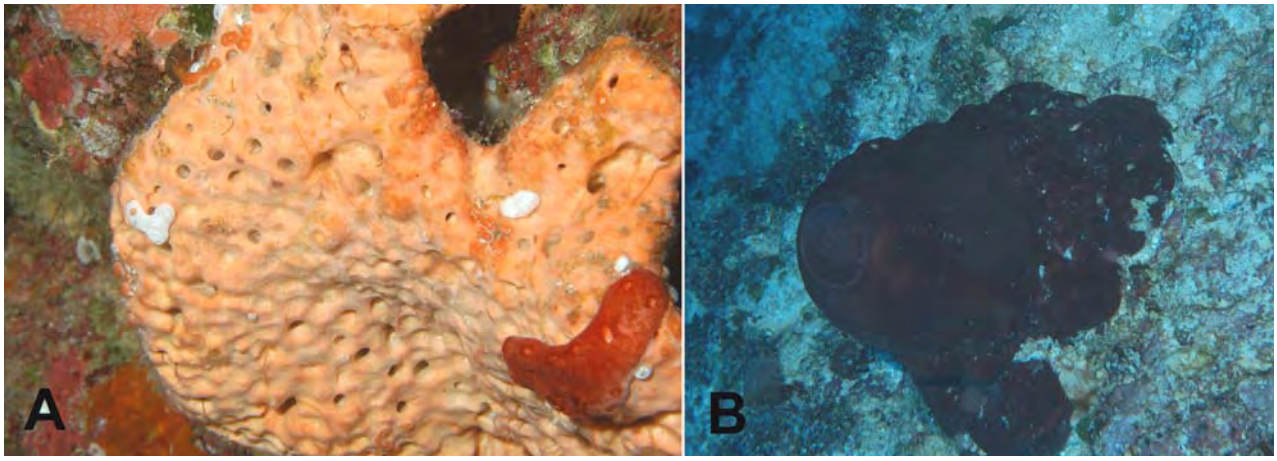

Figure 9. A. The large, rubbery orange 'ear' sponge, *Agelas* cf. *clathrodes* and B. large tubular *Theonella* sp. were common on the outer reef slope of Helen Reef.

There were several species of sponge common in the Sonsorol state islands but not found at Helen Reef. Some of these include the barrel sponge, *Xestospongia testudinaria*, and the yam sponge, *Rhabdastrella globostellata*.

1.b. Barrier Reef - Reef top

The barrier reef tops at Helen Reef are often wide, as much as 1 km in width. As currents or the tide tended to make it difficult to swim in such areas and our collection efforts were largely limited to the lagoon edge. They vary in cover from dense hard coral to wide expanses of open sand with scattered small patch reefs (Figure 10). We spent the most time in the area of the shipwreck on the western barrier reef, where there is a potential "iron algae" flat. This is discussed later in this report.

Many areas of the shallow reef tops had beautiful healthy populations of stony corals. In some areas beds of branching *Acropora* corals grew to the surface and coral cover was often very high, from about 80-100% cover over broad areas. The area along the break between the level reef top and the start of the slope into the lagoon usually had lush growths of stony corals (Figure 11). This high density coral growth often extended on the slope into the lagoon. On the eastern barrier reef we examined only one area of the reef top, accessing it from the lagoon side.

Figure 10. Reef top patch reefs (A & B) amongst wide expanses of sand on the eastern reef top of Helen Reef.

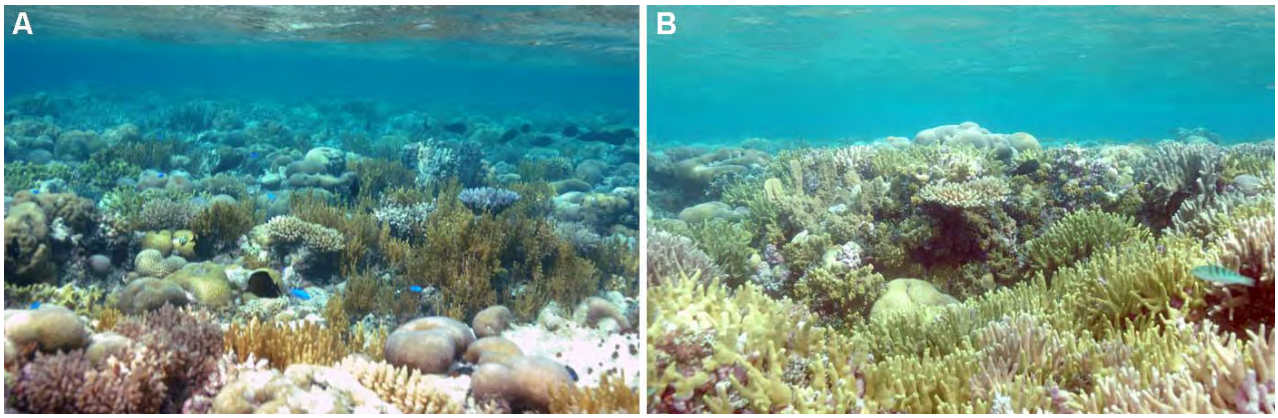

Figure 11. A. Shallow top of the barrier reef to back reef. B. The lagoon edge of shallow reef flat has a break from the flat reef top to where the slope begins to go into the lagoon.

1.c. Barrier Reef - Back reef slope

The back reef slope, from the lagoonward edge of the reef flat to the flat bottom of the lagoon, was examined in several locations. The slope is quite variable in its fauna, and may or may not have stony coral communities on it.

On the east side of the atoll, the lagoon slope typically had reef communities with a limited diversity of corals. Vast areas of the reef coral was dead, probably the result of the coral bleaching event in 1998, and populations of hard corals had not recovered to any degree. At depths of 20-25 such areas transition into sediment bottoms with reduced slope, merging with the general lagoon sediment bottom at 25-30 m depth.

On the west side of the lagoon, the general back reef slope was mostly sand sloping down the lagoon floor at about 30 m. This sand slope is near the angle of repose, and sediment from the barrier reef is transported into the lagoon here.

1.d. Barrier Reef - Back reef mini-lagoons

On the lagoon side of the eastern barrier reef there are numerous areas where there is a second shallow reef inside the main barrier reef, with an elongate lagoon between them (Fig. 12).

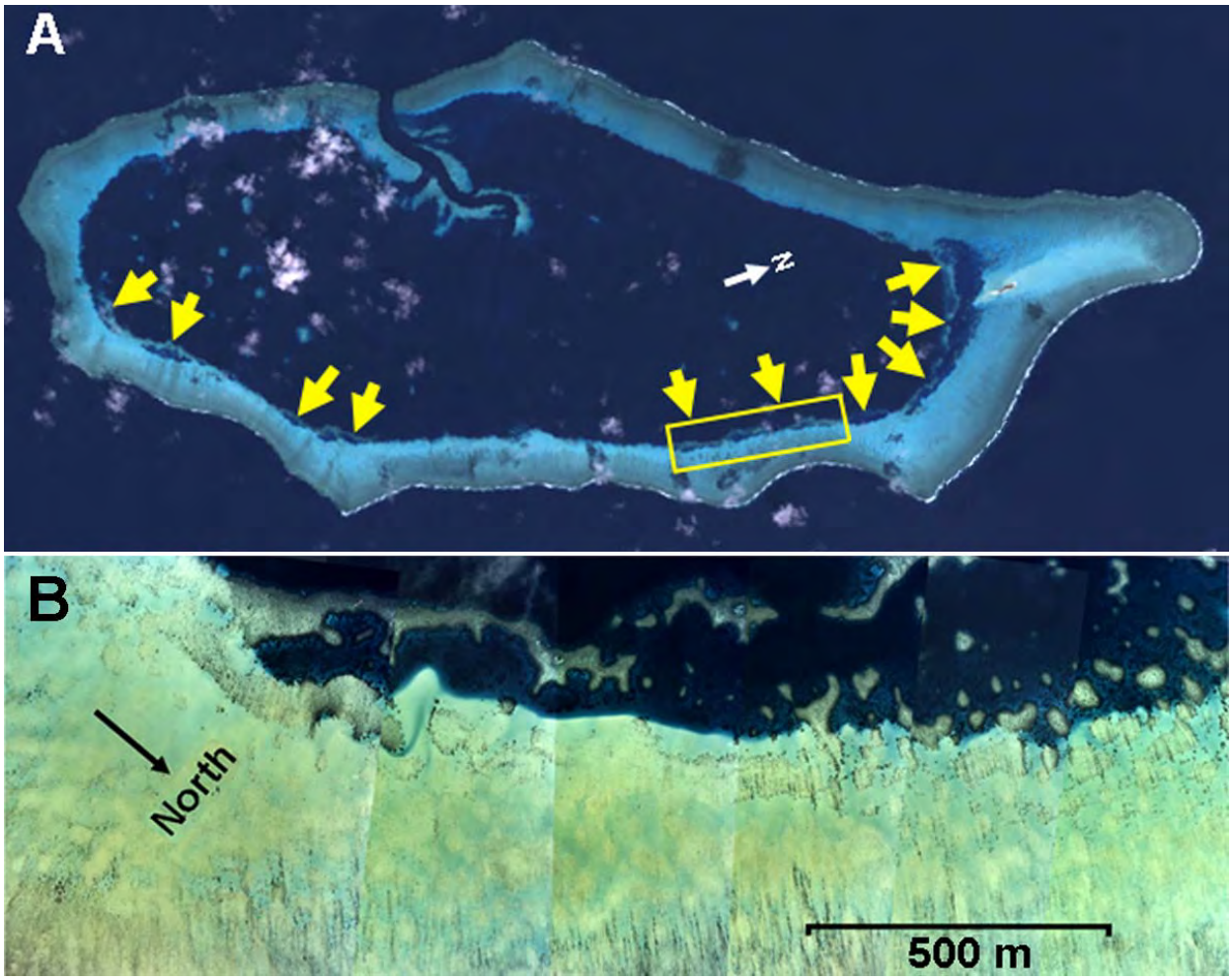

Figure 12. The north and eastern lagoon edge of the barrier reef of Helen Reef has "mini-lagoons" along its inner margin. A. Helen Reef atoll with yellow arrows showing the location of "mini-lagoons." B. Close-up of a "mini-lagoon" area on eastern reef. Shallow reef, nearly emergent at low tides, occurs inside the normal barrier reef producing protected embayments inside the barrier reef. The "mini-lagoons" are not found on the western or southern inner barrier reef.

These "back-reef mini-lagoons" were examined and have protection from waves and currents from both east and west. We visited one area of mini-lagoons shown in the box on Figure 12 and found lush coral communities containing coral species (or morphologies) typical of quiet, low water movement areas (Figure 13). The organisms occurring there were not different than other areas, but the overall reef appeared very healthy and diverse.

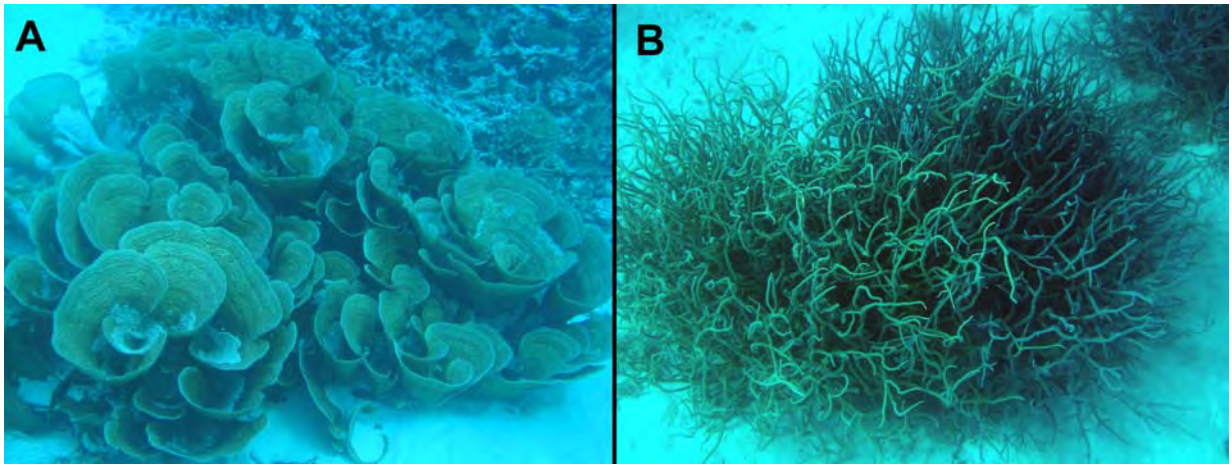

Figure 13. Some corals in an eastern barrier reef "mini-lagoon" showing the lush growth found in such areas. A. *Echinopora mammiformis* coral. B. Branching species of *Acropora*.

South of Helen Island is a complex of mini-lagoons and we installed one tide gauge there, as well as making a small series of collection stations there. This mini-lagoon was somewhat different from the ones we examined on the east side of the atoll. It was deeper (18 m versus 10 m on the east side) and wider in extent. Here we encountered some invertebrates that were not seen elsewhere at Helen Reef. One of these was a soft coral, in the genus *Sinularia*, which occurred in a dense stand on an open sand bottom (Fig. 14). The soft coral has its basal elements buried in the sand, but is not attached to any hard substratum.

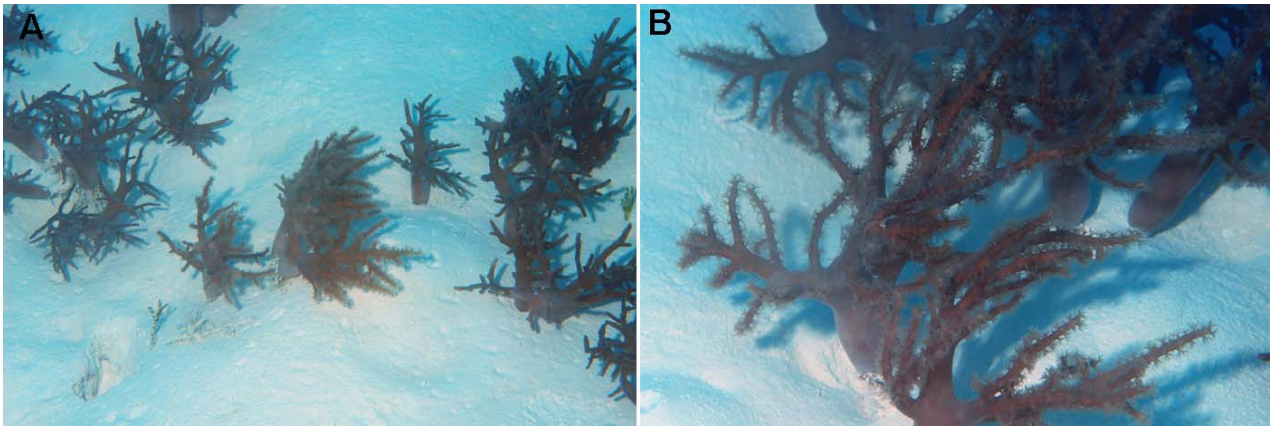

Figure 14. *Sinularia* sp. soft coral found on open lagoon sand at 15m. Basal elements of the soft coral anchor it into the soft sediment.

2.a. Barrier Reef Channel - Sides

The main channel between ocean and lagoon at Helen Reef has wonderful populations of some reef fishes, spectacular scenery and significant biodiversity. The benthic communities in the channel vary with the slope of the sides and between the sides and the bottom.

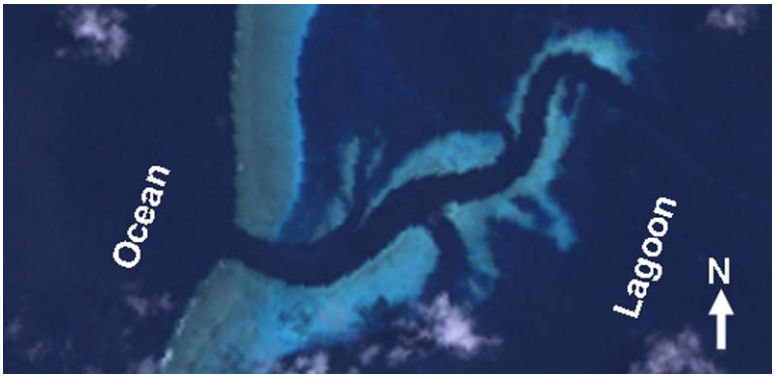

Figure 15. The Helen Reef Channel winds approximately 2 km between the open ocean on the west side of the atoll to the lagoon. It is a complex channel, with a number of side branches, but only a single opening on the ocean.

Approaching from the ocean the channel (Figure 15) arcs to the left and its main segment winds sinuously, tending NE into the lagoon. Some side channels branch off from the main one, a relatively shallow one to the left and a deeper arcing one to the right further up the channel. We dove and snorkeled at several areas within the channel. Facing the lagoon from the ocean, the right hand (south) side of the channel is a steep wall, in places going from about 5-8 m depth to over 30-35 m vertically (Figure 16). A number of dives were made in the Helen Reef channel area as it has high fish populations and a diverse complement of filter-feeding invertebrate species. The maximum depth found in the channel was 54 m (180 feet). There is no good bathymetric map available for the channel available.

Figure 16. Left: Area near the surface along the side of the Helen Reef channel. Right: Large patches of finger coral, such as these *Porites* spp. occur along the edge of the Helen Reef channel.

On the southern side, at an area that is near vertical, we encountered large areas of the wall covered in what we term "turf balls" (Fig. 17a). "Turf balls" are a mass of sponges, ascidians, hydroids and a variety of other small invertebrates that occur as tear resistant clumps of organisms about 10-15 cm across and a similar thickness. They are a community which is found in other geographic areas such as Papua New Guinea, but are unknown from the main Palau islands. Their occurrence at Helen Reef was a bit surprising and an interesting addition to the atolls habitat complement. The components of the "turf balls" are being identified by the taxonomists working on the NCI collection samples.

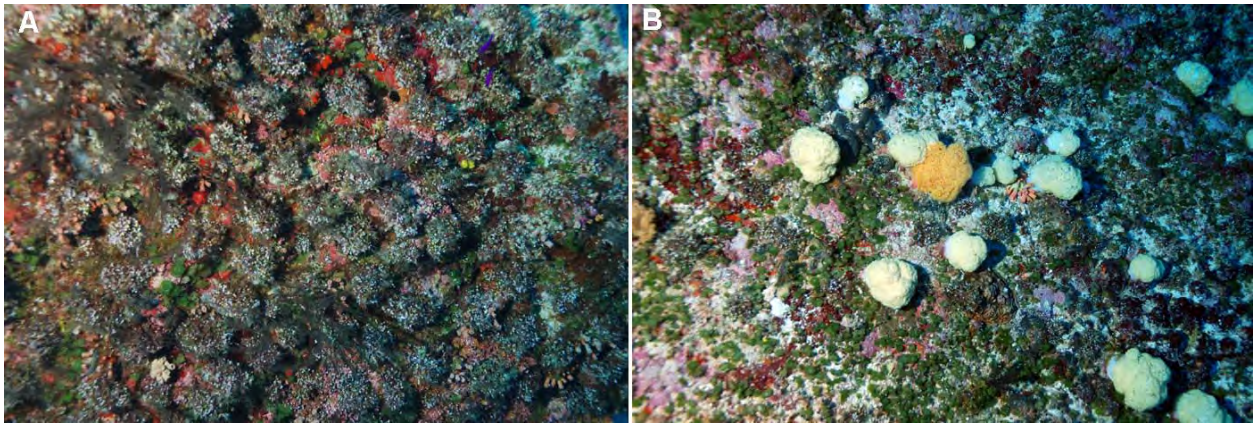

Figure 17. Helen Reef channel communities. A. "Turf balls" comprised of sponges, sea squirts, hydroids and other invertebrates on southern wall. B. Soft corals, *Dendronephthya* sp., on the channel bottom at 40 m depth.

There were a moderate number of antipatharian (black coral) "trees" along the channel wall. In addition to the large "tree" colonies, there were several other species of black corals found in the channel and on outer reef slopes. These were photographed for reference, and a listing of the species present could be prepared in the future. The species that we noted were similar to those found elsewhere, and it does not seem that there are any exceptional species or colonies of black coral at Helen Reef. The red sea fan, *Melithea* sp., sometimes used for jewelry, was also common in the Helen Reef channel (Figure 18) and on some of the other outer reef slopes of the oceanic islands.

Figure 18. The red sea fan, *Melithea* sp., was common in the Helen Reef channel and on other outer reef slopes. Sometimes used for jewelry, this would be an ideal location to study growth patterns of this gorgonian.

A school of about 50 bumphead parrofish, *Bolbometopon muricatum*, were usually found in the outer portion of the southern side of the channel wall. We were able to observe these fish in some detail, and saw several instances of possible preliminary courtship and aggressive interactions between fish. The behavior of *B. muricatum* is poorly known scientifically, and the school at the channel mouth would be an ideal group for which to examine their social and reproductive behavior in a dedicated study. Certainly given that we were able to count the numbers of fish in some detail, as well as document their location in detail, it would be possible to monitor this group over time. The fish is highly prized for food and is a good indicator species for fishing exploitation.

There were numerous areas of the upper lip of the channel where the reef had obviously slumped away and a large amount of material had slide down the slope into the channel. Some of these areas seemed to have collapsed relatively recently (last few years).

2.b. Barrier Reef Channel - Bottom

Some areas of the channel bottom are relatively flat, however, other areas have some development of ridges and reef structures that come up to within 25-30 m of the surface. On the southern side of the channel (the left hand side when exiting the lagoon) the bottom is deeper, up to about 56 m maximum depth. The southern wall of the channel slopes steeply to meet the bottom of the channel at a sharp interface. The channel bottom is large unconsolidated rubble and sediment with a community of organisms adapted for that type of bottom. Gorgonians, soft corals and a variety of sponges occur on the channel bottom (Figure 17b). *Soelencaulon* and *Dendronephthya* soft corals were common in the channel. The relatively strong currents that course through the channel determine the types of organisms that can occur there. The channel fauna was typical of that found in channels in the main island group.

Some unattached stony corals were found on the channel bottom. The hemispherical *Goniopora stokesi* was seen at one site. Some "coraliths" were also found here (Figure 19). A coralith is a coral colony which is not attached to the bottom and has living polyps on all surfaces.

Figure 19. Photo of a *Porites* coralith, a coral colony which is not attached to the bottom and has living polyps on all surfaces..

They typically occur only where there is coarse sand or rubble bottoms as well as strong currents and waves. The coralith is turned over by currents or waves at intervals sufficiently regular to prevent the coral polyps living on the side which lies against the substratum from dying and the coarse substrate prevents the coralith from settling into the sediment, again preventing the polyp from dying. The coraliths in the Helen Reef channel were a massive species of *Porites*.

Why is the channel deeper on the southern side? Likely it is because the southern side of the channel is the outer part of the channel curve and, typical of river bends, the outermost part of the bend has the deepest depth and stronger currents. Such depth configuration is typical of atoll and reef channels. The currents across the channel on incoming tides were observed to vary from side to side. The location of the current meter in the channel during our visit provides only one position for current measurements and it is likely currents at a second site, particularly on the opposite side of the channel, would be somewhat different in strength.

3.a. Lagoon - Patch reefs - tops

There are a moderate number of shallow patch reefs in the lagoon that are visible in Landsat images (see Fig. 1). About 30 come up to or very near the surface, although the exact number can not be determined due to clouds in the few images available and lack of higher resolution imagery. At least 21 of the patch reefs are found south of channel, while only about 7 are present north of channel. The southern lagoon (south of the channel) has a much smaller area than the north, so the density of patch reefs is possibly 3-4 times that of the northern lagoon.

3.b. Lagoon - Patch reefs - slopes

The slopes of the patch reefs are an area that appeared to be heavily impacted by coral mortality from the 1998 bleaching event (Figure 20). The gorgonian *Isis hippuris* (see below) dominated many of the patch reef slope areas.

3.c. Lagoon channel reefs

We examined an area that is the inner extension of the main channel in the deeper area of the lagoon. The main channel at Helen Reef comes in through the barrier reef, where it is delineated on each side by shallow (less than 1 m at low tide) reef. Once inside the barrier reef, the channel continues to exist as a deeper area, but the sides of the channel now occur at about 14-18 m depth. This area is shown in Figure 21. This is what might be called the "lagoon channel". It is about 30 m deep in its center, and the sides of the channel are sloping bottom rising up to about 14-18 m. Further out in the lagoon the channel bottom simply merges with the deeper lagoon bottom (no sloping walls alongside the central axis of the channel). In many respects the lagoon channel seems to be just another portion of the lagoon bottom. It is likely the lagoon portion of the channel represents a feature originally formed during glacial low sea levels

Figure 20. Many areas of lagoon patch reefs had low populations of living stony corals. These areas were almost certainly decimated by the 1998 coral bleaching event and have not recovered their stony coral populations to any great extent. A. This area at 14 m depth has a mound of dead branching *Acropora* debris, the coral colonies having crumbled and compacted after dying. Such areas are typical in the main Palau group from the bleaching and confirmed to have died from that event. B. A view of the reef from above shows the extent of coral death and the lack of new recruits which have obtained any significant size. Given enough time the area will probably recover its coral population, but this may take a few decades given the low level of recovery which has occurred in ten years.

10-15 thousand years ago. Prior to that, for nearly 100,000 years, Helen Reef would have been dry land. The depth where the channel is today (30 m) would have flooded due to rising sealevel about 10,000 years ago. At that point the channel would have drained a very shallow lagoon surrounded by a limestone ridge of dry land where the barrier reef is today. The channel had a sediment bottom covered with dense *Halimeda* algae and the hemispherical unattached coral *Goniopora stokesii* (Fig. 22a). No comparable habitat has been found in the main Palau island group.

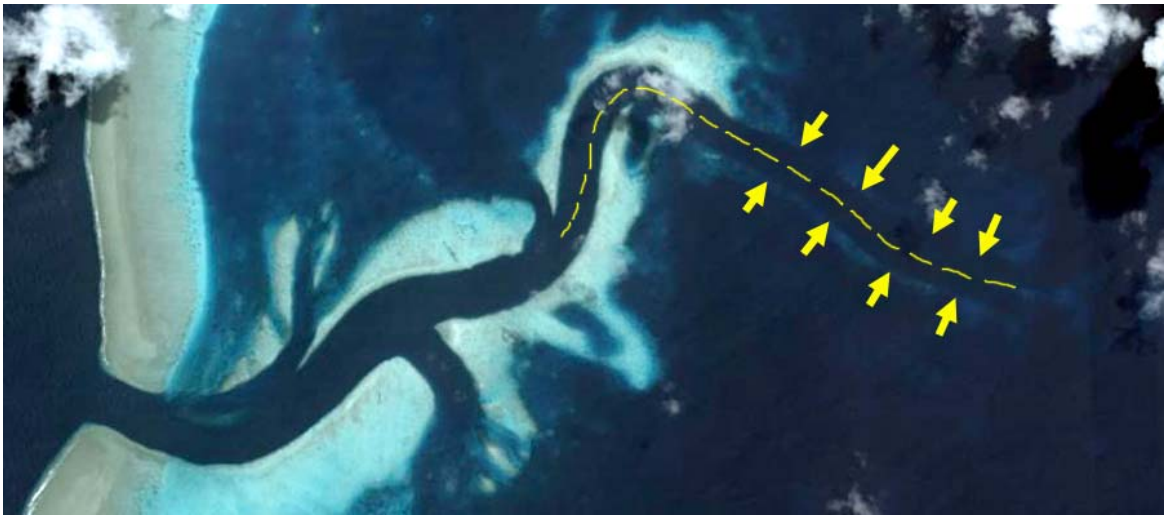

Figure 21. The "lagoon channel" at Helen Reef is an extension of the main channel which bisects the shallow barrier reef into the deeper lagoon. The center of the channel is shown by the dotted line, while the edges of channel are indicated by the arrows. The channel bottom is about 30-36 m deep while its sides are 14-18 m deep. The channel bottom has an algal flat community while its edges are hard bottom with reef.

3.d. Lagoon bottom - sediment

Most of the open lagoon bottom is probably sediment without a cover of algae or any particular coral or soft coral. The lagoon bottom was dominated by “volcano” sand mounds of callianassid shrimp. These crustaceans form burrow systems in the sediment bottom and the animals are never seen. There presence is obvious, however, due to abundance of the elevated conical mounds of sediment pumped from the burrows and pits where sand is taken into the burrow systems for processing for food.

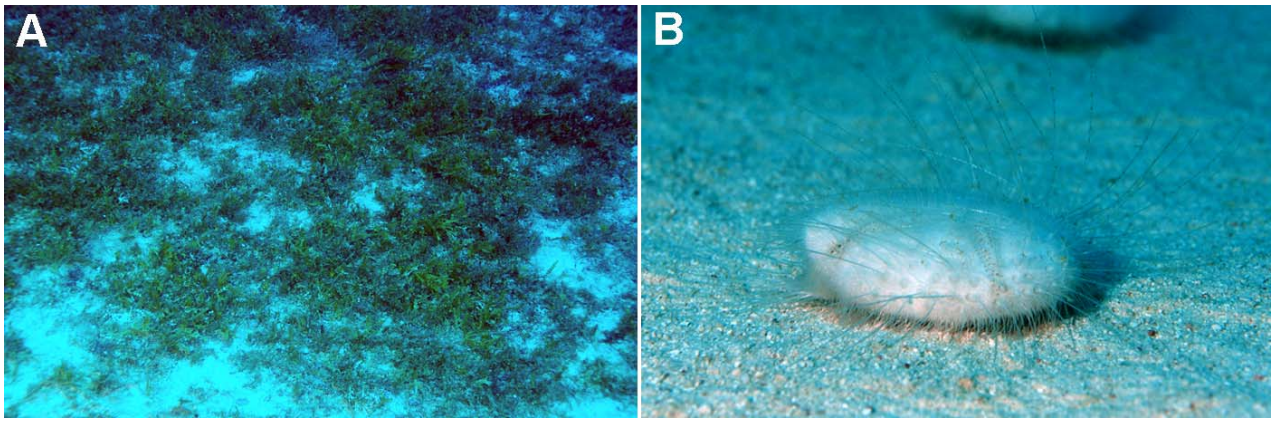

Figure 22. A. The bottom of the lagoon channel is dominated by Halimeda algae, interspersed with hemispherical Goniopora stokesii corals which sit on the open sediment. B. The heart urchin *Maretia planulata* occurs on open sand bottoms at 30 m on the lagoon margin below the sediment slope on the back side of the barrier reef.

There can be patches of lagoon bottom which have invertebrates that are not widely distributed on the sediment bottom. One surprising example of this is a large area (at least 20-30 m in extent) with several heart urchins, *Maretia planulata,* present per square meter on the sediment surface (Fig. 22b). Populations of heart urchins at this density level have never been found in the main Palau group, although the sediment environment on the lagoon slope is similar between the two areas.

3.f. Lagoon bottom - algal flat

We encountered an area of dense algal flat in the lagoon (at the site of our main anchorage) which has not been documented previously. The area was a flat sediment bottom at 33-35 m depth. It was dominated by two algae, *Caulerpa* and *Halimeda,* covering essentially 100% of the bottom (Figure 23 a). A probable member of the green algal genus *Rhipilia*, the "umbrella algae" was also seen on the deep algal flat and specimens for identification were collected.

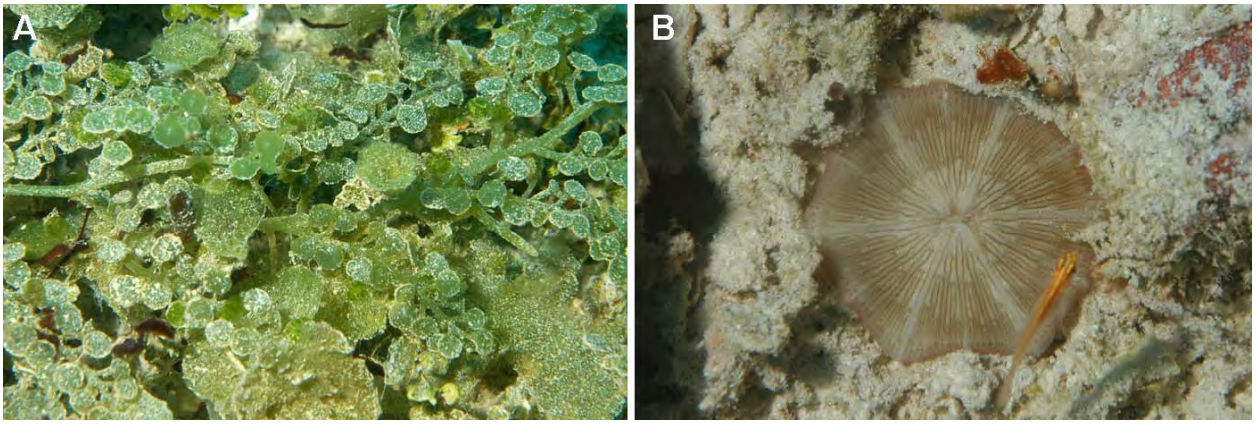

Figure 23. A. Algae on the algal flat at 33 m depth, with *Caulerpa nummularia* dominating, plus an umbrella like species of *Rhipilia sinuosa*. B. The stony coral *Cycloseris hexagonalis* was not previously known from Palau's water. Few individuals were found on the bottom at 30 m in the sandy margin between the algal flat and a low relief deep reef. This species adds another to the already diverse fauna of "mushroom corals" found in Palau.

3.f. Lagoon bottom - low patch reefs

In some areas out on the flat sediment bottom, low patches of reef which rose only a few meters (to about 25-27 m depth) above the general lagoon bottom were found. One of these was close to our main lagoon anchorage and was visited on three occasions. The low patch had a number of sponges not seen elsewhere at Helen Reef. The lower margin of the reef gradually sloped onto the lagoon bottom with a grazed "halo" around the reef. There was also a mix of rubble on this margin slope and we found a few specimens of the fungiid coral *Cycloseris hexagonalis*, at 33 m depth (Figure 23b). This coral was unknown from Palau, although it occurs in New Guinea a few hundred km to the south. It does not occur in the main Palau island group, so represents another of the coral triangle species which reach Palau's southwest islands, but not the main group.

SPECIES DISTRIBUTIONS AND GENERAL COMMUNITY STRUCTURE

The collection trip allowed many opportunities to make general observations on marine conditions at the various islands and Helen Reef atoll. There are great differences in outer slope communities between the oceanic islands and Helen reef atoll. Only a few scattered crown-of-thorns starfish (*Acanthaster planci*) were seen on the overall cruise and they do not, at this time, appear to pose any significant threat to coral reefs at Helen Reef or any of the islands.

The marine habitats around all the oceanic islands (Fana, Sonsorol, Pulo Ana, Merir and Tobi) are similar. The shallow reef flat has a relatively sharp edge at about 2-4 m depth sloping off quickly to great depths. The slope varies between locations on the islands. While we were not able to visit all areas of islands, the steepest (often overhanging) slope was seen at Pulo Ana. The shallow habitats are dominated by the blue coral, *Heliopora coerulea.*. This species grows in great abundance on the upper slope and edge of the reef flat. Fire corals, *Millepora* spp., were abundant on upper slope of outside reefs. There are relatively few species of soft corals in any abundance, although one *Nephthea* sp. was found in large mono-typic stands on most of the islands, and in the Helen Reef lagoon. There are relatively few species of ascidians, particularly at

the Sonsorol state islands. We only collected 9 species from all sites in Hatohobei State and none from Sonsorol State.

There were large amounts of lost long line fishing gear on the island slopes. Long lines were often strung horizontally along lengthy segments of reef, probably after drifting into the reef. The gear had been there for some time as corals and other invertebrates were growing on them.

The bath sponge *Spongia matamata* is very common at Helen Reef, both on the outer reef and in the lagoon, and is highly variable in morphology (Figure 24). This sponge is considered suitable for the natural bath sponge trade, however, it is not a preferred species since it is not as strong and tear resistant as others, such as the highly prized *Coscinoderma mathewsi* (which occurs in the main islands of Palau). We did not find the latter species in the SW Islands, despite specifically looking for it. Farmers in Pohnpei have been successful at growing *Spongia matamata*, however, and are finding a market for it overseas.

Figure 24. *Spongia matamata*, the natural bath sponge, was very common at Helen Reef, both on the outer reef and in the lagoon.

Coral Disease

We saw only one instance of coral disease. One coral with probable black band disease was seen in the lagoon. The general lack of coral disease is understandable given the isolation of Helen Reef, but none the less is good news.

Coral Bleaching

There is only scant information regarding the occurrence of coral bleaching during the 1998 bleaching event. Helen Reef was within the area with high water temperatures at that time (Fig. 25). There are vast areas of formerly luxuriant coral colonies in the Helen Reef lagoon today, on both the lagoon slopes inside the barrier reef and the slopes of lagoon patch reefs. These are dead, covered with algae and deteriorating into rubble. It is virtually certain these corals died as a result of the 1998 bleaching event, but incontrovertible evidence is presently lacking. Virtually every lagoon slope below 6-9 m had dead coral colonies either still in growth position or

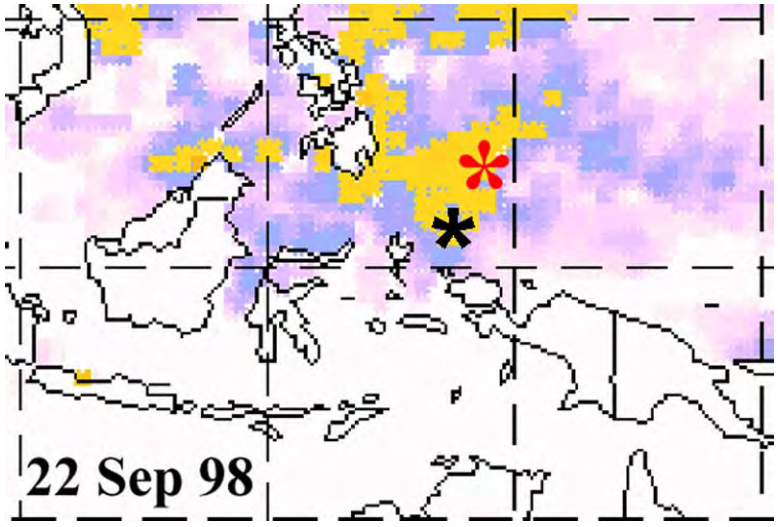

Figure 25. Distribution of ocean surface temperature in September 1998 during the coral bleaching event. The location the main Palau Island group is shown by the red symbol. The location of Helen Reef is indicated by the black symbol. Helen Reef was on the edge of the area that had a 2°C abnormally high water temperature on this day.

crumbling where they grew previously (see previous Fig. 20). These areas appear similar to reefs in the main Palau group where mortality from the bleaching event was verified. There are a reasonable number of new corals growing in such areas, but it will take a couple of decades for the reef to recover to anything approaching its previous status.

If this assumption of the 1998 bleaching event is accepted, the extent of coral bleaching appeared similar to that of the main Palau group. The most evident signs of recovery are the presence of fast growing conspicuous corals, such as the table *Acropora* and other branching species of *Acropora*. In deeper areas of the lagoon slopes vast areas of dead coral below about 12 m (40 ft.) along lagoon reef edges dominate. Apparently the foliose corals, such as *Echinopora* spp., were most affected in deeper lagoon areas. There has been little recovery in such areas, although some of the larger *Acropora* are fairly common. The sponge *Katiba milnei* was found in areas where coral bleaching had occurred. This sponge is a species that quickly settles after coral has died and colonizes the surface of bare rock. Its occurrence was similar to what has been seen in the main Palau group relative to the areas where high level coral mortality occurred due to the bleaching.

Iron-Algae Areas

The large wreck on the western side of Helen Reef has an unusual area of dark reef flat associated with it, as seen in satellite photos (Fig. 26). It is becoming well known that steel shipwrecks on reef fronts, or on the reef top, have areas of algae on lagoonward back reef flats associated with them. It is believed the iron in the shipwreck causes normally low populations of microalgae on the reef flat to "bloom" causing a dark area covered with algae. Iron is barely soluble in seawater, but has been shown to be a limiting nutrient in some areas of the ocean. The presence of a shipwreck, or other source of iron, may serve to enrich the water moving across the reef from ocean to lagoon in iron enough to stimulate additional algal growth. The presence of the iron may then cause another nutrient to become a new limited factor in algal growth.

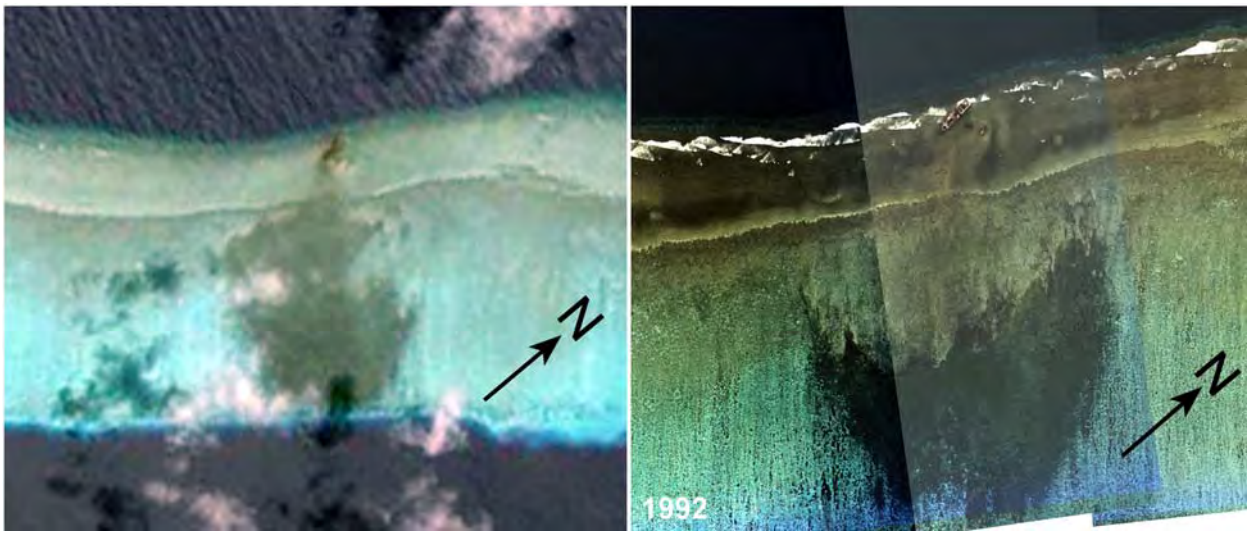

Figure 26. A. The area of the shipwreck on the western barrier reef is shown in a Google Earth image taken in the last few years (exact date unknown). B. The dark patch of reef bottom lagoonward of the wreck is clearly visible in this aerial photomosaic taken in 1992.

This area is an "algal flat" of compacted rubble with algae, encrusting ascidians and sea anemones covering the surface (Figure 27). We were able to collect samples of the relevant fauna and flora and will have them identified in the near future.

Figure 27. The community of benthic invertebrates occurring in the area of the dark patch inshore of the large shipwreck on the reef flat at Helen Reef . A. A mixture of ascidians, algae, sea anemones and other invertebrates forms a thick mat of living material tying together a substrate of coral rubble, principally from branching corals. B. Closeup view of ascidians (white and green) with sea anemones (brown) on coral rubble. C. In this photograph brown algae also are common in addition to the other organisms seen in (A) and (B).

There are several examples of probable iron enrichment on reefs in the main Palau group. Wrecks at Ngeruangl, Toachel Mid in Ngcharemlengui and near Denges Channel, Koror all have iron algae flats on the reef inshore from the wreck.

HELEN REEF- MARINE DIVERSITY

After samples from Helen Reef have been identified by taxonomists it will be easier to give a more thorough analysis of comparisons between the main Palau island group and the

southwest islands. However, a few striking faunal differences were noted and specific examples are recorded here.

As is well known, "giant clams" (Tridacnidae) are abundant at Helen Reef and the following species were recorded: *Tridacna gigas, T. squamosa, T. derasa, T. maxima, T. crocea, Hippopus hippopus* and *H. porcellanus* (Fig. 28). The last species is fairly rare at Helen Reef and elsewhere in Palau.

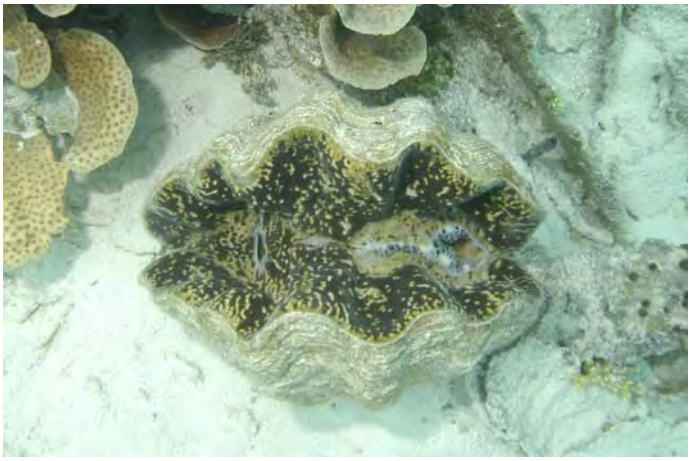

Figure 28. *Hippopus porcellanus* on a patch reef near Helen Island.

The flattened photosynthetic sponge *Phyllospongia* sp. was common in most areas of the Helen Reef lagoon (Fig. 29a). This genus is common throughout PNG/Philippines/Malaysia and the south Pacific. The only *Phyllospongia* sp. ever collected in Palau, a branching form, was found at Velasco Reef and has not yet been documented in the lagoon or on the outer reef slope.

Among soft corals there were also contrasts with species found in the southwest islands which are missing in the main Palau group. The gorgonian *Isis hippuris* was exceptionally common in lagoon environments (Fig. 29b). It occurred at every reef site in the lagoon and channel from shallow water to depths over 30 m. This is a genus which does not occur in the main Palau Island group.

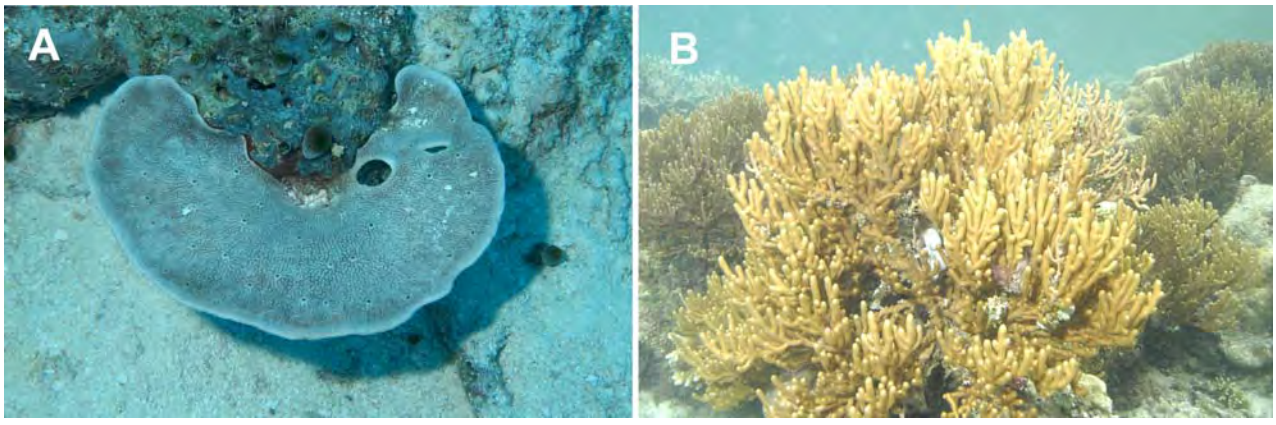

Figure 29. A. *Phyllospongia* sp. was one of the most common sponges found in the Helen Reef lagoon that is not found in the main islands of Palau. B. *Isis hippuris* is a gorgonian also not recorded from the main islands of Palau.

Among the stony corals (scleractinia) there were some interesting differences with the main Palau group. The fungiid coral *Cycloseris hexagonalis* was found in the lagoon at Helen Reef, a species not known from the main group (see previously Fig. 23b). A branching *Acropora* coral, *A. pichoni,* was common on many lagoon reefs at 70-100 feet depth. This coral is very distinctive, with broadly flattened branches with sharp tips (Fig. 30). This coral is rare in the main

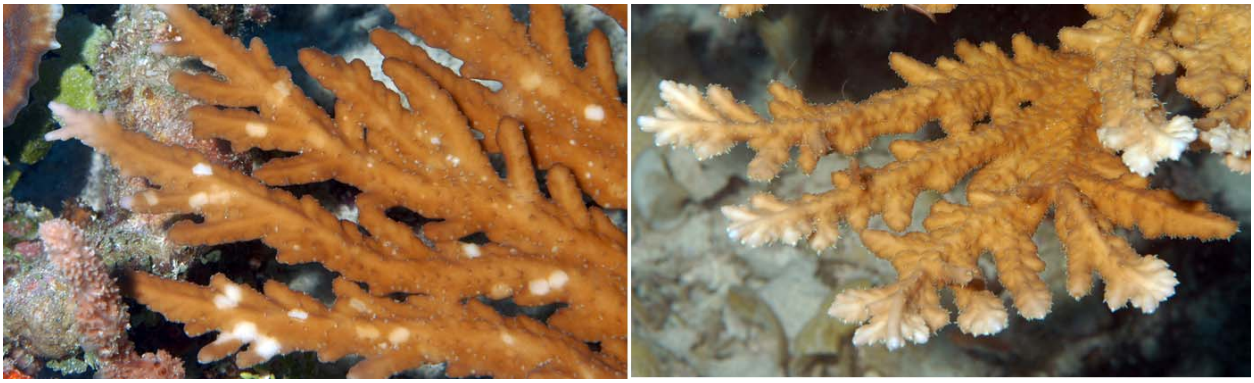

Figure 30. *Acropora pichoni* is a rare coral in the main Palau island group, but is common at moderate depths in the Helen Reef lagoon.

Palau group for unknown reasons. It is one of the readily identifiable species which is indicative of certain types of habitats.

At times some of the species making up the planktonic community in the lagoon were very common, and differ from organisms normally seen in the main Palau island group. A species of salp was seen near our main anchorage in the Helen lagoon (Figure 31). These salps were very abundant with around 1 per cubic meter of lagoon water near the surface over a 30 m deep bottom.

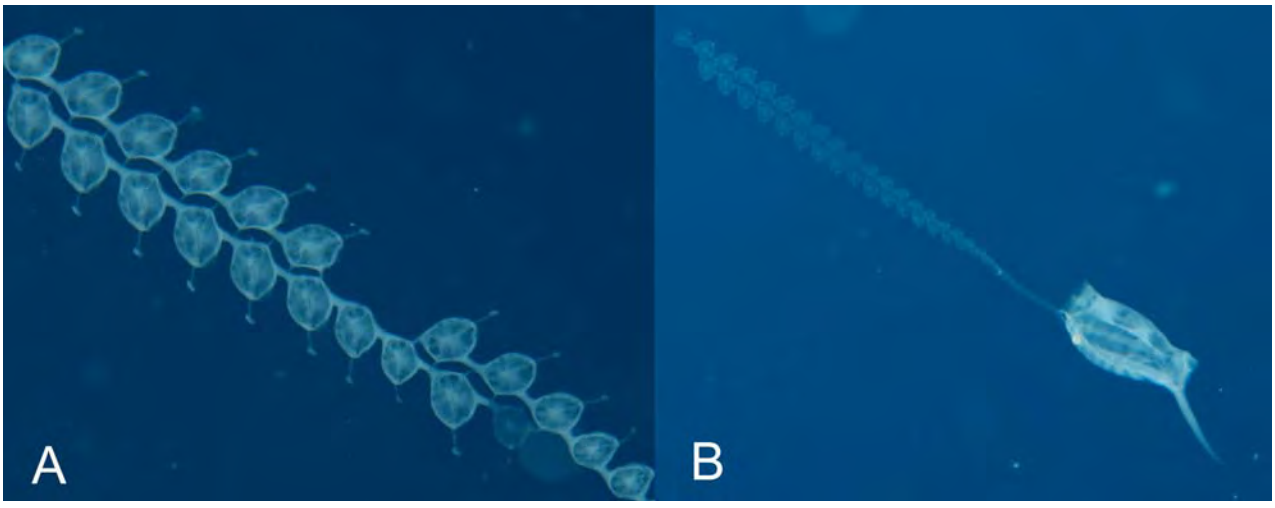

Figure 31. Salps are pelagic tunicates, related to sea squirts that live on the reef. This unidentified salp was common in the Helen Reef Lagoon. A. A closeup of the chain of asexual oozooids. B. The entire animal is shown here. The head of the animal actively swims and tows the oozooids behind it.

One seagrass was documented and a voucher collected from the Helen Reef lagoon, in the shallows around Helen Island. It is a species of *Halophila*, probably *H. ovalis* or *H. ovata.* This will be sent out for identification if necessary.

FISH BIOGEOGRAPHY

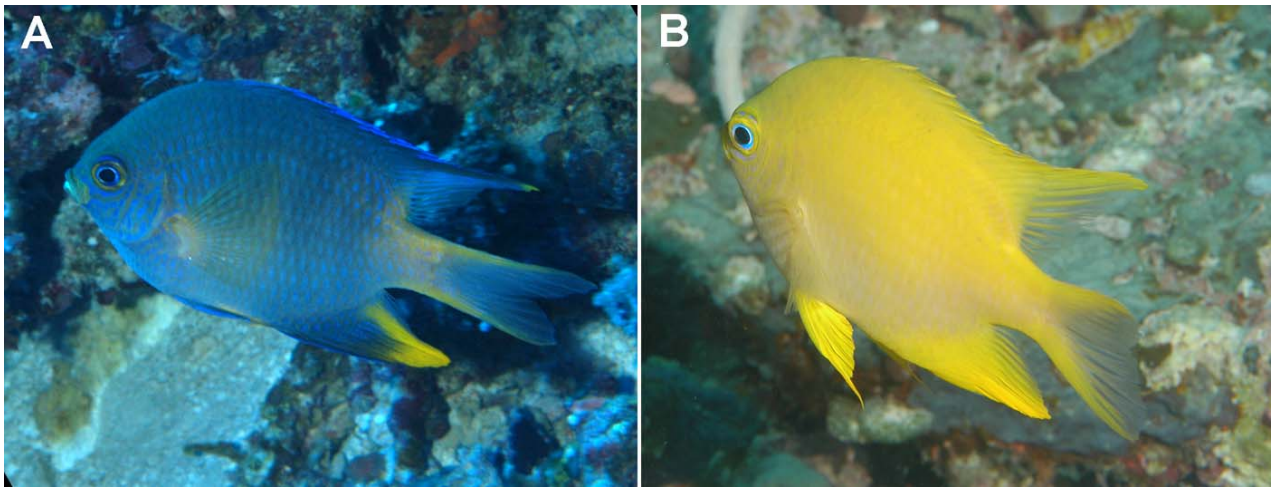

Figure 32. A. The damselfish *Amblyglyphidodon aureus* has a variant color form found at Sonsorol. The Sonsorol form has the body largely blue in color with only highlights of yellow on the fins and tail. B. The typical color form is uniformly yellow, and is found widely in the Indo-west Pacific. The status of the Sonsorol color form is under study.

The southwest islands have a number of reef fishes which are not found in the main Palau group. There is an interesting variant of the common reef damselfish *Amblyglyphidodon aureus* found at Sonsorol (Fig. 32). This is under study by M. Westneat.

Some of these differences in fishes are well known from previous work. The anemone fish *Amphiprion ocellaris* (the "Nemo" fish) (Fig. 33a) is found at Helen Reef and Tobi, but not in the main group. A second anemone fish, *Premnas biaculeatus*, is also found at Helen Reef which again does not reach the main Palau group (Fig. 33b). These zoogeographic anomalies were previously known (see Myers 1999) and it is useful to confirm that the species are still present in the southwest islands. Another fish species, *Diploprion bifasciatus*, not known from the main group, was found to be very common at Helen Reef during our previous trip in 1996, however during the present field work (which was much more extensive) not a single individual was seen. M. Westneat reported seeing one individual, but the extensive fish collections did not take a single specimen of this soapfish. Is the fish much more rare at Helen Reef than it was in 1996?

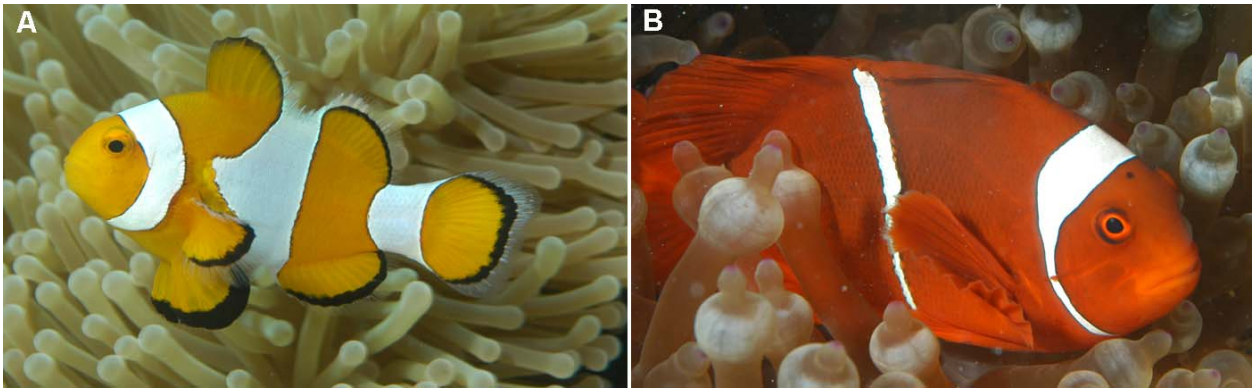

Figure 33. Two species of anemone fishes that occur at Helen Reef and Tobi are not found in the main Palau Island group. A. *Amphiprion ocellaris*. B. *Premnas biculeatus*, the spine-cheek anemonefish. Note the spine on the gill cover whose rear point goes over the white stripe.

Interestingly, the carpet anemone *Stichodactyla gigantea* is common in the shallow seagrass beds of Palau, but is always void of *Amphiprion ocellaris* which commonly inhabits it in the Helen Reef lagoon (Fig. 34).

Figure 34. *Amphiprion ocellaris* was often found in the sea anemone, *Stichodactyla gigantea*, in the Helen Reef lagoon. Because this anemone fish is does not occur in the main islands of Palau, there the sea anemone is empty of fish.

FISH SPAWNING AND SPAWNING AGGREGATIONS

A spawning aggregation of humphead wrasse (*Cheilinus undulatus*) was located in the area of the Helen Reef channel. The exact location was recorded, however is not recorded in this report to prevent possible use of that information to fish the site, and potentially wipe out the aggregation. This is in line with the guidelines of the Society for the Conservation of Reef Fish Aggregations (SCRFA) regarding the sensitivity of aggregation site location information.

Humphead wrasse are relatively abundant at Helen Reef, with many in the channel area and the outside slope. We were able to do one quantitative survey of *C. undulatus* abundance along two transects in the channel area. These data will be provided to the Helen Reef Project once they are compiled.