



CRUISE REPORT¹

VESSEL: *Hi'ialakai*, Cruise 08-03 (Fig. 1)

CRUISE PERIOD: 21 March–12 April 2008

AREA OF OPERATION: U.S. Line Islands

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED), Pacific Islands Fisheries Science Center, National Marine Fisheries Service (NMFS), NOAA, and their partner agencies conducted integrated coral reef ecosystem assessment and monitoring surveys in waters surrounding Jarvis Island, Palmyra Atoll, and Kingman Reef. All activities described in this report were covered by the following permits: USFWS 12521-08002, USFWS 12521-08003, USFWS 12521-08004, USFWS 12521-08005, USFWS 12521-08006, USFWS 12521-08007, and USFWS 12521-08008.

ITINERARY:

21 March Start of cruise. Embarked Robert Schroeder (Chief Scientist, fish), Marc Nadon (fish), Kevin O'Brien (fish), Paula Ayotte (fish), Bernardo Vargas-Angel (coral), Sarah Myhre (coral), Christi Richards (algae), Tony Perry III (algae), Russell Moffitt (invertebrates, algae, data manager), Molly Timmers (invertebrates), Scott Godwin (invertebrates), Stephane Charette (towed diver fish), Benjamin Richards (towed diver fish), Jason Helyer (towed diver benthic), Jacob Asher (towed diver benthic), Jamison Gove (oceanography), Charles Young (oceanography), Dwight Gledhill (oceanography), Daniel Merritt (oceanography), Jim Bostick (divemaster and chamber operator), Alex Wegmann (terrestrial biologist), and Susan Middleton (photographer). Departed Pago Pago, American Samoa at 1400 h and began transit to Jarvis Island.

¹ PIFSC Cruise Report CR-08-006
Issued 30 September 2008



- 22-25 March Continued transit to Jarvis Island. Boat orientation and dive safety briefings were performed as well as an introductory meeting for new scientific personnel. Training workshop held to review emergency scuba skills, oxygen administration, and other dive accident mitigation skills. Conducted simulated man overboard drill. CRED field teams met on March 25 to prepare Jarvis operations.
- 26 March Commenced field operations at Jarvis Island. Boats launched at 0745 h. The Rapid Ecological Assessment (REA) teams on HI-1 completed three multidisciplinary REA surveys at existing sites JAR-08, JAR-04, and JAR-11. Two sets of three Autonomous Reef Monitoring Systems (ARMS) were installed at JAR-08 and JAR-04. A second fish REA team on HI-2 completed three additional fish surveys (two deep, one shallow) at sites JAR-50, JAR-51, and JAR-52 chosen via a stratified random design. The towed-diver team conducted six towed-diver surveys, circuiting the island with a total distance of 14.5 km. The oceanography team replaced two and deployed one Subsurface Temperature Recorder (STR) and collected water samples at two sites for Dissolved Inorganic Carbon (DIC) analysis. Terrestrial team of Wegmann and Middleton were shuttled to island to conduct surveys (birds, mice, vegetation, etc.) and camped on island overnight. Deepwater conductivity-temperature-depth (CTDs) casts were conducted at 9 locations off the west side of Jarvis at night (35 chlorophyll, 35 nutrient, and 14 DIC samples).
- 27 March Continued operations at Jarvis Island. Primary fish and benthic REA teams surveyed three existing sites at JAR-01, JAR-02, and JAR-09. A set of three ARMS were installed at JAR-09. Second fish team surveyed two deep and two shallow new sites (JAR-53, JAR-54, JAR-55, JAR-56). Oceanography team replaced five STRs, one SST buoy, collected water samples at two sites for DIC analysis, and conducted eight shallow CTD casts (4 salinity, 2 chlorophyll, and 2 nutrient samples). Tow team completed five tows in shallow depths around the island (12 km). Susan Middleton was shuttled from Jarvis Island back to ship. Alex Wegmann remained on Jarvis Island. Deepwater CTDs were conducted at 8 sites off the east side of Jarvis at night (35 chlorophyll, 35 nutrient, 14 DIC samples).
- 28 March Continued operations at Jarvis Island. Strong currents prevented teams from working some primary sites. Fish and benthic REA teams surveyed three sites on the north, east, and west sides at JAR-10, JAR-07, and JAR-03. Some sample replicates were not completed at some sites due to challenging currents. Second fish

team surveyed two deep and two shallow new sites (JAR-57, JAR-58, JAR-59, JAR-60). Oceanography team replaced 1 STR, conducted 25 CTD casts (6 water samples—26 chlorophyll, 26 nutrient, 6 DIC, and 6 salinity samples), and conducted benthic DIC sampling at 2 sites (8 DIC, 2 chlorophyll, 2 nutrient, 4 salinity samples). Tow team completed 6 tows in both shallow and deep depths around the island (15 km). Alex Wegmann was shuttled from Jarvis Island back to ship. Ship departed from Jarvis Island at ~1700 h en route to Palmyra Atoll with several deep CTDs conducted along the route.

- 29 March Continued transit to Palmyra Atoll. Deepwater CTDs taken along route.
- 30 March Arrived at Palmyra Atoll ~0700 h. Commenced operations. REA teams completed three surveys at southern sites (PAL-01, PAL-26, PAL-16). A set of three ARMS were installed at PAL-01. Second fish team surveyed two deep and one shallow new sites (PAL-50, PAL-51, PAL-52). Oceanography team collected 22 CTDs (8 water sample sites—32 chlorophyll, 32 nutrient, 5 DIC, and 5 salinity samples). Tow team completed six tows covering most of the south side of the atoll (14 km). Alex Wegmann disembarked from the ship to stay on Palmyra to conduct terrestrial surveys (will fly back to Honolulu on April 8). Susan Middleton accompanied Wegmann to Palmyra for surveys and stayed overnight. Deepwater CTDs were conducted.
- 31 March Continued operations at Palmyra Atoll with strong winds and large seas. REA teams completed surveys at three monitoring sites along south and west sides (PAL-19, PAL-11, PAL-17). Two sets of three ARMS were installed at PAL-19 and PAL-17. Second fish team surveyed two deep and one shallow new sites along south (PAL-53, PAL-54, PAL-55). Tow team completed six tows along 60 ft contour around western bank and halfway along north side (16 km). Oceanography team deployed five STRs, recovered four STRs, deployed one EAR, recovered one SST buoy, and collected eight shallow CTDs. Middleton remained on island for another night.
- 1 April Continued operations at Palmyra Atoll. REA teams completed surveys at three sites along the central north to northwest sides (PAL-21, PAL-12, PAL-05). Second fish team was prevented from working north side by large swells and unsuitable boat (PIFSC SAFE boat with one engine offline), but surveyed one deep and two shallow new sites along the western bank (PAL-56, PAL-57, PAL-58). Tow team surveyed the northeast quadrant in

five tows (14 km), completing the initial circuit of the atoll. The oceanography team in HI-2 replaced the Coral Reef Early Warning System (CREWS) buoy inside the lagoon, recovered settlement plates at the CREWS anchor, and replaced three STRs. Middleton returned to the ship and began photographing invertebrates collected by the dive teams. Deepwater CTDs were conducted off the eastern side of the atoll at night.

- 2 April Continued operations around Palmyra Atoll. REA teams surveyed three monitoring sites (PAL-10, PAL-09, PAL-06). Second fish team completed surveys at three new sites (PAL-59, PAL-60, PAL-61). The oceanography team deployed one SST buoy and five STRs and recovered two STRs. The tow team conducted five tows (13 km). Deepwater CTDs were conducted at night offshore.
- 3 April Continued operations at Palmyra Atoll. REA teams surveyed two monitoring sites (PAL-02, PAL-04) and installed a set of three ARMS in the channel to the lagoon near PAL-27. Second fish team completed surveys at PAL-62 and PAL-63. The oceanography team collected four CTDs in the lagoon. Tow team completed two calibration dives along the western bank. After completing their work, most scientists and crew went ashore in mid-afternoon to visit The Nature Conservancy camp on Cooper Island. Departed Palmyra Atoll, en route to Kingman Reef and conducted two CTDs along the way.
- 4 April Arrived at Kingman Reef ~0600 h. Commenced field operations at ~0745. REA teams completed surveys at two backreef and one forereef sites (KIN-14, KIN-12, KIN-23). A set of three ARMS were installed at KIN-23. Second fish team surveyed three new sites in the same general area (KIN-50, KIN-51, KIN-52). From the lagoon, REA team observed shipwreck on reef flat of the NE arm, but no surveys were conducted at this time due to high surf. The tow team surveyed the outer NE arm of the atoll and east half of the south side (16 km). The oceanography team deployed an EAR, an ADCP, and STRs in the southern pass and collected benthic DIC samples. Susan Middleton conducted a dive with ship's divers to observe giant clams in the lagoon. At night, deep water CTDs were conducted to the west of the atoll at eight sites.
- 5 April Continued operations at Kingman Reef. REA teams surveyed two sites inside, and one site outside the atoll (KIN-08, KIN-10, KIN-13). A set of three ARMS were installed at KIN-13. The REA team conducted a brief survey around the grounded vessel on the reef flat of the northeast arm of the atoll. Growth of cyanobacteria was observed surrounding and down swell of the wreckage. See

wreck site report in Appendix E. Second fish team surveyed three new sites (KIN-53, KIN-54, KIN-55). The tow team surveyed along the NW and southern arms to complete their circuit around the atoll (16 km). The oceanography team exchanged three STRs and an SST buoy and collected DIC samples at four sites.

6 April

Continued operations at Kingman Reef. REA teams surveyed two large patch reefs and an outer reef slope site (KIN-07, KIN-05, KIN-11). A set of three ARMS were installed at KIN-05. The second fish team surveyed two backreef sites and deep forereef site (KIN-56, KIN-57, KIN-58). The tow team completed tows along the backreef of the northeast arm and half of the southern arm (15 km). The oceanography team collected CTDs around the outside of the atoll and some inside, collected 24 chlorophyll and nutrient samples, and exchanged an STR along the west side. Deepwater CTDs were conducted to the south of the atoll at night.

7 April

Continued operations at Kingman Reef. REA teams only finished one site and were recalled to their boat halfway through their second survey due to a fuel leak from the HI-1 diesel engine (KIN-03, KIN-16). HI-1 was towed by HI-5 and tow team SAFE boat back to the ship at ~1200. Invertebrate/ARMS, and fish REA team attempted a later dive from a different boat, but aborted shortly into the dive due to sudden large seas and very strong bottom currents. Three ARMSs were jettisoned. The second fish team conducted surveys at three new sites (KIN-59, KIN-60, KIN-61). The oceanography team conducted CTDs in the lagoon, collected benthic DIC samples at three sites (12 samples), exchanged three STRs, retrieved a 1200-lb CREWS anchor from the southeast lagoon, and retrieved an ADCP/anchor unit from the southeastern channel to the lagoon that was placed on 4 April 2008. HI-2 also had engine trouble around midday and was towed to the ship by the SAFE boat. The tow team completed three tows along the backreef before towing the two disabled boats. The oceanography team transferred to the tow team's SAFE boat to finish operations. Departed Kingman Reef at ~1700 h en route to Pearl Harbor, Hawaii. Four deepwater CTDs were conducted along the way several hundred miles north of Kingman for DIC and calibration.

8-11 April

En route to Pearl Harbor, Hawaii. Scientific personnel conducted end of cruise debriefings, and a post-cruise meeting was held with the ship's command and crew and the science team leaders.

12 April

Arrived at Pearl Harbor, Hawaii. Ship tied up dockside at ~ 1000 h. End of cruise.

Table 1.--Cruise statistics for HI0803.

	Jarvis	Palmyra	Kingman	Totals
Towed-Diver Habitat/Fish Surveys	17	24	18	59
Combined tow lengths (km)	41.29	61.93	55.78	159
Fish Rapid Ecological Assessments	20	28	23	71
Benthic Rapid Ecological Assessments	9	14	11	34
Invertebrate collection dives	9	15	12	36
ARMS deployed	9	12	9	30
Aquadopp ADCP temporary deployment			1	1
Single-point Current Sensor (RCM-9) Deployed			1	1
Ocean Data Platforms (ODP) Recovered	1			1
Ocean Data Platforms (ODP) Deployed	1			1
SST buoys recovered	1	1		2
SST buoys deployed	1	1	1	3
EARs recovered				
EARs deployed	1	1	1	3
STRs recovered	8	10	7	25
STRs deployed	9	14	9	32
CREWS buoys recovered		1		1
CREWS buoys deployed		1		1
Recruitment Plates recovered		12		12
Shallow water CTDs	25	26	29	80
Shallow water sample profiles taken (chlorophyll and nutrient samples at 1 to 4 depths as depth allows, and a microbiota sample at the shallowest depth)	6	8	6	20
Nutrient Samples	32	32	24	88
Chlorophyll Samples	32	32	24	88
Salinity Calibration Samples	18	6	21	45
Shallow Water DIC Samples	24	6	60	90
Deepwater CTDs to 300 m (from <i>Hi`ialakai</i>)	17	11	28	56
Deep water sample profiles collected (5 samples per profile, chlorophyll and nutrients)	17		24	41
Deepwater DIC profiles to 80 m (2 samples per profile)	14	1	18	33
ADCP lines run	17	11	24	52
SCUBA dives	177	229	220	626

MISSIONS:

- A. Conduct ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (< 35 m) coral reef ecosystems of Jarvis Island, Palmyra Atoll, and Kingman Reef.
- B. Deploy and recover an array of Coral Reef Early Warning System buoys, SST buoys, subsurface WTRs, STRs, and EARs to allow remote long-term monitoring of oceanographic and environmental conditions affecting coral reef ecosystems of Jarvis Island, Palmyra Atoll, and Kingman Reef.
- C. Conduct shallow water CTDs and water sampling casts to approximately 30 m in order to examine physical and biological linkages supporting and maintaining these island and atoll ecosystems.
- D. Conduct shipboard oceanographic and meteorological observations using CTDs deployed to a depth of 500 m, collecting water samples to a depth of 150 m, collecting ADCP data around reef ecosystems, measuring sea surface temperature and salinity and collecting fundamental meteorological data, such as air temperature, wind speed and direction, barometric pressure, and relative humidity, in order to examine physical and biological linkages supporting and maintaining these island and atoll ecosystems.
- E. Conduct two separate shipboard water sampling schemes at these locations: one to a depth of 75 m, to examine DIC for the calculation of ocean acidification over reef ecosystems, and the second to a depth of 500 m, each with five water samples, which will be used to study the chlorophyll and nutrient values of the open ocean in the vicinity of reefs. Shallow water sampling from small boats to a depth of approximately 30 m around reef ecosystems will be used to complement both of these open ocean data sets.
- F. Determine the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.
- G. Conduct terrestrial surveys of floral and faunal wildlife populations at Jarvis Island and Palmyra Atoll.

RESULTS:

See Appendices B through E.

SCIENTIFIC PERSONNEL:

Robert Schroeder, PhD, Chief Scientist / Fish Team, University of Hawaii (UH)-Joint Institute for Marine and Atmospheric Research (JIMAR), Pacific Islands Fisheries Science Center (PIFSC)-Coral Reef Ecosystems Division (CRED)
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Bernardo Vargas-Angel, PhD, Benthic Team – Coral Disease, UH-JIMAR, PIFSC-CRED
Molly Timmers, Benthic Team – Invertebrates/ARMS, UH-JIMAR, PIFSC-CRED
Scott Godwin, Benthic Team – Invertebrates/ARMS, UH – Hawaii Institute of Marine Biology
Christi Richards, Benthic Team - Algae, UH-JIMAR, PIFSC-CRED
Tony Perry III, Benthic Team – Algae, PIFSC-CRED
Russell Moffitt, Benthic Team – Invertebrates/ARMS, Algae, Data Manager, UH-JIMAR, PIFSC-CRED
Stephane Charette, Towed Diver Team – Fish, UH-JIMAR, PIFSC-CRED
Benjamin Richards, Towed Diver Team – Fish, UH-JIMAR, PIFSC-CRED
Jason Helyer, Towed Diver Team – Benthic, UH-JIMAR, PIFSC-CRED
Jacob Asher, Towed Diver Team – Benthic, UH-JIMAR, PIFSC-CRED
Jamison Gove, Oceanography Team, UH-JIMAR, PIFSC-CRED
Charles Young III, Oceanography Team, UH-JIMAR, PIFSC-CRED
Daniel Merritt, Oceanography Team, UH-JIMAR, PIFSC-CRED
Dwight Gledhill, Oceanography Team, NESDIS/ORA Coral Reef Watch
Alex Wegmann, Terrestrial Team, United States Fish and Wildlife Service (USFWS)
Susan Middleton, Terrestrial Team, Photographer

DATA COLLECTED:

Digital images from algal photoquadrats
Algal voucher specimens necessary for algal species identification
Algal field notes of species diversity and relative abundance
Video-transects of benthos and overall substrate characterization at each site
Number of coral colonies, by species, within belt transects of known area, and overall coral colony density at each site
Qualitative assessment (DACOR) of coral species' relative abundance at each site
Size class distributions of corals (by species and overall) at each site
Digital images of diseased coral
Field notes on signs of coral bleaching or disease
Samples of diseased coral for histopathological analysis
Digital still photos of overall site character and typical benthos at each site

Belt-transect surveys of all (diurnally active, non-cryptic) fish – density counts by species and individual estimated size (total length, TL)
Stationary point count surveys (new procedure) of all fish – density counts (15 m diameter circle) by species and individual estimated size
Fish species presence checklists for community diversity estimates at each site
Digital images to document rare, interesting, or characteristic fish species/habitat
Digital images of the benthic habitat from towboard surveys and estimate size
Macroinvertebrate counts from towboard surveys
Quantitative surveys of reef fishes (larger than 50 cm TL) to species level from towboards
Habitat lineation from towboard surveys
Benthic composition estimates from towboard surveys
Conductivity, temperature and depth (CTD) profiles to 500 m
Water Samples to 500 m: Chlorophyll and Nutrient – 5 depths per cast
Water Samples to 75 m: DIC and salinity – 2 depths per cast
Conductivity, Temperature, Depth (CTD) casts: 30 m
Shallow Water Samples (30 m): Chlorophyll and Nutrient – 4 depths per cast
Shallow Water Samples (30 m): DIC and salinity – 2 depths per cast
Environmental acoustics of reefs, marine mammals and boat traffic
Sea surface and subsurface temperature at variable depths
Sea surface and subsurface salinity at variable depths
Spectral wave energy and tidal elevation
Directional ocean currents
Solar radiation, air temperature, wind speed and direction, turbidity, and photosynthetically active radiation
Acoustic Doppler current profiler (ADCP) transects

(/s/Robert Schroeder)

Submitted by: _____
Robert Schroeder
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(/s/Kacky Andrews)

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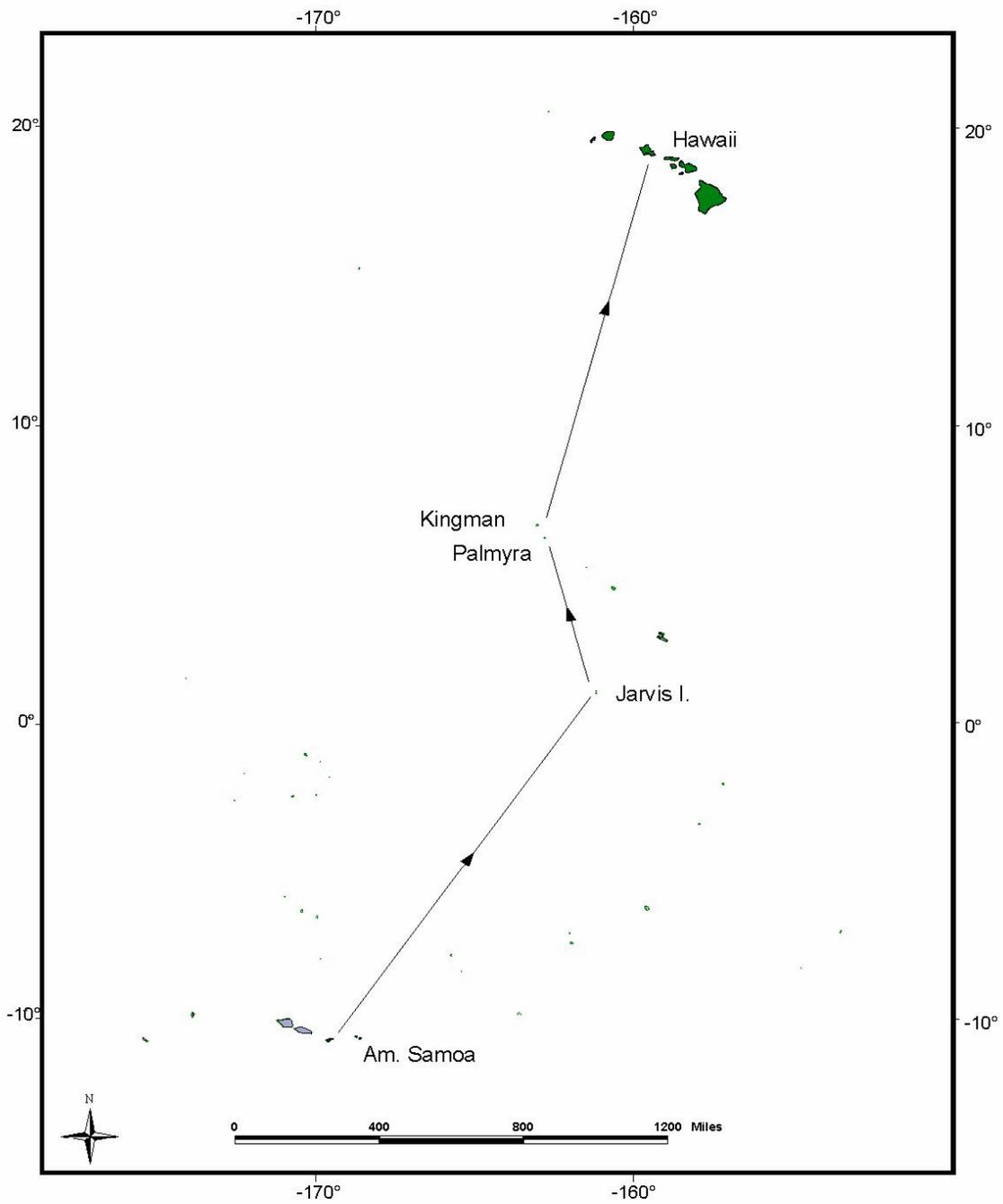


Figure 1.--Track of the NOAA Ship *Hi'ialakai* cruise HI-08-03, March 21 through April 12, 2008.

Appendix A: Methods

A.1. Oceanography and Water Quality Methods

(Jamison Gove, Daniel Merritt, Charles Young III, Dwight Gledhill)

The Coral Reef Ecosystem Division (CRED) has been conducting multidisciplinary research in the U.S. Line Islands since 2000. Considering that the oceanographic component of this research has been well established, the recovery/redeployment of instrument platforms and the continuation of oceanographic measurements represent ongoing monitoring and assessment of the island. During HI0803, the oceanography team utilized both established and new methods to monitor long-term trends and assess oceanographic conditions.

Long-term oceanographic monitoring and assessment is accomplished by deployment and retrieval of a variety of internally recording and near real-time telemetered instrument platforms. These instruments include:

- Sea Surface Temperature (SST) buoys: Measure and internally record high resolution surface water temperature and telemeter a subset of collected data in near real time.
- Wave and Tide Recorders (WTR): Measure surface gravity waves, tides and subsurface water temperature.
- Subsurface Temperature Recorders (STR): Measure high resolution subsurface water temperature.
- Environmental Acoustic Recorders (EAR): Record ambient subsurface sound.

Detailed in situ oceanographic and water quality surveys are accomplished with the following sampling techniques:

- Shallow water conductivity-temperature-depth (CTD) casts (max depth 30 m) conducted from small boats at regularly spaced intervals on the 30-m contour around each island/atoll/shoal with an SBE 19+ and an auxiliary transmissometer (Wetlabs C-Star). Shallow vertical water profiles can provide insight into local water property variation and water mass interactions. In addition to the standard set of shallow-water water quality sampling, a set of one surface and three near-bottom (< 200 cm) carbonate chemistry (alkalinity and total dissolved inorganic carbon [DIC]) water samples are hand collected from across a range of geomorphological reef zones, benthic habitat types and depths. A Seabird 19+ CTD with an SBE43 dissolved oxygen sensor is deployed concurrently with the carbonate chemistry collections, and salinity samples are regularly collected to aid in the calibration of the CTD 19+. All carbonate chemistry samples are immediately treated with saturated mercuric chloride and sealed in 500 cm³ high quality borosilicate glass bottles equipped with positive closure according to the

protocols of Dickson et al. (2007) and will be shipped to NOAA Pacific Marine Environmental Laboratory for post-cruise analysis.

- Shipboard deepwater CTD casts conducted from the NOAA Ship *Hi'ialakai* with an SBE 911+ and an auxiliary SBE 43 Dissolved Oxygen (DO) sensor and Wetlabs ECO FLNTU combination fluorometer and turbidity sensor. Shipboard CTD casts to 500 m, complemented by water samples collected at 3-, 80-, 100-, 125- and 150-m depths for nutrient (NUT) and chlorophyll (CHL) analysis are conducted at regularly spaced intervals around each island/atoll/shoal and other permanent stations. Additionally, shipboard CTD casts to below mixed layer depth, complemented by water samples collected at surface 2 and below mixed layer (75 m–150 m) depths are conducted at select locations for DIC and total alkalinity (TA) analysis.
- Surface and subsurface water temperatures as a function of depth are continuously recorded during all towed-diver operations, providing a broad and diverse spatial and thermal sampling method. Refer to the Towed-Diver Habitat/Fish Survey Team Activity Summary for site and isobath information. This data is part of the tow team ArcView project.
- Shipboard meteorological observations including wind speed and direction, relative humidity, air temperature, and barometric pressure.
- Shipboard oceanographic measurements of sea surface temperature, salinity, and currents using an acoustic Doppler current profiler (ADCP).

A.2 Rapid Ecological Assessment (REA) Methods

(Fish: Marc Nadon, Paula Ayotte, Kevin O'Brien, and Robert Schroeder; Corals: Bernardo Vargas-Angel and Sarah Myre; Algae: Christi Richards, Russell Moffitt, and Tony Perry III; Invertebrates: Scott Godwin, Molly Timmers, and Russell Moffitt)

The survey methodology for benthic resource data used during HI0803 is the same as used here in previous years. At each REA site, two 25-m transect lines were laid out, separated from each other by approximately 2–3 m. At most sites, transects were laid out at between 3 and 15 m depth. The survey methodology for fish data changed slightly from 2004 and 2006 surveys and is discussed below. REA methods for each specific discipline are as follows.

A.2.1 Algae

Standardized quantitative sampling methods for remote tropical Pacific islands were developed and published for marine algae (Preskitt et al., *Pacific Science*, 2004). To allow for vertical sampling in areas of high relief (walls), the method was modified slightly by Vroom et al. (in review, *Coral Reefs*) and entails photographing quadrats, collecting algal voucher specimens, creating in situ algal species lists, and ranking relative algal abundance. This modified “Preskitt method” has been used by CRED since

2003 in the Northwestern Hawaiian Islands, Guam/Mariana Islands, Pacific Remote Island Areas, and American Samoa.

Macroalgae were tentatively identified to genus in the field, and ranked abundance of algal genera was collected from 12 quadrats (0.18 m²) at each site (1 being the most abundant, 2 being the next most abundant, etc., with 10 being the maximum number of genera found in a single quadrat). Six quadrats were located at random points along the first two transects (3 per transect), and six quadrats were located at points 3-m perpendicular from each random point, in the direction of shallower water. Additionally, samples of macroalgae present within each quadrat were collected as voucher specimens (Preskitt et al., 2004) for microscopic analysis and species verification. A random swim at the end of each dive augmented macroalgal collections attained from quadrats and allowed cryptic species that predominantly occurred in shaded areas to be qualitatively recorded. Because of difficulties with identification, algae that fell within the functional groups of turf, cyanophytes, branching coralline algae, and crustose coralline algae were lumped into their respective categories. All ranked data were collected by the same individual to minimize the effects of observer bias.

A.2.2 Corals

To investigate the population dynamics and relative health states of the coral and benthic communities, three complementary survey techniques were employed: coral population surveys, coral health and disease assessments, and benthic cover assessments using the line point intercept (LPI) method. All three methods were conducted along two 25-m transects at each site.

A.2.2.1 Coral Population Survey

Information on coral population structure was collected along two 25-m transects using a belt survey method in which each coral colony whose center fell within one-half meter of either side of the transect line was identified to genus/species and assigned to a coral size class (10 cm bins with the exception of the 0–5 cm and 6–10 cm size classes) based upon the estimated length of each coral's maximum diameter. Coral population data will be used to estimate population size classes, mean diameter, density, diversity, and relative abundances of the coral species/genera recorded.

A.2.2.2. Coral Health and Disease Assessment

Health and disease surveys were used to quantitatively assess, evaluate, and monitor the health condition of coral colonies. Coral disease surveys consisted of documenting the presence of disease within 1–3 m on each side of the transect lines (approx. 100–300 m²). Within the survey belt, each diseased coral colony was identified to the lowest taxonomic level possible, and the following information recorded: (1) colony size; (2) type of affliction, including, but not limited to: bleaching (BLE), acute tissue loss or white syndrome (WSY), subacute tissue loss (TLS), skeletal growth anomalies (SGA), Pink line/spot syndrome (PLS), Hyperpigmented irritations/responses (HYP), discolorations

other than bleaching (DIS), algal infections (ALG), cyanobacterial infections (CYA), other unidentified diseases and syndromes (OTH); (3) percent live/dead, (4) severity or percent colony affected (mild: 1–10%, moderate: 10–25%, marked: 25–50%, severe: 50–75%, acute: 75–100%); (5) photographic records; and (6) tissue samples for histopathological analyses. In addition, samples and photographs will be used to aid in further disease characterization. Disease data will be used to estimate disease incidence and prevalence.

A.2.2.3. Line Point Intercept Method (LPI)

In addition, percent cover of the benthic substrate was quantified using the Line Point Intercept method. For each 25-m transect, the benthic element falling directly underneath each 50-cm mark on the transect line was recorded using the following scheme: live coral, recently dead coral, carbonate pavement, coral rubble, sand, rock, turf algae, macroalgae, crustose coralline algae, invertebrate, and other. Live benthic elements including coral, algae, and invertebrates were identified to the lowest taxonomic level possible. These data provide the basis for calculating quantitative estimates of live coral cover, as well as percent cover of the other benthic elements.

A.2.3 Fish

The Fish Team, composed of four divers, conducted two types of surveys at preselected sites: Belt transects (BLT) and new Stationary Point Counts (nSPC). Two separate teams were deployed to conduct the surveys; each team consisted of two divers conducting two nSPCs and two BLTs, conditions permitting. The first team accompanied the Benthic REA team and surveyed previously visited monitoring sites, while the second team was deployed on a separate boat and surveyed new sites, based on a (habitat/depth) stratified random design approach. Surveys were performed using a 30-m line set along a single depth contour. As the line was set, two observers swam along either side of the line identifying, counting, and sizing all fishes > 20 cm in total length (TL) within an area 25 m long and 4 m wide. Afterwards, the divers returned along their respective sides of the line identifying, counting, and sizing all fishes \leq 20 cm TL in a 2 m wide by 25 m long belt.

Once the belt transect was completed, the divers moved to the 7.5-m and 22.5-m marks on the transect line to start the stationary point counts (7.5 m radius). During the first 5 min of the nSPC, the divers only recorded the presence of species within their respective survey areas. Afterwards, the divers proceeded down their respective species list, counting and sizing all individuals within their 7.5-m radius cylinder, one species at a time. Individuals from a single species were only recorded once. Cryptic species missed during the initial 5-min survey could still be added to the list. Once completed, the transect line was moved to another nearby location and the procedure was repeated. At each location the BLT procedure was conducted first so as to minimize disruption to the fish community.

Fishes observed off transect or after the initial 5 min of the nSPC were recorded for presence data. No collections were made by the Fish Team during this survey period.

A.2.4 Macroinvertebrates

Quantitative counts and percent cover for specific target marine invertebrates were conducted along two separate 1 x 25 m belt transects at 5-m intervals. Size frequency distribution of urchin species was recorded for the first 25 individuals of each species. Based on data from previous REAs, a group of target species was chosen for quantitative counts. The species in this list were chosen because they have been shown to be common components of the reef habitats of the central and southern Pacific, and they are species that are generally visible (i.e., non-cryptic) and easily enumerated during the course of a single 50–60-min dive.

These target species are:

CNIDARIA

Octocorals – soft corals (*Sinularia*, *Cladiella*, *Lobophyton*, *Sarcophyton*, etc.)

Zoanthids – rubber corals

Actiniaria – Anemones (*Heteractis*, *Stichodactyla*, *Phymanthus* etc)

ECHINODERMS

Echinoids – sea urchins

Holothuroids – sea cucumbers

Asteroids – sea stars

MOLLUSCA

Bivalves – spondylid oysters, pearl oysters, tridacnid clams (Giant Clams)

Large Gastropods – *Charonia* (Triton's Trumpet) and *Lambis* sp. (Spider Conch)

Coralliophilidae gastropods

Cephalopods - octopus

CRUSTACEA

hermit crabs, lobsters, large crabs

Specific in situ methods for each transect

Conduct enumerations at 5-m intervals along the 1 x 25 m transect line:

- Count all species of urchins. Also record test diameter for the first 25 of all species present
- Presence/Absence (P/A) for octocorals (*Carijoa*, *Sarcophyton*, *Lobophyton*, *Cladiella*), zoanthids, colonial anemones
- Count Cnidarians = Anemones (> 7 cm diameter), sea fans
- Count Holothuroids = All visible species
- Count Asteroids = All visible species
- Count Molluscs = Bivalves (*Pinctada*, *Tridacna*), large gastropods (*Charonia*, *Lambis*), coralliophilid gastropods
- Count Crustacea = Large hermit crabs (e.g., *Dardanus* sp. and *Aniculus maximus*), large brachyuran (*Carpilius*, *Etisus*, *Dromia*), spiny and slipper lobster, trapezid crabs and small hermit crabs

In addition, Autonomous Reef Monitoring Systems (ARMS) were deployed at the forereef habitats. ARMS provide a mechanism to quantify marine invertebrates that are not easily identifiable or accountable on the transect lines. They remain on the benthos for 2 yr enabling the recruitment and colonization of lesser known, cryptic marine invertebrates.

A.3. Towed-diver Survey Methods

(Stephane Charette, Jason Helyer, Benjamin Richards, Jacob Asher)

The fish towboard, outfitted with a forward-looking digital video camera, recorded fish distribution and habitat complexity. The diver on this board recorded fishes larger than 50 cm total length (TL) along a 10-m swath during a 50-min survey. The downward looking benthic towboard, affixed with a high-resolution digital camera with dual strobes, photographed the benthic substrate every 15 s. The diver on this board calculated substrate percentage every 5 min, recorded habitat type and complexity, and tallied the quantity of macroinvertebrates. Each towboard was equipped with an SBE 39 which recorded temperature and depth every 5 s along the tow. A Garmin GPS76Map global positioning system was used to record position at 5-s intervals along each tow track to georeference the collected data.

Towed-diver surveys were conducted across multiple habitats including the forereef, backreef, lagoon, and insular shelf.

Appendix B: Jarvis Island

B.1. Oceanography and Water Quality

Moorings (Fig. B.1.1, Table B.1.1):

A total of eight subsurface temperature recorders (STRs) and one ocean data platform (ODP) were recovered and replaced at Jarvis Island during HI0803. A sea surface temperature (SST) buoy was reinstalled after the previously deployed unit was lost after breaking free of its mooring line. A new ecological acoustic recorder (EAR) and STR were deployed together next to the ODP on the southwest corner of the island.

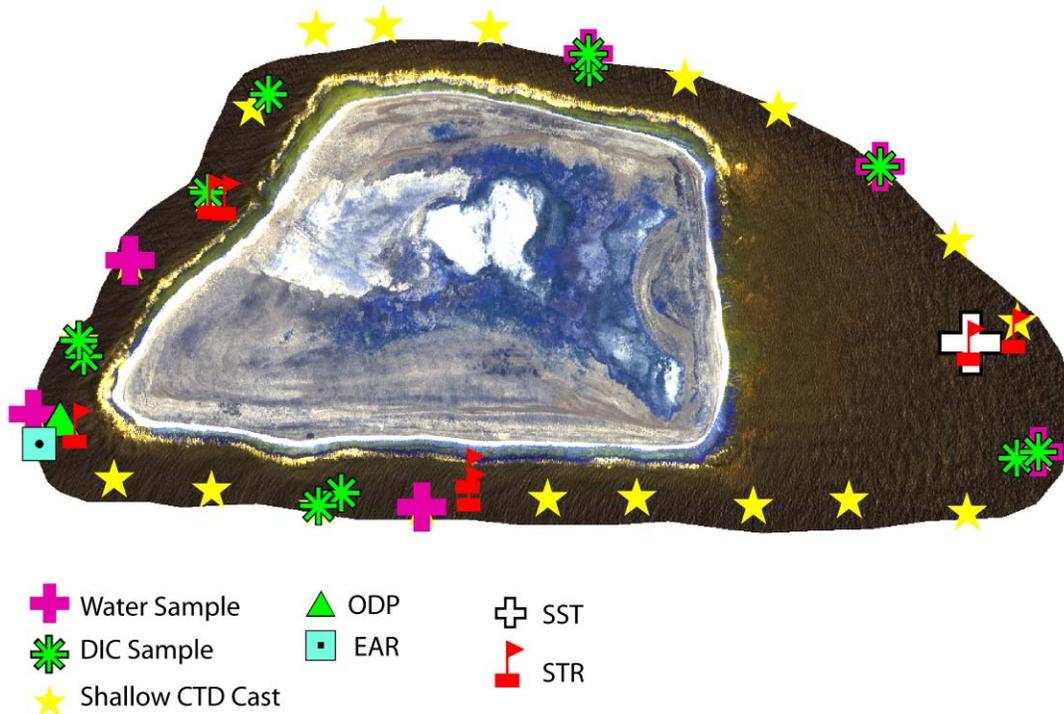


Figure B.1.1.--Moored Oceanographic instrumentation, shallow water conductivity-temperature-depth (CTD) cast, water sample and dissolved inorganic carbon (DIC) sample locations at Jarvis Island.

Table B.1.1.--Moored Oceanographic instrumentation table for Jarvis Island.

Instrument	Serial Number	Latitude	Longitude	Depth (m)	Data Start	Data End
ODP	267-006	0 22.7497 S	160 00.9240 W	14.6	3/20/2006 14:59	3/26/2008 20:00
STR	3939038-1861	0 21.7765 S	160 59.4681 W	29.0	3/21/2006 2:50	1/2/2008 5:50
STR	3939038-3007	0 21.7974 S	160 59.4657 W	9.8	3/21/2006 0:19	3/27/2008 0:49
STR	3939038-1817	0 22.5331 S	159 58.4558 W	12.8	3/20/2006 20:48	7/13/2007 11:48
STR	3939038-1859	0 22.9261 S	159 59.7966 W	32.6	3/21/2006 18:35	3/27/2008 22:35
STR	3939038-1858	0 22.9099 S	159 59.7991 W	10.1	3/21/2006 22:43	1/12/2008 22:13
STR	3939038-1860	0 22.1368 S	160 00.4932 W	32.0	3/21/2006 21:57	3/28/2008 1:27
STR	3939038-1818	0 22.1413 S	160 00.4824 W	6.4	3/21/2006 23:06	2/6/2007 8:06
STR	3939038-1853	0 22.5000 S	159 58.3370 W	32.0	3/20/2006 23:25	3/28/2008 20:25
EAR	39	0 22.7556 S	160 00.9312 W	15.2	LOGGING DATA	
ODP	267-008	0 22.7497 S	160 00.9240 W	14.6	LOGGING DATA	
SST	306-023	0 22.5331 S	159 58.4558 W	12.8	LOGGING DATA	
STR	3929252-0906	0 22.7556 S	160 00.9312 W	15.2	LOGGING DATA	
STR	3948689-4041	0 21.7765 S	160 59.4681 W	29.0	LOGGING DATA	
STR	3930159-0838	0 21.7974 S	160 59.4657 W	9.8	LOGGING DATA	
STR	3933179-1198	0 22.5331 S	159 58.4558 W	12.8	LOGGING DATA	
STR	3948689-4039	0 22.9261 S	159 59.7966 W	32.6	LOGGING DATA	
STR	3948689-4035	0 22.9099 S	159 59.7991 W	10.1	LOGGING DATA	
STR	3934869-3868	0 22.1368 S	160 00.4932 W	32.0	LOGGING DATA	
STR	3932718-1070	0 22.1413 S	160 00.4824 W	6.4	LOGGING DATA	
STR	3947493-3489	0 22.5000 S	159 58.3370 W	33.2	LOGGING DATA	

Preliminary Mooring Results

All STRs recovered from Jarvis Island yielded quality data sets (Fig. B.1.2); however, four stopped recording prematurely for unknown reasons. Between March 2006 and March 2008, subsurface water temperatures around the island showed a transition from typical seasonal forcing to being dominated by interannual forcing. The second half of the 2-year deployment in all temperature time series exhibits a slow drop in temperatures, well below temperatures recorded the previous year. This temperature drop coincided with the development of a mild La Niña in early 2007 which continued to strengthen into early 2008. La Niña conditions result in cooler temperatures in the eastern and central equatorial region, principally due to increased trade winds and a shallow thermocline. In addition, all temperature records from the western side of the island, regardless of depth, show high frequency temperature fluctuations, or cold spikes, occurring at ~ 12-h return periods. Temperature records from the deep deployments (~ 30 m) on the south and north of the island exhibit high frequency temperature changes, albeit much weaker compared to that observed to the west. The source of these temperature fluctuations are principally derived from current-topography interactions occurring on the western side, hence the strong signal to the west, the weaker signal to the north and south, and the absence of internal forcing to the east of the island.

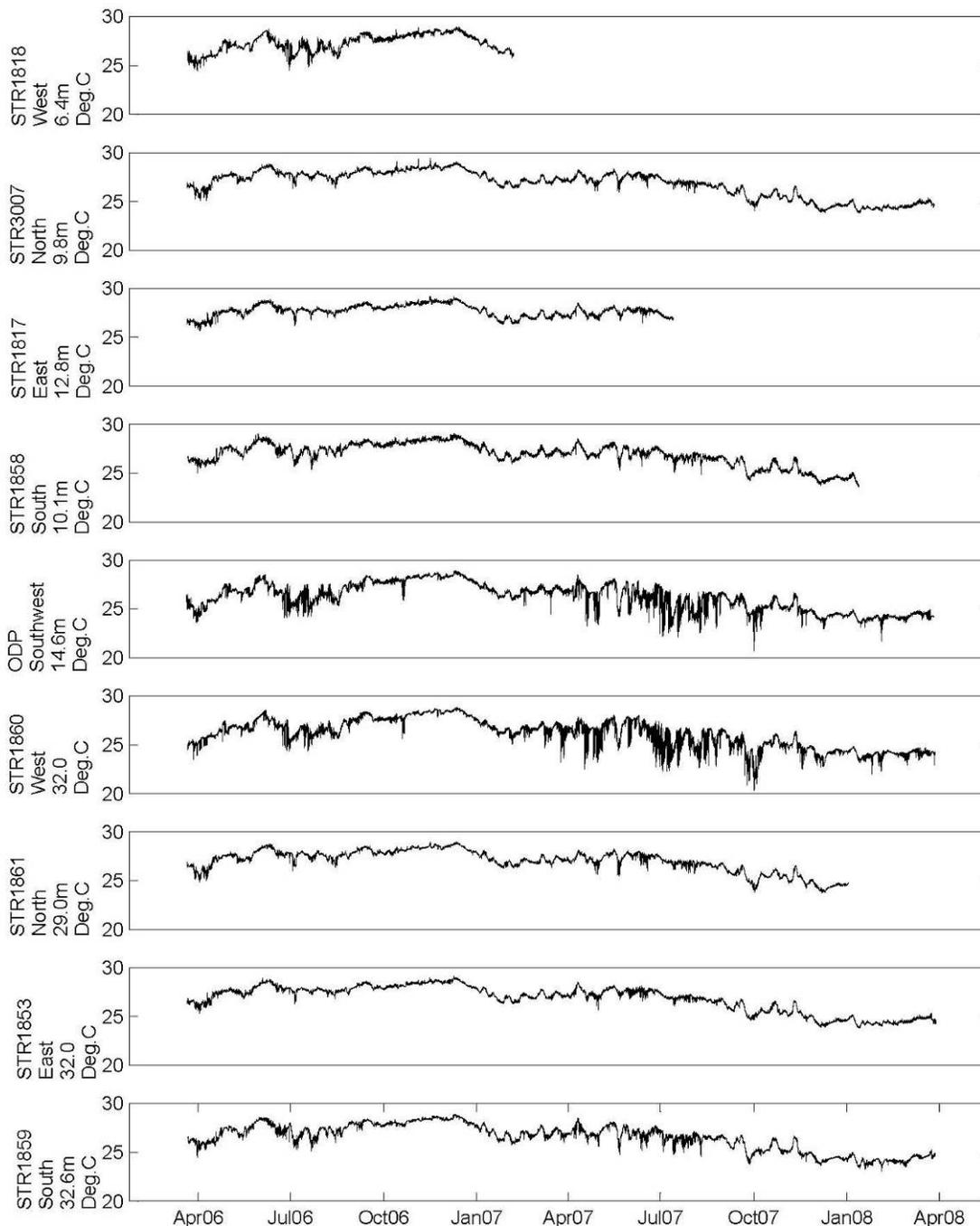


Figure B.1.2.--Temperature data obtained from eight STR and one ODP locations locations around Jarvis Island.

Water Quality

Twenty-five shallow water CTDs were conducted at the 30-m bathymetric contour around Jarvis Island at 500-m intervals (Fig. B.1.3). All shallow water CTD casts were conducted on March 28, 2008 (Local Time). Discrete water samples from a daisy chain of Niskin bottles at 1-m, 10-m, 20-m and 30-m depth bins were collected concurrently

with shallow water CTD casts at six of the shallow water CTD sites. Nutrient and chlorophyll samples were processed and stored according to protocol and will be sent out for analysis following the cruise. Samples were also collected for carbonate chemistry analysis (alkalinity and total dissolved inorganic carbon) and precision salinity from the 10-m depth bin and stored according to protocols established by the Pacific Marine Environmental Lab.



Figure B.1.3.--Shallow water CTD and water sampling locations around Jarvis Island, labeled by cast number.

In addition to the water samples from the Niskin daisy chain as part of the standard CTD shallow-water cast, a set of benthic water chemistry samples were collected for carbonate analysis (alkalinity and total dissolved inorganic carbon). Samples were recovered from close proximity (< 200 cm) at a variety of benthic habitats from cardinal points around Jarvis Island. Selected sites were collocated spatially and at depths (12 to 15 m) previously surveyed by benthic REA teams providing for detailed habitat characterization. A total of five sites were selected with one site on the west side of Jarvis revisited a second time to capture diurnal variation. At each site, three water samples were collected directly above the bottom and one at approximately 2 m below the surface. A Seabird 19+ CTD with a SBE43 dissolved oxygen sensor was deployed concurrently with the carbonate chemistry water collections. Samples were collected and stored according to protocols established by the Pacific Marine Environmental Lab. Chlorophyll and nutrient samples were collected concurrently at one site in each of the areas, and salinity samples were taken every third DIC water sample to aid in the calibration of the CTD 19+. All data will be processed following the cruise.

Table B.1.2.--Benthic water carbonate chemistry sampling table for Jarvis Island.

Area	Loc	CTD Cast ID	Bottom Depth (m)	Carbonate Chem.	Salinity	Nutrient	Chl-a	Replicate
REA JAR-8	North Jarvis	HI0803_JAR002	14	Yes	Yes	No	No	No
REA JAR-8	North Jarvis	HI0803_JAR003	13	Yes	No	No	No	No
REA JAR-8	North Jarvis	HI0803_JAR004	15	Yes	No	No	No	No
REA JAR-8	North Jarvis	HI0803_JAR005	2 (surface)	Yes	Yes	Yes	Yes	No
REA JAR-4P	South Jarvis	HI0803_JAR006	14	Yes	Yes	No	No	No
REA JAR-4P	South Jarvis	HI0803_JAR007	14	Yes	No	No	No	No
REA JAR-4P	South Jarvis	HI0803_JAR008	14	Yes	No	No	No	No
REA JAR-4P	South Jarvis	HI0803_JAR009	2 (surface)	Yes	Yes	Yes	Yes	No
REA JAR-7	West Jarvis	HI0803_JAR010	15	Yes	Yes	No	No	No
REA JAR-7	West Jarvis	HI0803_JAR011	13	Yes	No	No	No	No
REA JAR-7	West Jarvis	HI0803_JAR012	15	Yes	No	No	No	No
REA JAR-7	West Jarvis	HI0803_JAR013	2 (surface)	Yes	Yes	Yes	Yes	No
REA JAR-9	West Jarvis	HI0803_JAR014	16	Yes	Yes	No	No	No
REA JAR-9	West Jarvis	HI0803_JAR015	16	Yes	No	No	No	No
REA JAR-9	West Jarvis	HI0803_JAR016	16	Yes	No	No	No	No
REA JAR-9	West Jarvis	HI0803_JAR017	2 (surface)	Yes	Yes	Yes	Yes	No
REA JAR-7	West Jarvis	HI0803_JAR018	15	Yes	Yes	No	No	No
REA JAR-7	West Jarvis	HI0803_JAR019	13	Yes	No	No	No	No
REA JAR-7	West Jarvis	HI0803_JAR020	15	Yes	No	No	No	No
REA JAR-7	West Jarvis	HI0803_JAR021	2 (surface)	Yes	Yes	Yes	Yes	Yes
REA JAR-9	East Jarvis	HI0803_JAR022	15	Yes	Yes	No	No	No
REA JAR-9	East Jarvis	HI0803_JAR023	17	Yes	No	No	No	No
REA JAR-9	East Jarvis	HI0803_JAR024	16	Yes	No	No	No	No
REA JAR-9	East Jarvis	HI0803_JAR025	2 (surface)	Yes	Yes	Yes	Yes	No

Seventeen standard shipboard CTD casts were conducted near Jarvis Island between March 27 and March 29, 2008 (Fig. B.1.4). Shipboard CTD casts were conducted to 300 m in two transects; one to the east and one to the west of the island. Water samples were collected at 2, 80, 100, 125 and 150 m for nutrient and chlorophyll analysis, and 2 and 80 m for DIC analysis at 14 CTD locations. A total of 168 samples were collected, processed and stored according to protocol and will be sent out for analysis following the cruise. Additionally, acoustic Doppler current profile (ADCP) lines were run between the shipboard CTD casts.



Figure B.1.4.--Shipboard CTD and water sample sites at Jarvis Island during HI0803.

B.2. Rapid Ecological Assessment (REA) Site Descriptions

Twenty REA (Rapid Ecological Assessment) sites were visited by a team of up to eight scientists around Jarvis Island from March 26 to March 28, 2008. Eleven of those sites were only surveyed by the fish scientists in additional depth ranges. Site locations are listed in Figure B.2.1 and survey dates and efforts in Table B.2.1 (benthic surveys) and Table B.2.2 (Fish surveys). Individual site descriptions are included for: coral, coral and coralline disease, macroinvertebrates, algae, and fish.

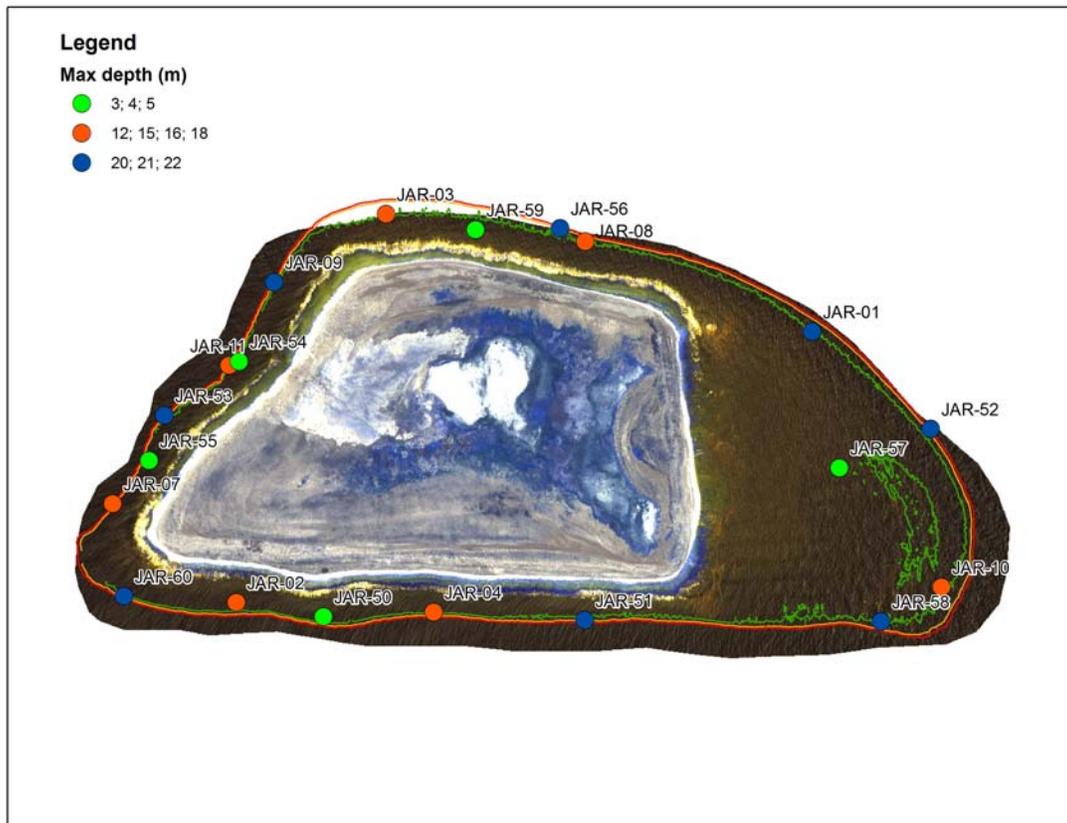


Figure B.2.1.--Jarvis Island 2008 REA site locations.

Table B.2.1.--Jarvis Island 2008 benthic REA site survey dates, teams present and additional comments.

Site ID	Date	Teams Present	Comments
JAR-08	3/26/2008	Coral, Disease, Algae, Invertebrate	ARMS deployment
JAR-11	3/26/2008	Coral, Disease, Algae, Invertebrate	
JAR-04	3/26/2008	Coral, Disease, Algae, Invertebrate	ARMS deployment
JAR-01	3/27/2008	Coral, Disease, Algae, Invertebrate	
JAR-02	3/27/2008	Coral, Disease, Algae, Invertebrate	
JAR-09	3/27/2008	Coral, Disease, Algae, Invertebrate	ARMS deployment
JAR-03	3/28/2008	Coral, Disease, Algae, Invertebrate	
JAR-07	3/28/2008	Coral, Disease, Algae, Invertebrate	
JAR-10	3/28/2008	Coral, Disease, Algae, Invertebrate	

Table B.2.2.--Jarvis Island fish survey sites 2008. At each site two 25 m x 4 m belt transects (BLT) and two 7.5-m radius circular plot point counts (nSPC's) were performed unless otherwise noted.

Site	Date	Depth (m)	Strata	Divers/Reps
JAR-01	03/27/2008	11	Forereef Mid	1 nSPC
JAR-02	03/27/2008	12	Forereef Mid	1nSPC
JAR-03	03/28/2008	12	Forereef Mid	
JAR-07	03/28/2008	12	Forereef Mid	1 nSPC
JAR-08	03/26/2008	12	Forereef Mid	1 REP
JAR-09	03/27/2008	13	Forereef Mid	1 REP
JAR-10	03/28/2008	11	Forereef Mid	1 REP
JAR-11	03/26/2008	12	Forereef Mid	BLTs only
JAR-4P	03/26/2008	12	Forereef Mid	1 REP
JAR-50	03/26/2008	7	Forereef Mid	
JAR-51	03/26/2008	21	Forereef Deep	1 nSPC
JAR-52	03/26/2008	21	Forereef Deep	1 REP
JAR-53	03/27/2008	21	Forereef Deep	1 REP
JAR-54	03/27/2008	3	Forereef Shallow	
JAR-55	03/27/2008	4	Forereef Shallow	1 nSPC
JAR-56	03/27/2008	21	Forereef Deep	1 nSPC
JAR-57	03/28/2008	5	Forereef Shallow	
JAR-58	03/28/2008	21	Forereef Deep	1 REP
JAR-59	03/28/2008	4	Forereef Shallow	1 REP
JAR-60	03/28/2008	20	Forereef Deep	1 REP

March 26, 2008

JAR-08

S 0 ° 36.325, W 159 ° 99.116

Depth range: 9.0–9.7 m

This site was on the northern side of the island and had very little benthic complexity, with abundant overgrown coral skeletons and rubble. The coral community was dominated by encrusting *Montiporids*, small *Pocilloporids*. Line point intercept (LPI) data showed live coral cover to be 8.8%, mainly composed of platy *Montipora* sp. and a few colonies of *Pocillopora verrucosa*. Percent coralline algal cover represented 6% and macroalgae 7%. Turf- and rubble-covered pavement accounted for ~ 75% of the benthic cover. Dominated by turf and crustose coralline red algae with a low percent cover of *Halimeda opuntia*. Coral disease and health assessment studies found one case of bleaching on *Montipora* sp., one case of barnacle infestation on *Acropora*, and nine cases of predation on *Montipora* sp. in a 300 m² survey area. Macroinvertebrate populations were low except for cryptic sessile fauna associated with coral rubble. The only common mobile macroinvertebrates were the sea stars *Linckia multifora* and *Linckia guildingi* and the hermit crabs *Calcinus isabellae* and *Dardanus longior*. A red turf algae and other macroalgae dominates the substrate throughout the site. Cryptic sessile and mobile fauna can be found associated with unconsolidated reef rubble. These cryptic organisms were usually bryozoans, didemnid tunicates, sponges and mobile crustaceans (shrimp and crabs). The most common didemnid tunicate was a greenish species from the genus *Diplosoma*. The holothuroid *Holothuria atra* was common at the site. Fish diversity and abundance were relatively high at this site. Anthias (*Pseudanthias bartlettorum*, *P. olivaceous*) and damsels (*Lepidozygus tapeinosoma*, *Chromis vanderbilti*) were counted

in large numbers. The shark, *Carcharhinus amblyrhynchos*, was counted during the nSPC. Of note, a large tuna, *Thunnus albacares*, was seen off-transect.

JAR-04

S 0 ° 38.230, W 160 ° 00.294

Depth range: 10.6–11.8 m

This was a southern site which had very high coral cover, with scrolling *Montiporids*, *Pocilloporids* thickets, large *Millepora* colonies dominating the community. LPI data showed live coral cover to be 56%, mainly composed of platy *Montipora* sp., but also *Pocillopora verrucosa*, and the fire coral *Millepora* sp. Percent coralline algal cover represented 2% and macroalgae 1%. Turf- and rubble-covered pavement accounted for nearly 35% of the benthic cover. Dominated by turf and crustose coralline red algae with a low percent cover of *Valonia utricularis*. Coral disease and health assessment studies found one case of predation on *Montipora* sp. in a 150 m² survey area (only one transect surveyed). *Montipora* and *Pocillopora* dominated community with abundant crustacean and gastropod fauna. The dominant macroinvertebrate species were hermit crabs of genera, *Calcinus* and *Dardanus*, cone shell gastropods and the sea urchins, *Echinothrix* and *Diadema*. Trapezid crabs, *Trapezia flavopunctata*, *Trapezia tigrina* and *Trapezia bidentata* were seen commonly in *Pocillopora* heads. Clouds of *Pseudanthias bartlettorum*, *Luzonichthys whitley*, and *Lepidozygus tapeinosoma* also dominated this site. Also numerous were the pomacentrids *Plectroglyphidodon dickii* and *Chromis margaritifer*. Larger fish observed included *Triaenodon obesus*, *Carcharhinus melanopterus*, *Scarus frenatus*, *Caranx melampygus*, *C. lugubris*, and *Aphareus furca*.

JAR-11

S 0 ° 22.135, W 160 ° 00.485

Depth range: 12–13.3 m

This was a western site with very high coral cover; scrolling *Montiporids* dominate, most over 1 m in diameter. Very monospecific, with little diversity but huge abundance. LPI data found live coral cover to be 77%, mainly composed of platy *Montipora* sp., but also *Porites lobata*, *Pavona explanulata*, and *Pocillopora eydouxi*. Percent coralline algal cover represented 4% and macroalgae < 1%. Turf- and rubble-covered pavement accounted for > 11% of the benthic cover. Dominated by turf and crustose coralline red algae. Coral disease and health assessment studies found six cases of predation on *Montipora* sp. in a 140 m² survey area (only one transect surveyed). *Montipora* and *Pocillopora* dominated community with echinoderms, gastropods and crustaceans being the most common macroinvertebrates. Two species of sea stars, *Linckia multifora* and *Linckia guildingi* were extremely abundant throughout the habitat. Also abundant were the sea urchins, *Echinothrix* and *Diadema*. The giant clams, *Tridacna squamosa* and *Tridacna maxima* were noted in the shallow reef crest in a depth of 15–20 feet. At shallow depths (20–30 feet), two color variants of the cup coral *Tubastrea* were common. One variant was the typical orange color but the other was a deep green. The trapezid crab, *Trapezia flavopunctata*, was abundant in the *Pocillopora* coral heads. Overall fish diversity was relatively high. As at other sites, anthias were the most abundant fish species. A school of *Naso hexacanthus* contributed greatly to the biomass, as did a fair number of *Caranx lugubris*.

JAR-50

S 0 ° 22.921, *W* 160 ° 0.233

Depth range: ~ 5 m

This site is located on the south side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had medium coral cover with medium reef complexity. Visibility was relatively low. Many large sharks were seen (blacktip, whitetip, and gray reef). Many large fish were also observed (snapper and parrotfish).

JAR-51

S 0 ° 22.931, *W* 160 ° 59.452

Depth range: ~ 21 m

This site is located on the south side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had high coral cover with medium reef complexity. The site is on a steep slope. Many large fish and sharks were observed. Of note was a sighting of three large scalloped hammerhead sharks off transect.

JAR-52

S 0 ° 22.361, *W* 160 ° 58.418

Depth range: ~ 21 m

This site is located at the eastern tip of the eastern shelf of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had low coral cover and complexity. However, the quantity of large fish observed here was astounding. As many as 10–15 gray reef sharks and a scalloped hammerhead shark were observed at this site. A large school of Heller's barracudas, a large dog tooth tuna, a large school of *Odonus niger*, and numerous groupers were seen. Anthias were enumerated in the thousands.

March 27, 2008

JAR-02

S 0 ° 38.173, *W* 160 ° 00.803

Depth range: 12–13.6 m

This southern site was a mostly coral dominated slope, with slightly higher diversity than other sites, dominated by scrolling *Montiporids* and some coral rubble. LPI data found live coral cover to be 44%, mainly composed of platy *Montipora* sp., but also *Pocillopora verrucosa*. Percent coralline algal cover represented 14% and macroalgae 41%, dominated by *Lobophora variegata*, turf and crustose coralline red algae. Turf-covered rubble and pavement accounted for > 35% of the benthic cover. Coral disease and health assessment studies found three cases of predation on *Montipora* sp. and *Pocillopora verrucosa*, one case of skeletal growth anomaly on *Montipora* sp., and six cases of coralline lethal disease in a 170 m² survey area. Echinoderms were the only common macroinvertebrate species present. These were found along the steep slope and were the sea star *Linckia multifora*, the holothuroids *Holothuria atra* and *Actinopyga obesa*. An unknown zoanthid was rare at the site. Fish diversity was high at this site.

Large numbers of anthias were the most distinguishing characteristic, with *Pseudanthias bartlettorum* and *Luzonichthys whitleyi* being the most numerous. The mimic damsel, *Lepidozygus tapeinosoma* was also present, schooling with the anthias.

JAR-09

S 0 ° 21.922, W 160 ° 00.382

Depth range: 12–13 m

Only one transect was deployed for benthic surveys due to strong current at this northwestern site. LPI data found live coral cover to be 67%, mainly composed of platy *Montipora* sp., but also *Pocillopora verrucosa*. Percent coralline algal cover represented 9%, and turf-covered rubble and pavement accounted for 19% of the benthic cover; no macroalgae was recorded on the LPI, dominated by *Valonia utricularis*, turf and crustose coralline red algae. Coral disease and health assessment studies found one case of pink-line/spot syndrome detected on *Porites* sp. within a 120 m² survey area. The dominant macroinvertebrate fauna were echinoderms and cryptic crustaceans. The echinoderms present were the sea stars *Linckia multifora* and *Linckia guildingi*, the holothuroid *Holothuria atra* and the urchin *Echinothrix*. The trapezid crabs, *Trapezia flavopunctata* and *Trapezia tigrina* were common in the *Pocillopora* heads, as were the hermit crabs *Calcinus haigae*. Fish included large numbers of anthias, with *Pseudanthias bartlettorum* and *Luzonichthys whitleyi* being the most numerous. The mimic damsel, *Lepidozygus tapeinosoma* was also present, schooling with the anthias. High numbers of the site-attached damsel, *Plectroglyphidodon dickii*, were recorded. Fish diversity was medium-high.

JAR-01

S 0 ° 36.745, W 159 ° 97.950

Depth range: 11.5–12 m

This northeastern site was dominated by rubble habitat, and large coral skeletons were abundant. LPI data found live coral cover to be 5.8%, mainly composed of platy *Montipora* sp., but also *Pocillopora verrucosa*. Percent coralline algal cover represented 14%, and turf-covered rubble and pavement accounted for > 73% of the benthic cover; macroalgae represented nearly 5% LPI. Dominated by turf and crustose coralline red algae with a low percent cover of *Chondrocanthus* sp. and *Dictyosphaeria versluisii*. Coral disease and health assessment studies found 10 cases of predation on *Montipora* sp., and 1 case of coralline fungal disease were noted within a 300 m² survey area. This site was similar to JAR-08 but shows signs of historical high coral cover. The unconsolidated rubble at this site showed both massive plate and finger forms of coral were once present. The red turf algae present at JAR-08 was abundant at this site as well. All macroinvertebrate species present were uncommon. These species were the sea stars *Linckia multifora* and *Linckia guildingi*, the holothuroid *Holothuria atra*, the urchin *Echinothrix*, and the diogenid hermit crab *Dardanus longior*. Fish diversity was moderate at this site. *Pseudanthias olivaceus* was the most numerous anthias, while notably absent were *P. bartlettorum* and *L. whitleyi*. Of note was a rare aggregation of *Cheilinus trilobatus*. Small pomacentrids dominated in terms of total numbers.

JAR-53

S 0 ° 22.320, W 160 ° 0.708

Depth range: ~ 21 m

This site is located on the west side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef deep stratum. This current-swept site had high coral cover with medium reef complexity. Fish diversity was high, with large numbers of anthias. Adding to the crowded water column was a relatively large number of *Caranx lugubris* and unusually high numbers of the soldierfish, *Myripristis berndti* and *M. amaena* found in the coral crevices, as well as a large eel, *Gymnothorax javanicus*. Gray and whitetip reef sharks were also counted within the nSPC.

JAR-54

0 ° 22.158, W 160 ° 0.486

Depth range: 3–30 m

This site is located on the west side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. This spur-and-groove site had low coral cover with high reef complexity. Fish diversity and abundance were low at this site. Of the fish present, *Stegastes aureus*, *Plectroglyphididon dickii*, *Thalassoma quinquevittatum*, and *Chromis vanderbilti* constituted the most numerous fish species. Scarids comprised the greatest number of large fish seen, including *Scarus rubroviolaceus*, *S. altipinnis*, *S. tricolor*, and *S. frenatus*.

JAR-55

S 0 ° 22.455, W 160 ° 0.755

Depth range: ~ 4 m

This site is located on the west side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. This site was similar to JAR-54 with low coral cover and high reef complexity with spur-and-groove formations, and relatively low fish diversity and abundance. Of the fish present, *Stegastes aureus*, *Plectroglyphididon dickii*, *Acanthurus nigricans*, and *Chromis vanderbilti* constituted the most numerous fish species. A school of hundreds of *A. triostegus* was seen off-transect.

JAR-56

S 0 ° 21.761 W 160 ° 59.525

Depth range: ~ 21 m

This site is located on the north side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had low coral cover with low reef complexity. The substrate was characterized by mostly rubble, red algae, and some table corals. Overall fish abundances were not high except for schools of the anthias *Pseudanthias bartlettorum* and *Luzonichthys whitleyi*. A few large fish were counted, including the sharks *C. amblyrhynchos* and one *Triaenodon obesus*, the parrotfish *Scarus rubroviolaceus*, and the snapper *Lutjanus bohar*.

March 28, 2008

JAR-10

S 0 ° 38.058, W 159 ° 97.242

Depth range: 10.3–11.8 m

This site was on the southeastern terrace, and only one transect was surveyed due to strong current. LPI data found live coral cover to be 27%, mainly composed of branching *Pocillopora verrucosa*. Percent coralline algal cover represented 11% and turf-covered rubble and pavement accounted for nearly 53% of the benthic cover. Dominated by *Chondrocanthus* sp., turf and crustose coralline red algae. Coral disease and health assessment studies found no specific diseases in the area surveyed (150 m²); however numerous colonies of *Pocillopora verrucosa* exhibited profuse sponge overgrowth. Initial impressions are an area that receives heavy currents and wave energy due to the fact that many filter and suspension feeding sessile organisms were present. The sessile fauna was made up of sponges, hydrozoans, and bryozoans. The most numerous sessile organisms was the hydroid *Pennaria* cf. *disticha* sponge from the genus *Dysidea* (see photo) that had a purple and green morph. The hydrozoan *Distichopora* was common but was patchy in its distribution. The fish community was characterized by many large individuals (lutjanids, scarids), including many gray reef sharks. Large groups of *Pseudoanthias bartlettorum* were also observed.

JAR-07

S 0 ° 37.610, W 160 ° 01.423

Depth range: 12–13 m

This unique site was found on the southwestern corner of the island. *Sinularian* soft corals dominated benthic cover, some colonies up to 2 m in diameter. Other corals included scrolling *Montiporids*, some massive *Porites* colonies. LPI data found live coral cover to be 18%, mainly composed of platy *Montipora* sp., but also *Porites* sp., and *Pocillopora verrucosa*. The octocoral, *Sinularia*, accounted for 42% of the benthic cover. Percent coralline algal cover represented 13% and turf-covered rubble and pavement accounted for nearly 2% of the benthos. Dominated by turf and crustose coralline red algae with a low percent cover of *Lobophora variegata*. Coral disease and health assessment studies found six cases of tube worm infestation and three cases of predation on *Montipora* sp. within a 300 m² survey area. Reef structure composed of buttresses and channels with extensive sand expanse at the base. This site was dominated by the soft coral *Sinularia* sp. and hard coral *Montipora*. The sea star *Linckia multifora* and *Echinothrix calamaris* sea urchins were common. A single *Tridacna squamosa* giant clam was recorded on the upper portion of a buttress. The holothuroid *Holothuria atra* was also common in the sand patch areas. The fish community was composed of mainly medium-sized individuals (acanthurids common) with a large number of anthias (*Pseudoanthias bartlettorum*). A hammerhead shark was spotted, as were several gray reef sharks.

JAR-03

S 0 ° 36.196, W 160 ° 00.076

Depth range: 10–11 m

This northwestern site had not been visited since 2000 and Global Positioning System (GPS) data available positioned this site at a greater depth (> 30 m). For the surveys herein (fish and benthic) the site was relocated to a shallower, workable depth. For convenience, site ID (i.e., JAR-03) was preserved. Rubble and algae dominated the benthic habitat. LPI data found live coral cover to be 2%, mainly composed of branching *Pocillopora verrucosa*. Percent coralline algal cover represented 16%, macroalgae represented 3%, and turf-covered rubble and pavement accounted > 75% of the benthic cover. Dominated by turf and crustose coralline red algae with a low percent cover of *Lobophora variegata* and *Halimeda fragilis*. Coral disease and health assessment studies found one case of tube worm infestation on *Montipora* sp. within a 300 m² survey area. northwest corner of the island. Low coral cover area dominated by turf algae. The only common macroinvertebrates were holothuroids. The most common species was *Holothuria atra* and there was a rare occurrence of *Actinopyga mauritiana*. Hermit crabs, *Calcinus isabellae*, were noted at this site but were not abundant. The fish community was mainly composed of medium-sized individuals (Scarids and Acanthurids). Few large fish were observed here (no sharks or large snappers).

JAR-57

S 0 ° 22.477, W 160 ° 58.691

Depth range: ~ 5 m

This site is located on the east side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had medium coral cover with medium reef complexity. The site is located on a shallow shelf that extends for some distance off the east end of the island. Of note was high coverage of the substrate by red algae. Fish diversity and abundance were low at this site. Of the fish present, *Thalassoma quinquevittatum*, *Chromis vanderbilti*, and *Pseudanthias olivaceus* constituted the most numerous fish species. Of note was an on-transect sighting of one *Triaenodon obesus*, and one off-transect sighting of *Sphyaena barracuda*.

JAR-58

S 0 ° 22.936, W 160 ° 58.566

Depth range: 20–21 m

This site is located on the southeast side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had medium/high coral cover with medium reef complexity. This current-swept site was located along the steep drop-off of the southeast shelf. While Anthias species represented the highest numbers of fishes, *Naso hexacanthus* represented the most biomass, with large schools of 40–50 cm individuals entering the survey area. Large fish were well represented. Of note were two *Carcharinus amblyrhynchos* and one *Triaenodon obesus*. Additionally, one *Chelinus undulatus* was sighted off-transect.

JAR-59

S 0 ° 21.765, W 160 ° 59.779

Depth range: ~ 4 m

This site is located on the north side of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had low coral cover with high reef complexity. This surge area was composed of deep spur-and-groove formations. Fish diversity seemed high, despite the low coral cover. *Thalassoma quinquevittatum*, *Stegastes aureus*, and *Chromis vanderbilti* were the species with the most numerous counts. Of note was an off-transect sighting of *Triaenodon obesus*.

JAR-60

S 0 ° 22.860, W 160 ° 0.829

Depth range: ~ 20 m

This site is located at the southwest tip of Jarvis Island. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had high coral cover with medium reef complexity. Located on the steep slope of the forereef, this area harbored Anthias, composed of *P. bartlettorum*, *L. whitleyi*, *P. olivaceus*, and the damsel *L. tapaeinosoma*. Several species of jacks were observed on-transect including *C. ferdau*, *C. melampygus*, and *C. lugubris*. Of note were off-transect sightings of *Carcharinus amblyrhynchos*, *Triaenodon obesus*, *Chanos chanos*, and *Gymnosarda unicolor*.

B.3. Benthic Environment

B.3.1. Algae

Quantitative algal surveys were conducted at nine forereef sites at Jarvis Island. All sites exhibited relatively little macroalgae (Table B.3.1.1). Macroalgal diversity was low and consistent across all sites at the island except JAR-11. Seven species of macroalgae were recorded along survey lines: four species of green algae, one species of red algae, and two species of brown algae, as well as crustose coralline red algal and turf algal functional groups.

Table B.3.1.1.--Algal genera or functional groups recorded in photoquadrats at Jarvis Island. Numbers indicate the percentage of photoquadrats in which an alga occurred. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	JAR-01	JAR-02	JAR-03	JAR-04	JAR-07	JAR-08	JAR-09	JAR-10	JAR-11
GREEN ALGAE									
Dictyosphaeria cavernosa			*						
Dictyosphaeria versluysii	33	17	25	8		8	17	17	
Halimeda fragilis	50	25	42		8		*	17	
Halimeda opuntia	8			8		50			
Valonia utricularis		42	*	25			67		
RED ALGAE									
Chondracanthus sp.	25	8	8		*		*	67	
crustose coralline red algae	100	83	25	83	83	92	67	100	100
OCHROPHYTA									
Dictyota ceylanica		8							
Lobophora variegata	58	83	25	42	50	50	33	17	
FUNCTIONAL GROUPS									
turf algae	100	100	100	100	83	100	83	100	100

B.3.2. Corals

B.3.2.1 Percent Benthic Cover

Percent benthic cover surveys at Jarvis Island were conducted in concert with the fish, coral population, algae, and invertebrate REA surveys at nine different sites established during prior CRED cruises in 2000, 2004, and 2006. The line-point intercept (LPI) methodology was conducted along two, end-to-end 25-m transects (51 points per transect) at each site, except for sites JAR-10 and JAR-09, where strong surge and swell only allowed surveys along one transect each. LPI surveys totaled 816 points along 400 m of forereef coral communities at survey depths ranging between 10 and 14 m for all locales visited. Patterns of intra-island variability in percent benthic cover, derived from the nine independent REA surveys in 2008, are reflected in Figure B.3.2.1.1. Island-wide, turf algae, scleractinian corals, and encrusting coralline red algae were the primary benthic components, contributing $42.8 \pm 9.1\%$, $34.1 \pm 9.3\%$, and $11.2 \pm 1.4\%$ of total, respectively (mean \pm SE). The greatest values for live coral cover were encountered at sites JAR-11 and JAR-09 (77.5 % and 66.4%, respectively) along the west- and northwest-facing shores. Site JAR-04 on the south-facing shore also presented moderately high percent live coral cover; 55.9%. In addition, carpets of red, turf algae were particularly abundant at north- and east-facing sites JAR-03, JAR-08, JAR-01, and JAR-10 (75.4%, 74.5%, 73.5%, and 55.9%, respectively). At these locales, algae grew on

stabilized staghorn and table coral rubble. As observed in previous years, the octocoral *Sinularia* was particularly abundant at site JAR-07 on the southwest tip of the island, accounting for over 40% of the benthic cover. Of the eight scleractinian genera enumerated along the LPI transects, the genera, *Montipora*, *Pocillopora*, and *Porites* contributed over 93% of the scleractinian cover, accounting for 74%, 17%, and 3%, respectively.

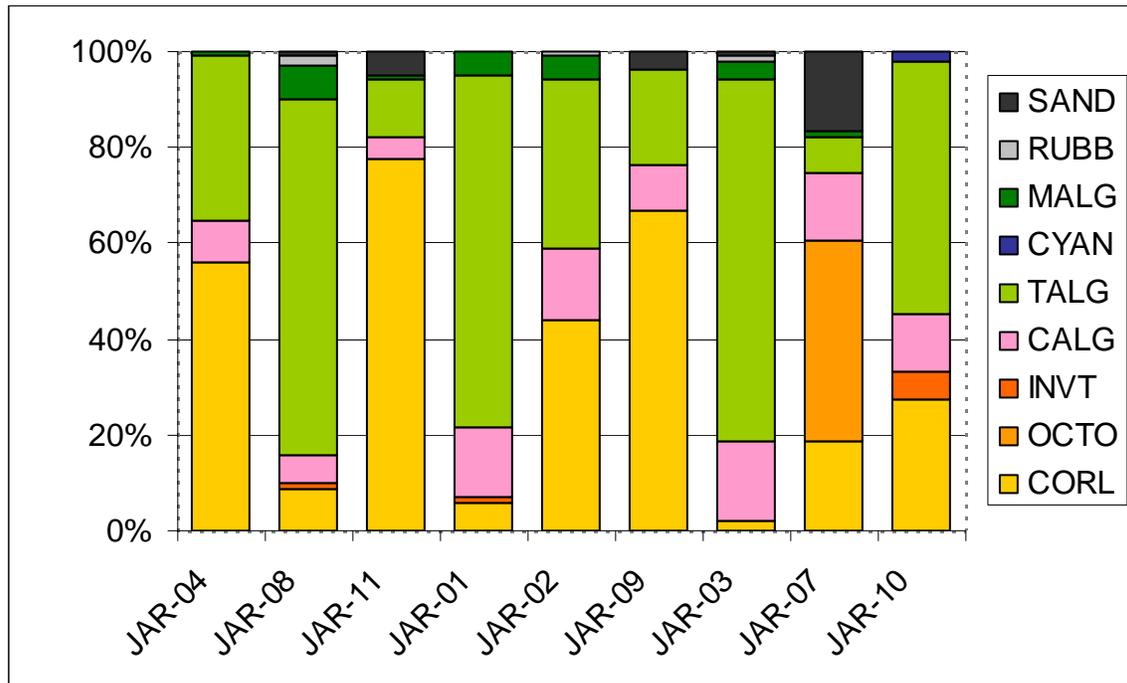


Figure B.3.2.1.1.--Mean percent cover of selected benthic elements derived from nine independent REA surveys at Jarvis Island, ASRAMP 2008 (March 26–28, 2008). CORL: live scleractinian and hydrozoan stony corals; OCTO: Octocorals; INVT: other sessile invertebrates; CALG: coralline algae; TALG: turf algae (on pavement, rubble, and dead coral); CYAN: cyanophyte; MALG: macroalgae; RUBB: coral rubble; and SAND: sand.

The quantitative data above documents important characteristics of the coral reef benthic assemblages, providing the opportunity to monitor for change in response to alterations in the reef environment. An abridged comparison of percent live coral cover based on surveys conducted in the last 2 years is illustrated in Figure B.3.2.1.2. For all sites visited in 2006 and 2008 combined, the mean average difference between the two surveys was less than 5%. Due to the lack of permanent stations at most of the sites surveyed, a rigorous statistical comparison of results is precluded.

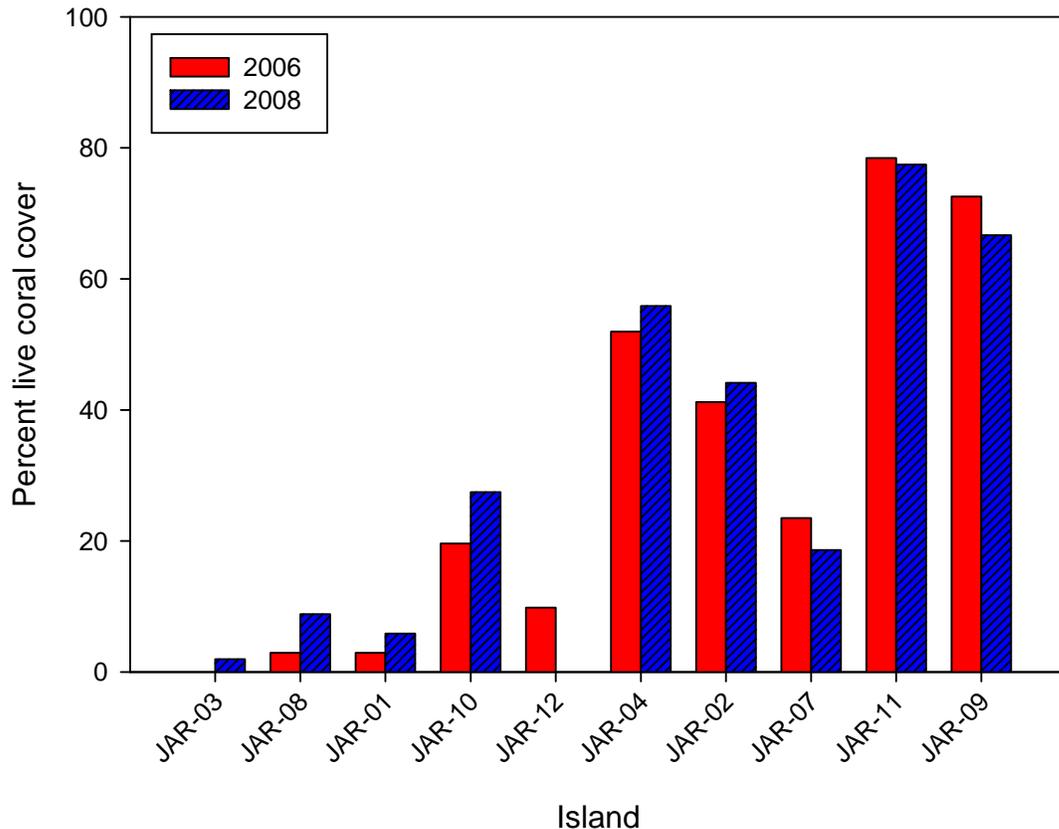


Figure B.3.2.1.2.--Percent live coral cover for 9 REA sites at Jarvis Island contrasted for survey years 2006 and 2008.

B.3.2.2. Coral Populations

A total of 308 m² of reef benthos was surveyed around Jarvis Island in 2008. A total number of 2,522 colonies were counted within this area (Table B.3.2.2.1). Nine genera of scleractinian coral and one genus of hydrozoan coral were observed at Jarvis. In addition, soft corals and zoanthids were also seen. Encrusting and scrolling *Montiporid* corals dominate the coral community at Jarvis (71.37 % of colonies observed) and are responsible for much of the three-dimensional heterogeneity of the reef. *Pocilloporids* were the second dominant anthozoan geuns (15.03 % of colonies observed). Soft corals, such as *Sinularia*, *Lobophytum*, and *Sarcophyton* were also enumerated (4.48 % of colonies observed).

Apex coral communities were seen on the southern and western shores of Jarvis Island. The north western terrace absorbs most of the wave energy experienced by the island. The terrace benthos was mostly scoured hard bottom, with a diminutive associated coral community. Coral community structure at Jarvis was typified by low generic diversity and high benthic coverage. Jarvis is unique in this regard and differs from the other Line Islands.

Table B.3.2.2.1.--Genera of coral colonies enumerated at Jarvis Island; data shown as total number of colonies for the Island, and the generic percent of total.

Jarvis	Number of Colonies	Percent of Total
<i>Acropora</i>	4	0.16
<i>Distichopora</i>	73	2.89
<i>Fungia</i>	7	0.28
<i>Millepora</i>	11	0.44
<i>Montipora</i>	1800	71.37
<i>Pavona</i>	76	3.01
<i>Pocillopora</i>	379	15.03
<i>Porites</i>	18	0.71
<i>Psammocora</i>	7	0.28
Soft Coral	113	4.48
<i>Tubastrea/Balanophyllia</i>	33	1.31
<i>Zoanthus</i>	1	0.04
<i>Total</i>	2522	

B.3.2.3 Coral Health and Disease

In 2008, a total area of ~1930 m² at 9 sites was assessed for coral and coralline algae disease during the REA surveys. Coral disease occurrence and abundance were low; a total of 11 cases of 7 categorized diseases and disorders were tallied. A summary of disease occurrence, relative abundance, and taxa affected are presented in Figures B.3.2.3.1 and B.3.2.3.2, respectively. Barnacle and tube worm infestations were the most common afflictions to scleractinian corals. Several cases of the of coralline algae disease were also noted.

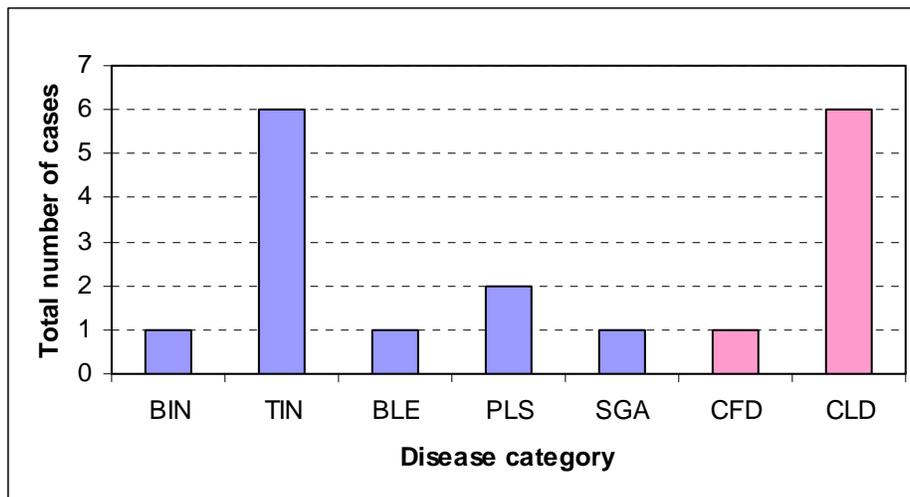


Figure B.3.2.3.1.--Number of cases of coral (blue bars) and coralline algal (pink bars) disease enumerated during REA surveys, Jarvis Island, 2008. BIN: barnacle infestation; TIN: tube worm infestation; BLE: bleaching; PLS: pink line/spot syndrome; SGA: skeletal growth anomalies; CFD: coralline fungal disease; and CLD; coralline lethal disease.

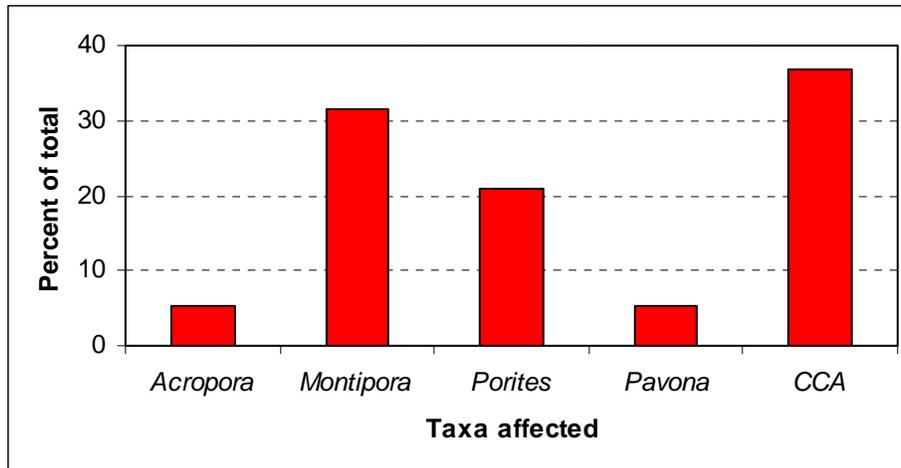


Figure B.3.2.3.2.--Percent occurrence of disease affecting coral and coralline algal taxa (CCA: crustose coralline algae).

B.3.3. Macroinvertebrates

Non-cryptic invertebrates were relatively low around Jarvis Island. Trapezid crabs and the asteroid, *Linckia multifora*, were the most abundant. Trapezid crab densities were greatest at sites JAR-10, JAR-07, and JAR-03 (1.46, 0.09 and 0.09/m², respectively). *Linckia multifora* densities were greatest at JAR-02 and JAR-09 (0.56 and 0.09/m², respectively). The holothuroid, *Holothuria atra*, was common at site JAR-03 with a density of 0.11/m². Additional echinoderms observed were echinoids from the genera *Diadema* and *Echinothrix*, and one additional species of asteroid, *Linckia guildingi*. Echinoids were most abundant at sites JAR-11 and JAR-01. The holothuroid, *Actinopyga mauritiana*, was observed off the transect area at site JAR-03. Although no giant clams were recorded during transect surveys, *Tridacna squamosa* and *Tridacna maxima* were seen outside the transect areas in reef crest habitat at a depth range of 15–20 feet at sites JAR-11 and JAR-07. A hydroid, which appears to be *Pennaria disticha*, was extremely abundant at sites on the eastern terrace (JAR-01 and JAR-10). This hydroid, if it is indeed *P. disticha*, is considered an alien species to the tropical Pacific and was only recorded as abundant at one site on the eastern terrace in 2006 (JAR-12). The population of this hydroid appears to be expanding on the eastern terrace and warrants scrutiny in future surveys. The soft corals, *Sinularia* and *Lobophyton* were only observed at site JAR-07 on the southwest corner. With the exception of the sea urchins, sea stars and sea cucumbers, most macroinvertebrates noted were small sessile and mobile cryptic species associated with unconsolidated rubble areas on the eastern terrace.

B.3.3.1. Urchin and Giant Clam Measurements

The table below reveals the average test diameter of urchins from the genus *Diadema* and *Echinothrix* encountered at each site. Only sites where ≥ 5 measurements were recorded for a species are represented. Measurements were not recorded specifically along the survey transect, rather throughout the site.

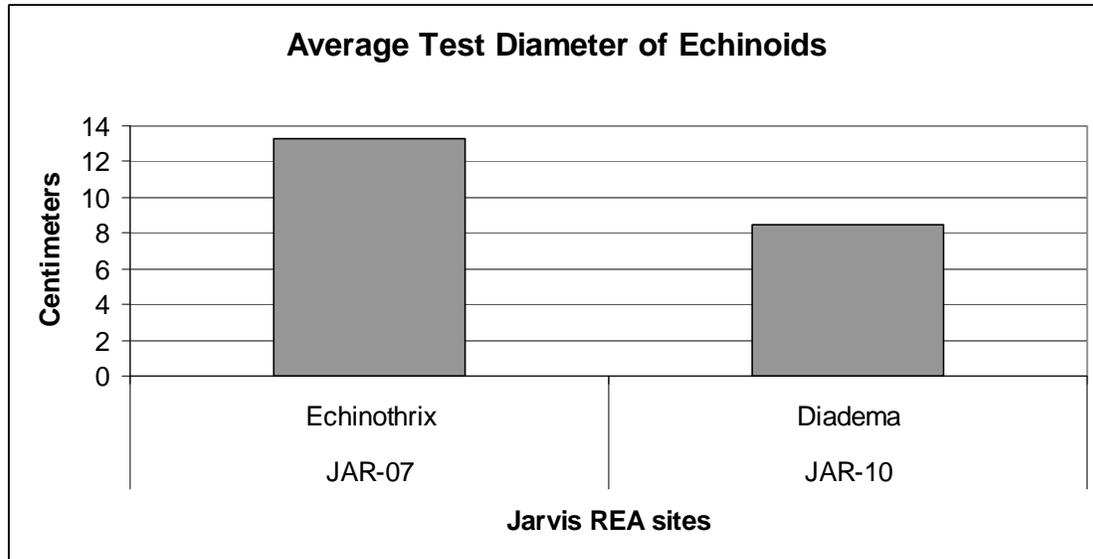


Figure B.3.3.1.1.--Average test diameter of echinoids at Jarvis Island REA sites.

B.3.3.2. Autonomous Reef Monitoring Systems (ARMS) Deployment

ARMS were deployed at the following REA sites around Jarvis. Each site contains three ARMS.

Table B.3.3.2.1.--ARMS deployment locations around Jarvis Island.

	Latitude	Longitude
JAR-04	00° 22.938 S	160° 00.177 W
JAR-08	00° 21.795 S	159° 59.470 W
JAR-09	00° 21.922 S	160° 00.382 W

B.3.3.3. Invertebrate Collections

Nondestructive tissue samples of the following organisms were collected for the Hawaii Institute of Biology for the purpose of genetic analysis.

Table B.3.3.3.1.--Invertebrate tissue collection information for specimens from Jarvis Island.

Species	Number	REA site	Latitude	Longitude
<i>Holothuria atra</i>	12	JAR-08	00° 21.795 S	159° 59.470 W
<i>Holothuria atra</i>	27	JAR-03	00° 21.718 S	160° 00.046 W
<i>Linckia multifora</i>	25	JAR-08	00° 21.795 S	159° 59.470 W
<i>Linckia multifora</i>	5	JAR-02	00° 22.904 S	160° 00.482 W
<i>Ophiocoma erinaceus</i>	1	JAR-08	00° 21.795 S	159° 59.470 W

B.3.4 Towed-diver Benthic Surveys

A total of 17 towed-diver surveys covering 43 kilometers of benthic habitat were completed along the forereefs of Jarvis Island. Three habitat strata within the forereef were surveyed: the shallow forereef (eight tows), mid-depth forereef (six tows) and deep

forereef (three tows). Discussion of diver observations are broken down into the three respective habitat strata.

Shallow Forereef

The average total hard coral cover for all pooled surveys on the shallow forereef was 28.5% (range (12-58%; Fig. B3.4.1). The highest average coral cover was observed along the western side of the island (58%) where scrolling *Montipora* colonies dominated the substrate. Coral cover in the shallow depth strata along the rest of the island was moderately high ranging from 12 to 39% and composed of a mix of mainly *Montipora* and *Pocillopora* colonies. Soft coral cover was low in the shallow depth strata ranging from 0 to 3% with *Sinularia* being the most common genus. Hard coral stress levels were low averaging 1.7% for all pooled surveys (range 0.5–3.3%). An interesting note, hydroids accounted for a notable percentage of the benthic substrate for parts of shallow tows along the southeastern side of Jarvis where cover constituted up to half of the benthic substrate during one tow segment.

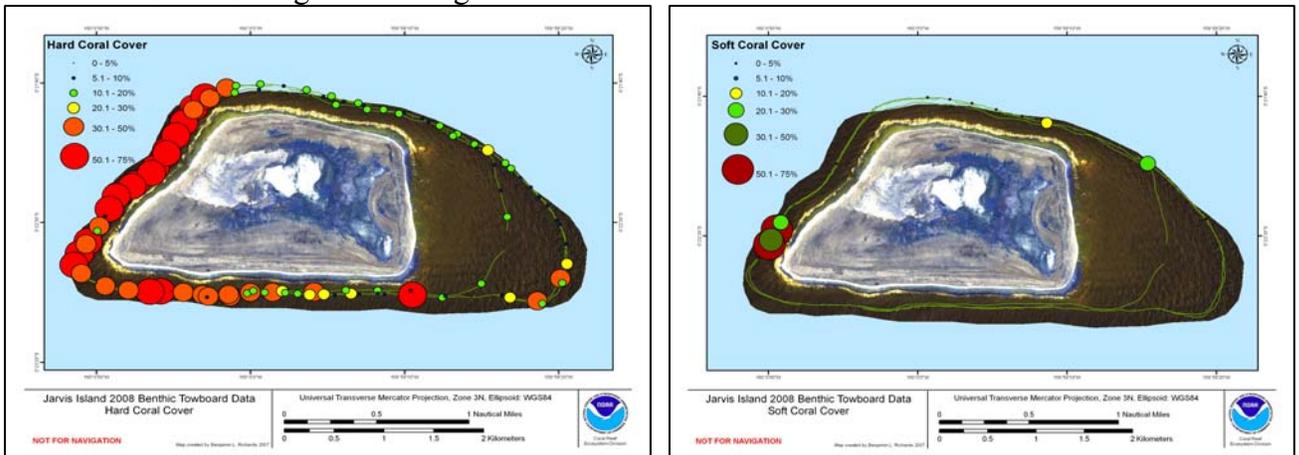


Figure B.3.4.1.--Hard coral and soft coral cover recorded during the 2008 towed-diver surveys around Jarvis Island.

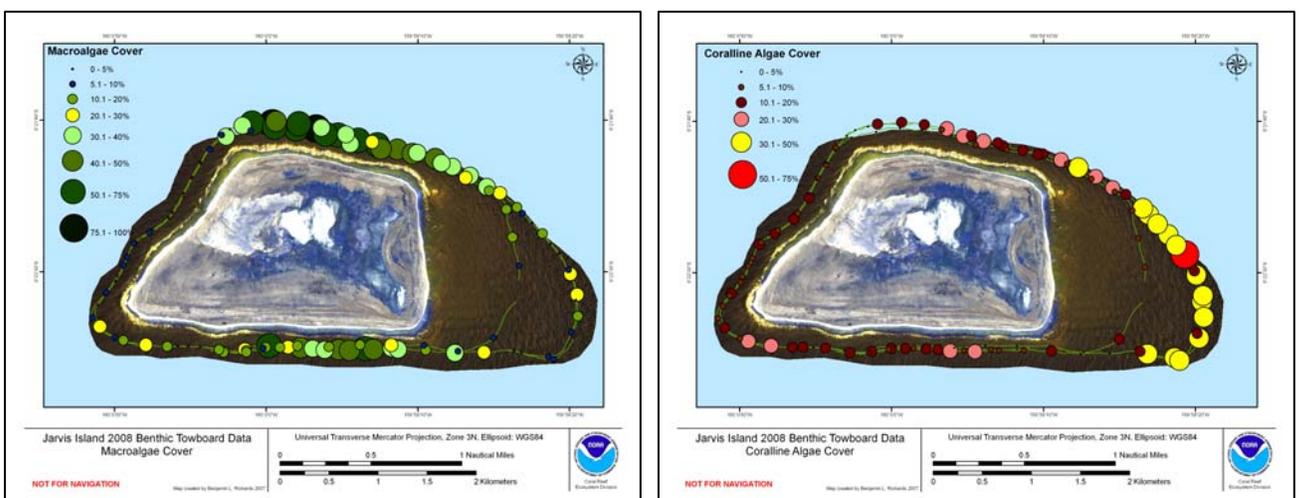


Figure B.3.4.2.--Macroalgae and coralline algae cover recorded during the 2008 towed-diver surveys around Jarvis Island.

Macroalgal cover averaged 26.0% for all pooled surveys (range 6.3–51.1%), with the highest macroalgae recorded along the northern (average: 51%) and southern forereef (average: 46%). The predominant genera belonged to *Halimeda* with *Valonia* and *Dictyosphaeria* also being noted. Coralline algal cover averaged 6.4% for all pooled surveys (range 0.3–16.3%). The highest cover (average 16.3%) was recorded along the eastern side of Jarvis and was low along the remainder of the island.

Macroinvertebrate counts in the shallow depth strata at Jarvis Island were highest among the three-depth strata. The most abundant macroinvertebrate was the sea cucumber of which more than 829 individuals were observed. Counts were highest along the shallow northern forereef where small *Holothuria atra* were abundant with between 100 and 250 individuals observed during a single segment. In addition, several individuals of the species *Actinopyga mauritiana* were also observed. Sea urchins were also more common in the shallow depth ranges with more than 313 individuals observed. Urchins were more common along the northern forereef. Only two giant clams were observed during towed-diver surveys in the shallow depth strata, both on the northern forereef. No crown-of-thorns (COTs) were observed.

Mid-depth Forereef

The average total hard coral cover for all pooled surveys on the shallow forereef was 28.2% (range (11–51%). The highest average coral cover was observed along the western side of the island (58%) where scrolling *Montipora* colonies dominated the substrate. Coral cover in the mid-depth strata along the rest of the island was moderately high ranging from 12 to 39% and composed of a mix of mainly *Montipora* and *Pocillopora* colonies. Soft coral cover was low in the mid-depth strata ranging from 0 to 1.5% with the exception of a section of the tow along the northern section of Jarvis where *Sinularia* dominated the benthic substrate. Hard coral stress levels were low averaging 1.3% for all pooled surveys (range 0.5–2.1%). An interesting note, the hydroids noted on the southeast shallow forereef were also present in the mid-depth range.

Macroalgal cover averaged 23.2% for all pooled surveys (range 11.4–42.9%), with the highest macroalgae recorded along the northern forereef (50–75%). Of particular interest was an unidentified red algae, which appeared to form a monotypic carpet along the rubble bottom (towards the northern tip of Jarvis). Other genera included *Halimeda*, *Valonia* and *Dictyosphaeria*. Coralline algal cover averaged 14.2% for all pooled surveys (range 4.1–24.0%). The highest cover (average 24.0%) was recorded along the northern side of Jarvis and was relatively low along the remainder of the island.

Macroinvertebrates were relatively scarce along the mid-depth strata at Jarvis. The most common macroinvertebrate observed was the sea urchin (*diadema*) with more than 426 individuals recorded. Sea urchins were most abundant along the eastern and western sides of the island. The only other target macroinvertebrate observed was the sea cucumber (*Holothuria atra*) with 11 individuals being noted.

Deep Forereef

The average total hard coral cover for all pooled surveys on the shallow forereef was 24.6% (range 12–58%). The highest average coral cover was observed along the southwestern corner of the island (58%) where scrolling *Montipora* colonies and *Pocillopora* dominated the substrate. Coral cover in the deep depth strata along the rest of the island was moderately low ranging from 12 to 15% and composed of a mix of mainly *Montipora*, *Favia*, *Pavona* and *Pocillopora* colonies. Soft coral cover was low in the deep depth strata ranging from 0.3 to 10.4% with *Sinularia* being the most common genus; however, sea fans were also noted in a number of tow segments. Hard coral stress levels were low averaging 1.0% for all pooled surveys (range 0.4–2.5%).

Macroalgal cover averaged 19.5% for all pooled surveys (range 5.8–43.2%), with the highest macroalgae recorded along the northwest forereef (40–75%). Visible genera included several red algae, *Halimeda*, *Valonia*, and *Dictyosphaeria*. Coralline algal cover averaged 24.3% for all pooled surveys (range 10–38.5%). The highest cover (average 38.5%) was recorded along the southeast side of Jarvis and was relatively low along the remainder of the island.

Macroinvertebrates were relatively scarce along the deep depth strata at Jarvis. The most common macroinvertebrate observed was the sea urchin (*diadema*) with more than 200 individuals recorded. Sea urchins were most abundant along the southeast side of the island. The only other target macroinvertebrate observed was the sea cucumber (*Holothuria atra*) with 19 individuals being noted.

B.4 Fish

B.4.1 REA Fish Surveys

Stationary Point Count data (new methodology)

A total of about 30 individual nSPC surveys were conducted at 20 sites around Jarvis Island (5 forereef shallow, 9 forereef mid depth, 6 forereef deep depth). Sharks (Carcharhinidae) were the largest contributor to total biomass with 9.0 kg 100 m⁻². Surgeonfish (Acanthuridae) and snappers (Lutjanidae) were also abundant, with a biomass of ~4.0 kg 100m⁻² (Table B.4.1.2, Fig. B.4.1.1).

Belt transect data

During the survey period, about 52 belt transect surveys were conducted at 26 sites around Jarvis Island (see SPC for stratum breakdown). Surgeonfishes (Acanthuridae) were the largest contributor to total biomass with 6.3 kg 100 m⁻². Anthias (Anthiniidae) and sharks (Carcharhinidae) were also abundant, each with a biomass of ~4.0 kg 100 m⁻² (Table B.4.1.1).

Overall observations

A total of 183 fish species were observed during the survey period by all divers. The average total fish biomass at the sites in Jarvis during the survey period was 2.7 ton ha⁻¹

for the nSPC surveys (Table B.4.1.2), and the average fish biomass was 2.54 ton ha⁻¹ for the belt transect surveys (Table B.4.1.1).

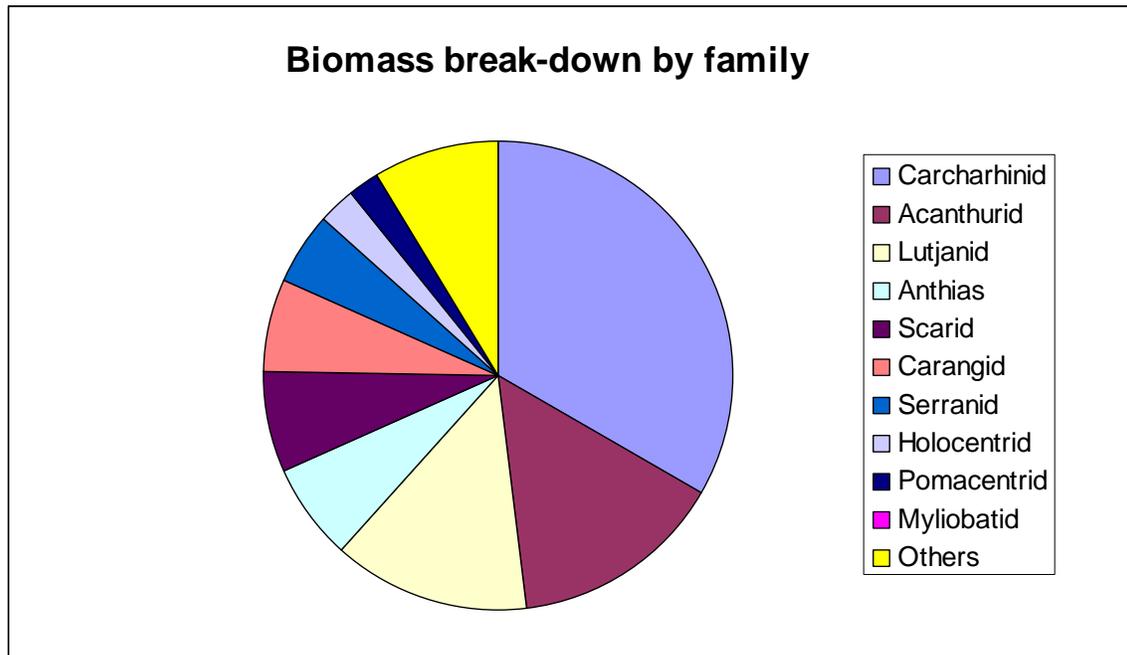


Figure B.4.1.1.--Total fish biomass composition by family, measured by nSPC.

Table B.4.1.1.--Coral reef fish biomass (kg 100m⁻²) at sites around Jarvis Island as measured by belt transects.													
Stratum-Depth	Site	Total	Acanth.	Anthias	Carangid	Shark	Holocentrid	Lutjanid	Myliobatid	Pomacent.	Scarid	Serranid	Others
Forereef – Deep	JAR-51	87.8	1.47	0.89	0.21	15.88	1.63	3.60	0.00	0.43	1.58	2.31	59.77
	JAR-52	56.4	1.88	11.42	1.43	28.25	2.28	5.37	0.00	0.06	2.94	1.88	0.88
	JAR-53	27.4	0.72	8.81	0.27	0.00	10.45	1.97	0.00	0.07	2.04	2.01	1.02
	JAR-56	23.3	1.49	2.40	1.19	12.50	0.08	2.79	0.00	0.18	0.00	1.85	0.79
	JAR-58	86.4	77.14	4.34	0.67	0.00	0.36	0.14	0.00	0.18	0.94	1.63	1.02
	JAR-60	12.9	2.14	5.96	0.00	0.00	0.00	0.14	1.37	0.00	1.16	0.65	1.15
Forereef – Mid	JAR-01	16.7	4.35	0.09	0.00	6.30	0.58	1.24	0.00	0.31	1.39	0.21	2.21
	JAR-02	22.1	3.19	8.41	0.89	0.00	1.32	1.34	0.00	1.96	1.53	0.96	2.50
	JAR-03	14.8	2.18	5.51	0.00	0.00	2.16	0.22	0.00	1.00	1.36	0.73	1.68
	JAR-04	35.1	9.26	2.32	0.55	0.00	0.14	0.37	0.00	2.47	3.12	0.38	16.52
	JAR-07	22.6	1.74	7.22	0.95	2.99	2.08	1.42	0.00	2.28	0.34	2.21	1.40
	JAR-08	24.9	3.79	0.52	0.49	12.61	0.00	0.67	0.00	0.46	2.27	0.82	3.28
	JAR-09	10.1	2.52	4.18	0.00	0.00	0.00	0.12	0.00	1.13	0.89	0.36	0.90
	JAR-10	18.9	2.06	5.08	0.38	0.00	1.62	3.43	0.00	0.62	3.68	0.39	1.59
	JAR-11	30.9	8.29	7.86	4.46	0.00	0.75	0.25	0.00	4.01	0.67	1.63	2.94
	JAR-50	8.8	3.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	1.68	0.58
Forereef – Shallow	JAR-50	3.5	0.38	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	1.95
	JAR-54	6.0	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.57	2.00	0.05	1.13
	JAR-55	6.9	1.49	0.00	0.64	0.00	0.00	0.13	0.00	0.47	2.79	0.36	1.03
	JAR-57	12.6	1.16	0.60	0.00	8.51	0.00	1.13	0.00	0.24	0.41	0.02	0.48
	JAR-59	5.0	1.10	0.00	0.00	0.00	0.00	0.24	0.00	0.99	1.25	0.00	1.48
Average		25.4	6.3	3.6	0.6	4.1	1.1	1.2	0.0	1.0	1.5	0.9	5.0

Table B.4.1.2.--Coral reef fish biomass (kg 100m⁻²) at sites around Jarvis Island as measured by nSPC.

Stratum-Depth	Site	Total	Acanthurid	Anthias	Carangid	Shark	Holocent.	Lutjanid	Myliobatid	Pomacent.	Scarid	Serranid	Others
Forereef - Deep	JAR-51	14.6	3.11	1.33	0.31	0.00	0.23	3.70	0.00	0.73	1.66	2.98	0.50
	JAR-52	60.8	0.91	7.32	2.53	16.72	1.46	8.58	0.00	0.22	1.98	5.35	15.71
	JAR-53	21.4	0.55	2.25	2.98	7.38	4.37	0.86	0.00	0.04	0.67	1.67	0.65
	JAR-56	18.9	2.61	2.84	2.89	4.42	0.03	1.34	0.00	0.07	1.16	3.02	0.54
	JAR-58	91.0	36.05	2.17	3.37	35.90	0.29	8.78	0.00	0.07	0.63	2.20	1.59
	JAR-60	16.1	5.16	2.22	4.60	0.00	0.25	0.08	0.00	0.18	1.34	1.47	0.78
Forereef - Mid	JAR-01	22.2	1.98	0.51	0.53	13.10	0.66	0.56	0.00	0.94	1.23	0.61	2.13
	JAR-02	15.9	2.13	2.84	3.19	0.00	1.28	2.25	0.00	0.84	0.98	1.11	1.26
	JAR-03	15.7	1.54	3.19	0.27	3.56	0.19	0.44	0.00	0.38	2.50	1.76	1.86
	JAR-04	27.9	2.68	2.78	0.60	11.68	0.05	2.38	0.00	1.09	2.34	0.95	3.32
	JAR-07	29.5	1.46	3.10	3.62	16.74	0.58	0.13	0.00	0.43	0.49	1.63	1.35
	JAR-08	25.8	1.81	1.08	1.13	17.51	0.08	0.36	0.00	0.65	2.03	0.22	0.94
	JAR-09	9.8	1.43	2.76	0.79	0.00	0.26	0.74	0.00	0.70	0.98	1.21	0.94
	JAR-10	15.4	1.06	1.38	0.41	0.00	2.88	3.71	0.00	0.30	2.56	0.99	2.12
	JAR-50	74.4	6.84	0.08	3.20	29.87	0.00	24.58	0.00	1.77	1.95	0.69	5.41
Forereef - Shallow	JAR-50	45.4	4.78	0.00	3.83	17.95	0.00	6.44	0.00	1.16	9.05	0.07	2.16
	JAR-54	6.8	1.90	0.00	0.00	0.00	0.00	0.82	0.00	0.57	1.88	0.20	1.38
	JAR-55	13.7	1.93	0.00	0.30	4.56	0.55	1.47	0.00	0.63	2.47	0.60	1.23
	JAR-57	8.0	1.31	0.90	0.00	0.00	0.00	4.67	0.00	0.23	0.00	0.32	0.58
	JAR-59	6.2	1.16	0.00	0.00	0.00	1.21	0.69	0.00	0.52	0.57	0.16	1.88
Average		27.0	4.0	1.8	1.7	9.0	0.7	3.6	0.0	0.6	1.8	1.4	2.3

B.4.2 Towed-diver Fish Surveys

During the 2008 RAMP mission, the CRED Towboard team completed 18 surveys at Jarvis Island covering 43 km (43 ha) of ocean floor (Table B.4.2.1). Mean survey length was 2.4 km with a maximum length of 3.4 km and a minimum of 1.6 km. Mean survey depth was 14.6 m with a maximum depth of 23.4 m and a minimum of 7.5 m. Mean temperature on these surveys was 24.6 °C with a maximum temperature of 24.9 °C and a minimum of 24.3 °C making Jarvis the coldest of the three areas surveyed during this leg of the cruise.

Table B.4.2.1.--Survey statistics for towboard sampling during HI0803.

Island	#	Length (km)					Depth (m)				Temperature (°C)			
		Sum	Mean	Max	Min	SD	Mean	Max	Min	SD	Mean	Max	Min	SD
Jarvis	18	43	2.4	3.4	1.6	0.5	14.6	23.4	7.5	3.9	24.6	24.9	24.3	0.2
Palmyra	24	61	2.5	3.1	1.9	0.3	14.4	20.7	5.2	2.9	26.6	26.8	26.4	0.1
Kingman	21	54	2.6	2.9	2	0.3	14.2	18.7	2.1	4.3	26.8	27.1	26.7	0.1

During surveys at Jarvis, 26 species of fish greater than 50 cm total length (> 50 cm TL) were observed. Overall numeric density for the island was 50.28 individuals per hectare. Overall biomass was 0.34 T/Ha. The five most common species in decreasing order of abundance were: *Caranx sexfasciatus*, *Sphyraena qenie*, *Carcharhinus amblyrhynchos*, *Naso hexacanthus*, and *Lutjanus bohar* (Table B.4.2.2). In terms of biomass, the five greatest contributors were: *Sphyrna lewini*, *Carcharhinus amblyrhynchos*, *Caranx sexfasciatus*, *Manta birostris*, and *Sphyraena qenie* (Table B.4.2.3).

Table B.4.2.2.--All species of fishes > 50 cm TL encountered at Jarvis Island in decreasing order of abundance.

Species	Total (#)	Density (#/Ha)
<i>Caranx sexfasciatus</i>	539	12.53
<i>Sphyraena qenie</i>	400	9.30
<i>Carcharhinus amblyrhynchos</i>	292	6.79
<i>Naso hexacanthus</i>	243	5.65
<i>Lutjanus bohar</i>	237	5.51
<i>Caranx lugubris</i>	108	2.51
<i>Triaenodon obesus</i>	64	1.49
<i>Scarus rubroviolaceus</i>	57	1.33
<i>Chanos chanos</i>	42	0.98
<i>Caranx melampygus</i>	35	0.81
<i>Variola louti</i>	26	0.60
<i>Carcharhinus melanopterus</i>	24	0.56
<i>Sphyrna lewini</i>	23	0.53
<i>Elagatis bipinnulata</i>	20	0.47
<i>Naso brevirostris</i>	17	0.40
<i>Carangoides orthogrammus</i>	9	0.21
<i>Sphyraena helleri</i>	7	0.16
<i>Taeniura meyeri</i>	4	0.09

Species	Total (#)	Density (#/Ha)
<i>Manta birostris</i>	4	0.09
<i>Chlorurus microrhinos</i>	3	0.07
<i>Fistularia commersonii</i>	2	0.05
<i>Pseudobalistes flavimarginatus</i>	2	0.05
<i>Acanthocybium solandri</i>	1	0.02
<i>Gymnosarda unicolor</i>	1	0.02
<i>Cheilinus undulatus</i>	1	0.02
<i>Tylosurus crocodilus</i>	1	0.02
Jarvis Total	2162	50.28

Table B.4.2.3.--All species of fishes > 50cmTL encountered at Jarvis Island in decreasing order of biomass.

Species	Total (T)	Density (T/ha)
<i>Sphyrna lewini</i>	3.648	0.08
<i>Carcharhinus amblyrhynchos</i>	2.524	0.06
<i>Caranx sexfasciatus</i>	1.629	0.04
<i>Manta birostris</i>	1.398	0.03
<i>Sphyrna genie</i>	1.348	0.03
<i>Chanos chanos</i>	1.195	0.03
<i>Lutjanus bohar</i>	0.634	0.01
<i>Triaenodon obesus</i>	0.565	0.01
<i>Naso hexacanthus</i>	0.515	0.01
<i>Caranx lugubris</i>	0.286	0.01
<i>Carcharhinus melanopterus</i>	0.156	0.00
<i>Scarus rubroviolaceus</i>	0.148	0.00
<i>Taeniura meyeri</i>	0.090	0.00
<i>Caranx melampygus</i>	0.084	0.00
<i>Naso brevirostris</i>	0.059	0.00
<i>Variola louti</i>	0.054	0.00
<i>Cheilinus undulatus</i>	0.021	0.00
<i>Carangoides orthogrammus</i>	0.019	0.00
<i>Gymnosarda unicolor</i>	0.014	0.00
<i>Chlorurus microrhinos</i>	0.008	0.00
<i>Pseudobalistes flavimarginatus</i>	0.007	0.00
<i>Acanthocybium solandri</i>	0.006	0.00
<i>Sphyrna helleri</i>	0.005	0.00
<i>Elagatis bipinnulata</i>	0.003	0.00
<i>Tylosurus crocodilus</i>	0.001	0.00
<i>Fistularia commersonii</i>	0.001	0.00
Jarvis Total	14.418	0.34

A large school of *Sphyrna genie* was encountered off the northeastern corner of Jarvis Island (Fig. B.4.2.1). Elsewhere, numeric distribution of fishes was generally uniform with slightly higher levels in the southwestern, southern, and eastern areas. In the southwest *Naso hexacanthus*, *Caranx lugubris*, and *Elagatis bipinnulata* were found in

high numbers while *Carcharhinus amblyrhynchos*, *Lutjanus bohar*, and *Caranx lugubris* dominated in the southeast. Along the southern coast, *Naso hexacanthus* and *Chanos chanos* were well represented.

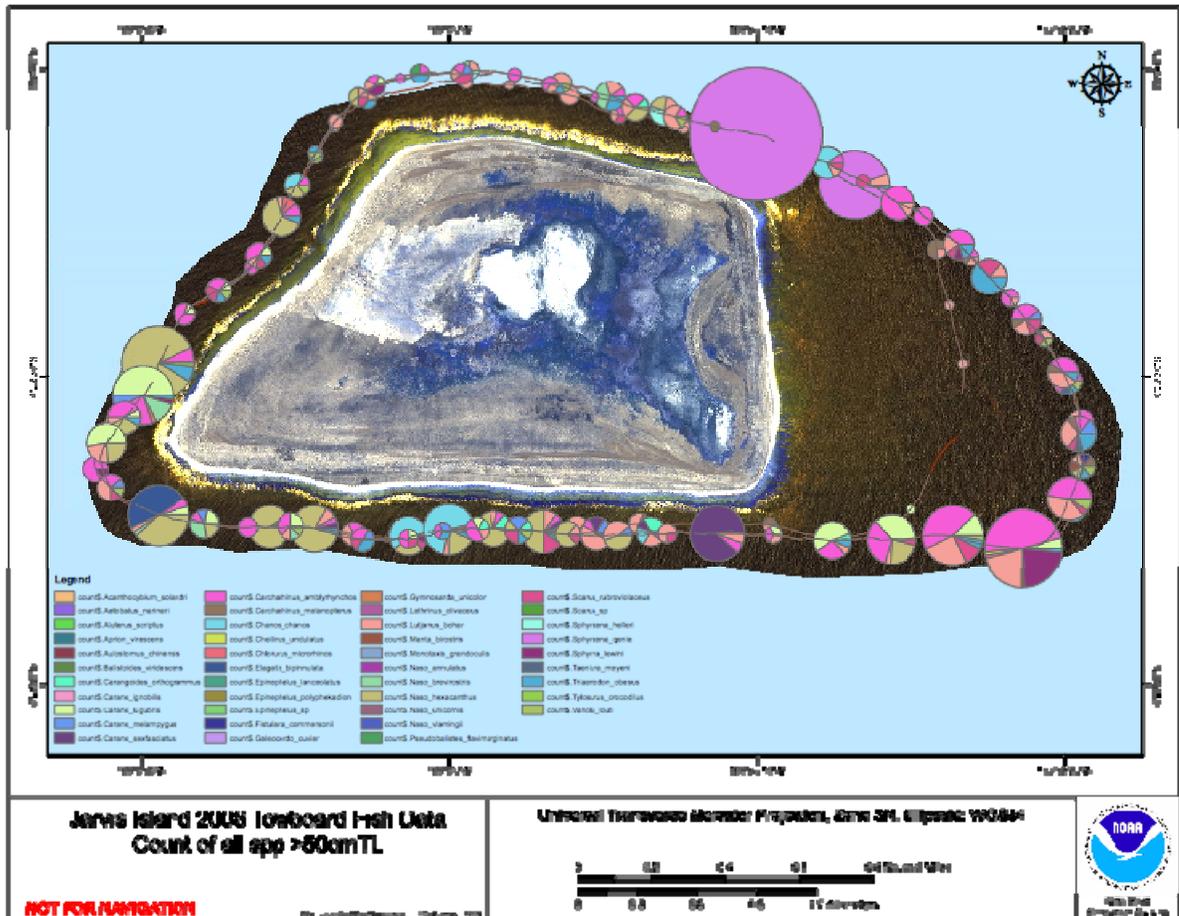


Figure B.4.2.1.--Numeric distribution of all fishes > 50 cm TL around Jarvis Island.

Initial observations suggest that the biomass distribution of fishes around Jarvis is generally uniform with the following exceptions (Fig. B.4.2.2). The highest biomass levels were found at the southeastern tip of the eastern shelf and primarily resulted from the observation of several large *Sphyrna lewini*, *Carcharhinus amblyrhynchos*, and *Manta birostris*. High biomass levels found near the middle of the southern coast of the island and were due to contributions from *Chanos chanos* and *Sphyrna lewini*. High biomass levels near the northwestern and northeastern tips of Jarvis were due to contributions from *Sphyrna lewini* and *Sphyrna genie*. High biomass levels near the southwestern tip of the island resulted from a more diverse species assemblage including *Sphyrna lewini*, *Carcharhinus amblyrhynchos*, *Caranx lugubris*, and *Naso hexacanthus*.

Appendix C: Palmyra Atoll

C.1. Oceanography and Water Quality

Moorings (Fig. C.1.1, Table C.1.1):

A total of 10 subsurface temperature recorders (STRs), 1 Coral Reef Early Warning System (CREWS) buoy, 1 sea surface temperature (SST) buoy, and 12 coral recruitment settlement plates were recovered at Palmyra Atoll during HI0803. Fourteen STRs were deployed, two new STR depth transects were added to the far east and far west sides of the atoll at ~ 20 m and 30 m, and one CREWS buoy was deployed. The SST buoy deployed during HI0604 that broke free of its mooring line was recovered and the deployment site was relocated to the eastern portion of the atoll just north of the “Coral Gardens.” A new ecological acoustic recorder (EAR), collocated with an STR, was deployed on the forereef outside the main channel to Palmyra Lagoon.

Preliminary Mooring Results

Eight out of the 10 STRs recovered from Palmyra Atoll yielded quality data sets (Fig. C.1.2); the housing of the remaining two STRs were cracked and caused the units to flood. The SST buoy, which broke free of its mooring, collected data in the East Lagoon until May of 2007. The CREWS buoy temperature and salinity sensor recorded data until its collection on April 1, 2008.

Between March 2006 and April 2008, water temperatures inside Palmyra’s Atoll fluctuated with typical seasonal variability for these latitudes with lows occurring during January–March (~ 27 °C) and highs between September–November (~ 32 °C). Temperatures in 2008 appear to be approximately 1 °C cooler than in 2007, likely due to the La Niña event. Large diurnal fluctuations are seen inside the lagoon near the CREWS buoy site suggesting daily heating and cooling with little mixing from oceanic waters. Surface temperatures at the CREWS site regularly reach 34 °C. A temperature depth transect deployed in the East Lagoon in 2006 shows typical diurnal heating and cooling on the surface, with very little variability seen as depth increases. This suggests that the water in the East Lagoon at depths below the first few meters is poorly mixed with high residents’ time. Temperatures in the “Coral Gardens” on the east side of the atoll varied with typical diurnal variability for shallow depths with daily highs reaching ~ 33 °C on a regular basis. Temperatures on the south shore forereef show a well mixed system with typical seasonal variability. Cold spikes experienced on the forereef in late 2007 hints at a shallower than normal thermocline associated with the La Niña.

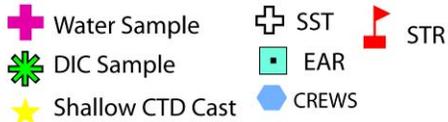


Figure C.1.1.--Moored Oceanographic instrumentation, shallow water conductivity-temperature-depth (CTD), water sampling, and dissolved inorganic carbon (DIC) sample locations around Palmyra Atoll.

Table C.1.1.--Moored Oceanographic Instrumentation Table for Palmyra.

Instrument	Serial Number	Latitude	Longitude	Depth (m)	Data Start	Data End
CREWS	279-001	5 53.0777 N	163 6.1736 W	9.14	3/26/2006 12:59	4/1/2008 20:59
SST	10017320	5 52.9654 N	162 3.7089 W	4.27	3/24/2006	5/14/2007 21:00
STR	3939038-3009	5 51.8504 N	162 7.6158 W	15.24	CRACKED HOUSING	
STR	3939038-1722	5 52.9654 N	162 3.7089 W	24.99	3/24/2006 22:44	2/27/2008 15:14
STR	3939038-1850	5 52.9654 N	162 3.7089 W	15.85	3/23/2006 22:25	1/8/2008 2:26
STR	3939038-3049	5 52.9654 N	162 3.7089 W	4.27	3/23/2006 21:46	3/30/2008 12:16
STR	3939038-3002	5 53.0777 N	163 6.1736 W	9.14	3/25/2006 23:12	4/1/2008 21:12
STR	3932718-1068	5 53.0777 N	163 6.1736 W	0.91	3/26/2006 0:00	10/17/2007 12:30
STR	3939038-1819	5 51.8529 N	162 1.8394 W	10.97	3/25/2006 23:20	3/2/2008 22:50
STR	3939038-1724	5 52.2183 N	162 2.7026 W	1.52	3/25/2006 23:58	6/18/2007 15:58
STR	3939038-1851	5 53.1732 N	162 5.1535 W	3.35	3/24/2006 1:46	11/15/2007 18:16
STR	3939038-3055	5 52.9456 N	162 7.2777 W	3.96	CRACKED HOUSING	
CREWS	261-003	5 53.0777 N	163 6.1736 W	9.14	LOGGING DATA	
EAR	38	5 51.8504 N	162 7.6158 W	15.24	LOGGING DATA	
SST	919GC	5 52.4699 N	162 2.4264 W	5.18	LOGGING DATA	
STR	3929252-0900	5 51.8504 N	162 7.6158 W	15.24	LOGGING DATA	
STR	3948689-4038	5 53.0492 N	162 10.1465 W	32.92	LOGGING DATA	
STR	3947493-3545	5 53.0259 N	162 10.1155 W	19.51	LOGGING DATA	
STR	3929252-0903	5 52.9654 N	162 3.7089 W	4.27	LOGGING DATA	
STR	3948689-4030	5 52.9212 N	162 3.7413 W	24.99	LOGGING DATA	
STR	3924022-0355	5 53.0777 N	163 6.1736 W	9.14	LOGGING DATA	
STR	3929252-0902	5 53.0777 N	163 6.1736 W	0.91	LOGGING DATA	
STR	3948689-4033	5 51.8529 N	162 1.8394 W	10.97	LOGGING DATA	
STR	3947493-3491	5 52.2183 N	162 2.7026 W	1.52	LOGGING DATA	
STR	3924022-0356	5 52.4699 N	162 2.4264 W	5.18	LOGGING DATA	
STR	3948689-4043	5 52.5819 N	162 0.1235 W	32.61	LOGGING DATA	
STR	3948689-4036	5 52.5667 N	162 0.1421 W	18.59	LOGGING DATA	
STR	3947943-3537	5 53.1732 N	162 5.1535 W	3.35	LOGGING DATA	
STR	3947493-3493	5 52.9456 N	162 7.2777 W	3.96	LOGGING DATA	

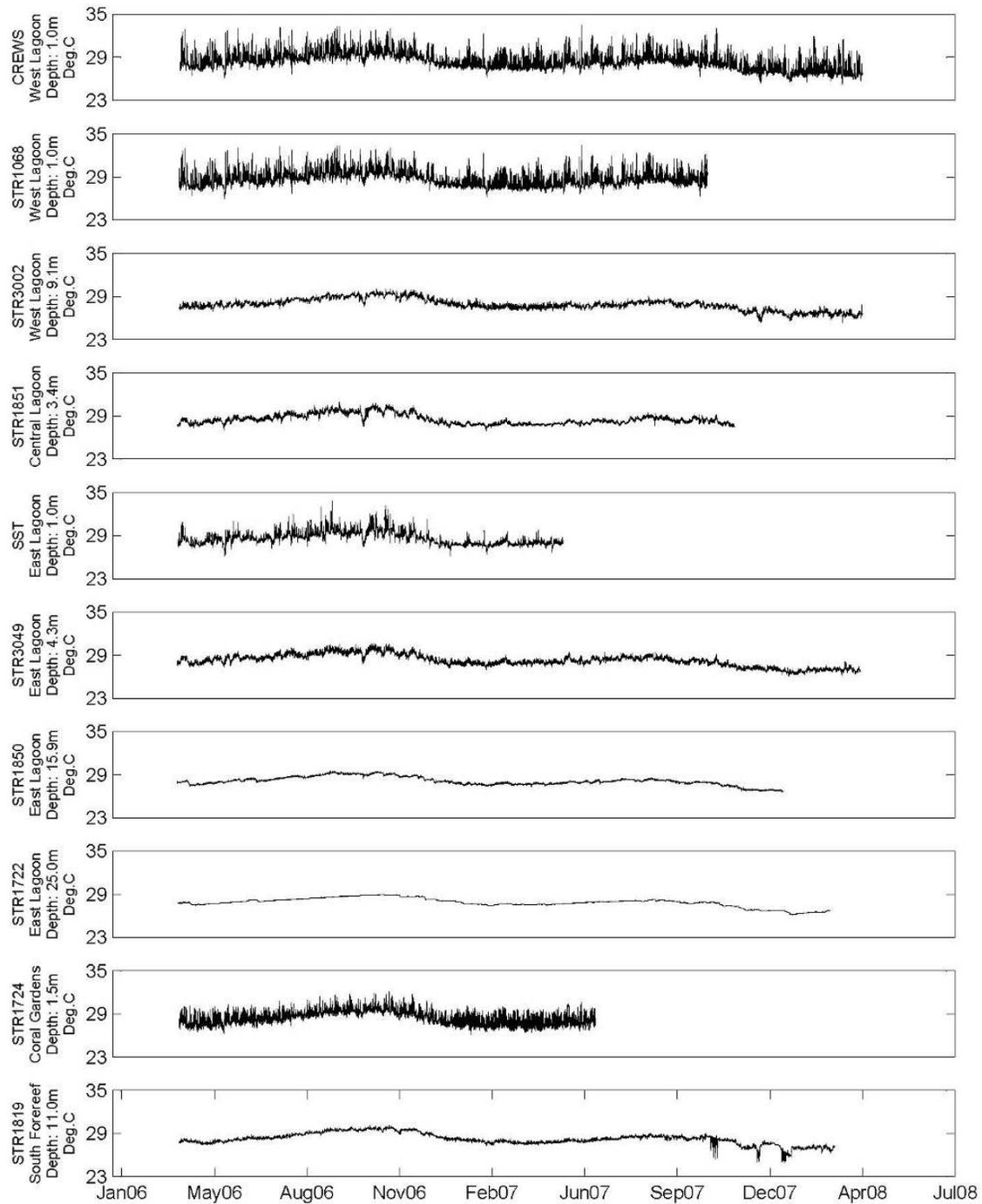


Figure C.1.2.--Temperature data obtained from eight STRs, one CREWS buoy, and one SST from locations around Palmyra Atoll.

Water Quality

Twenty-two shallow water CTDs were conducted at the 30-m bathymetric contour around Palmyra Atoll at 2-km intervals (Fig. C.1.3). Shallow water CTD casts around the atoll were conducted on March 30, 2008 (Local Time). Four additional CTD casts were conducted as a transect was set through the lagoon on April 4, 2008 (Local Time). Discrete water samples from a daisy chain of Niskin bottles at 1-m, 10-m, 20-m, and 30-m depth bins were collected concurrently with shallow water CTD casts at eight of the shallow water CTD sites. A total of 32 NUT and 32 CHL samples were collected, processed, and stored according to protocol and will be sent out for analysis following the cruise.

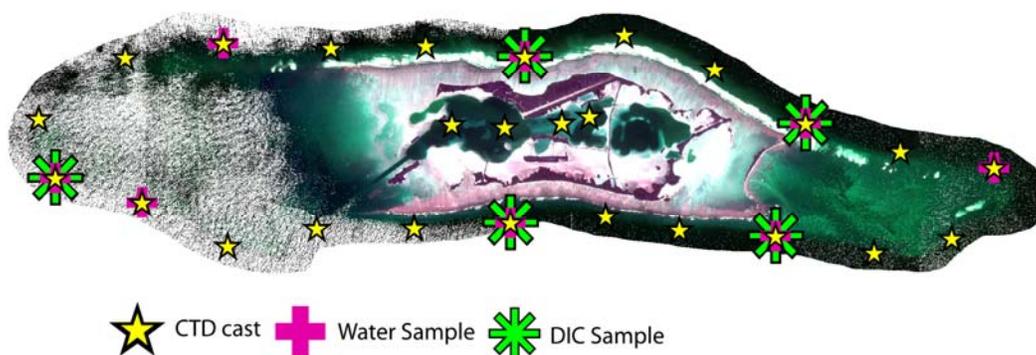


Figure C.1.3.--Shallow water CTD, water sampling and carbonate chemistry locations around Palmyra Atoll.

In addition to the standard set of shallow-water water quality sampling, a set of near-shore carbonate chemistry samples were collected as part of the water sampling cast at five areas around Palmyra Atoll. While Palmyra Atoll was not included as part of the original carbonate chemistry sampling plan, a surplus of sample bottles remained from HI0801 and HI0802 legs, six samples were allocated to investigating the diurnal variations in carbonate chemistry within the Coral Garden. The Coral Garden, located on the eastern side of Palmyra Atoll, is semi-confined during low tide versus relatively well flushed during high tide. As a result, it is anticipated that broad ranges in aragonite saturation state might transpire across tidal periods. A set of three near-bottom (< 200 cm) carbonate chemistry (alkalinity and total dissolved inorganic carbon) water samples were hand collected for from within the Coral Garden near high tide on April 2. A Seabird 19+ CTD with an SBE43 dissolved oxygen sensor was deployed concurrently with the water collections along with a salinity sample to aid in the calibration of the CTD 19+. The three sites were then revisited near low tide on April 3 and the sampling, CTD, and dissolved oxygen measurement repeated. All carbonate chemistry samples were immediately treated with saturated mercuric chloride and sealed in 500 cm³ high quality borosilicate glass bottles equipped with positive closure according to the protocols of Dickson et al. (2007).

Eleven standard shipboard CTD casts were conducted between March 31 and April 4, 2008 Universal Time Coordinated (UTC) near Palmyra Atoll (Fig. C.1.5). Shipboard CTD casts were conducted to 300 m and in two zonal transects; one transect to the east and one to the west of the atoll. The west transect casts were performed ~ 5 km from each other, while the east transect spacing was ~ 10 km. Only one carbonate chemistry and salinity shipboard water sample was collected at 3 m and 80 m at the easternmost CTD site. Additionally, acoustic Doppler current profiler (ADCP) lines were run between the shipboard CTD casts.



Figure C.1.5.--Shipboard CTD locations around Kingman Atoll during HI0803.

C.2. Rapid Ecological Assessment (REA) Site Descriptions

Twenty eight REA (Rapid Ecological Assessment) sites were visited by a team of up to eight scientists around Palmyra Island between March 30 and April 3, 2008. Fourteen of those sites were only surveyed by the fish scientists in additional depth ranges. The site locations are listed in Figure C.2.1, and survey dates and efforts in Table C.2.1 (benthic surveys) and Table C.2.2 (fish surveys). Individual site descriptions are included for the following discipline communities: coral, coral and coralline disease, macroinvertebrates, algae, and fish.

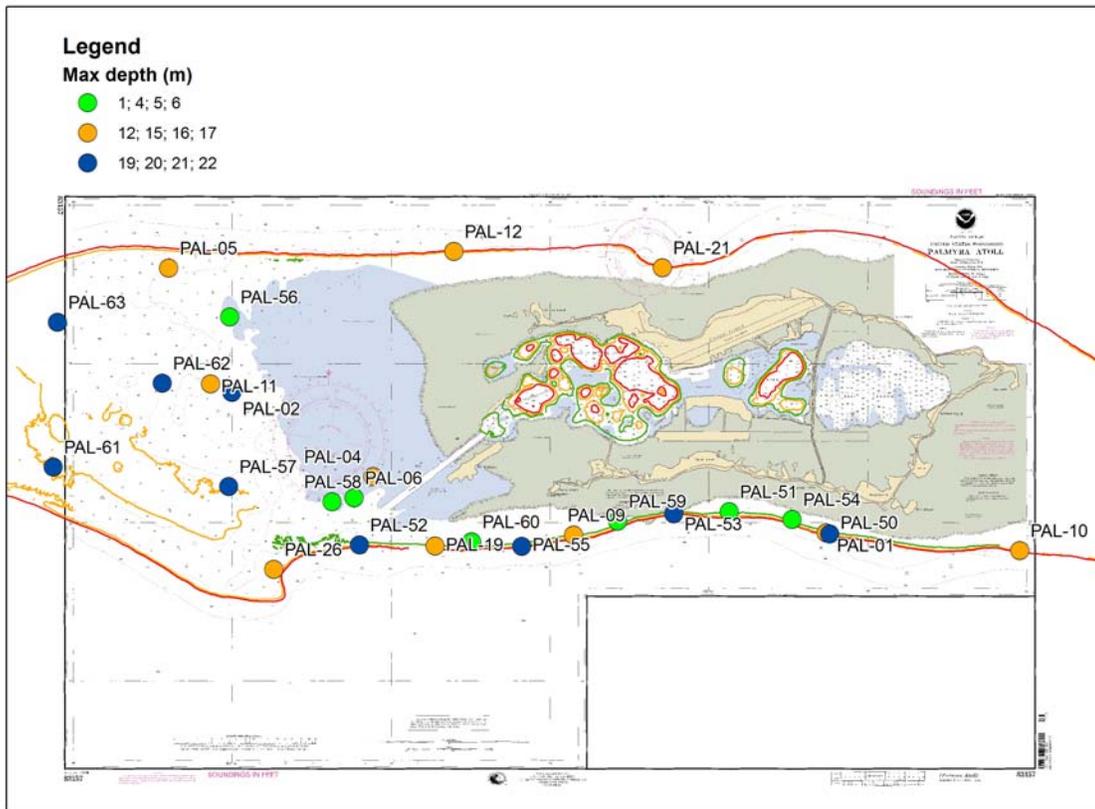


Figure C.2.1.--Palmyra Island 2008 REA site locations.

Table C.2.1.--Palmyra Island 2008 benthic REA site survey dates, teams present, and additional comments.

Site ID	Date	Teams Present	Comments
PAL-26	3/30/2008	Coral, Disease, Algae, Invertebrate	
PAL-01	3/30/2008	Coral, Disease, Algae, Invertebrate	* ARMS
PAL-16	3/30/2008	Coral, Disease, Algae, Invertebrate	
PAL-11	3/31/2008	Coral, Disease, Algae, Invertebrate	
PAL-19	3/31/2008	Coral, Disease, Algae, Invertebrate	
PAL-17	3/31/2008	Coral, Disease, Algae	ARMS deployment, no invertebrate survey
PAL-05	4/1/2008	Coral, Disease, Algae, Invertebrate	
PAL-21	4/1/2008	Coral, Disease, Algae, Invertebrate	
PAL-12	4/1/2008	Coral, Disease, Algae, Invertebrate	
PAL-10	4/2/2008	Coral, Disease, Algae, Invertebrate	
PAL-06	4/2/2008	Coral, Disease, Algae, Invertebrate	
PAL-09	4/2/2008	Coral, Disease, Algae, Invertebrate	
PAL-02	4/3/2008	Coral, Disease, Algae, Invertebrate	
PAL-04	4/3/2008	Coral, Disease, Algae, Invertebrate	

*Autonomous Reef Monitoring Systems

Table C.2.2.--Palmyra Island fish survey sites 2008. At each site two 25 m x 4 m belt transects (BLT) and two 7.5-m radius circular plot point counts (nSPC's) were performed unless otherwise noted.

Site	Date	Depth (m)	Strata	Divers/Reps
PAL-01	03/30/2008	12	Forereef Mid	
PAL-02	04/03/2008	12	Forereef Mid	1 nSPC
PAL-04	04/03/2008	4	Forereef Shallow	
PAL-05	04/01/2008	13	Forereef Mid	
PAL-06	04/02/2008	6	Forereef Shallow	
PAL-09	04/02/2008	11	Forereef Mid	1 nSPC
PAL-10	04/02/2008	12	Forereef Mid	1 nSPC
PAL-11	03/31/2008	13	Forereef Mid	
PAL-12	04/01/2008	13	Forereef Mid	
PAL-16	03/30/2008	3	Forereef Shallow	
PAL-17	03/31/2008	20	Forereef Deep	
PAL-19	03/31/2008	13	Forereef Mid	
PAL-21	04/01/2008	13	Forereef Mid	
PAL-26	03/30/2008	14	Forereef Mid	
PAL-50	03/30/2008	21	Forereef Deep	1 REP
PAL-51	03/30/2008	5	Forereef Shallow	1 BLT
PAL-52	03/30/2008	21	Forereef Deep	1 REP
PAL-53	03/31/2008	21	Forereef Deep	1 REP
PAL-54	03/31/2008	4	Forereef Shallow	1BLT
PAL-55	03/31/2008	21	Forereef Deep	1 REP
PAL-56	04/01/2008	4	Forereef Shallow	
PAL-57	04/01/2008	20	Forereef Deep	1 nSPC
PAL-58	04/01/2008	4	Forereef Shallow	
PAL-59	04/02/2008	4	Forereef Shallow	
PAL-60	04/02/2008	4	Forereef Shallow	
PAL-61	04/02/2008	22	Forereef Deep	1 nSPC
PAL-62	04/03/2008	21	Forereef Deep	1 nSPC
PAL-63	04/03/2008	21	Forereef Deep	1 nSPC

Site Descriptions:

March 30, 2008

PAL-01

N 5 ° 86.802, *W* 162 ° 06.928

Depth range: 8.0–10.6 m

This southern site was characterized by stabilized staghorn and table coral rubble. LPI data found live coral cover to be 11.7%, mainly composed of platy *Pocillopora meandrina*, and a few colonies of *Montipora*, *Favia*, and *Montastrea*. Percent coralline algal cover represented over 30% and macroalgae nearly 25% (mainly *Halimeda*). Turf

algae-covered rubble and pavement accounted for ~ 20% of the benthic cover. Dominated by *Halimeda opuntia*, turf and crustose coralline red algae. Coral disease and health assessment studies found two cases of bleaching on *Montipora* sp. and *Hydnophora microconnos*, two cases of barnacle infestation on *Hydnophora microconnos* and *Leptastrea* sp., one case of skeletal growth anomaly on *Pocillopora meandrina*, one case of white syndrome on *Montipora* sp., and eight cases of coralline fungal disease in a ~ 200 m² survey area. The only abundant mobile macroinvertebrates were the hermit crab, *Calcinus haigae* and the trapezid crab, *Trapezia flavopunctata*. As with previous years, two green didemnid tunicate species (cf. *Diplosoma*) covered a majority of the coral rubble. The hydrozoan *Styaster* was present but was not abundant. Fish species diversity was high at this site, with no species in particular standing out as being most numerous. Small, mid-water schooling labrids were observed, with moderate numbers of *Thalassoma amblycephalum* and *Cirrhilabrus exquisitus* juveniles recorded. Additionally, *Carcharhinus melanopterus* was recorded on-transect.

PAL-26

N 5 ° 86.391 , *W* 162 ° 12.719

Depth range: 14.3–15 m

This southwestern site line point intercept (LPI) data found live coral cover to be 60%. The diverse community was mainly composed of *Porites lobata*, *Porites* cf. *lutea*, *Pocillopora* spp., and *Favia* spp. Percent coralline algal cover represented over 20% and macroalgae nearly 7% (mainly *Halimeda*). Turf-algae covered rubble and pavement accounted for ~ 10% of the benthic cover. Dominated by turf and crustose coralline red algae with a low percent cover of *Halimeda opuntia* and *Halimeda taenicola*. Coral disease and health assessment studies found 12 cases of barnacle infestation on *Porites* and *Montipora*, 1 case of skeletal growth anomaly on *Porites*, 1 case of tissue loss on *Porites*, 1 case of pink line/spot syndrome on *Porites*, 1 case of necrosis on the alcyonarian *Lobophytum*, and 3 cases coralline fungal disease in a ~ 90 m² survey area. The dominant sessile macroinvertebrates were the hydrozoans, *Styaster* and *Distichopora* and the hydroids, *Aglaophenia* and *Gymangium*. Additional sessile fauna was a large anemone from the genus *Heteractis* and a rust brown colored sponge. The ophiasterid sea star, *Fromia milleporella* was noted as common at this site. Fish species diversity seemed high at this site. Small pomacentrids were numerous, with *Chromis vanderbilti*, *C. margaritifer*, and *C. xanthura* recorded in fairly large numbers. Of note was one off-transect sighting of *Cheilinus undulatus*.

PAL-16

N 5 ° 87.177, *W* 162 ° 11.234

Depth range: 3–4 m

This was a southern lagoonal site. LPI data found live coral cover to be 5%; mainly composed of *Montipora* spp. and *Pocillopora damicornis*. Percent coralline algal cover represented over 10% and macroalgae nearly 55% (mainly *Halimeda*). Turf algae-covered rubble and pavement accounted for ~ 25% of the benthic cover. Dominated by *Lobophora variegata*, turf and crustose coralline red algae. Coral disease and health assessment studies found no diseases in a 300 m² survey area adjacent to transects. However, a roving swim along an approximate area of 200 m² indicated the presence of

one case of white syndrome on *Montipora*; two cases of skeletal growth anomalies on *Montipora* and *Porites*, respectively; and one case of pink line/spot syndrome on *Porites lobata*. This site is recovering from a bleaching event and has had few sessile or mobile macroinvertebrates recorded historically. The common sessile macroinvertebrate was the corallimorpharian *Rhodactis howseii*, which has never been recorded at this station in the past. The giant clam *Tridacna maxima* was present but rare. The only mobile macroinvertebrates recorded were the cowrie *Cypraea moneta* and the facelinid nudibranch *Pteraeolidia ianthina*, the sea stars *Linckia multifora* and *Ophidiaster* sp. and the holothuroid *Bohadschia argus*. Fish species diversity was low at this site. Acanthurid biomass was high, however, with *Ctenochaetus striatus* being very numerous. The parrot *Chlorurus sordidus* was abundant in its initial phase as well. Noticeable was the absence of small pomacentrids.

PAL-50

N 6 ° 52.061, W 162 ° 4.113

Depth range: ~ 21 m

This site is located on the southeast corner of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had medium coral cover with medium reef complexity. The substrate at this site was dominated by *Halimeda* algae. *Chromis margaritifer* was the most abundant fish present, followed by *Pseudanthias bartlettorum* and *P. olivaceous*. Various species of larger fish seen, including *Carcharhinus melanopterus*, *Lutjanus bohar*, *Naso hexacanthus*, *Acanthurus xanthopterus*, and *Chlorurus sordidus*. Off transect, a school of *Elegatis bipinulatus* was observed, and a curious *Caranx ignobilis* visited the divers during their safety stop.

PAL-51

N 6 ° 52.203, W 162 ° 4.745

Depth range: ~ 5 m

This site is located on the southeast side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. This surge site had low coral cover with medium reef complexity, and again, *Halimeda* algae was abundant. The outstanding feature was a very large (~ 800) school of *Acanthurus triostegus* roaming throughout the transect. *Acanthurus nigricans* was fairly common, as was *Thalassoma quinquevittatum*. Several large *Lutjanus bohar* were also seen.

PAL-52

N 6 ° 51.991, W 162 ° 7.075

Depth range: ~ 21 m

This site is located on the southwest side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had medium coral cover with medium reef complexity. Small fish were mostly represented by the damselfish *Chromis margaritifer* as the dominant fish species, but their biomass was far outweighed by several gray reef sharks swimming through the transect.

March 31, 2008

PAL-19

N 5 ° 86.633, *W* 162 ° 10.984

Depth range: 13–16 m

This site was located on the south forereef. LPI data found that live coral cover was 31%, mainly composed of *Porites* spp., *Favia* spp., and *Pocillopora* spp. Percent coralline algal cover represented nearly 30% and macroalgae over 35% (mainly *Halimeda*). Dominated by *Halimeda opuntia*, crustose coralline red algae, and *Dictyosphaeria cavernosa*. Coral disease and health assessment studies found three cases of bleaching on *Hydnophora microconnos*, *Porites*, and *Favites*; one case of skeletal growth anomaly on *Porites lobata*; one case of white syndrome on *Favia stelligera*; four cases of tissue loss on *Porties*; one case of coralline fungal disease; and one case of coralline lethal disease in a ~ 140 m² survey area. The dominant sessile macroinvertebrate was the hydrozoan, *Disticopora*. The soft corals, *Sinularia* and *Sacrophyton*, were common. Trapezid crabs and hermit crabs were common. A green didemnid tunicate was present on dead coral heads. Fish included numerous small pomacentrids, with *Chromis acares* and *C. margaritifera* also recorded in fairly large numbers. The small wrasse *Cirrilabrus exquisitus* was also abundant. Of note was one off-transect sighting of *Cheilinus undulatus*. Also of interest was a large school of hundreds of the parrotfish, *Scarus oviceps*, traveling eastward.

PAL-11

N 5 ° 88.347, *W* 162 ° 13.351

Depth range: 13–17 m

This site was found on the western forereef terrace. LPI data found live coral cover to be 17%, mainly composed of *Porites lobata* and *Pavona duerdeni*. Percent coralline algal cover represented over 51% and macroalgae nearly 12% (mainly *Halimeda* Turf algae-covered rubble and pavement accounted for ~ 7% of the benthic cover. Dominated by crustose coralline red algae, and *Dictyosphaeria cavernosa*. Coral disease and health assessment studies found 1 case of bleaching, *Favia* cf. *speciosa*; 2 cases of tissue loss on *Porites*; 1 case of white syndrome on *Montastrea* cf. *curta*; 1 case of pink line/spot syndrome on *Porites*; 2 cases of coralline lethal disease; and 16 cases of coralline fungal disease in a 120 m² survey area. Non-cryptic macroinvertebrates were low. Trapezid crabs and hermit crabs were common. One *Tridacna maxima* was observed off-transect. A green didemnid tunicate was present on dead coral heads. Small damsels (*Chromis vanderbilti* and *C. margaritifera*) were also the most abundant fish at this site. *Lutjanus bohar* and *Scarus frenatus* were large fish counted, while both blacktip and whitetip reef sharks were seen off transect.

PAL-17

N 5 ° 87.494, *W* 162 ° 13.939

Depth range: 18–20 m

This site was on the western forereef terrace, and only one transect was laid due to depth. LPI data found live coral cover to be 27%, mainly composed of *Porites lobata* and *Pavona varians*, and *Favia stelligera*. Percent coralline algal cover represented over 45% and macroalgae nearly 16% (mainly *Halimeda*). Turf algae-covered rubble and pavement

accounted for ~ 15% of the benthic cover. Dominated by *Halimeda opuntia*, crustose coralline red algae, and *Dictyosphaeria cavernosa*. Coral disease and health assessment studies found one case of skeletal growth anomalies on *Porites*, four cases of tissue loss on *Porites* and *Turbinaria*, one case of discoloration on *Porites*, two cases of coralline lethal disease, and seven cases of coralline fungal disease in a 100 m² survey area. No invert survey was conducted due to lengthy ARMS deployment. Large fish were fairly common at this site, including *Lutjanus bohar*, *Cephalopholis argus*, *Monotaxis grandoculis*, *Gracila albomarginata*, *Chlorurus sordidus*, *C. microrhinos*, *Epinephelus macrospilos*, *E. polyphkadion* and *Aphareus furca*. Blacktip reef shark and the emperor *Lethrinus olivaceus* were other large fish seen off transect.

PAL-53

N 6 ° 52.189, W 162 ° 5.095

Depth range: ~ 21 m

This site is located on the south side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had medium coral cover with medium reef complexity. The substrate at this site was dominated by *Halimeda* algae. Small fish were numerous here, with *P. bartlettorum*, *C. margaritifer*, *C. acares*, and *P. olivaceus* yielding the highest counts. *Lutjanus bohar* was present in great numbers as well. Of note was one on-transect sighting of *Lethrinus xanthocheilus* and *Pseudanthias dispar*.

PAL-54

N 6 ° 52.152, W 162 ° 4.349

Depth range: 4 m

This site is located on the south side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had high coral cover with medium/high reef complexity. This was a beautiful site with healthy, diverse coral. Scarids were plentiful at this site with *S. frenatus*, *S. oviceps*, *S. rubroviolaceus*, *S. spinus*, and *C. sordidus* present. *Chromis vanderbilti* was most numerous, hovering in clouds above the reef. Species diversity appeared high.

PAL-55

N 6 ° 51.983, W 162 ° 6.053

Depth range: ~ 21 m

This site is located on the south side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had medium coral cover with medium reef complexity. Species diversity was high at this site. High numbers of < 10-cm fishes were the defining characteristic here. *Chromis acares*, *Chromis margaritifer*, as well as *Pseudanthias olivaceus*, and *P. bartlettorum* were present in large schools. In terms of larger fish, *Lutjanus bohar* were numerous. Of note was a record of *Pseudanthias dispar* within the survey area.

April 1, 2008

PAL-21

N 5 ° 89.546, W 162 ° 08.648

Depth range: 11.8–15 m

This site was on the northern forereef. LPI data found live coral cover to be 15%, mainly composed of *Pocillopora* and *Porites*. Percent coralline algal cover represented over 38% and macroalgae nearly 24% (mainly *Halimeda*). Turf algae-covered rubble and pavement accounted for ~ 14% of the benthic cover. Dominated by *Halimeda opuntia* and crustose coralline red algae. Coral disease and health assessment studies found one case of tissue loss on *Porites*, three cases of pink line/spot syndrome on *Porites*, two cases of bleaching on *Hydnophora* and *Porites*, one case of necrosis on *Sinularia*, and one case of discoloration on *Porites* in a 200 m² survey area. The holothuroid, *Holothuria atra* and the sea star, *Fromia milleporella* were the only large macroinvertebrate to be recorded. The hydrozoans, *istichopora* and *Stylaster* were abundant in cryptic habitats. The hermit crab, *Calcinus haigae* was very abundant, while *Ciliopagurus* was rare. Soft corals and zoanthid were common, and the most common were the soft corals Sarcophyton, Lobophyton and *Sinularia* and the zoanthid *Palythoa*. Fish included small chromis, comprised of *Chromis margaritifer* and *C. vanderbilti*, which were the most abundant fish seen at this site; *Pseudanthias olivaceus* was also observed in large numbers. *Carcharinus melanopterus* was observed during the nSPC as well as off-transect; other species seen off-transect were *C. amblyrhyncos*, *Sphyaerena barracuda*, and *Cheilinus undulatus*.

PAL-12

N 5 ° 89.699, W 162 ° 10.810

Depth range: 11.8–13.6 m

This site was found on the northwestern side of the forereef. LPI data found live coral cover to be 33%, mainly composed of *Pocillopora* and *Porites*, but also *Favia*, *Favites*, *Pavona*, *Hydnophora*, *Psammocora*, and *Montipora*. Percent coralline algal cover represented over 21% and macroalgae nearly 12% (mainly *Halimeda*). Turf algae-covered rubble and pavement accounted for ~ 15% of the benthic cover. Dominated by *Halimeda opuntia*, *Halimeda taenicola* and crustose coralline red algae with a low percent cover of *Halimeda fragilis*. Coral disease and health assessment studies found three cases of barnacle infestation on *Porites* and *Favia*, one case of bleaching on *Hydnophora*, two cases of skeletal growth anomalies on *Pavona* and *Pocillopora*, two cases of tissue loss on *Porites* and *Pavona*, one case of discoloration on *Porites*, one case of tissue loss/predation on *Turbinaria*, one case of coralline lethal disease, and one case of coralline fungal disease in a 200 m² survey area. The only large echinoderm recorded was the holothuroid *Holothuria atra*. Cryptic brittle stars, mostly *Ophiocoma dentata* and *Ophiocoma erinaceus*, were present under rubble. Soft corals were abundant (Sarcophyton and Lobophyton), as was the hard coral *Pocillopora*. The hermit crab, *Calcinus haigae*, was abundant at the site and there was a single sighting of the octopus, *Octopus cyanea*. The snapper, *Lutjanus bohar*, was common at this site; other large fish observed included *L. gibbus*, *Scarus tricolor*, and *Chlorurus sordidus*. Schools of

Chromis vanderbilti were commonly seen, while *C. margaritifer* was found in smaller but appreciable numbers.

PAL-05

N 5 ° 89.626, W 162 ° 13.787

Depth range: 11.8–13.6 m

This site was located on the northwestern forereef. LPI data found live coral cover to be 10%, mainly composed of *Pocillopora meandrina*; the alcyonarians *Sinularia*, *Sarcophyton*, and *Lobophytum* were abundant. Percent coralline algal cover represented over 21% and macroalgae nearly 2% (mainly *Halimeda*). Turf algae-covered rubble and pavement accounted for ~ 50% of the benthic cover. Dominated by crustose coralline red algae and a low percent cover of *Halimeda fragilis*, *Halimeda taenicola*, and *Caulerpa cupressoides*. Coral disease and health assessment studies found one case of coralline fungal disease in a 200 m² survey area. Dominated by the soft corals *Sarcophyton*, *Lobophyton* and *Dendronephthya* with very little hard corals. Cryptic ophiuroid and sessile fauna, such as colonial tunicates, were the common macroinvertebrates at the site. Fish species diversity was fairly high at this site, and notably, larger fish diversity (> 20 cm). Small pomacentrids, however, were the most numerous. This site exhibited disturbance in the form of surge-driven sand clouds, which obscured fish and created periods of time when fish moved elsewhere.

PAL-56

N 6 ° 53.428, W 162 ° 7.892

Depth range: ~ 4 m

This site is located on the northwest side of Palmyra Atoll, on the western reef shelf. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had low coral cover with low reef complexity. Patches of dead corals were covered with incrusting fleshy green algae. The rest of the dead coral was covered in an orange-colored coralline algae. Few large fish were observed. Most of the small fish were damselfish.

PAL-57

N 6 ° 52.362, W 162 ° 7.899

Depth range: ~ 20 m

This site is located on the west side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had medium coral cover with medium reef complexity. Fish community was healthy with many large fish observed (*Lutjanus bohar*, scarids).

PAL-58

N 6 ° 52.264, W 162 ° 7.246

Depth range: ~ 4 m

This site is located on the west side of Palmyra Atoll, south of the channel. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had low coral cover with low reef complexity. This site did not appear

particularly healthy. Reef fish biomass and diversity seemed low. The visibility was low, potentially because of lagoon outflow.

April 2, 2008

PAL-10

N 5 ° 86.603, W 162 ° 04.842

Depth range: 14–14.6 m

This site was on the southeastern forereef. LPI data found live coral cover to be 27%, mainly composed of *Porites lobata* and *Favia stelligera*; other scleractinian genera present along the LPI included *Pocillopora*, *Hydophora* and *Pavona*. The alcyonarians *Sinularia*, *Sarcophyton*, and *Lobophyton* were also relatively abundant. Percent coralline algal cover represented over 18%, macroalgae nearly 24% (mainly *Halimeda*), and turf-covered rubble and pavement accounted for 10% of the benthic cover. Mixed assemblage of *Halimeda opuntia*, crustose coralline red algae, and *Dictyosphaeria cavernosa*. Coral disease and health assessment studies found two cases of barnacle infestation on *Montipora* and *Leptastrea*, one case of focal bleaching on *Lobophyllia*, two cases of discoloration on *Hydnophora microconnos*, eight cases of tissue loss and discoloration on *Porites*, and three cases of coralline fungal disease in a ~ 130 m² survey area. High coral cover with abundant soft corals made up of *Dendronephthya*, *Sinularia*, *Lobophyton* and *Sarcophyton*. This site had few macroinvertebrates except for coralliophilid mollusks, *Coralliophila violacea* and the common hermit crab, *Calcinus haigae*. The hermit crab *Calcinus gouti*, which is a newly described species, was recorded at this site. The holothuroids *Bohadschia argus* and *Holothuria atra* were recorded but were rare. The hydrozoans, *Distichopora* and *Stylaster*, were abundant throughout the site. Fish diversity at this site was high, with small fish being the most abundant. *Chromis vanderbilti* constituted the highest numbers, with *C. acares* occasionally present in the mix. Hiding in the coral heads was a fair number of *Plectroglyphididon dickii*. A roaming blacktip reef shark wandered into the BLT and nSPC.

PAL-09

N 5 ° 86.751, W 162 ° 09.508

Depth range: 11.8–14.8 m

This was a southern forereef site. LPI data found live coral cover to be 31%. mainly composed of *Porites lobata*, *Pavona varians*, and *Favia stelligera*; other scleractinian genera present along the LPI included *Pocillopora*, *Hydophora*, and *Lobophyllia*. Percent coralline algal cover represented over 21% and macroalgae 45% (mainly *Halimeda*) of the benthic cover. Dominated by *Halimeda opuntia* and crustose coralline red algae. Coral disease and health assessment studies found one case of focal bleaching on *Lobophyllia* and one case of widespread bleaching on *Montipora*, two cases of discoloration on *Hydnophora microconnos*, three cases of tissue loss and discoloration on *Porites*, and four cases of coralline fungal disease in a ~ 200 m² survey area. The soft corals, *Sarcophyton* and *Lobophyton*, were abundant throughout the site. Large quantities of coral rubble were consolidated in sand channels and this provided refuge for hermit crabs (*Calcinus haigae*) and brittle stars (*Ophiocoma* sp. and *Ophiopeza* sp.). A green didemnid tunicate, likely a *Diplosoma*, was pervasive at this site and was associated with

old coral rubble. No large echinoderm species were recorded at this site. This site was similar to PAL-10 regarding fish assemblages; *Chromis vanderbilti* were ubiquitous. *Pseudanthias olivaceous* and *Cirrilabrus exquisitus* were common. Larger fish were not extremely common, though a single blacktip reef shark was seen off transect.

PAL-06

N 5 ° 87.148, W 162 ° 11.847

Depth range: 5–7 m

This site was found in the southwestern lagoonal ship channel. LPI data found live coral cover to be 20%, mainly composed of *Acropora nobilis*, *Montipora* spp., and *Porites rus*. The corallimorph *Rhodactis edwardsi* was very abundant, smothering some of the scleractinian corals and represented over 52% of the benthic cover. Percent coralline algal cover represented 3%, macroalgae 2% (mainly *Halimeda*), turf algae 8%, and cyanophytes > 10% of the benthic cover. Low percent cover of *Halimeda opuntia*. Coral disease and health assessment studies found one case of discoloration and predation on *Montipora*, one case of algal infection on *Porites rus*, and one case of cyanophyte infection (yellow-green band) on *Platygyra* in a 300 m² survey area. The site is an isolated reef area surrounded by an extensive rubble field and is dominated by the corallimorpharian *Rhodactis howseii*, which is acting very invasively in the area. This corallimorpharian has overgrown a large portion of the extensive *Acropora* that once dominated the reef. A green didemnid tunicate from the genus *Diplosoma* was also very pervasive but was associated with the coral rubble. A qualitative search of the rubble field yielded an unknown synaptid holothuroid, which was very common. Over a dozen manta rays dominated the fish biomass at this site, in addition to a number of gray, whitetip, and blacktip reef sharks. Other large fish included *Lutjanus bohar*, *Chlorurus microrhinos*, *Caranx ignobilis*, *C. melampygus*, and *Naso lituratus*. A humphead wrasse, *Cheilinus undulatus*, was seen off transect.

PAL-59

N 6 ° 52.143, W 162 ° 5.447

Depth range: ~ 4 m

This site is located on the south side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had medium coral cover with medium reef complexity. Triggerfish were numerous here, with large numbers of *Melichthys niger* and *M. vidua*. *Chromis vanderbilti* were also found in large numbers, as was *Thalassoma quinquevittatum*. There was nothing particularly unique about this site.

PAL-60

N 6 ° 52.011, W 162 ° 6.367

Depth range: ~ 4 m

This site is located on the shallow side of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had medium coral cover with medium reef complexity. Small pomacentrids dominated this site, with *Chromis vanderbilti*, *Plectroglyphidodon dickii*, *Plectroglyphidodon*

johnstonianus, and *Stegastes aureus* being the most numerous. Additionally, there seemed to be unusually high numbers of *Stethojulis bandanensis* here.

PAL-61

N 6 ° 52.485, W 162 ° 9.004

Depth range: ~ 22 m

This site is located on the western shelf of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had high coral cover with medium reef complexity. Relief of the substrate was relatively low here. The fish population was typical with high numbers of *Chromis vanderbilti* and *Chromis xanthura*. Several *Lutjanus bohar* were present, comprising the majority of larger fish. Scarids were almost absent from this site. Of particular note was one on-transect record of *Balistoides viridescens*.

April 3, 2008

PAL-02

N 5 ° 88.258, W 162 ° 13.154

Depth range: 12.7–14.2 m

This site was found in the western terrace. LPI data found live coral cover to be 14%, mainly composed of an amalgam of *Porites* cf. *lobata* and *Pavona duerdeni*; other scleractinian genera present along the LPI included *Pocillopora* and *Montipora*. Percent coralline algal cover represented 28% and macroalgae over 50%; mainly *Halimeda* but also *Dictyosphaeria* and *Lobophora*. Dominated by *Halimeda opuntia*, crustose coralline algae, and *Lobophora variegata* with patches of *Dictyosphaeria cavernosa*. Coral disease and health assessment studies found two cases of discoloration on *Porites*, one case of pink line syndrome on *Porites*, one case of barnacle infestation on *Montipora*, one case of algal infection on *Platygyra*, two cases of necrosis on *Sinularia*, and five cases of coralline fungal disease in a 200 m² survey area. Site was dominated by hard coral and *Halimeda* algae. Very few macroinvertebrates were present other than trapezid crabs associated with *Pocillopora* coral heads. The coralimorph *Rhodactis howseii* and the soft coral *Dendronephthya* were present but rare. Fish abundant at this site were *Ctenochaetus striatus* as were smaller individuals of *Chlorurus sordidus* and *Scarus frenatus*. *Chromis vanderbilti* was probably the most numerous species here.

PAL-04

N 5 ° 87.377, W 162 ° 11.649

Depth range: 5–6 m

This site was found on the terrace/lagoon, west of the boat channel. LPI data found live coral cover to be 3%, mainly composed of *Pocillopora damicornis*. Macroalgae (possibly *Rhodymenia*) accounted for nearly 50% and turf algae-covered rubble and pavement accounted for over 34% of the benthic cover. Dominated by *Rhodymenia* sp. and turf algae composed primarily of *Galaxaura* sp. Coral disease and health assessment studies found no diseases in the 200 m² survey area. The only common coral was the cup coral *Tubastrea coccinea*. Most of the area was covered with a red algae and sparse *Halimeda*. The hydrozoan *Distichopora* was common at the site. The coralimorpharian *Rhodactis*

howseii was present but was rare. This site was characterized by large numbers of surgeonfish. *Ctenochaetus striatus* was particularly abundant, as was *Acanthurus triostegus*. The latter interrupted our surveys with an inundation of several thousand individuals. This shallow site exhibited fairly high species diversity.

PAL-62

N 6 ° 53.010, W 162 ° 8.317

Depth range: ~ 21 m

This site is located on the western shelf of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had high coral cover with medium reef complexity. This site was very similar to other deep western shelf sites (PAL-61).

PAL-63

N 6 ° 53.393, W 162 ° 8.977

Depth range: ~ 21 m

This site is located on the western shelf of Palmyra Atoll. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had high coral cover with medium reef complexity. This site was very similar to other deep western shelf sites (PAL-61, PAL-62).

Marine Alien Species and Intertidal Survey

PAL-22

North side of western lagoon at the end of the airstrip. Survey conducted from the shoreline to 3 m depth. Habitat was composed of concrete and dredge rubble along the shoreline with a sand bottom. A series of old dock pilings was located within 5 m of the shoreline and were included in the survey. Four species of sponge were common throughout the site on the man-made and natural substrate. Gastropods were abundant from the shoreline to 1 m depth. The shoreline was inhabited predominantly by the gastropods *Littoraria pintado*, *Littoraria scabra*, *Nerita picea*, *Nerita plicata*, and *Nerita polita*. Subtidally, the gastropods *Cypraea moneta* and *Strombus maculatus* were common and the asteroid *Echinaster luzonicus* was occasional. The dock pilings had extensive growth of the cup coral *Tubastrea coccinea*, the macroalgae *Caulerpa* cf. *racemosa* and the alien hydroid *Pennaria disticha*. It is suspected that two of the four species of sponge present are alien species.

PAL-24

Survey conducted on the dock and seawall located on the north side of the western lagoon. Habitat was dominated by the macroalgae *Galaxura* and three species of sponge. Two of the sponge species are possibly alien species. Intertidally, exposed sea wall and dock piling substrates were occupied by the gastropods *Littoraria pintado*, *Littoraria scabra*, *Nerita picea*, *Nerita plicata*, and *Nerita polita*. Subtidally, sponges and *Galaxura* were dominant. The pen shell *Atrina* was common and the cephalopod *Octopus cyanea* was rare. Another macroalgae, *Caulerpa* cf. *racemosa*, was also common throughout the site

PAL-27

Southern part of western lagoon near channel at Sand Island. A survey from the shoreline to a subtidal depth of 1 m was conducted. Sand Island was created from dredge spoil and has become colonized with coconut palms and *Pisonia* trees. The shoreline is composed of consolidated dredge spoil and unconsolidated coral rubble. The subtidal zone is composed of sand and coral rubble. The shoreline was dominated by gastropods and sesarmid and xanthid crabs. The coconut crab *Birgus latro* was commonly seen foraging at the edge of the shoreline. Subtidally, the gastropod *Cypraea moneta* was dominant and two species of sponges were common. The two sponge species recorded from this site were also recorded at sites PAL-24 and PAL-22 and are possibly alien species. The holothuroids *Holothuria edulis*, *Holothuria atra*, *Holothuria whitmaei*, and *Bohadschia argus* were very abundant in the subtidal zone at 1 m depth but were mostly absent beyond this depth. A new record for this site was the bryozoan *Zoobotryon*, which was alien to this region. *Zoobotryon* was noted as growing in bushy masses at a depths of 15 ft and appears to be quite common.

PAL-28

Northern section of the central lagoon. This was a protected cove with a shoreline composed of coral rubble and sand. The subtidal zone was fine silty sand with periodic carbonate structure. The shoreline was dominated by sesarmid crabs and small coenobitid land hermit crabs. The subtidal area had a large abundance of two gastropod species, *Cypraea moneta* and *Strombus maculatus*. Also present were the holothuroid species *Holothuria atra* and *Stichopus chloronotus*. One species of sponge that is possibly an alien species was seen on the hard carbonate structure at the site but was not common. This sponge was one of the species recorded at both PAL-24 and PAL-22.

C.3. Benthic Environment

C.3.1. Algae

Quantitative algal surveys were conducted at 12 forereef sites at Palmyra Island. Only qualitative surveys were conducted at PAL-21 and PAL-12. All sites exhibited relatively high macroalgal cover (Table C.3.1.1). Macroalgal diversity was higher than that found at Jarvis Island and consistent across all sites at the island except PAL-04. Ten species of macroalgae were recorded along survey lines: eight species of green algae, one species of red algae, and one species of brown algae, as well as crustose coralline red algal and turf algal functional groups. Site PAL-04 exhibited almost a monoculture of the red algae species *Rhodomenia* sp. which was only found at this site.

Table C.3.1.1.--Algal genera or functional groups recorded in photoquadrats at Palmyra Island. Numbers indicate the percentage of photoquadrats in which an alga occurred. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	PAL-01	PAL-02	PAL-04	PAL-05	PAL-06	PAL-09	PAL-10	PAL-11	PAL-16	PAL-17	PAL-19	PAL-26
GREEN ALGAE												
<i>Avrainvillea lacerata</i>	*	8			*	17		8	17	33*		
<i>Caulerpa cupressoides</i>				25		*	*		*			
<i>Caulerpa serrulata</i>			8									
<i>Dictyosphaeria cavernosa</i>		92				*	8	83*	*		8	8
<i>Dictyosphaeria versluysii</i>		25*				*	8	25	42	17	17	8
<i>Halimeda fragilis</i>		*		8		17*	*		*		25*	
<i>Halimeda opuntia</i>	67	83*			33	92	83	75	100	50	75	33
<i>Halimeda taenicola</i>	17	42		67		42	17	17		*	33	25
<i>Valonia utricularis</i>		*	*			*	*					*
RED ALGAE												
<i>Chondracanthus sp.</i>			*									
crustose coralline red algae	100	100	42	100	50	100	92	100	100	100	100	83
<i>Rhodymenia sp.</i>			100									
OCHROPHYTA												
<i>Dictyota bartayresiana</i>					*							
<i>Lobophora variegata</i>	*	92	67	50	17	67	50	25	100	17	83	8
FUNCTIONAL GROUPS												
turf algae	92	25	100	100	50	67	67	83	100	83	75	100

C.3.2. Corals

C.3.2.1 Percent Benthic Cover

In 2008, percent benthic cover surveys at Palmyra Atoll were conducted in concert with the fish, coral population, algae, and invertebrate REA surveys at 14 different sites established during CRED cruises in 2000, 2004, and 2006. The LPI methodology assessed two, end-to-end 25-m transects (51 points per transect) at each site, except for PAL-17, a deep site, where only one transect was completed due to bottom time limitations. LPI surveys totaled 1377 points along 675 m of forereef and lagoon coral communities with survey depths ranging between approximately 3 and 20 m. Spatial patterns of percent benthic cover variability, derived from the 14 independent REA surveys are reflected in Figure C.3.2.1.1. Atoll-wide, macroalgae, coralline algae and scleractinian corals were the primary benthic components, representing $26.9 \pm 4.8\%$, $25.5 \pm 3.5\%$, and $22.1 \pm 3.9\%$ of total, respectively (mean \pm SE). The greatest values for live coral cover were observed at PAL-26 on the western terrace and PAL-12 on north-

facing shore (59.8 % and 33.3%, respectively). Lawns of the green calcifying algae *Halimeda* were particularly abundant at south-facing sites PAL-09 and PAL-19 (43% and 34%, respectively). In contrast, the red alga *Rhodymenia* was abundant at site PAL-04 on the western side of the lagoon channel. Carpets of *Rhodactis edwardsi* continued to be common in the area adjacent to the lagoon channel wreck site, including site PAL-16, where this corallimorph accounted for over 50% of the benthic cover. Of the 19 scleractinian genera enumerated along the LPI transects, *Porites*, *Pocillopora*, *Pavona*, and *Favia* contributed over 75% of the scleractinian cover, accounting for 38%, 16%, 11%, and 10%, respectively. Table C.3.2.1.1 provides an itemized analysis of relative contribution of the different scleractinian taxa to the total percent live coral cover.

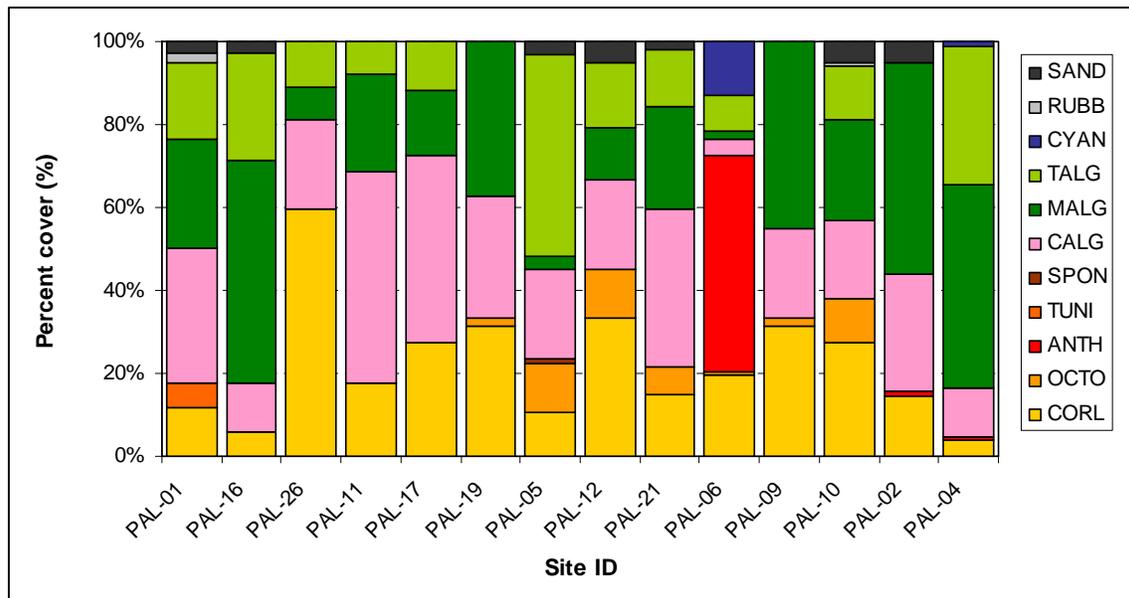


Figure C.3.2.1.1.--Mean percent cover of selected benthic elements derived from 14 independent REA surveys at Palmyra Atoll, ASRAMP 2008 (March 30–April 3, 2008). CORL: live scleractinian and hydrozoan stony corals; OCTO: octocorals; ANTH: other anthozonans; TUNI: tunicates; SPON: sponges; CALG: coralline algae; MALG: macroalgae; TALG: turf algae (on pavement, rubble, and dead coral); CYAN: cyanophyte; RUBB: coral rubble; and SAND: sand.

Table C.3.2.1.1.--Island-wide relative abundance of the different scleractinian and octocoral stony coral taxa enumerated along the LPI transects.

<i>Genus</i>	Relative abundance (%)
<i>Porites</i>	38.4
<i>Pocillopora</i>	16.2
<i>Pavona</i>	11.3
<i>Favia</i>	10.3
<i>Montipora</i>	7.3
<i>Acropora</i>	3.3
<i>Hydnophora</i>	2.3
<i>Fungia</i>	1.7
<i>Psammocora</i>	1.3
<i>Favites</i>	1.0
<i>Merulina</i>	1.0
<i>Montastrea</i>	1.0
<i>Platygyra</i>	1.0
<i>Stylophora</i>	1.0
<i>Turbinaria</i>	1.0
<i>Herpolitha</i>	0.7
<i>Leptoseris</i>	0.7
<i>Gardineroseris</i>	0.3
<i>Lobophyllia</i>	0.3

The quantitative data above documents important characteristics of the coral reef benthic assemblages, providing the framework to monitor for temporal change in response to alterations in the reef environment. An abridged comparison of percent live coral cover based on surveys conducted in the last 2 years is illustrated in Figure C.3.2.1.2.

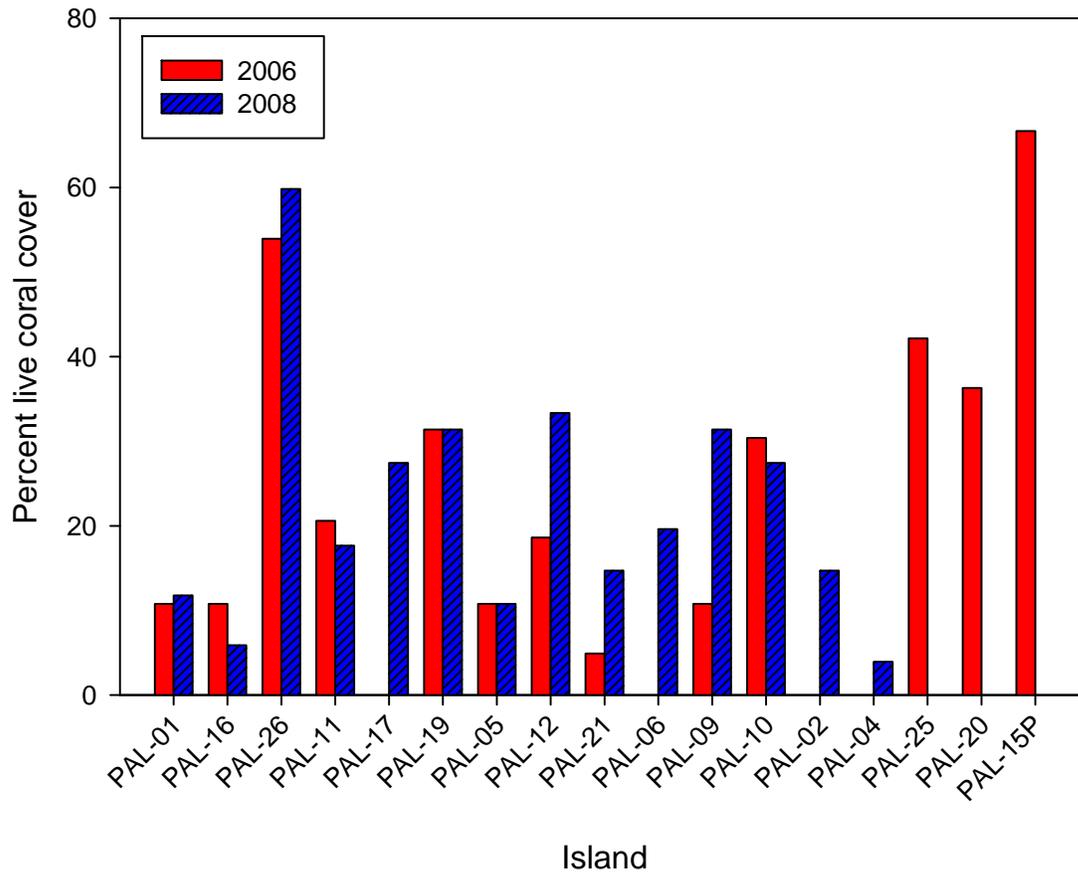


Figure C.3.2.1.2.--Percent live coral cover for 14 REA sites at Palmyra Atoll contrasted for survey years 2006 and 2008.

C.3.2.2. Coral Populations

A total of 452 m² of reef benthos was surveyed around Palmyra Atoll in 2008. A total number of 5,349 colonies were counted within this area (Table C.3.2.2.1). A total of 25 genera of scleractinian corals and 1 genus of hydrozoan corals were enumerated at Palmyra Atoll. Coralimorphs, zoanthids, and soft corals were also tallied at Palmyra Atoll.

Table C.3.2.2.1.--Anthozoan genera enumerated at Palmyra Atoll, shown in total number of colonies for the atoll, and the generic percent of total.

Palmyra	Number of Colonies	Percent of Total
<i>Acanthastrea</i>	1	0.02
<i>Acropora</i>	80	1.50
<i>Astreopora</i>	3	0.06
<i>Coralimorphia</i>	115	2.15
<i>Dendronephthya</i>	9	0.17
<i>Distichopora</i>	153	2.86
<i>Favia</i>	301	5.63
<i>Favites</i>	66	1.23
<i>Fungia</i>	244	4.56
<i>Gardineroseris</i>	2	0.04
<i>Goniopora/Alveopora</i>	24	0.45
<i>Herpolitha</i>	4	0.07
<i>Hydnophora</i>	39	0.73
<i>Leptoseris</i>	71	1.33
<i>Lobophyllia</i>	40	0.75
<i>Lobophytum</i>	307	5.74
<i>Montastrea</i>	47	0.88
<i>Montipora</i>	179	3.35
<i>Palythoa</i>	39	0.73
<i>Pavona</i>	764	14.28
<i>Platygyra</i>	18	0.34
<i>Pocillopora</i>	962	17.98
<i>Porites</i>	1301	24.32
<i>Psammocora</i>	48	0.90
<i>Sarcophyton</i>	170	3.18
Soft Coral	63	1.18
<i>Stylophora</i>	90	1.68
<i>Tubastrea/Balanophyllia</i>	3	0.06
<i>Turbinaria</i>	142	2.65
<i>Zoanthus & Palythoa</i>	64	1.20
Total	5349	

Palmyra is unique within the Line Islands system because of the historical impact of military operations at the Atoll. Emergent land at Palmyra and the nearshore habitat was dramatically restructured because of military efforts before and during the Second World War. The primary impacts to the reef environment based on this historical use included, habitat dredging and sedimentation from shoreline construction and ship channel expansion.

Porites (24.32 % of colonies enumerated) was the dominant coral genus at Palmyra. *Pocillopora* (17.98 % of colonies observed) and *Pavona* (14.28 % of colonies enumerated) were the second and third most abundant genera observed at the Atoll. The

branching *Pocilloporids* account for much of the three-dimensional heterogeneity of the reefs at Palmyra. Coral community structure at Palmyra Atoll is typified by high diversity and relatively smaller colony size.

C.3.2.3 Coral Health and Disease

In 2008, a total area of approximately 2850 m² at 14 sites was assessed for coral and coralline algae disease during the REA surveys. Occurrence of coral disease and other health impairments was relatively low; a total of 120 cases of 12 categorized diseases and disorders were tallied. A summary of disease occurrence, relative abundance, and taxa affected are presented in Figures C.3.2.3.1 and C.3.2.3.2, respectively. Barnacle infestations and patchy bleaching were the most common afflictions to scleractinian corals. In addition, several cases of tissue necrosis were noted on the alcyonarians *Sinularia* and *Lobophytum* (Fig. C.3.2.3.3); this type of lesion is not common and worth investigating. Diseases of coralline algae were relatively numerous, with 55 cases of coralline fungal disease and coralline lethal disease. Finally, an itemized list of tissue samples collected for coral disease histological analyses is presented in Table C.3.2.3.1.

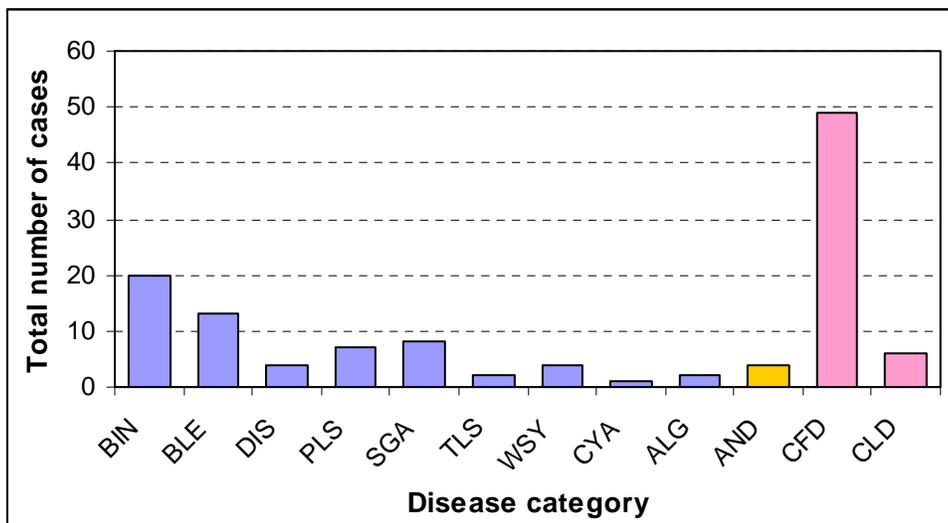


Figure C.3.2.3.1.--Number of cases of scleractinian (blue bars), alcyonarian, and coralline algal (pink bars) diseases enumerated during REA surveys, Palmyra Atoll, 2008. BIN: barnacle infestation; BLE: bleaching; DIS: discolorations other than bleaching; PLS: pink line/spot syndrome; SGA: skeletal growth anomalies; TLS: tissue loss; WSY: white syndrome; CYA: cyanophyte infections; ALG: algal infections; AND: alcyonarian necrotic disease; CFD: coralline fungal disease; and CLD; coralline lethal disease.

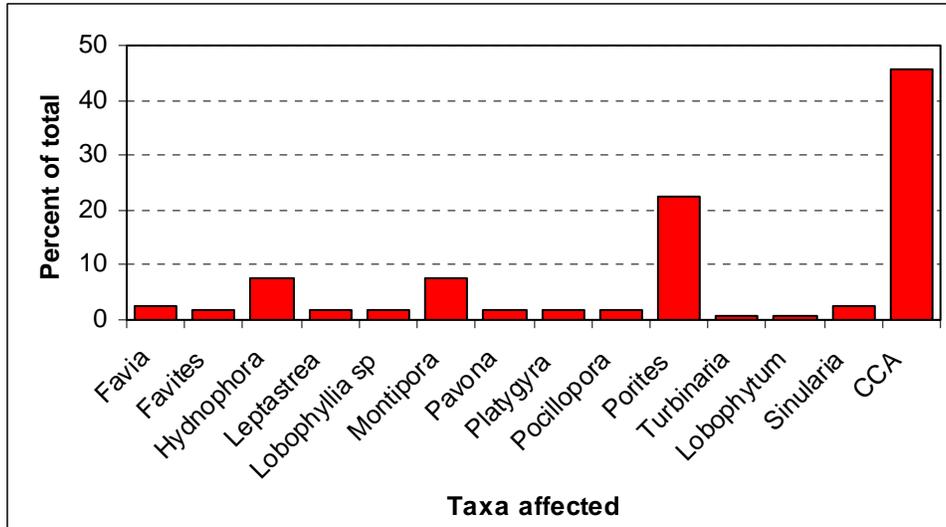


Figure C.3.2.3.2.--Percent occurrence of disease affecting coral and coralline algal taxa (CCA: crustose coralline algae).



Figure C.3.2.3.3.--Underwater photograph illustrating the alcyonarian necrotic disease on *Sinularia* encountered at Palmyra Atoll (photo: Bernardo Vargas-Ángel).

Table C.3.2.3.1.--Coral tissue sample log of diseased specimens collected at Palmyra Atoll.

Island	Site ID	Date	Taxon	Disease state	Sample number
Palmyra	PAL-01	3/30/2008	<i>Montipora</i> sp.	White syndrome	HI0803-003
Palmyra	PAL-19	3/31/2008	<i>Favia stelligera</i>	White syndrome	HI0803-004
Palmyra	PAL-21	4/1/2008	<i>Porites lobata</i>	Pink line/spot syndrome	HI0803-005
Palmyra	PAL-02	4/3/2008	<i>Sinularia</i> sp.	Alcyonarian necrotic disease	HI0803-006
Palmyra	PAL-02	4/3/2008	<i>Porites</i> sp.	Pink line/spot syndrome	HI0803-007/08
Palmyra	PAL-02	4/3/2008	<i>Porites</i> sp.	Pink line/spot syndrome	HI0803-007/08

C.3.3. Macroinvertebrates

Non-cryptic invertebrates were extremely low around Palmyra Atoll. Trapezid crabs and hermit crabs were the most abundant. Trapezid densities were highest at sites PAL-01, PAL-09, PAL-02, and PAL-26 (0.35, 0.25, 0.24, and 0.24/m², respectively). Hermit crabs densities were greatest at sites PAL-01, PAL-21, and PAL-12 (0.37, 0.34, and 0.21/m², respectively). Coralliophilidae mollusks were common at sites PAL-01, PAL-10, PAL-12, and PAL-19 (0.12, 0.10, 0.10, and 0.14/m², respectively). Echinoderms were rare. The only echinoderm recorded on-transect was the asteroid, *Fromia milleporella*. Boring and free urchins were not observed and holothuroids were extremely rare on the foreereef. Only two *Holothuria atra* were observed off-transect. However, at an inner tidal collection site within the lagoon, Site-27, the following holothuroid species were abundant: *Holothuria atra*, *Bohadaschia argus*, and *Holothuria edulis*. Soft corals were present at all REA surveyed sites. The coralimorph, *Rhodactis*, was observed at the following sites: PAL-02, PAL-04, PAL-06, and PAL-16. It nearly covered the entire site at PAL-06. Based on presence/absence, *Lobophyton* and *Sarcophyton* were present at 77% of the sites and *Sinularia* was present at 69% of the sites. Only one giant clam, *Tridacna* sp., was observed on transect.

C.3.3.1. Urchin and Giant Clam Measurements

No urchin species were recorded at surveyed REA sites and no *Tridacna* sp. were measured.

C.3.3.2. ARMS Deployment

ARMS were deployed at the following REA sites around Palmyra. Each site contains three ARMS.

Table C.3.3.2.1.--ARMS deployment locations around Palmyra Atoll.

	Latitude	Longitude
PAL-01	05° 53.081 N	162° 04.156 W
PAL-19	05° 51.98 N	162° 06.59 W
PAL-17	05° 52.497 N	162° 06.59 W
PAL-27	05° 52.662 N	162° 06.262 W

C.3.3.3. Invertebrate Collections

Nondestructive tissue samples of the following organisms were collected for the Hawaii Institute of Biology for the purpose of genetic analysis.

Table B.3.3.3.1.--Invertebrate tissue collection information for specimens from Palmyra Atoll.

Species	Number	REA site	Latitude	Longitude
<i>Holothuria atra</i>	49	PAL-27	05° 52.662 N	162° 06.262 W
<i>Calcinus laevimanus</i>	30	PAL-23	05° 52.891 N	162° 05.055 W

C.3.4 Towed-diver Benthic Surveys

A total of 24 towed-diver surveys totaling 61 km were completed around Palmyra. The overall hard coral cover was 24.92% (range 0.1 – 62.5%) for all pooled surveys, with the highest coral cover for any single towed-diver survey recorded along the western shelf bordering the (western) edge of the deep/central dropoff (Fig. C.3.4.1). Habitat consisted primarily of medium-low to medium complexity continuous reef. Hard coral cover ranged from 30.1 to 62.5%, with the highest cover recorded during segments 2-4 and 8-10 (50.1–62.5%). *Porites* species were very common (incl. patches of *Porites rus*), along with *Pocillopora* and *Turbinaria*. Other genera represented included *Favia*, *Montipora*, and *Stylophora*. An additional area around the northeastern forereef, approaching Sawle Pointe in approximately 14–17 m depth also recorded high coral cover (average 45.38%, range 30.1–75%), with the highest cover recorded during time segment 4 (62.5–75%). Numerous genera were represented, and the area generally appeared to represent some of the higher genera/species diversity seen around Palmyra. A final area of note included the survey conducted off the southwestern forereef/shelf edge approximately 0.6 km from the channel entrance heading west (average 40.38%, range 10.1–62.5%), with the highest cover noted for segments 2, 4, and 5 (50.1–62.5%). *Porites* and *Turbinaria* were prevalent components within all 10 time segments, while *Pocillopora* (segments 1-3, 6-7), *Fungia* (segments 9, 10), *montipora* (segment 10), *Favia* (segments 1, 2, 4-10), and *Millepora* (segment 3; complex tower formations) were also common along specific segments.

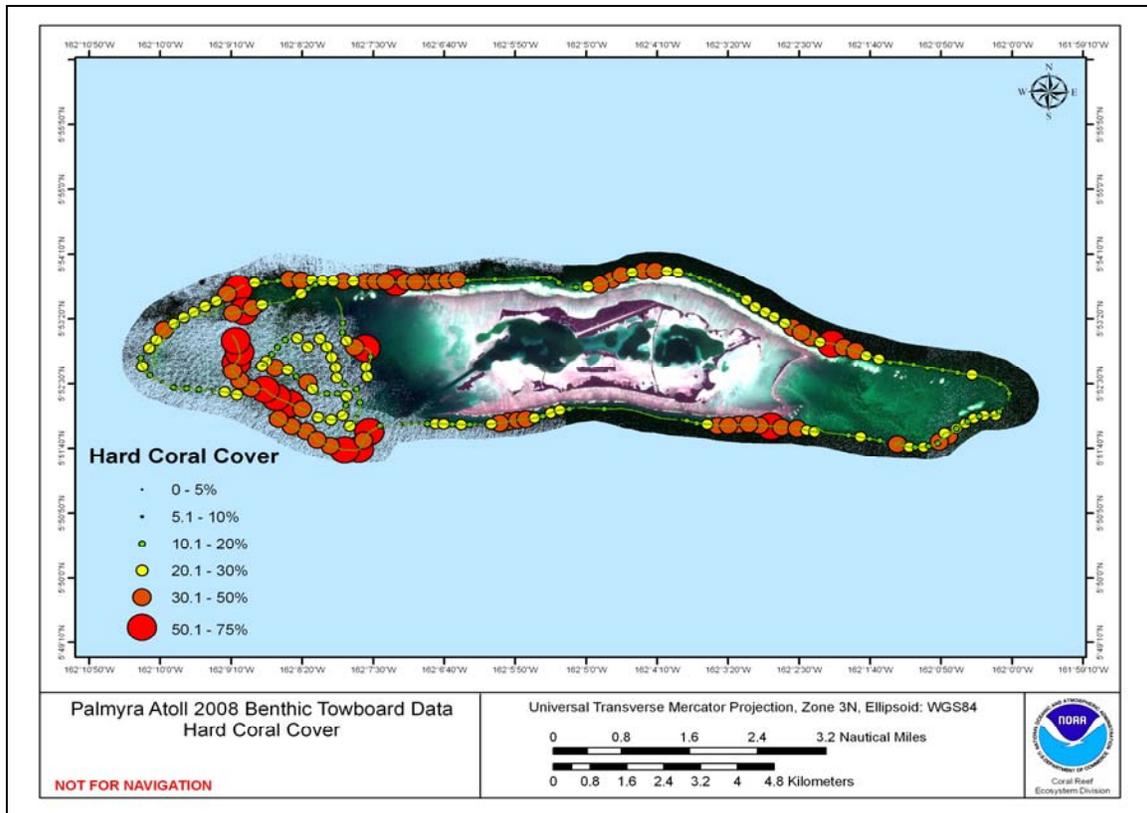


Figure C.3.4.1.--Hard coral cover recorded during the 2008 towed-diver surveys around Palmyra Atoll.

Coral stress remained generally low around Palmyra, averaging 1.75% (range 0–10%). Particular interest was focused towards some of the *hydnothora* colonies, which showed signs of disease and/or paling.

Soft coral cover averaged 18.03% (range 0–62.5%) for all pooled surveys. The highest soft coral cover was recorded on the northeast side of Palmyra heading east past Aviation, Quail, and Whippoorwill Islands (Fig. C.3.4.2). Predominant habitat was continuous reef with medium low to medium complexity. Soft coral cover was high throughout the survey, averaging 45.25% (range 30.1–62.5%) and consisting of *Sinularia*, *Sarcophyton*, and patchy *Pachyclavaria*. Higher levels of soft coral cover were noted for northern forereef surveys (northern section of the western shelf) vs. other surveys around Palmyra.

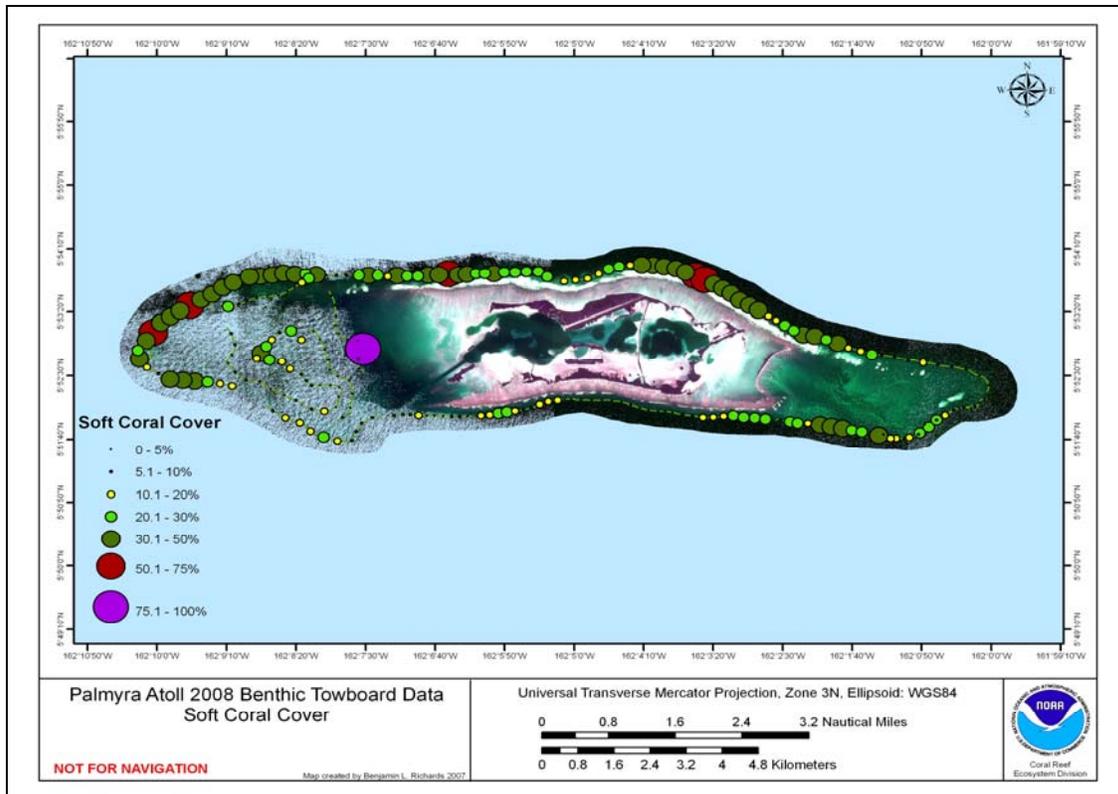


Figure C.3.4.2.--Soft coral cover recorded during the 2008 towed-diver surveys around Palmyra Atoll.

Macroalgae and coralline algae cover averaged 11.66% (range 0.1–50%) and 17.10% (range 0.1–62.5%), respectively. The highest macroalgae cover was recorded along the southern forereef off of Paradise Island, heading eastward (Fig. C.3.4.3). Habitat consisted primarily of medium complexity continuous reef along a moderate slope. Macroalgae averaged 37% (range 20.1–50%), with the last four time segments recording 40.1–50% cover. *Halimeda* mats were prevalent, while areas of *Dictyosphaeria versluyii* and *Cavernosa* were patchier. The percentage of macroalgae cover was distinctively higher along the southern forereef surveys vs. surveys in other areas around Palmyra. Coralline algae averaged 35.5% (range 5.1–50%) during a survey completed along the western shelf, along the (eastern) edge of the deep/central dropoff. Coralline algae cover was low in the first three segments and increased to between 40 and 50% for the remainder of the tow (Fig. C.3.4.4). Coralline algae cover appeared to be higher along the central portion of the western shelf/forereef vs. other areas of Palmyra.

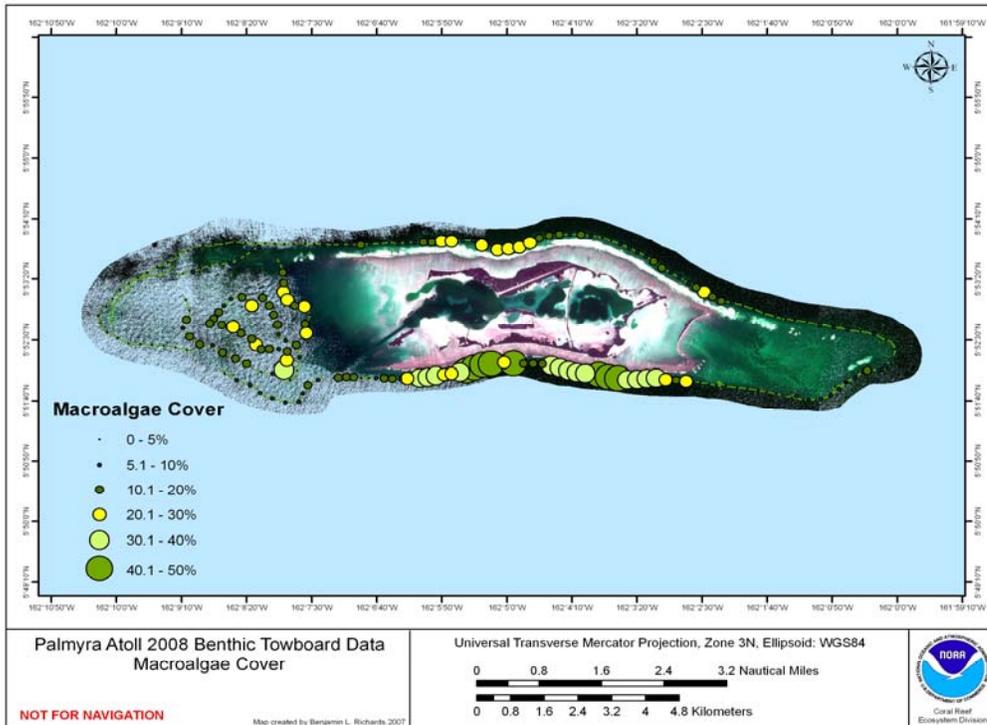


Figure C.3.4.3.--Macroalgae cover recorded during the 2008 towed-diver surveys around Palmyra Atoll.

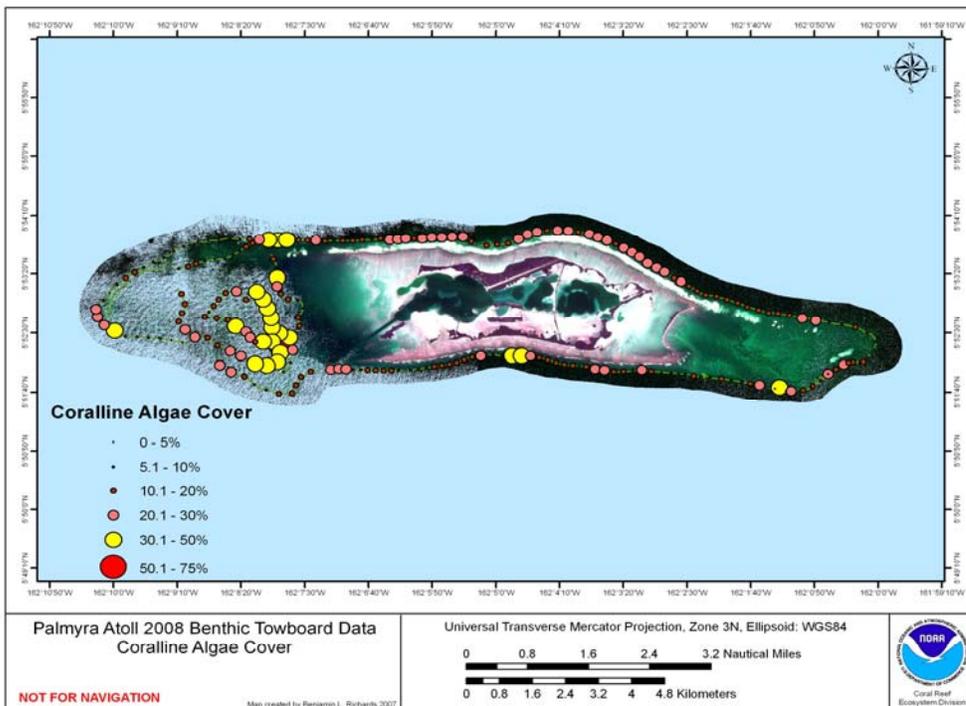


Figure C.3.4.4.--Coralline cover recorded during the 2008 towed-diver surveys around Palmyra Atoll.

Macroinvertebrate populations at Palmyra Atoll were generally very low. Only one COT was recorded, and no sea urchins (either free or boring) were recorded by divers. A total of 19 sea cucumbers (0.31 sea cucumbers/ha) and 11 giant clams (0.18 giant clams/ha) were recorded during surveys around the island, with no more than 2 individuals recorded per respective time segment. The highest concentration of sea cucumbers (8/single survey; 3.38 sea cucumbers/ha) was noted for a survey completed along the northern forereef heading east. The highest concentration of giant clams (4/single survey; 1.36 giant clams/ha) was located along the eastern edge of the deep/central dropoff, which also coincided with the highest recorded levels of coralline algae.

C.4 Fish

C.4.1 REA Fish Surveys

Stationary Point Count data (new methodology)

A total of about 56 individual nSPC surveys were conducted at 28 sites around Palmyra Atoll (10 forereef mid depth, 9 forereef deep depth, 9 forereef shallow depth). Sharks (Carcharhinidae) were the largest contributors to total biomass with 3.2 kg 100 m⁻². Snappers (Lutjanidae) and surgeonfish (Acanthuridae) were also relatively abundant, with a biomass of ~ 2.0 kg 100 m⁻² (Table C.4.1.2, Fig. C.4.1.1).

Belt transect data

During the survey period, about 56 belt transect surveys were conducted at 28 sites around Palmyra Atoll (see SPC for stratum breakdown). Surgeonfishes (Acanthuridae) were the largest contributor to total biomass with 2.6 kg 100 m⁻². Snappers (Lutjanidae) and sharks (Carcharhinidae) were also relatively abundant, with a biomass of 0.9 and 1.8 kg 100 m⁻², respectively (Table C.4.1.1).

Overall observations

A total of 210 species were observed during the survey period by all divers. The average total fish biomass at the sites in Palmyra during the survey period was 0.94 ton ha⁻¹ for the nSPC surveys (Table C.4.1.2), and the average fish biomass was 0.83 ton ha⁻¹ for the belt transect surveys (Table C.4.1.1).

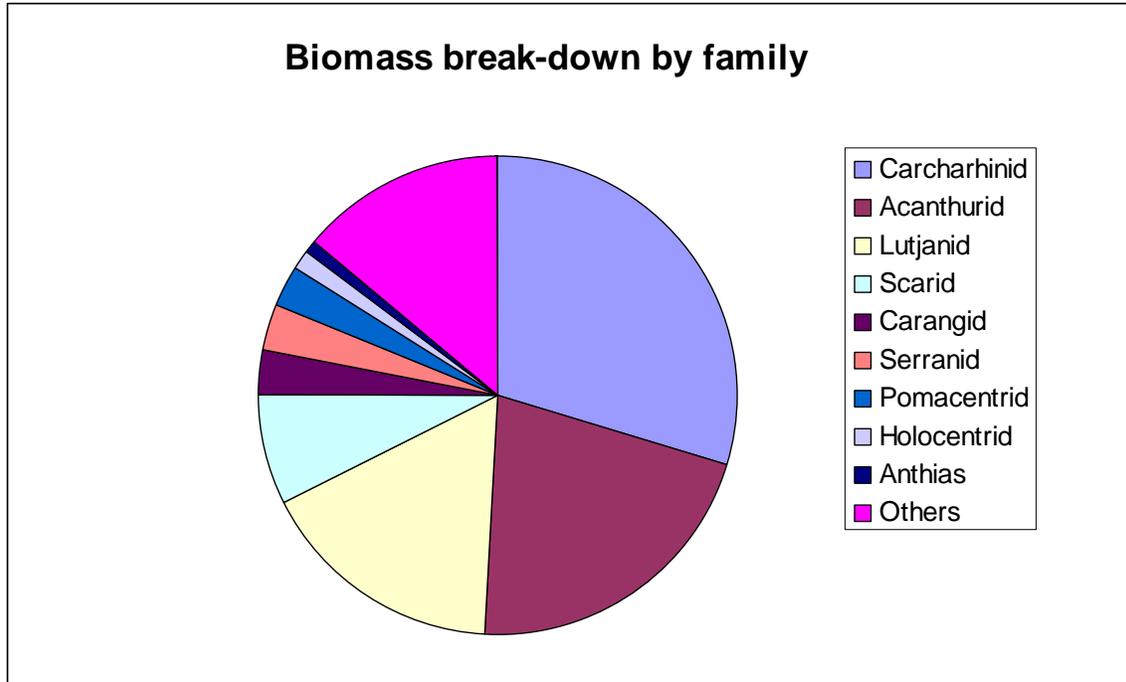


Figure C.4.1.1: Total fish biomass composition by family, measured by nSPC.

Table C.4.1.1.--Coral reef fish biomass (kg 100 m⁻²) at sites around Palmyra Atoll as measured by belt transects.

Stratum-Depth	Site	Total	Acanth.	Anthias	Carangid	Shark	Holocentrid	Lutjanid	Myliobatid	Pomacent.	Scarid	Serranid	Others	
Forereef – Deep	PAL-17	3.0	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.32	0.16	1.38	
	PAL-50	4.0	0.45	0.63	0.00	0.00	0.00	0.31	0.00	0.55	1.22	0.39	0.40	
	PAL-52	16.4	1.47	0.00	0.00	10.01	0.06	2.48	0.00	0.85	0.67	0.09	0.80	
	PAL-53	3.0	0.21	0.04	0.34	0.00	0.09	0.75	0.00	0.35	0.00	0.37	0.88	
	PAL-55	24.2	4.14	0.81	0.35	12.61	0.12	2.77	0.00	1.52	0.13	1.00	0.73	
	PAL-57	4.7	1.58	0.00	0.00	0.00	0.00	0.84	0.00	0.27	0.91	0.10	1.01	
	PAL-61	8.2	0.35	0.30	0.00	4.04	0.54	1.07	0.00	0.39	0.86	0.18	0.50	
	PAL-62	5.3	0.99	0.00	0.00	0.00	0.04	1.29	0.00	0.37	0.87	0.18	1.59	
	PAL-63	2.3	0.63	0.06	0.00	0.00	0.00	0.10	0.00	0.26	0.33	0.28	0.62	
Forereef – Mid	PAL-01	8.0	1.84	0.35	0.00	3.91	0.00	0.27	0.00	0.39	0.46	0.15	0.65	
	PAL-02	5.4	3.03	0.00	0.00	0.00	0.00	0.99	0.00	0.14	0.66	0.09	0.53	
	PAL-05	3.4	0.79	0.00	0.00	0.00	0.00	0.23	0.00	0.15	1.29	0.65	0.28	
	PAL-09	4.4	1.75	0.07	0.00	0.00	0.00	0.38	0.00	1.03	0.54	0.17	0.45	
	PAL-10	13.2	1.40	0.21	0.28	5.01	1.67	0.83	0.00	0.74	1.06	0.43	1.62	
	PAL-11	3.2	1.72	0.00	0.00	0.00	0.00	0.35	0.00	0.13	0.47	0.06	0.43	
	PAL-12	3.9	0.42	0.01	0.07	0.00	0.00	2.02	0.00	0.43	0.40	0.02	0.55	
	PAL-19	6.9	0.66	0.10	0.12	0.00	0.34	1.58	0.00	0.57	0.91	0.02	2.61	
	PAL-21	5.0	1.57	0.07	0.00	0.00	0.00	0.74	0.00	0.62	0.15	0.13	1.68	
	PAL-26	6.6	0.55	0.04	0.00	0.00	0.00	1.42	1.60	0.00	0.20	1.89	0.05	0.89
	Forereef - Shallow	PAL-04	26.0	22.47	0.00	0.00	0.00	0.00	1.25	0.00	0.06	0.90	0.57	0.76
PAL-06		41.4	8.59	0.00	6.06	15.41	0.11	3.69	0.00	0.12	5.60	0.76	1.08	
PAL-16		8.2	5.59	0.00	0.00	0.00	0.00	0.65	0.00	0.02	1.52	0.05	0.37	
PAL-51		4.2	2.32	0.00	0.00	0.00	0.00	0.04	0.00	0.13	0.73	0.15	0.80	
PAL-54		4.1	1.58	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.65	0.10	0.69	
PAL-56		5.4	3.28	0.00	0.00	0.00	0.00	0.28	0.00	0.07	0.55	0.11	1.10	
PAL-58		3.5	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.31	0.00	0.51	
PAL-59		4.8	0.69	0.00	0.00	0.00	0.00	1.55	0.00	0.48	0.50	0.32	1.22	
PAL-60		2.7	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.76	0.04	0.93	
Average		8.3	2.6	0.1	0.3	1.8	0.2	0.9	0.0	0.4	0.9	0.2	0.9	

Table C.4.1.1.--Coral reef fish biomass (kg 100 m⁻²) at sites around Palmyra Atoll as measured by nSPC.

Stratum-Depth	Site	Total	Acanth.	Anthias	Carangid	Shark	Holocentrid	Lutjanid	Myliobatid	Pomacentrid	Scarid	Serranid	Others	
Forereef - Deep	PAL-17	5.8	0.86	0.00	0.00	0.00	0.00	1.50	0.00	0.27	1.26	0.61	1.26	
	PAL-50	25.5	8.04	0.63	0.35	12.78	0.04	1.32	0.00	0.63	0.85	0.43	0.38	
	PAL-52	24.2	0.45	0.00	0.42	21.01	0.00	0.75	0.00	0.21	0.48	0.05	0.81	
	PAL-53	5.7	0.97	0.17	0.54	0.00	0.00	2.22	0.00	0.47	0.25	0.43	0.62	
	PAL-55	3.6	0.30	0.36	0.19	0.00	0.09	1.34	0.00	0.44	0.11	0.19	0.53	
	PAL-57	6.1	2.20	0.03	0.00	0.00	0.00	1.31	0.00	0.11	1.30	0.00	1.14	
	PAL-61	6.3	0.59	0.26	0.00	0.00	0.00	0.16	2.08	0.00	0.38	0.22	0.27	2.35
	PAL-62	12.2	1.32	0.00	0.14	0.00	0.00	0.08	4.66	0.00	0.33	0.81	0.73	4.13
	PAL-63	7.6	0.56	0.12	0.00	0.00	0.00	0.02	1.84	0.00	0.43	0.88	0.51	3.23
Forereef - Mid	PAL-01	8.4	4.04	0.54	0.22	0.00	0.00	1.17	0.00	0.38	0.61	0.45	0.99	
	PAL-02	6.8	2.34	0.00	0.00	0.00	0.03	2.98	0.00	0.14	0.46	0.40	0.50	
	PAL-05	7.7	0.92	0.00	1.05	0.00	0.03	1.83	0.00	0.19	0.88	0.28	2.53	
	PAL-09	10.6	0.74	0.07	0.00	0.00	0.00	4.29	0.00	0.42	0.87	0.36	3.81	
	PAL-10	14.3	0.89	0.09	0.27	9.04	0.78	0.52	0.00	0.33	1.43	0.50	0.49	
	PAL-11	3.9	1.40	0.00	0.00	0.00	0.00	0.71	0.00	0.20	0.84	0.29	0.47	
	PAL-12	3.9	0.38	0.01	0.00	0.00	0.00	1.66	0.00	0.51	0.50	0.24	0.63	
	PAL-19	6.4	0.98	0.27	0.23	0.00	0.45	0.41	0.00	0.33	1.19	0.25	2.25	
	PAL-21	14.3	3.18	0.11	0.32	4.52	0.05	3.69	0.00	0.37	0.88	0.39	0.84	
	PAL-26	17.5	0.72	0.12	0.49	6.51	1.61	3.22	0.00	0.35	1.16	0.36	2.94	
Forereef - Shallow	PAL-04	9.9	5.21	0.00	0.26	0.00	0.04	1.56	0.00	0.04	2.00	0.31	0.45	
	PAL-06	1126.5*	3.97	0.00	3.81	30.60	0.11	4.06	1080.88	0.05	0.80	0.40	1.85	
	PAL-16	8.1	3.77	0.00	0.00	0.92	0.13	1.62	0.00	0.03	0.71	0.35	0.63	
	PAL-51	13.0	8.68	0.00	0.21	0.00	0.00	2.70	0.00	0.07	0.58	0.14	0.63	
	PAL-54	5.4	1.42	0.00	0.30	0.00	0.04	0.11	0.00	0.38	0.85	0.23	2.04	
	PAL-56	7.5	5.42	0.00	0.00	0.00	0.00	0.67	0.00	0.07	0.64	0.22	0.46	
	PAL-58	6.4	1.92	0.00	0.68	1.69	0.00	0.02	0.00	0.12	0.49	0.08	1.43	
	PAL-59	6.0	1.21	0.00	0.21	0.00	0.00	0.41	0.00	0.59	0.62	0.26	2.66	
	PAL-60	7.2	1.41	0.00	0.00	1.69	0.00	0.69	0.00	0.44	1.08	0.18	1.70	
Average		9.4	2.3	0.1	0.3	3.2	0.1	1.8	38.6	0.3	0.8	0.3	1.5	

* Manta rays excluded from overall average.

C.4.2 Towed-diver Fish Surveys

During the 2008 RAMP mission, the CRED Towboard team completed 24 surveys at Palmyra Atoll covering 61 km (61 ha) of ocean floor (Table C.4.2.1). Mean survey length was 2.5 km with a maximum length of 3.1 km and a minimum of 1.9 km. Mean survey depth was 14.4 m with a maximum depth of 20.7 m and a minimum of 5.2 m. Mean temperature on these surveys was 26.6 °C with a maximum temperature of 26.8 °C and a minimum of 26.4 °C.

Table C.4.2.1.--Survey statistics for towboard sampling during HI0803.

Island	#	Length (km)					Depth (m)				Temperature (°C)			
		Sum	Mean	Max	Min	SD	Mean	Max	Min	SD	Mean	Max	Min	SD
Jarvis	18	43	2.4	3.4	1.6	0.5	14.6	23.4	7.5	3.9	24.6	24.9	24.3	0.2
Palmyra	24	61	2.5	3.1	1.9	0.3	14.4	20.7	5.2	2.9	26.6	26.8	26.4	0.1
Kingman	21	54	2.6	2.9	2	0.3	14.2	18.7	2.1	4.3	26.8	27.1	26.7	0.1

During surveys at Palmyra, 27 species of fish greater than 50 cm total length (> 50 cm TL) were observed. Overall numeric density for the island was 16.31 individuals per hectare. Overall biomass was 0.24 T/Ha. The five most common species in decreasing order of abundance were: *Lutjanus bohar*, *Chanos chanos*, *Carcharhinus amblyrhynchos*, *Lethrinus olivaceus*, and *Cheilinus undulatus* (Table C.4.2.3). In terms of biomass, the five greatest contributors were: *Chanos chanos*, *Sphyrna lewini*, *Carcharhinus amblyrhynchos*, *Manta birostris*, and *Cheilinus undulatus* (Table C.4.2.4).

Table C.4.2.3--All species of fishes > 50 cm TL encountered at Palmyra Atoll in decreasing order of abundance.

Species	Total	Density
<i>Lutianus bohar</i>	286	4.69
<i>Chanos chanos</i>	229	3.75
<i>Carcharhinus</i>	189	3.1
<i>Lethrinus olivaceus</i>	54	0.89
<i>Cheilinus undulatus</i>	51	0.84
<i>Chlorurus microrhinos</i>	35	0.57
<i>Carcharhinus melanopterus</i>	33	0.54
<i>Naso hexacanthus</i>	18	0.3
<i>Sphyrna lewini</i>	16	0.26
<i>Triaenodon obesus</i>	13	0.21
<i>Caranx melampygus</i>	10	0.16
<i>Aetobatus narinari</i>	7	0.11
<i>Balistoides viridescens</i>	7	0.11
<i>Caranx sexfasciatus</i>	6	0.1
<i>Naso annulatus</i>	6	0.1
<i>Manta birostris</i>	6	0.1
<i>Variola louti</i>	5	0.08
<i>Caranx ignobilis</i>	5	0.08
<i>Naso unicornis</i>	5	0.08
<i>Epinephelus polycephaloides</i>	3	0.05
<i>Pseudobalistes</i>	3	0.05
<i>Epinephelus</i> sp	2	0.03
<i>Anrion virescens</i>	2	0.03

Species	Total	Density
<i>Galeocerdo cuvier</i>	1	0.02
<i>Sphyrna genie</i>	1	0.02
<i>Monotaxis grandoculis</i>	1	0.02
<i>Aluterus scriptus</i>	1	0.02
Palmyra Total	995	16.31

Table C.4.2.4.--All species of fishes > 50 cm TL encountered at Palmyra Atoll in decreasing order of biomass.

Species	Total (T)	Density (T/Ha)
<i>Chanos chanos</i>	6.417	0.11
<i>Sphyrna lewini</i>	2.099	0.03
<i>Carcharhinus amblyrhynchos</i>	1.725	0.03
<i>Manta birostris</i>	1.651	0.03
<i>Cheilinus undulates</i>	0.796	0.01
<i>Lutjanus bohar</i>	0.703	0.01
<i>Galeocerdo cuvier</i>	0.417	0.01
<i>Carcharhinus melanopterus</i>	0.215	0
<i>Lethrinus olivaceus</i>	0.130	0
<i>Triaenodon obesus</i>	0.114	0
<i>Chlorurus microrhinos</i>	0.091	0
<i>Aetobatus narinari</i>	0.083	0
<i>Caranx ignobilis</i>	0.051	0
<i>Naso hexacanthus</i>	0.038	0
<i>Balistoides viridescens</i>	0.023	0
<i>Caranx melampygus</i>	0.021	0
<i>Caranx sexfasciatus</i>	0.018	0
<i>Naso unicornis</i>	0.013	0
<i>Naso annulatus</i>	0.013	0
<i>Pseudobalistes flavimarginatus</i>	0.010	0
<i>Variola louti</i>	0.010	0
<i>Sphyrna genie</i>	0.010	0
<i>Aprion virescens</i>	0.007	0
<i>Epinephelus polyphemadion</i>	0.006	0
<i>Epinephelus sp</i>	0.004	0
<i>Monotaxis grandoculis</i>	0.003	0
<i>Aluterus scriptus</i>	0.000	0
Palmyra Total	14.668	0.24

Numeric distribution of fishes around Palmyra was generally uniform with higher levels at the eastern and western tips and to the west of the channel leading out of the lagoon on the southern side of the atoll (Fig. C.4.2.3). In the east, high numbers of *Carcharhinus amblyrhynchos*, *Lethrinus olivaceus*, *Chanos chanos*, *Lutjanus bohar*, and *Cheilinus*

undulatus were found. In the west and near the mouth of the channel, *Chanos chanos* was the dominant species by number. *Lutjanus bohar* were commonly found in all areas of the atoll.

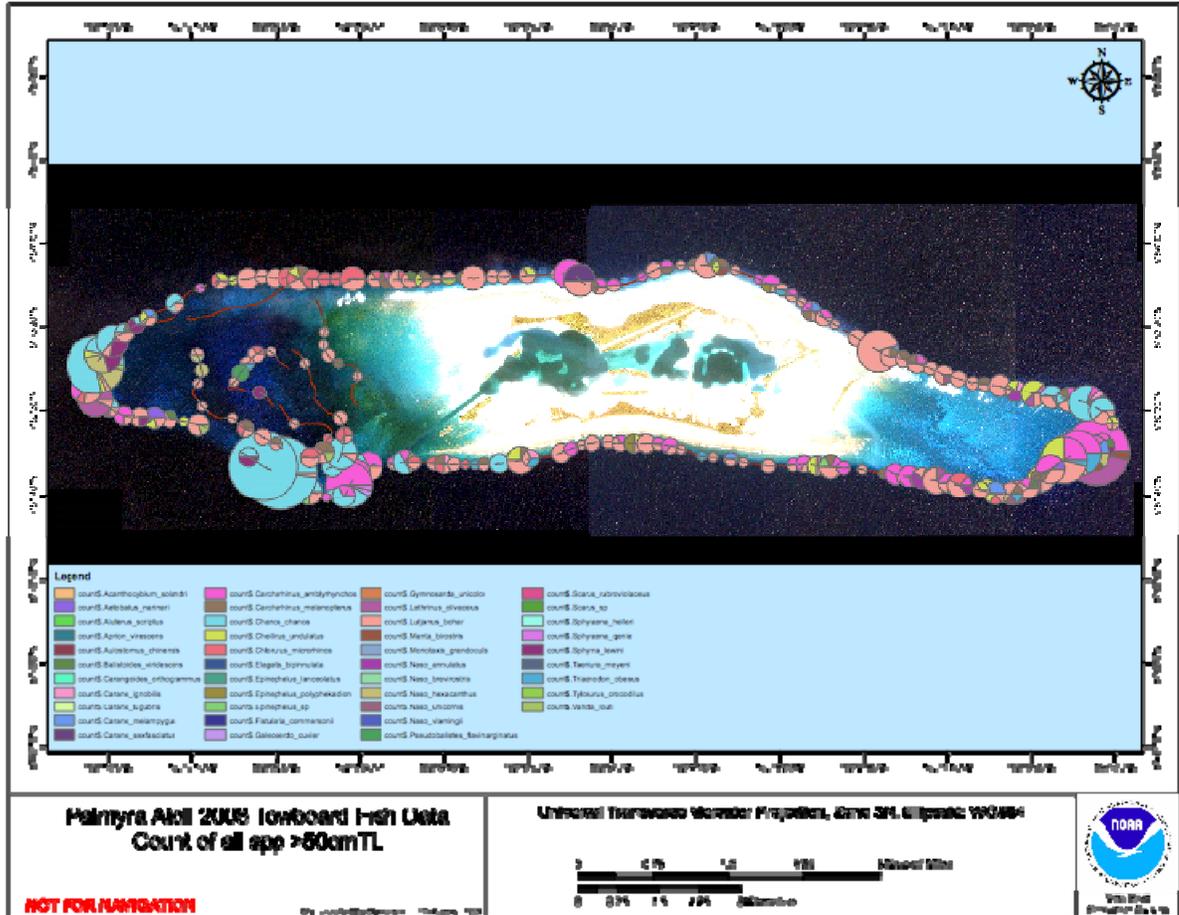


Figure C.4.2.3.--Numeric distribution of all fishes > 50 cm TL around Palmyra Atoll.

Initial observations suggest that the biomass distribution of fishes around Palmyra is concentrated at the eastern and western tips of the atoll and along the southern margin of the western shelf (Fig. C.4.2.4). The highest biomass levels were found along the southern margin of the western shelf just west of the channel leading into the central lagoon. Elevated biomass in this area was due primarily to the observation of large schools of *Chanos chanos*, several large *Sphyrna lewini*, *Manta birostris*, and *Carcharhinus amblyrhynchos* and one large *Galeocerdo cuvier*. High biomass levels at the western tip of the atoll resulted from *Chanos chanos* and *Sphyrna lewini*, while at the eastern tip *Manta birostris*, *Carcharhinus amblyrhynchos*, *Chanos chanos*, and *Cheilinus undulatus* predominated.

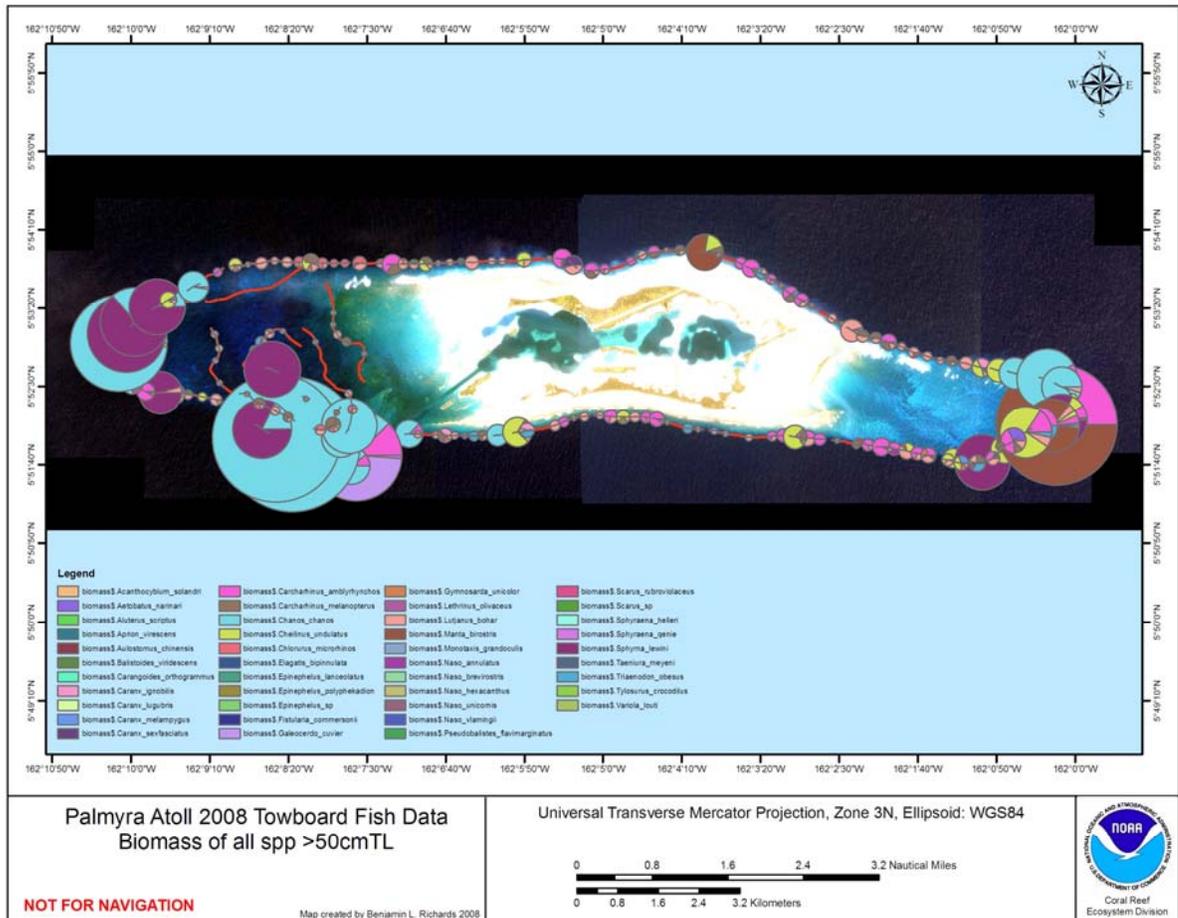


Figure C.4.2.4.--Biomass distribution of all fishes > 50 cm TL around Palmyra Atoll.

Appendix D: Kingman Reef

D.1. Oceanography and Water Quality

Moorings (Fig. D.1.1, Table D.1.1):

A total of seven subsurface temperature recorders (STRs) were recovered and replaced at Kingman Atoll during HI0803. A sea surface temperature (SST) buoy was reinstalled after the previously deployed unit broke free of its mooring. A new ecological acoustic recorder (EAR) was deployed with an STR to the south of the atoll, and two new STRs were deployed on the western slope of the atoll. A single-point current sensor (RCM-9) was deployed in the southeast pass, reestablishing a previous monitoring site of nearshore currents from 2002 to 2004. An Aquadopp acoustic Doppler profiler (ADP) and an STR/pressure sensor were temporarily deployed in the southeast channel and the southeast interior, respectively. These temporary instrument deployments will be used to assess water movements within Kingman Reef.

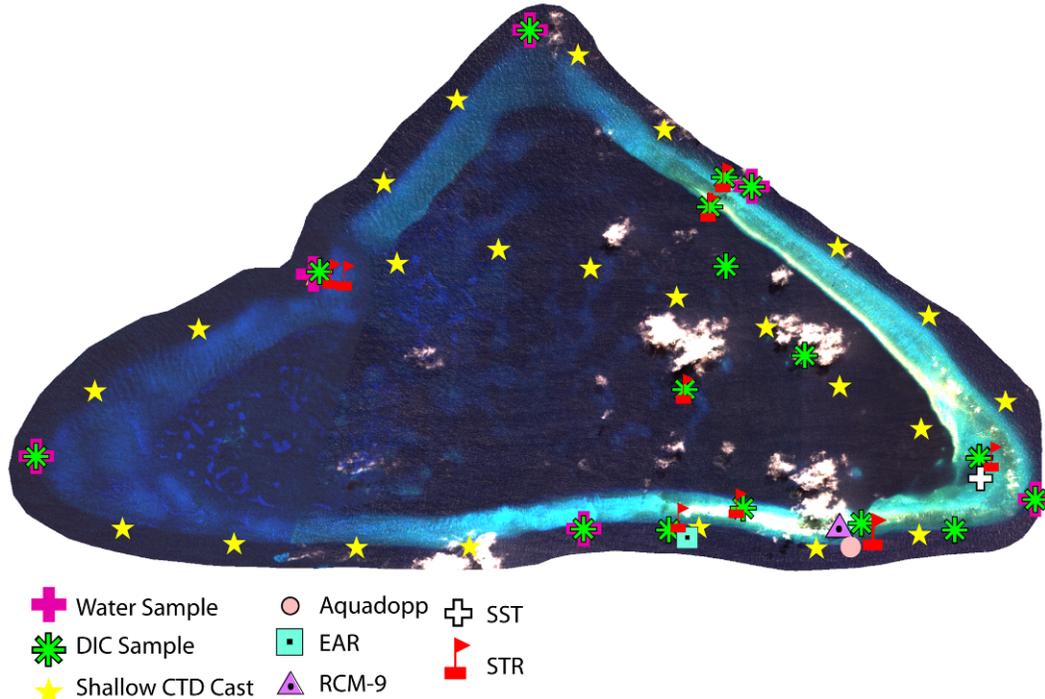


Figure D.1.1.--Moored Oceanographic instrumentation, shallow water conductivity-temperature-depth (CTD), water sampling, and dissolved inorganic compound (DIC) sample locations around Kingman Reef.

Table D.1.1.--Moored Oceanographic Instrumentation Table for Kingman Reef.

Instrument	Serial Number	Latitude	Longitude	Depth (m)	Data Start	Data End
SST	10005694	6 23.5444 N	162 20.5294 W	6.71	MISSING	
STR	3939038-3008	6 22.9484 N	162 23.0637 W	7.01	3/30/2006 0:34	4/4/2008 21:34
STR	3939038-3050	6 22.961 N	162 21.5572 W	4.88	3/29/2006 20:01	4/4/2008 20:01
STR	3939038-3006	6 23.1311 N	162 22.6438 W	3.96	3/30/2006 0:20	4/4/2008 23:20
STR	3939038-3023	6 23.5444 N	162 20.5294 W	6.71	3/29/2006 22:42	4/5/2008 19:12
STR	3939038-3003	6 24.1309 N	162 23.1146 W	10.06	4/2/2006 18:51	4/5/2008 22:51
STR	3939038-3000	6 25.7329 N	162 22.9082 W	5.18	3/30/2006 20:01	4/7/2008 2:01
STR	3939038-3040	6 25.9919 N	162 22.781 W	8.23	3/31/2006 0:26	4/6/2008 0:56
AQUADOPP	NORTEK AQUADOPP	6 22.961 N	162 21.5572 W	4.88	4/4/2008 20:00	4/8/2008 1:00
SBE39TP	3927172-0493	6 23.5468 N	162 20.5257 W	6.10	4/5/2008 1:52	4/8/2008 1:00
EAR	43	6 22.9484 N	162 23.0637 W	7.01	LOGGING DATA	
RCM9	414	6 22.961 N	162 21.5572 W	4.88	LOGGING DATA	
SST	10018192	6 23.5444 N	162 20.5294 W	6.71	LOGGING DATA	
STR	3948689-3906	6 22.9484 N	162 23.0637 W	7.01	LOGGING DATA	
STR	3948689-3912	6 22.961 N	162 21.5572 W	4.88	LOGGING DATA	
STR	3948689-4032	6 23.1311 N	162 22.6438 W	3.96	LOGGING DATA	
STR	3948689-4042	6 23.5444 N	162 20.5294 W	6.71	LOGGING DATA	
STR	3948689-4034	6 24.1309 N	162 23.1146 W	10.06	LOGGING DATA	
STR	3948689-4037	6 25.0926 N	162 26.3256 W	17.68	LOGGING DATA	
STR	3948689-4031	6 25.1324 N	162 26.3486 W	32.92	LOGGING DATA	
STR	3947493-3490	6 25.7329 N	162 22.9082 W	5.18	LOGGING DATA	
STR	39474930-3485	6 25.9919 N	162 22.781 W	8.23	LOGGING DATA	

Preliminary Mooring Results

The seven STRs recovered from Kingman Reef yielded quality data sets (Fig. D.1.2). Between March 2006 and April 2008, subsurface water temperatures around Kingman Reef revealed typical seasonal variability for these latitudes with an interesting perturbation in temperature coinciding with the La Niña event which started in December 2007. Temperature lows generally occur during February-June (~27 °C) and highs between August and December (~30 °C). All STR data sets are similar in trend, regardless of deployment location, suggesting that the oceanic influences affecting Kingman Reef are the same whether inside or outside the lagoon.

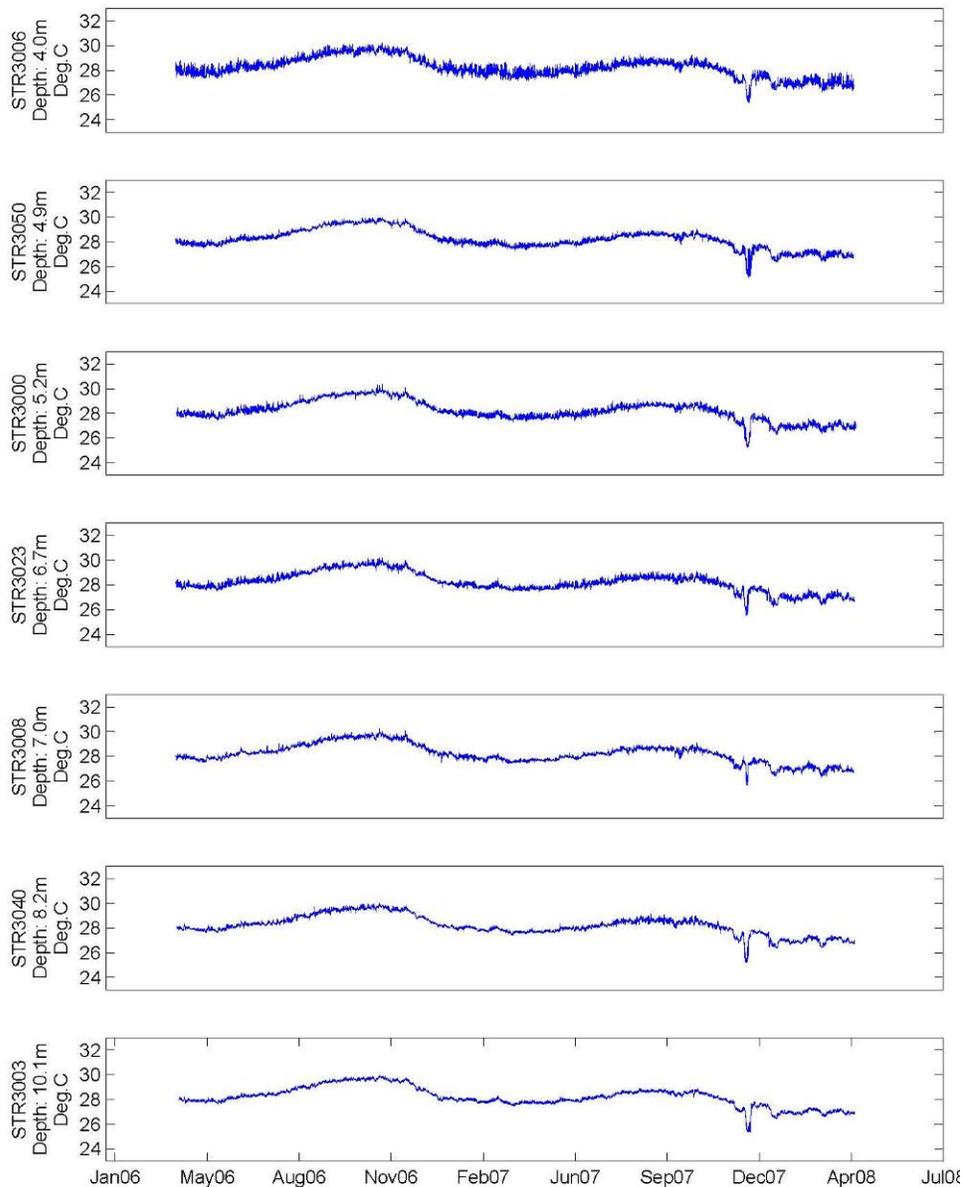


Figure D.1.2.--Temperature data obtained from seven STR locations around Kingman Reef.

Water Quality

Twenty-nine shallow water CTDs were conducted at the 30-m bathymetric contour around Kingman Reef at 2-km intervals (Fig. D.1.3). Shallow water CTD casts were conducted between April 6 and 7, 2008 (UTC). Discrete water samples from a daisy chain of Niskin bottles at 1-m, 10-m, 20-m and 30-m depth bins were collected concurrently with shallow water CTD casts at six of the shallow water CTD sites. A total of 24 NUT and 24 CHL samples were collected, processed, and stored according to protocol and will be sent out for analysis following the cruise. Additionally, at all water sample locations surrounding Kingman Atoll, carbonate chemistry (alkalinity and total DIC) water samples were recovered from the 10-m Niskin bottle.

In addition to the standard set of shallow-water water quality sampling, a set of one surface and three near-bottom (< 200 cm) carbonate chemistry (alkalinity and total DIC) water samples at 12 sites were hand collected from across a range of geomorphological reef zones, benthic habitat types and depths (5 m–22 m). A Seabird 19+ CTD with a SBE43 dissolved oxygen sensor was deployed concurrently with the water collections, and salinity samples were regularly collected to aid in the calibration of the CTD 19+. One shallow lagoon site (6 23.5441 N, 162 20.5299 W) was visited near high tide and again near low tide to assess temporal variations in carbonate chemistry. All carbonate chemistry samples were immediately treated with saturated mercuric chloride and sealed in 500 cm³ high quality borosilicate glass bottles equipped with positive closure according to the protocols of Dickson et al. (2007) and will be shipped to NOAA Pacific Marine Environmental Laboratory for post-cruise analysis.

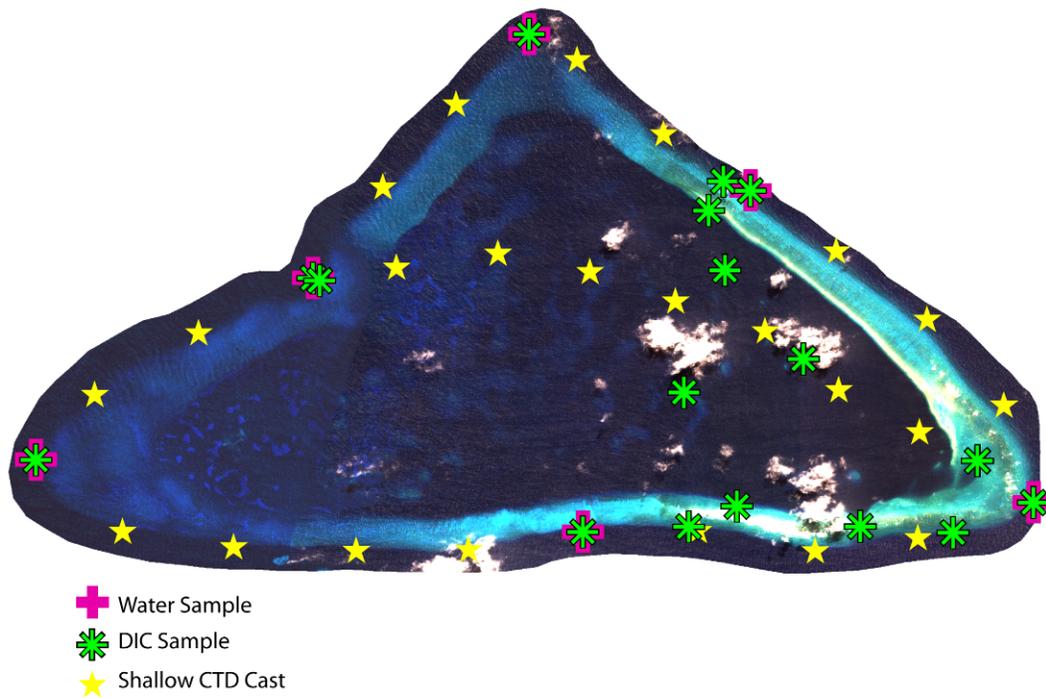


Figure D.1.3.--Shallow water CTD and water sampling locations around Kingman Reef.

Table D.1.2.--Benthic carbonate chemistry water sampling table for Kingman Reef.

Benthic Site	Start Cast	End Cast	Latitude	Longitude	Alk/DIC	Salinity	Replicates	Depth Range (m)
1	HI0803_DIC_KIN001	HI0803_DIC_KIN004	6 22.9484 N	162 23.0637 W	4	4	0	6 - 7
2	HI0803_DIC_KIN006	HI0803_DIC_KIN009	6 23.1311 N	162 22.6438 W	5	2	1	7 - 8
3	HI0803_DIC_KIN010	HI0803_DIC_KIN013	6 23.5468 N	162 20.5257 W	4	2	0	6 - 8
4	HI0803_DIC_KIN014	HI0803_DIC_KIN017	6 23.5441 N	162 20.5299 W	5	2	1	5 - 6
5	HI0803_DIC_KIN018	HI0803_DIC_KIN021	6 24.13 N	162 23.1148 W	4	2	0	10 - 11
6	HI0803_DIC_KIN022	HI0803_DIC_KIN025	6 25.2093 N	162 22.763 W	4	2	0	7 - 15
7	HI0803_DIC_KIN026	HI0803_DIC_KIN029	6 25.9922 N	162 22.782 W	5	1	1	9 - 11
8	HI0803_DIC_KIN037	HI0803_DIC_KIN040	6 25.733 N	162 22.9078 W	5	0	1	6 - 22
9	HI0803_DIC_KIN041	HI0803_DIC_KIN044	6 24.4316 N	162 22.0652 W	4	0	0	21 - 22
10	HI0803_DIC_KIN045	HI0803_DIC_KIN048	6 25.0926 N	162 26.3256 W	5	2	1	18 - 18
11	HI0803_DIC_KIN049	HI0803_DIC_KIN052	6 22.961 N	162 21.5572 W	4	2	0	5 - 7
12	HI0803_DIC_KIN053	HI0803_DIC_KIN056	6 22.9104 N	162 20.739 W	5	2	1	9 - 13

Twenty-four standard shipboard CTD casts were conducted near Kingman Reef (Fig. D.1.4). Shipboard CTD casts 037-060 were conducted at the four cardinal points around the reef between April 4 and 8, 2008 (UTC) to 300 m depth. Water samples were collected at 3, 80, 100, 125 and 150 m for NUT analysis. Water samples for NUT were collected at all but 4 CTD locations, a total of 70 NUT samples. Samples were collected, processed, and stored according to protocol and will be sent out for analysis following the cruise. Additionally, ADCP lines were run between the shipboard CTD casts. Besides the standard 300-m shipboard CTD casts, 14 shipboard casts were used to collect offshore samples for carbonate chemistry analyses, with water samples collected at the surface (2 m) and below the mixed layer depth (100–150 m). Nutrient samples were often collected concurrently with the carbonate chemistry samples. Salinity samples were also recovered at regular intervals to aid in the calibration of the shipboard CTD.

In addition to sampling carbonate chemistry about the cardinal directions of Kingman Atoll out to a distance of 25 km, a 100-km transect was performed during the return transit back to port. This transect consisted of four CTD/Niskin cast at 25-km intervals where carbonate chemistry samples were collected at the surface (2 m) and below the mixed layer depth (150 m) with salinity collected at regular intervals. This transect will aid in satellite algorithm development and validation as part of an effort being advanced by NOAA/National Environmental Satellite, Data, and Information Service Coral Reef Watch. During one of these casts, the rosette was outfitted with the CTD +19 so as to provide for calibration against the shipboard CTD and precision salinity samples.

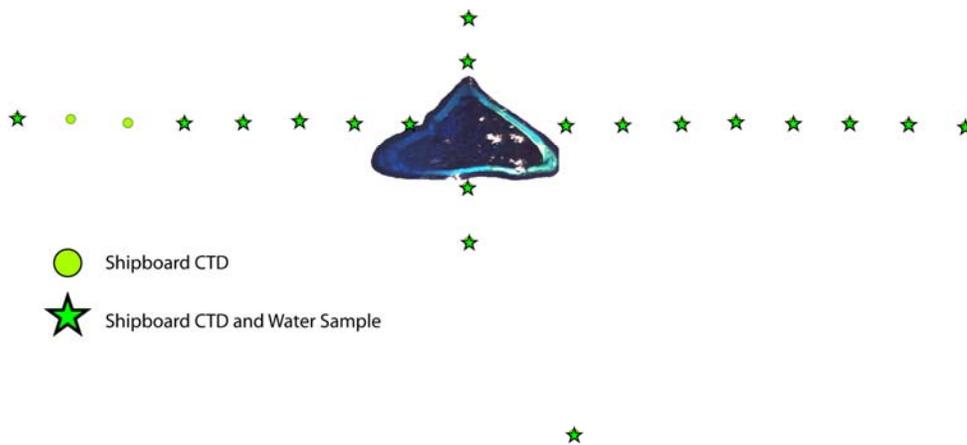


Figure D.1.4.--Shipboard CTD locations around Kingman Reef during HI0803.

D.2. Rapid Ecological Assessment (REA) Site Descriptions

Twenty three REA (Rapid Ecological Assessment) sites were visited by a team of up to eight scientists around Kingman Reef between April 4 and 7, 2008. Twelve of those sites were only surveyed by the fish scientists in additional depth ranges outside. The site locations can be seen in Figure D.2.1, and the survey dates and efforts can be seen in Table D.2.1 (benthic surveys) and Table D.2.2 (Fish surveys). Individual site descriptions are included for the following discipline communities: coral, coral and coralline disease, macroinvertebrates, algae, and fish.

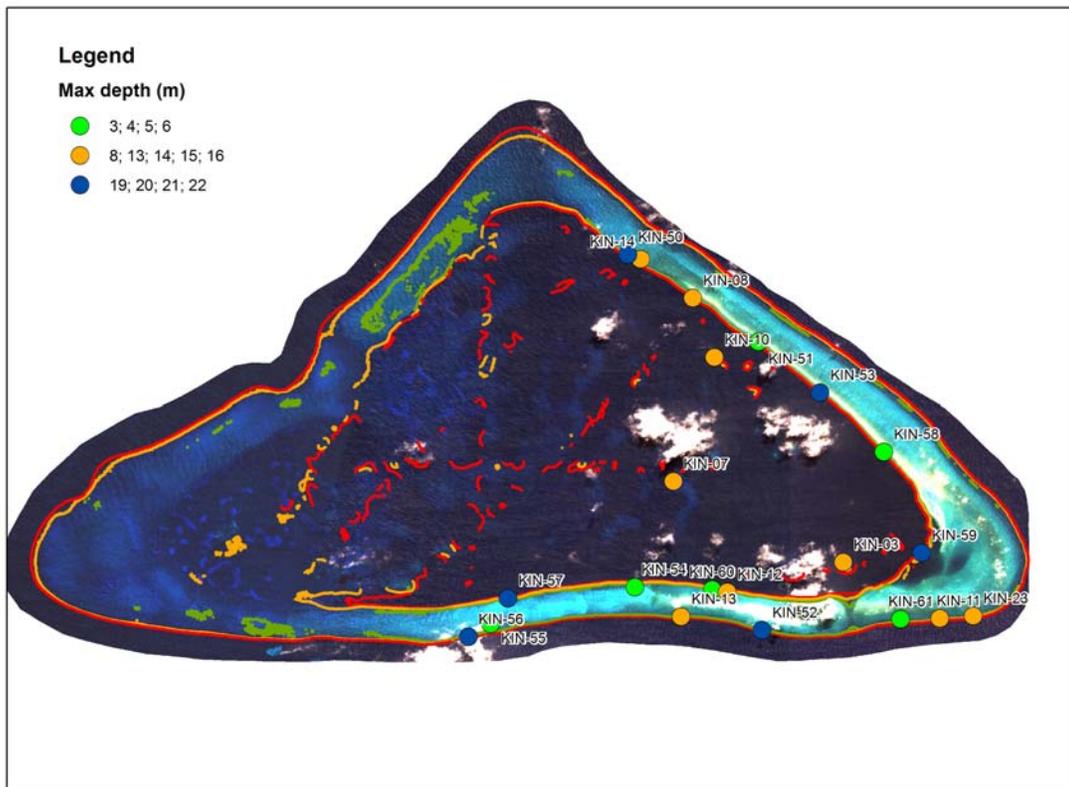


Figure D.2.1.--Kingman Reef 2008 REA site locations.

Table D.2.1.--Kingman Reef 2008 benthic REA site survey dates, teams present and additional comments. All dives were conducted in the forereef stratum.

Site ID	Date	Teams Present	Comments
KIN-12	4/4/2008	Coral, Disease, Algae, Invertebrate	
KIN-14	4/4/2008	Coral, Disease, Algae, Invertebrate	
KIN-23	4/4/2008	Coral, Disease, Algae, Invertebrate	*ARMS
KIN-08	4/5/2008	Coral, Disease, Algae, Invertebrate	
KIN-13	4/5/2008	Coral, Disease, Algae, Invertebrate	ARMS
KIN-10	4/5/2008	Coral, Disease, Algae, Invertebrate	
KIN-11	4/6/2008	Coral, Disease, Algae, Invertebrate	

Site ID	Date	Teams Present	Comments
KIN-07	4/6/2008	Coral, Disease, Algae, Invertebrate	
KIN-05	4/6/2008	Coral, Disease, Algae, Invertebrate	
KIN-03	4/7/2008	Coral, Disease, Algae, Invertebrate	
KIN-16	4/7/2008	Coral, Disease, Algae, Invertebrate	Partial survey due to diver recall

*Autonomous Reef Monitoring Systems

Table D.2.2.--Kingman Reef fish survey sites 2008. At each site two 25 m X 4 m belt transects (BLT) and two 7.5-m radius circular plot point counts (nSPC's) were performed unless otherwise noted.

Site	Date	Depth (m)	Strata	Divers/Reps
KIN-03	04/07/2008	14	Lagoon Mid	1 nSPC
KIN-05	04/06/2008	12	Backreef Mid	
KIN-07	04/06/2008	13	Lagoon Mid	
KIN-08	04/05/2008	12	Backreef Mid	
KIN-10	04/05/2008	13	Lagoon Mid	
KIN-11	04/06/2008	12	Forereef Mid	
KIN-12	04/04/2008	13	Backreef Mid	
KIN-13	04/05/2008	9	Forereef Mid	
KIN-14	04/04/2008	13	Backreef Mid	
KIN-16	04/07/2008	6	Forereef Shallow	1 REP
KIN-23	04/04/2008	13	Forereef Mid	1 nSPC
KIN-50	04/04/2008	21	Backreef Deep	
KIN-51	04/04/2008	4	Backreef Shallow	
KIN-52	04/04/2008	21	Forereef Deep	1 nSPC
KIN-53	04/05/2008	19	Backreef Deep	1 nSPC
KIN-54	04/05/2008	5	Backreef Shallow	
KIN-55	04/05/2008	6	Forereef Shallow	
KIN-56	04/06/2008	20	Forereef Deep	1 nSPC
KIN-57	04/06/2008	19	Backreef Deep	
KIN-58	04/06/2008	3	Backreef Shallow	
KIN-59	04/07/2008	22	Backreef Deep	
KIN-60	04/07/2008	3	Backreef Shallow	
KIN-61	04/07/2008	3	Forereef Shallow	

Site Descriptions:

April 04, 2008

KIN-14

N 6° 43.408, W 162° 38.991

Depth range: 11–13 m

This site was found on the northern backreef in abundant coral rubble. Point count survey found live coral cover to be 8%, mainly composed of *Porites*, *Favia stelligera*, and *Fungia*. Percent coralline algal cover represented over 65% and macroalgae only 2%. Turf algae-covered rubble and pavement accounted for nearly 20% of the benthic cover. Dominated by turf and crustose coralline red algae with a low percent cover of *Halimeda taenicola* and *Halimeda fragilis*. Coral disease and health assessment studies found one case of bleaching on *Porites* sp., one case of discoloration on *Porites* sp., two cases of predation on *Porites* sp., and one case of tissue loss on *Porites* sp. in a ~ 300 m² survey area. The dominant macroinvertebrates were the anemone *Heteractis magnifica* and the holothuroids *Actinopyga obesa*, *Holothuria atra*, *Holothuria edulis*, *Stichopus chloronotus*, *Bohadschia argus*, and *Thelenota ananas*. It was noted that the corallimorpharians *Rhodactis howseii* was common at shallow depths of 15-20 feet. A single predatory strombid gastropod, *Lambis crocata*, was collected at this site. The fish community was fairly basic at this site. The rubble zone had small groups of damsel fish (*Pomacentrus coelestis*) and very few medium-large individuals (mostly *Chlorurus microrhinos*). However, the fish community was slightly more diverse off-transect, in the shallower portion of the site; three to four gray reef sharks were observed.

KIN-12

N 6° 38.600, W 162° 37.784

Depth range: 12–14.5 m

This site was found on the south backreef/patch reef. Point count survey found live coral cover to be 19%, mainly composed of *Porites* cf. *lobata* and *Montipora capitata*. Percent coralline algal cover represented 20% and macroalgae only 3%. Turf algae-covered rubble and pavement accounted for nearly 32% of the benthic cover. Dominated by turf and crustose coralline red algae with a low percent cover of *Halimeda opuntia*. Coral disease and health assessment studies found one case of bleaching on *Porites* sp., one case of discoloration on *Porites* sp., two cases of predation on *Porites* sp., and one case of pink line/spot syndrome on *Porites* sp. in a ~ 210 m² survey area. *Tridacna maxima* were very abundant, as were holothuroids and echinoids. The holothuroids were *Bohadschia graeffii*, *Bohadschia argus*, *Actinopyga obesa*, and *Euapta*. The echinoids *Echinothrix calamaris* and *Echinothrix diadema* were present, with the later being most abundant at depths ranging from 15 to 20 feet. The bivalve *Spondylus* was common and the predatory gastropod *Cassia cornuta* was rare. The anemones *Heteractis magnifica* and *Phymanthus* were present, with the former being common and the later being rare. The fish community was characterized by a fair number of medium-large fish (wrasses, surgeons, parrotfish) with three to four gray reef sharks sighted.

KIN-23

N 6 ° 22.945, W 162 ° 20.475

Depth range: 11–13 m

This site was found on the southeast corner of the forereef. Point count survey found live coral cover to be 33%, mainly composed of *Favia stelligera*, *Porites* spp., and *Pocillopora* spp.; and *Pavona duerdeni*. Other scleractinian genera present along the line point intercept (LPI) transects included: *Acropora*, *Hydnophora*, and *Montipora*. Percent coralline algal cover represented 30% and macroalgae only 2%. Turf algae-covered rubble and pavement accounted for nearly 27% of the benthic cover. Dominated by turf algae with a low percent cover of *Halimeda fragilis*. Coral disease and health assessment studies found 1 case of bleaching on *Hydnophora microconos*, 1 case of discoloration on *Porites* sp., 1 case of pink line/spot syndrome on *Porites* sp., 2 cases of tissue loss on *Hydnophora* cf. *exesa* and *Acropora nobilis*, 1 case of white syndrome on *Acropora hyacinthus*; and 12 cases of coralline fungal disease in a ~ 140 m² survey area. The echinoid, *Echinothrix*, was abundant. Trapezid crabs and hermit crabs were common. The corallivore, *Acanthaster planci*, was rare. The hydroid, *Distichopora*, was abundant. Large fish were particularly abundant here (mainly *Chlorurus microrhinos*), with an exceptional number of gray reef sharks (15–20 individuals). Smaller fish were also abundant (damselfish and wrasses).

KIN-50

N 5 ° 26.132, W 162 ° 23.529

Depth range: ~ 21 m

This site is located on the northeast backreef of Kingman Reef. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had low coral cover with low reef complexity. The substrate here was composed almost entirely of rubble. Coral cover was less than 1%. The fish community here was depauperate and was composed primarily of smaller pomacentrids and labrids. Grey reef sharks made several appearances on and off transect.

KIN-51

N 5 ° 25.361, W 162 ° 22.375

Depth range: ~ 4 m

This site is located on the northeast backreef of Kingman Reef. It was established by the REA fish team as a new sampling location in the backreef shallow stratum. The site had high coral cover with medium/low reef complexity. Unusually high numbers of the wrasse, *Thalassoma amblycephalum*, were observed at this site. Grey reef and whitetip reef sharks made several appearances, as did two *Manta birostris*.

KIN-52

N 5 ° 22.812, W 162 ° 22.342

Depth range: ~ 21 m

This site is located on the south forereef of Kingman Reef. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had high coral cover with medium/high reef complexity. Unusually high numbers of soldierfish were observed here, taking cover under large *Acropora* plates. Three individual species

were recorded: *M. berndti*, *M. kuntee*, *M. amaena*. Small chromis, however, were the most abundant overall fish. Grey reef sharks were common.

April 5, 2008

KIN-08

N 6 ° 42.877, W 162 ° 38.208

Depth range: 12–14.5 m

This site was found on the internal backreef. Point count survey found live coral cover to be 14%, mainly composed of *Porites* cf. *lobata* and *Turbinaria reniformis*. Percent coralline algal cover represented 25% and macroalgae only 6%. Turf algae-covered rubble and pavement accounted for nearly 37% of the benthic cover. Dominated by crustose coralline red algae with a low percent cover of *Halimeda opuntia*, *Halimeda taenicola*, and *Caulerpa cupressoides*. Coral disease and health assessment studies found one case of bleaching on *Porites* sp., three cases of snail predation on *Porites* cf. *lobata*, five cases of *Acanthaster* predation on *Porites*, *Favia*, *Montipora* and *Echinophyllia*, and one case of barnacle infestation on *Porites* sp.. in a ~ 200 m² survey area. The site had abundant giant clams and echinoderms throughout. Both *Tridacna maxima* and *Tridacna squamosa* were present, and there was a solitary sighting of an octopus. The holothuroids *Holothuria atra*, *Actinopyga obesa*, *Bohadschia argus*, *Bohadschia graeffii*, and *Thelonota ananas* were common throughout the site. Fish species diversity was fairly high at this site, with typical community composition. Small pomacentrids were the most numerous, with *Pomacentrus coelisticus* and *Chromis margaritifer* dominating. *Chromis lepidolepis* was also recorded here, which was previously a rarely sighted species.

KIN-10

N 6 ° 42.014, W 162 ° 37.960

Depth range: 12–13.5 m

This site was found on the northern patch reef. Point count survey found live coral cover to be 49%, mainly composed of *Porites* spp., but also *Fungia*, and *Favia* spp. Percent coralline algal cover represented 40% and macroalgae only 1%. Turf algae-covered rubble and pavement accounted for nearly 4% of the benthic cover. Dominated by crustose coralline red algae with a low percent cover of *Halimeda taenicola* and *Caulerpa cupressoides*. Coral disease and health assessment studies found two cases of bleaching on *Porites* sp., four cases of snail predation on *Porites* cf. *lobata*, one case of discoloration and tissue loss (potential predation) on *Porites* cf. *lobata*, two cases of pink line/spot on *Porites* cf. *lobata*, and one case of skeletal growth anomaly on *Porites* cf. *lobata* in a ~ 180 m² survey area. This site was dominated by the giant clam *Tridacna maxima*, with a rare occurrence of *Tridacna squamosa*. The urchin *Echinothrix diadema* was abundant, while the other echinoid *Heterocentrotus* was rare in the depth zone being surveyed. Crown-of-thorns sea stars were seen at shallower depths than the survey site. The anemone *Heteractis magnifica* was common above 30 feet. Fish species diversity was low at this site. A school of *Caesio teres* was partially recorded on-transect, and high numbers of *Chromis xanthura* were observed within the survey area. Of note was one on-transect recording of *Triaenodon obesus*.

KIN-13

N 6 ° 38.219, W 162 ° 38.429

Depth range: 12–14.5 m

This site was found on the southern external backreef. Point count survey found live coral cover to be 40%, diverse community, mainly composed of *Pocillopora meandrina*; *Favia stelligera*, *Porites* spp., *Fungia*, *Acropora* and *Montipora*. Percent coralline algal cover represented 35% and macroalgae 22%. Coral disease and health assessment studies found one case of tissue loss (white band) on *Acropora nobilis*, two cases of predation on *Porites* cf. *lobata* and *Montipora* sp., and three cases of coralline fungal disease in a ~ 140 m² survey area. This site had less echinoderms compared to the two previous sites. The dominant species was the echinoid *Echinothrix diadema* with moderate numbers of the holothuroids *Holothuria atra* and *Bohadschia graeffii*. Fish species diversity was fairly high at this site. A school of *Caesio teres* was recorded on-transect. In terms of small fish, *Pseudanthias olivaceous* was the only species present in unusually large numbers.

KIN-53

N 5 ° 24.909, W 162 ° 21.829

Depth range: ~ 19 m

This site is located on the east backreef of Kingman Reef. It was established by the REA fish team as a new sampling location in the backreef deep stratum. The site had low coral cover with low reef complexity. At KIN-50, fish diversity and abundances were low. Very small pomacentrids, including *Pomacentrus coelestis* and *Dascyllus auripinnis* were the only fish counted in appreciable numbers.

KIN-54

N 5 ° 23.195, W 162 ° 23.468

Depth range: ~ 5 m

This site is located on the east backreef of Kingman Reef. It was established by the REA fish team as a new sampling location in the backreef shallow stratum. The site had low to medium coral cover with medium reef complexity, with coral, rubble, and crustose coralline algae comprising the substrate. Although fish diversity was moderate, fish abundances were low; *Chromis vanderbilti* were the most abundant fish, and even these were counted in modest numbers.

KIN-55

N 5 ° 22.869, W 162 ° 24.740

Depth range: ~ 6 m

This site is located on the south forereef of Kingman Reef. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had low coral cover with low reef complexity, comprised of small patches of coral, rubble, sand, and green macroalgae. *Thalassoma amblycephalum* was the most abundant fish present, followed by *Chromis vanderbilti*. Larger fish were not common with the exception of two patrolling grey reef sharks and a school of fusiliers that traversed the transect.

April 6, 2008

KIN-07

N 6 ° 40.251, W 162 ° 38.551

Depth range: 13.5–14.5 m

This site was found on a central lagoonal patch reef. Point count survey found live coral cover to be 34%, mainly composed of *Porites* spp. and *Favia* spp. Percent coralline algal cover represented 22%, macroalgae 4%, and turf algae-covered pavement and rubble accounted for 21% of the benthic cover. Dominated by crustose coralline red algae, *Halimeda opuntia* and *Halimeda fragilis*. Coral disease and health assessment studies found one case of pink line/spots on *Porites*, one case of barnacle infestation on *Porites*, one case of skeletal growth anomaly on *Porites*, three cases of predation on *Porites* cf. *lobata* and *Turbinaria reniformis*, and one case of coralline fungal disease in a ~ 300 m² survey area. This site was characterized by low coral cover with high abundance of holothuroid echinoderms. The holothuroids represented were primarily *Holothuria atra* and *Actinopyga obesa*, but *Bohadschia argus* and *Bohadschia graeffii* were also present. The urchin *Echinothrix calamaris* was present in moderate numbers, while the sea star *Acanthaster planci* was uncommon. There was a rare occurrence of the helmet shell *Cassis cornuta*, and *Tridacna maxima* was occasional. Fish species diversity and abundance were low at this site. *Chlorurus microrhinos* and *Ctenochaetus striatus* were fairly numerous, however. Five species of scarids were represented, but absent were the high numbers of pomacentrids.

KIN-05

N 6 ° 39.342, W 162 ° 34.762

Depth range: 12.5–14.5 m

This site was located on a southeastern lagoonal patch reef. Point count survey found live coral cover to be 23%, mainly composed of *Porites* spp. Percent coralline algal cover represented 14%, macroalgae 7%, and turf algae-covered pavement and rubble accounted for 35% of the benthic cover. Dominated by turf algae with a low percent cover of *Halimeda opuntia*. Coral disease and health assessment studies found only one case of skeletal growth anomaly on *Porites*. However, many colonies exhibited *Acanthaster* predation scars and were stricken by algal infections. In an area of approximately 80 m², a total of 44 *Acanthaster* scars were counted, ~ 90% of which occurred on *Porites* and the rest on *Fungia*, *Montipora*, *Astreopora*, and *Psammocora*. In addition, within the ~300 m² coral disease survey area, a total of 11 COTS were counted. The giant clam *Tridacna maxima* was very abundant throughout depths from 50 to 15 ft deep. The urchins *Diadema setosum* and *Echinothrix calamaris* were the next most dominant macroinvertebrates at the site. The predatory sea star *Acanthaster planci* was common at the 50–35 ft depth range. The anemones *Heteractis magnifica* and *Heteractis* sp. were common throughout the depth range of 50–15 feet. The cryptic anemones *Phymanthus* and *Cryptodendrum* were rare at the site. Fish species diversity was low at this site. Gray reef sharks were very numerous, however, with several recorded within the survey area. *Dascyllus auripinnis* was common, aggregating in small groups around individual anemones. Of note was the sighting of the small wrasse, *Labropsis unilineatus*.

KIN-11

N 6 ° 38.191, W 162 ° 34.562

Depth range: 12.5–14 m

This site was located on the southeastern backreef. Point count survey found live coral cover to be 33%, diverse community, mainly composed of *Porites* cf. *lobata*, *Favia* spp., *Pocillpora* spp., and *Fungia* spp. Percent coralline algal cover represented 29% macroalgae 8%, and turf algae-covered rubble and pavement 10%. Dominated by *Halimeda opuntia* and crustose coralline red algae with a low percent cover of *Halimeda taenicola* and *Halimeda fragilis*. Coral disease and health assessment studies found 1 case of tissue loss (white band) on *Acropora nobilis*, 1 case of discoloration on *Porites* cf. *lobata*, 1 case of skeletal growth anomaly on *Porites*, 1 case of tubeworm infestation on *Hydnophora cf. exesa*, and 11 cases of coralline fungal disease in a ~ 200 m² survey area. The soft coral *Sinularia* was common, as were the urchins *Echinothrix calamaris* and *Echinothrix diadema*. Tridacnid clams were rare, as were the holothuroids *Bohadschia graeffii* and *Bohadschia argus*. The hydrozoans *Distichopora* and *Stylaster* were common throughout the site. There was a rare occurrence of the anemones *Heteractis magnifica* and *Cryptodendrum adhaesivum*. Fish species diversity was high at this site. Abundance was fairly evenly distributed, with no species in particular dominating. Gray reef sharks were present, with several individuals recorded on-transect.

KIN-56

N 5 ° 22.754, W 162 ° 24.938

Depth range: ~ 20 m

This site is located on the south forereef of Kingman Reef and was typical of this side of the island. It was established by the REA fish team as a new sampling location in the forereef deep stratum. The site had high coral cover with medium reef complexity. Sharks and other large fish were common here.

KIN-57

N 5 ° 23.094, W 162 ° 24.587

Depth range: ~ 19 m

This site is located on the south backreef of Kingman Reef. It was established by the REA fish team as a new sampling location in the backreef deep stratum. The site had zero coral cover with very low reef complexity. The site was a large rubble field, similar to other deep sites on the Kingman backreef. Small fish were practically absent (a few wrasses, damselfish). However, many large fish were recorded, especially towards the end of the transects, which was more solid reef habitat (*Microrhinos*, *Lutjanus gibbus*, sharks, etc.).

KIN-58

N 5 ° 24.391, W 162 ° 21.266

Depth range: ~ 3 m

This site is located on the east backreef of Kingman Reef. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had high coral cover with high reef complexity. This site is located just north of the shipwreck. Many small and large fish were present with a moderate abundance of gray reef sharks.

April 7, 2008

KIN-03

N 6 ° 38.986, W 162 ° 36.076

Depth range: 12.7–13.6 m

The site was located at the southeastern patch reef. Point count survey found live coral cover to be 8%, mainly composed of *Porites* cf. *lobata*. Percent coralline algal cover represented 25% macroalgae 8%, and turf algae-covered rubble and pavement 42%. Dominated by turf and crustose coralline red algae. Coral disease and health assessment studies found 1 case of discoloration on *Porites* cf. *lobata* and 12 cases of bleaching on *Turbinaria reniformis*, *Sinularia*, *Porites*, and *Astreopora* in a ~ 300 m² survey area. Holothuroid echinoderms and tridacnid clams were the dominant macroinvertebrates. The holothuroids present were *Holothuria atra*, *Holothuria edulis*, *Holothuria hilla*, *Holothuria whitmaei*, *Bohadschia paradoxa*, *Bohadschia argus*, *Bohadschia graeffii*, *Thelonota ananas*, *Stichopus chloronotus*, *Actinopyga obsesa*, and *Euaptia*. The asteroid echinoderms were *Fromia millepora*, *Linckia guildingi*, and *Acanthaster planci* were present. An urchin species, tentatively assigned the genus *Echinometra*, was very abundant under rubble. *Tridacna maxima* were present in above average abundances, while the large predatory gastropod *Lambis lambis* was rare. The anemones *Heteractis magnifica*, *Heteractis* sp., *Cryptodendrum adhaesivum* and *Phymanthus* were all present, with the first two being the most abundant. This site had low fish diversity and abundance, with small pomacentrids (*Pomacentrus coelestis*) most common. Large fish were virtually absent, with the exception of a single *Scarus frenatus*.

KIN-16

N 6 ° 39.216, W 162 ° 34.263

Depth range: 6–7 m

This site was found on the southeastern lagoonal patch reef. Point count survey found live coral cover to be 65%, mainly composed of *Porites* cf. *lobata*, but also *Fungia* spp., and *Montipora* spp. Percent coralline algal cover represented 5%, macroalgae 2%, and turf algae-covered rubble and pavement 2%. Low percent cover of *Halimeda taenicola* and crustose coralline red algae. Coral disease and health assessment studies completed a partial disease assessment due to diver recall; five cases of tissue loss on *Porites* cf. *lobata* in a ~ 50 m² survey area. The dominant macroinvertebrate was the giant clam *Tridacna maxima*, which had amazingly high densities throughout the site. The urchins, *Echinometra*, *Diadema setosum*, and *Echinothrix calamaris* were common throughout the site. This beautiful site, though rich in invertebrate life, was depauperate of fish. A single large *Lutjanus bojar* was observed on transect; an interesting sighting off transect was a pair of the spadefish *Platax orbicularis*.

KIN-59

N 5 ° 23.498, W 162 ° 20.932

Depth range: ~ 22 m

This site is located on the southeast corner of the Kingman backreef; visibility was low. It was established by the REA fish team as a new sampling location in the backreef deep stratum. The site had medium coral cover (surprising amount of fungiids) with medium

reef complexity. Very few small fish were observed overall, despite relative quality of reef. Mostly large fish were seen, including many gray reef sharks.

KIN-60

N 5 ° 23.171, W 162 ° 22.782

Depth range: ~ 3 m

This site is located on the south backreef of Kingman Reef, just off a sand/rubble island. It was established by the REA fish team as a new sampling location in the backreef shallow stratum. The site had high coral cover (e.g., acroporids) with medium reef complexity. This site is a beautiful reef with clear water and many small fish (e.g., damselfish). Three large milkfish (*Chanos chanos*) were seen off transect.

KIN-61

N 5 ° 22.910, W 162 ° 21.119

Depth range: ~ 3 m

This site is located on the south forereef of Kingman Reef, east of the south channel. It was established by the REA fish team as a new sampling location in the forereef shallow stratum. The site had high coral cover (e.g., acroporids) with medium reef complexity. This site is a beautiful reef with clear water and many small fish (e.g., damselfish).

D.3. Benthic Environment

D.3.1. Algae

Quantitative algal surveys were conducted at 10 sites at Kingman Reef, including 2 forereef, 3 backreef and 5 patch reef sites. Only a qualitative survey was conducted at site KIN-05. All sites exhibited relatively high macroalgal cover (Table D.3.1.1). Macroalgal diversity was relatively high and consistent across all sites at the reef. Nine species of macroalgae were recorded along survey lines: eight species of green algae and one species of brown algae, as well as crustose coralline red algal and turf algal functional groups.

Table D.3.1.1.--Algal genera or functional groups recorded in photoquadrats at Kingman Reef. Numbers indicate the percentage of photoquadrats in which an alga occurred. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats.

	KIN-03	KIN-07	KIN-08	KIN-10	KIN-11	KIN-12	KIN-13	KIN-14	KIN-16	KIN-23
GREEN ALGAE										
Avrainvillea lacerate		25	8	*	8	8	*		*	
Caulerpa cupressoides		8	17	*	*		*	*		
Dictyosphaeria cavernosa					8					*
Dictyosphaeria versluysii		17	8	8	*		*		17	8
Halimeda fragilis	8	17	8	*	42	8	8	17	*	42
Halimeda opuntia	92	50	17	*	42	58	83	*	*	8
Halimeda taenicola	8	58	83	58	8	8	25	17	17	8
Valonia utricularis				8	8					
RED ALGAE										
crustose coralline red algae	100	100	92	92	83	92	100	100	100	92
OCHROPHYTA										
Lobophora variegata	50		17		8		25	8	8	17
FUNCTIONAL GROUPS										
turf algae	100	100	100	92	100	100	100	100		92

D.3.2. Corals

D.3.2.1 Percent Benthic Cover

Percent benthic cover surveys at Kingman Reef were conducted in concert with the fish, coral population, algae, and invertebrate REA surveys at 11 different sites established during prior CRED cruises in 2000, 2004, and 2006. The line-point intercept (LPI) methodology was conducted along two, end-to-end 25-m transects (51 points per transect) at each site, totaling 1122 points along 550 m of forereef and lagoonal patch coral communities at depths ranging between 6 and 14.5 m. Spatial patterns of percent benthic cover variability derived from the 11 independent REA surveys in 2008 are

reflected in Figure D.3.2.1.1. Atoll-wide, scleractinian corals, coralline algae, and turf algae, were the primary benthic components, accounting for over 80% of the living benthos ($30.7 \pm 4.8\%$, $28.8 \pm 4.4\%$, and $21.0 \pm 4.3\%$ of total; mean \pm SE, respectively). The greatest values for live coral cover were observed at KIN-16 and KIN-10 (65% and 49%, respectively) along the southeast corner of the atoll and the northeastern lagoon, respectively. In agreement with surveys conducted in 2006, site KIN-16 continued to exhibit prolific coral development and elevated generic diversity. Encrusting coralline algae were abundant at the northern backreef site KIN-10, and tridacnid clams were notoriously abundant at KIN-10 and KIN-16, both lagoonal sites. Of the 15 scleractinian and hydrozoan genera enumerated along the LPI transects, *Porites*, *Favia*, *Fungia*, *Montipora*, and *Pocillopora* contributed over 90% of the stony coral cover, with *Porites* alone accounting for 62%. The other genera represented 8.7%, 7.3%, 6.1% and 6.0, respectively. Table D.3.2.1.1 provides an itemized analysis of the relative contribution of the different scleractinian and hydrozoan taxa to the total percent live coral cover.

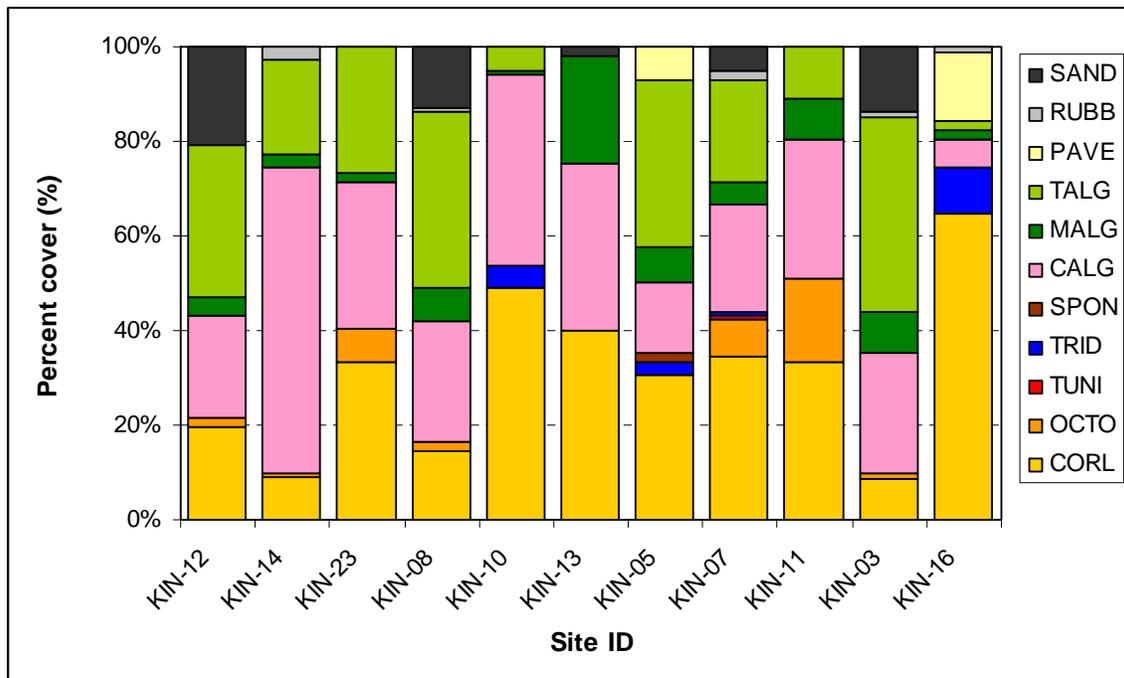


Figure D.3.2.1.1.--Mean percent cover of selected benthic elements derived from 11 independent REA surveys at Kingman Reef, ASRAMP 2008 (April 4–7, 2008). CORL: live scleractinian and hydrozoan stony corals; OCTO: Octocorals; TUNI: tunicates; TRID: *Tridacna* spp.; SPON: sponges; CALG: coralline algae; MALG: macroalgae; TALG: turf algae (on pavement, rubble, and dead coral); PAVE: carbonate pavement; RUBB: coral rubble; and SAND: sand.

Table D.3.2.1.1.--Atoll-wide relative abundance of the different scleractinian and hydrozoa taxa enumerated along the LPI transects at Kingman Reef, 2008.

Genus	Relative abundance (%)
<i>Porites</i>	62.2
<i>Favia</i>	8.7
<i>Fungia</i>	7.3
<i>Montipora</i>	6.1
<i>Pocillopora</i>	6.1
<i>Acropora</i>	2.6
<i>Pavona</i>	2.0
<i>Turbinaria</i>	1.5
<i>Hydnophora</i>	1.2
<i>Leptastrea</i>	0.6
<i>Psammocora</i>	0.6
<i>Astreopora</i>	0.3
<i>Millepora</i>	0.3
<i>Platygyra</i>	0.3
<i>Stylophora</i>	0.3

The quantitative data above documents important characteristics of the coral reef benthic assemblages, providing the framework to monitor for change in response to alterations in the reef environment. An abridged comparison of percent live coral cover based on surveys conducted in the last 2 years is illustrated in Figure D.3.2.1.2. For all the sites visited in both 2006 and 2008, the mean average difference between the two surveys was less than over 11%. Because of the lack of permanent stations at most the sites surveyed, a rigorous statistical comparison of results is precluded.

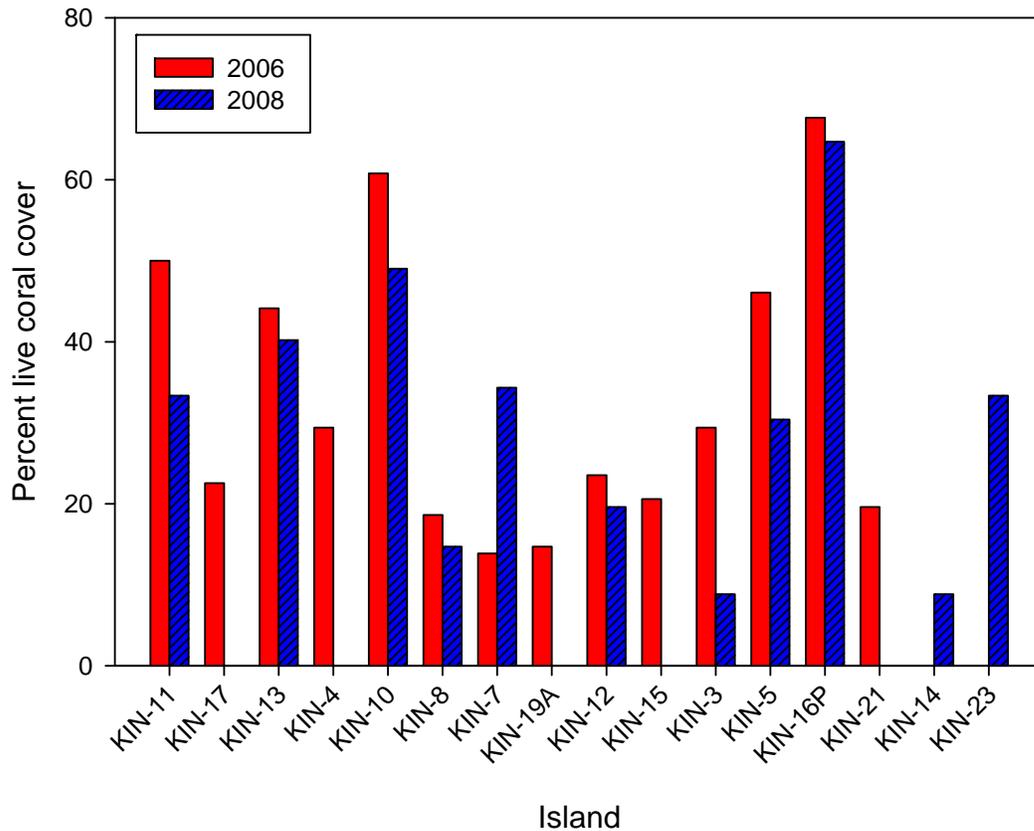


Figure D.3.2.1.2.--Percent live coral cover for 11 REA sites at Kingman Reef contrasted for survey years 2006 and 2008.

D.3.2.2. Coral Populations

A total of 286 m² of reef benthos was surveyed around Kingman Reef in 2008. A total number of 5,222 colonies were counted within this area (Table D.3.2.2.1). A total of 27 genera of scleractinian coral and one genus of hydrozoan coral were enumerated at Kingman reef. Soft corals, coralimorphs, and zoanthids were also observed. The genus *Porites* had the highest colony counts (39.35 % of colonies observed); this corresponds with qualitative observations of backreef communities. The backreef and lagoonal communities of Kingman Reef are dominated by large *Porites* colonies of mounding/mushroom morphology. Interestingly, these communities are more highly developed (i.e., larger colonies, denser benthic community) in depths shallower than 45 ft.

Faviids (11.6 % of colonies observed) and *Montiporids* (5.34 % of colonies observed) were the second and third most abundant genera at Kingman reef. While this data does not show differences between backreef/lagoonal habitat and forereef habitat, it is important to keep in mind that the REA surveys at Kingman Reef surveyed two separate habitat types. These habitat types experience different tidal and current energy regimes;

therefore, they are exposed to differing larval and reproductive products dispersal dynamics, The forereef community is less represented in this data than the backreef/lagoonal community. The forereef community, based upon qualitative observations, was dominated by branching *acroporids* and encrusting *montiporids*. Forereef and backreef/lagoonal community differences are distinct. The backreef/lagoon *Porites* and *Fungia* gardens typify this system and make it unique within the Line Islands.

Table D.3.2.2.1.--Genera of coral colonies seen at Kingman Reef; data shown as total number of colonies for the reef, and the generic percent of total.

Kingman	Number of Colonies	Percent of Total
<i>Acanthastrea</i>	13	0.25
<i>Acropora</i>	41	0.79
<i>Astreopora</i>	2	0.04
<i>Coralimorphia</i>	16	0.31
<i>Discosoma</i>	2	0.04
<i>Distichopora</i>	4	0.08
<i>Echinophyllia</i>	77	1.47
<i>Favia</i>	609	11.66
<i>Favites</i>	111	2.13
<i>Fungia</i>	506	9.69
<i>Fungia/Cycloseris/Diaseris</i>	1	0.02
<i>Goniastrea</i>	24	0.46
<i>Goniopora</i>	2	0.04
<i>Goniopora/Alveopora</i>	133	2.55
<i>Herpolitha</i>	7	0.13
<i>Hydnophora</i>	7	0.13
<i>Leptoseris</i>	15	0.29
<i>Lobophyllia</i>	1	0.02
<i>Lobophytum</i>	470	9.00
<i>Merulina</i>	11	0.21
<i>Millepora</i>	3	0.06
<i>Montastrea</i>	26	0.50
<i>Montipora</i>	279	5.34
<i>Palythoa</i>	4	0.08
<i>Pavona</i>	207	3.96
<i>Platygyra</i>	62	1.19
<i>Pocillopora</i>	114	2.18
<i>Porites</i>	2055	39.35
<i>Psammocora</i>	72	1.38
<i>Sarcophyton</i>	63	1.21
<i>Sinularia</i> and other soft corals	15	0.29
<i>Stylophora</i>	21	0.40
<i>Turbinaria</i>	226	4.33
<i>Zoanthus & Palythoa</i>	23	0.44
Total	5222	

D.3.2.3 Coral Health and Disease

In 2008, a total area of approximately 2300 m² at 11 sites was surveyed for coral and coralline algae disease during the REA surveys. Occurrence of coral disease and other health impairments was relatively low; a total of 78 cases of 9 categorized diseases and disorders were tallied. Summaries of disease occurrence, relative abundance, and taxa affected are presented in Figures D.3.2.3.1 and D.3.2.3.2, respectively. Patchy bleaching was the most common anomaly on scleractinian and soft corals (Fig. D.3.2.3.3), followed by discolorations, and subacute tissue loss. In addition, a total of 27 cases of coralline fungal disease were enumerated. Additionally, an itemized list of tissue samples collected for coral disease histological analyses is presented in Table D.3.2.3.1.

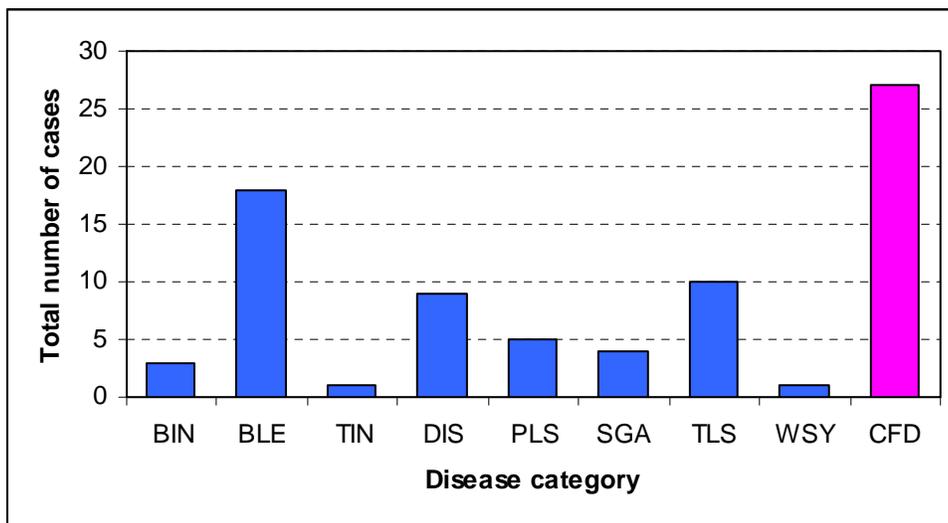


Figure D.3.2.3.1.--Number of cases of scleractinian (blue bars) and coralline algal (pink bars) diseases enumerated during REA surveys, Kingman Reef, 2008. BIN: barnacle infestation; BLE: bleaching; TIN: tubeworm infestations; DIS: discolorations other than bleaching; PLS: pink line/spot syndrome; SGA: skeletal growth anomalies; TLS: tissue loss; WSY: white syndrome; and CFD: coralline fungal disease.

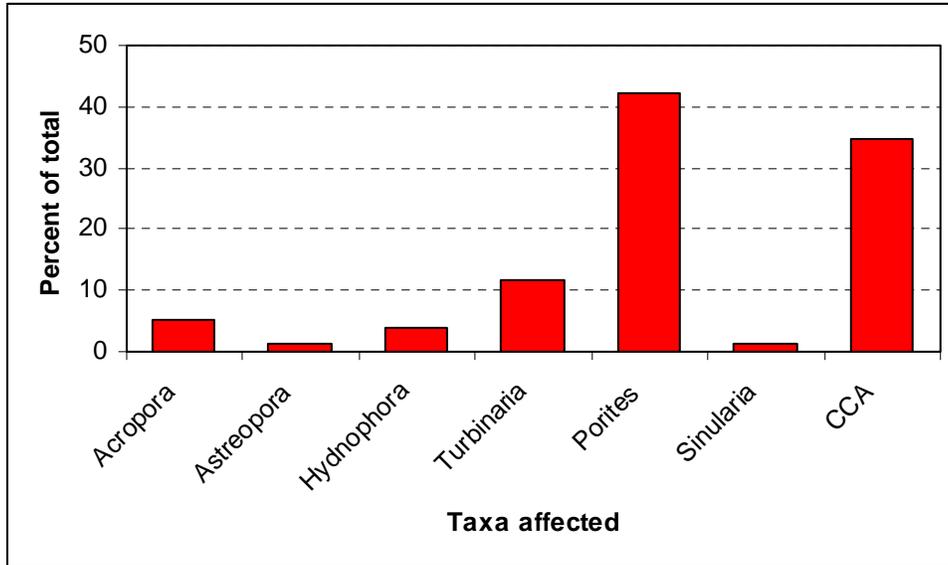


Figure D.3.2.3.2--Percent occurrence of disease affecting coral and coralline algal taxa (CCA: crustose coralline algae).



Figure D.3.2.3.3--Underwater photograph illustrating the patchy bleaching (arrows) on a specimen of *Sinularia* at site KIN-03. Also note clusters of mollusk eggs laid on the oral surface of the specimen (photo: Bernardo Vargas-Ángel).

Table D.3.2.3.1--Coral tissue sample log of diseased specimens collected at Kingman Reef.

Island	Site ID	Date	Taxon	Disease state	Sample number
KIN	KIN-23	4/4/2008	<i>Acropora nobilis</i>	Subacute tissue loss	HI0803-001/02
KIN	KIN-23	4/4/2008	<i>Acropora nobilis</i>	Subacute tissue loss	HI0803-001/02
KIN	KIN-23	4/4/2008	<i>Hydnophora exesa</i>	Subacute tissue loss	HI0803-009
KIN	KIN-23	4/4/2008	<i>Acropora hyacinthus</i>	White syndrome	HI0803-010
KIN	KIN-13	4/5/2008	<i>Acropora nobilis</i>	Subacute tissue loss	HI0803-011
KIN	KIN-11	4/6/2008	<i>Acropora nobilis</i>	Subacute tissue loss	HI0803-012

D.3.3. Macroinvertebrates

Unlike Palmyra, 40 miles to the southeast, Kingman Reef was rich and diverse in non-cryptic macroinvertebrates. *Tridacna* clams were the most abundant and predominantly in the backreef, patchreef, and lagoon areas. They were present in all but two southeastern forereef sites, KIN-11 and KIN-23. Figure D.3.3.1 represents the density of clams/m² at the remaining surveyed sites.

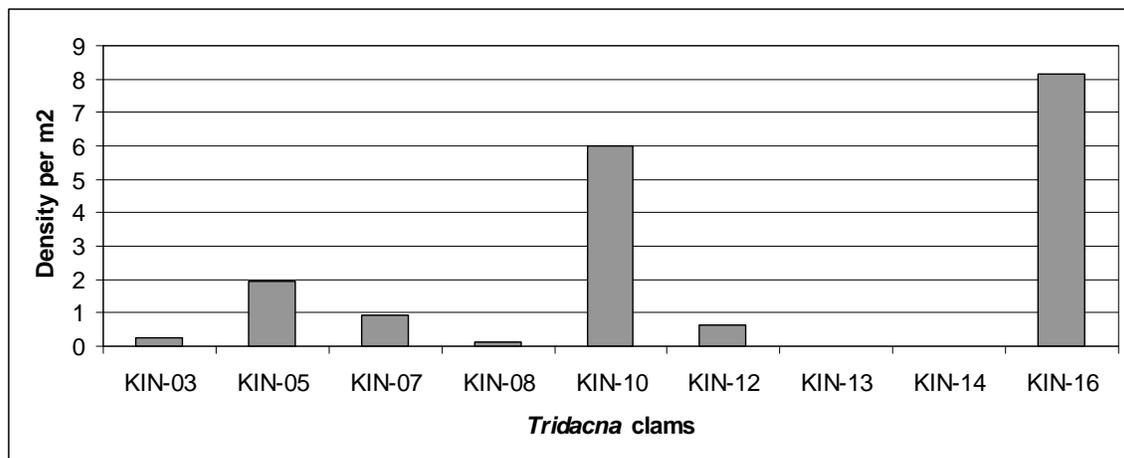


Figure D.3.3.1--Density of clams/m² at Kingman Reef REA sites.

Holothuroids were diverse and common. At the patch reef site, KIN-03, 11 species were observed: *Thelenota ananas*, *Holothuria hilla*, *Bohadschia argus*, *Holothuria whitmaei*, *Stichopus chloronotus*, *Bohadschia paradoxa*, *Actinopyga obsesa*, *Bohadschia graeffei*, *Holothuria edulis*, *Euapta*, and *Holothuria atra*. The densities of *Actinopyga obsea* were highest at this site with 0.18/m². Although not quantified on transect, *Holothuria hilla*, were abundant under dead rocks and coral heads off transect. The echinoid, *Echinometra*, was common at KIN-03 and KIN-16 (0.39 and 0.18/m². respectively) and *Echinothrix* was common at KIN-10 and KIN-23 (0.11 and 0.61/m², respectively). The corallivorous asteroid, *Acanthaster planci*, was observed at KIN-03, KIN-05, KIN-07, KIN-11, and

KIN-23 but densities were negligible on transect. However, at KIN-05 the sea star was common in the 50–35 ft depth range. Overall, the presence of *A. planci* has declined from previous surveyed years. The coralimorpharian, *Rhodactis howseii*, was observed at both KIN-14 and KIN-12. Anemones from the genus *Heteractis* were common at two patch reef sites, KIN-03 and KIN-10 (0.04 and 0.15/m², respectively). *Coralliophilidae* snails were most common in the lagoon patch reef, KIN-16, with a density of 0.61/m² and in the northern backreef site, KIN-14, with at a density of 0.35/m². Both trapezid crabs and hermit crabs were most common on the forereef sites, KIN-13 and KIN-23. Trapezid crab densities were 0.21 and 0.24/m², and hermit crab densities were 0.14 and 0.17/m², respectively at these two sites. Soft corals were present at 10 of the 11 surveyed sites. Based on presence/absence, *Lobophyton* was present at 82% of the sites, *Sarcophyton* was present 73%, and *Sinularia* was present 54%.

D.3.3.1. Urchin and Giant Clam Measurements

Figure D.3.3.1.1 reveals the average test diameter of urchins from the genus *Diadema*, *Echinometra*, and *Echinothrix* encountered at each site. Only sites where ≥ 5 measurements were recorded for a species are represented.

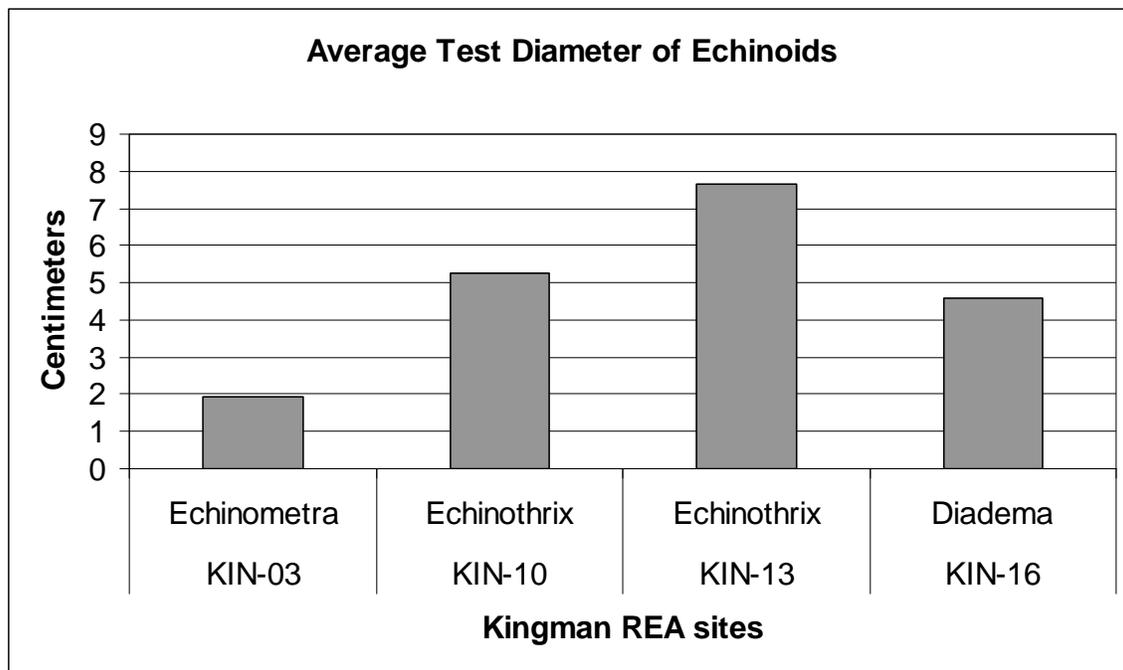


Figure D.3.3.1.1.--Average test diameter of echinoids at Kingman Reef REA sites.

D.3.3.2. ARMS Deployment

ARMS were deployed at the following REA sites around Kingman. Each site contains three ARMS.

Table D.3.3.2.1.--ARMS deployment locations around Kingman Reef.

	Latitude	Longitude
KIN-23	06° 22.954 N	162° 20.475 W
KIN-13	06° 22.932 N	162° 23.045 W
KIN-05	06° 23.605 N	162° 20.858 W

D.3.3.3. Invertebrate Collections

Nondestructive tissue samples of the organisms listed in Table B.3.3.3.1 were collected for the Hawaii Institute of Marine Biology for the purpose of genetic analysis.

Table B.3.3.3.1.--Invertebrate tissue collection information for specimens from Kingman Reef.

Species	Number	REA site	Latitude	Longitude
<i>Holothuria atra</i>	5	KIN-14	06° 26.045 N	162° 23.394 W
<i>Holothuria atra</i>	3	KIN-08	06° 25.726 N	162° 22.925 W
<i>Holothuria atra</i>	7	KIN-11	06° 22.915 N	162° 20.738 W
<i>Holothuria whitmaei</i>	5	KIN-14	06° 26.045 N	162° 23.394 W
<i>Holothuria whitmaei</i>	15	KIN-03	06° 23.392 N	162° 21.246 W
<i>Linckia multifora</i>	5	KIN-14	06° 26.045 N	162° 23.394 W
<i>Linckia multifora</i>	4	KIN-07	06° 24.150 N	162° 23.131 W
<i>Linckia multifora</i>	6	KIN-05	06° 23.605 N	162° 20.858 W

D.3.4 Towed-diver Benthic Surveys

A total of 21 towed-diver surveys covering 54 kilometers of benthic habitat were completed along the forereefs of Kingman Atoll. Three habitat strata were surveyed: the mid-depth forereef (12 tows), mid-depth backreef (7 tows), and the shallow backreef (2 tows). Discussions of diver observations are broken down into the three respective habitat strata; figures of percent cover and macroinvertebrate densities are presented for the entire atoll (all depth strata) at the end of this section.

Mid-Depth Forereef

The average total hard coral cover for all pooled surveys on the mid-depth forereef was 39.6% (range: 18–56.9%). Coral cover was moderately high around most of the island with the exception of the southern forereef which appeared to have higher percentages of rubble and dead coral. Mounding colonies of *Porites* were the most common coral for most of the mid-depth forereef except for the eastern side of Kingman which consisted of higher percentages of *Pocillopora* and branching and tabulate *Acropora* colonies including many young (5–20 cm colonies). Coral stress remained low along much of the mid-depth forereef averaging 1.75% and ranging from 0.5 to 2.5%. Soft coral cover averaged 26.4% for all surveys with the highest cover recorded along the west and southwest forereef. The main soft coral genera that were observed were *Sinularia*, *Sarcophyton*, *Lobophyton*, and patches of the encrusting star coral *Pachyclauvaria*.

Macroalgae cover averaged 8.0% for all pooled surveys (range: 0.7–33.2%), with the highest macroalgae recorded along the southeast forereef (average: 33.2%). Macroalgae cover was low (< 5%) around the rest of Kingman's forereef. Common macroalgae genera included *Halimeda* sp. and *Caulerpa cupressoides*. Coralline algal cover averaged 12.7% for all pooled surveys (range 3.0–27.3%). The highest coralline cover (average 33.2%) was recorded along the eastern half of the southern forereef. Coralline algae cover was exceptionally low for the entire west side of the atoll.

Sea urchins, mostly *Echinothrix* and *Diadema*, were the most common macroinvertebrates observed on the mid-depth forereef at Kingman. More than 1883 individuals were observed mostly along the southern forereef; abundances never exceeding 42 individuals in a single tow for the rest of the Atoll. Sea cucumbers were more common along the western and southern forereefs where the majority of the 179 individuals were observed. *Holothuria* sp. was the most common sea cucumber observed with *Bohadscia* sp. and *Thelonata anans* also noted. Giant clams were recorded around the perimeter of Kingman Atoll (107 individuals); however, they were sighted in much higher frequencies along the west and southwest forereefs. Only one COT was observed on the forereef, occurring east of the channel near the southeast point.

Shallow Backreef

Two tows within the shallows on the southeast backreef were dominated by high coral cover, crustose coralline algae, and giant clams. Hard coral cover averaged 40.8% and was dominated by mounding colonies of *Porites*. *Fungids*, *Pocillopora*, and encrusting *Montipora* were also common as were many young colonies of *Acropora* in a few segments. Coral stress was relatively low averaging 3.0%. Soft coral cover was extremely low covering on average 0.8% of the benthos. Macroalgae was also extremely low averaging 1.4% cover. Crustose coralline algae was a major space occupier accounting for an average of 37.2% of the benthos. The rest of the substrate was dominated by giant clams which were estimated at well over 1000 individuals per 5-min dive segment for each tow. Sea urchins were also noted in the shallows with more than 77 individuals observed, a mix of *Echinothrix*, *Diadema* and large *Heterocentrus*. Only one sea cucumber was observed. Although coral stress levels were estimated to be low, 77 COTs were observed, mostly in two areas of reef where 35 and 16 individuals were recorded in relatively small areas.

Mid-depth Backreef

The average total hard coral cover for all pooled surveys on the mid-depth backreef was 36.1% (range: 7.8–21.8%). Coral cover was moderately low around most of the island with the exception of the tow in the southwest corner. Tows along the southern backreef were characterized by low coral cover with numerous dead colonies of *Porites* and tabulate *Acropora* as well as rubble fields from branching *Acropora* thickets. As the tows rounded the southeast corner, percentage of stressed coral spiked affecting between 20–40% of colonies. The majority of coral in this area was medium-sized mounds of *Porites* which had numerous scars likely from COTs whose abundance was noted in the area. Fungids were also abundant in this area. Coral stress was relatively low at the remaining survey sites (0.5–5.25%). Soft coral cover averaged 12.7% for all surveys with the

highest cover (38.2 and 30.6%) recorded along the two tows in the west and southwest backreef. From the ikonos imagery, it appears that these tows may be better described as “lagoon” strata as the location is some distance off the forereef crest compared to the other backreef tows. For the southern and eastern backreef surveys, soft coral was relatively low averaging between 4.5 and 7.8%. The main soft coral genera that were observed were *Sinularia*, *Sarcophyton*, and *Lobophyton*. Patches of the coralimorph *Rhodactis* were noted along the southern tow near the middle of the atoll with percent cover increasing to between 80 and 90% for nearly 200 m of reef. Colony size of individuals was much smaller than colony sizes observed on patches of *Rhodactis* recorded elsewhere in the Pacific (Howland and Baker) suggesting that coverage of the coralimorph may be recent.



Figure D.3.4.1.--Scars on mounding colonies of *Porites lobata* near the southeast backreef.

In an interesting note, an unidentified tunicate was observed in 3-time segments passing the LaPaloma Channel near the southern backreef, covering 30, 40, and 50% of the substrate. The tunicate appeared to be prevalent on coral rubble and old/dead colonies, but did not appear to be overgrowing live corals.

Macroalgae cover averaged 6.2% for all pooled surveys (range: 0.7–33.2%), with slightly higher macroalgae cover recorded along the southern backreef. *Halimeda* was the most visible component of the algal flora. Coralline algal cover averaged 9.8% for all pooled surveys (range: 0.1–32.5%). The highest coralline cover (average 32.5%) was recorded along the southern side of Kingman. heading west.

Macroinvertebrate observations in the mid-depth backreef were highlighted by the abundance of COTs near the southeast corner. A total of 225 individuals were observed with the highest abundances in any one segment being 56 individuals. COTs were not observed along the western backreef. Giant clams and sea cucumbers were also relatively abundant along southeastern and eastern backreef tows with more than 2650 clams and 1472 sea cucumbers recorded. Sea urchins were less abundant with more than 547 individuals recorded, mostly during the tow along the southern backreef. Macroinvertebrates were less abundant on the two western tows with low counts of giant clams (~ 42 individuals), sea cucumbers (16 individuals) and sea urchins (20 individuals).

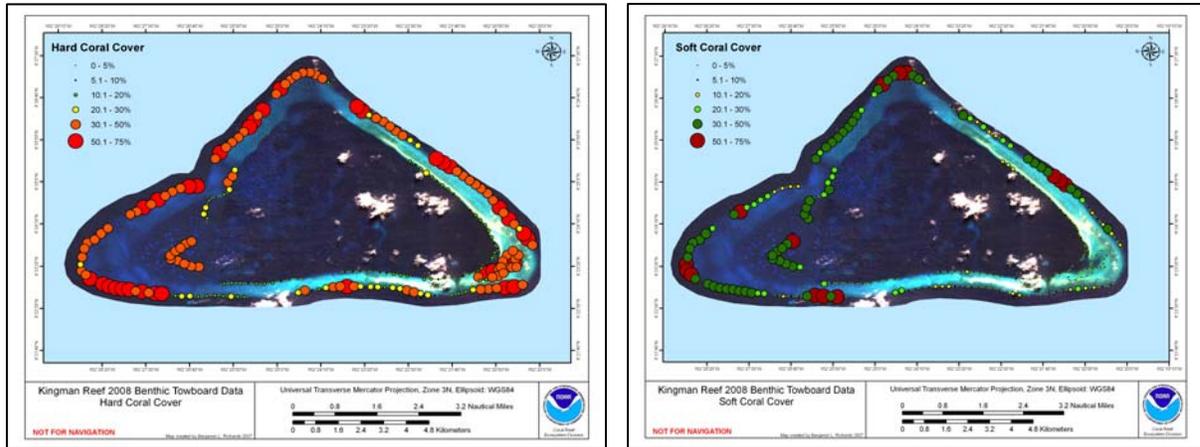


Figure D.3.4.2.--Hard coral and soft coral cover recorded during the 2008 towed-diver surveys around Kingman Atoll.

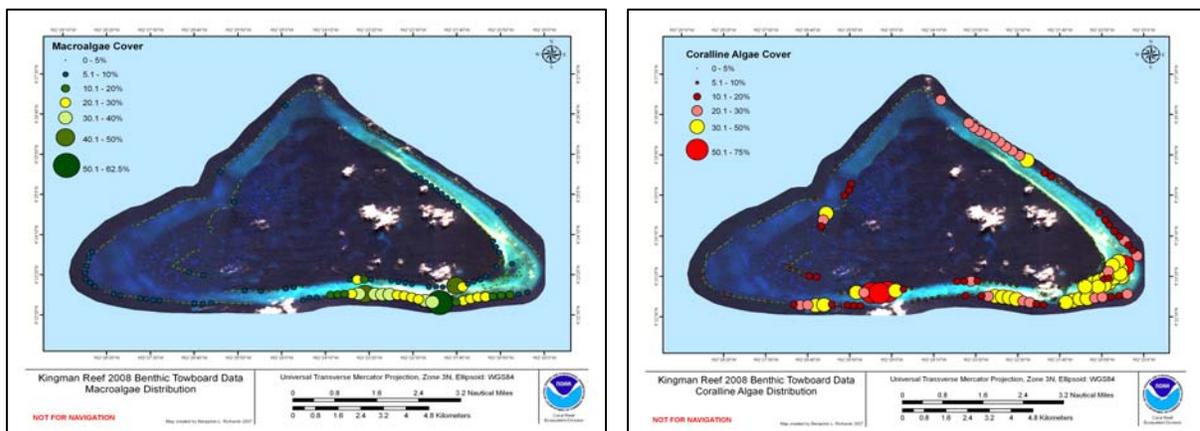


Figure D.3.4.3.--Macroalgae and coralline algae cover recorded during the 2008 towed-diver surveys around Kingman Atoll.

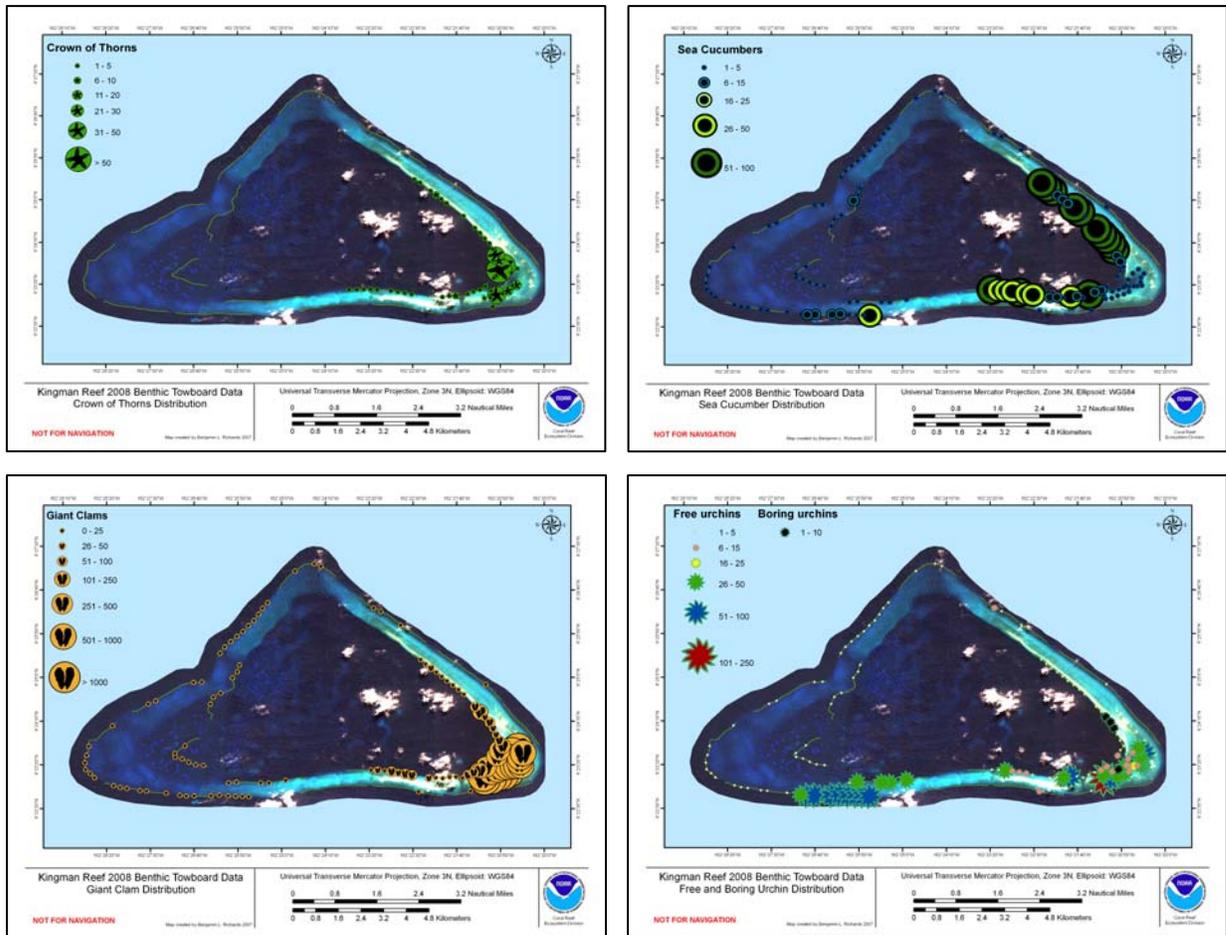


Figure D.3.4.4.--Macroinvertebrate counts recorded during the 2008 towed-diver surveys around Kingman Atoll. Clockwise from top left (a) COTs, (b) Sea Cucumbers (c) Giant Clams, and (d) Sea Urchins.

D.4 Fish

D.4.1 REA Fish Surveys

Stationary Point Count data (new methodology)

A total of about 46 individual nSPC surveys were conducted at 23 sites around Kingman Atoll (5 backreef shallow, 4 backreef mid-depth, 4 backreef deep, 3 lagoon mid-depth, 3 forereef mid-depth, 2 forereef deep, 2 forereef shallow depth). Sharks (Carcharhinidae) were the largest contributor to total biomass with 6.9 kg 100 m⁻². Snappers (Lutjanidae) and parrotfishes (Scaridae) were also relatively abundant, each with a biomass of ~ 1.0 kg 100 m⁻² (Table D.4.1.2, Fig. D.4.1.1).

Belt transect data

During the survey period, about 46 belt transect surveys were conducted at 23 sites around Kingman Atoll (see SPC for stratum breakdown). Sharks (Carcharhinidae) contributed most to total biomass with 7.1 kg 100 m⁻². Snappers (Lutjanidae) and

parrotfishes (Scaridae) were also relatively abundant, each with a biomass of ~ 1.1 kg 100 m⁻² (Table D.4.1.1).

Overall observations

A total of 180 species were observed during the survey period by all divers. The average total fish biomass at the sites in Kingman during the survey period was 1.4 ton ha⁻¹ for the nSPC surveys (Table D.4.1.2), and the average fish biomass was 1.3 ton ha⁻¹ for the belt transect surveys (Table D.4.1.1).

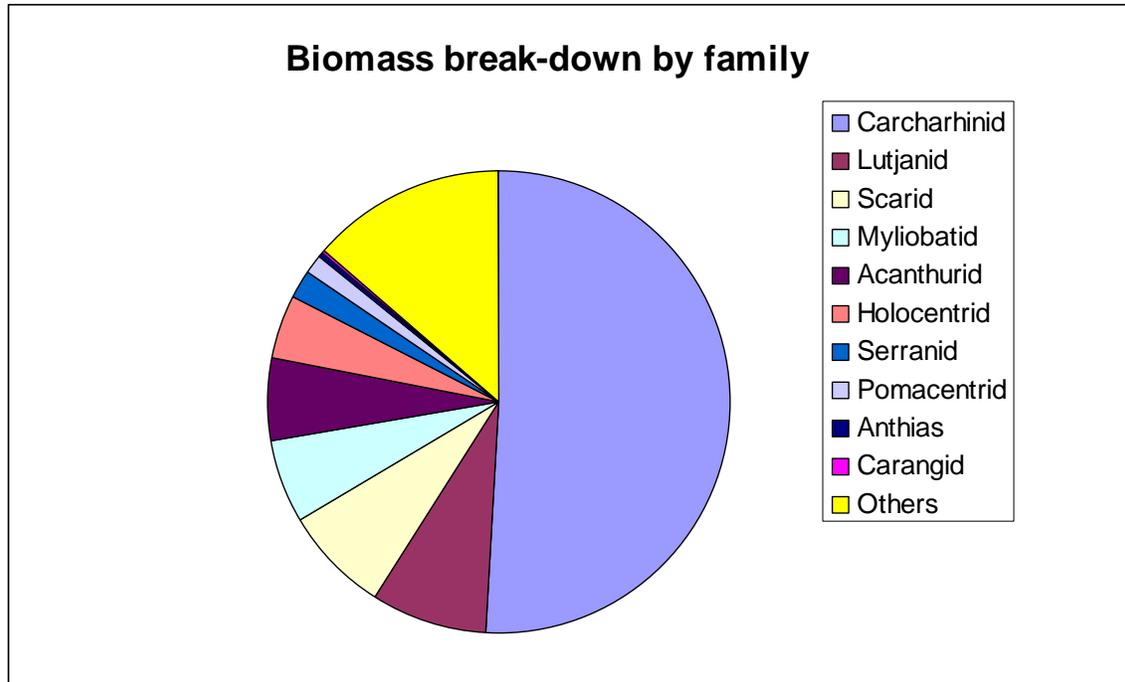


Figure D.4.1.1.--Total fish biomass composition by family, measured by nSPC.

Table D.4.1.1.--Coral reef fish biomass (kg 100m⁻²) at sites around Palmyra Atoll as measured by belt transects.

Stratum-Depth	Site	Total	Acanth.	Anthias	Carangid	Carch.	Holocentrid	Lutjanid	Myliobatid	Pomacentrid	Scarid	Serranid	Others
Backreef - Deep	KIN-50	1.8	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.27	1.29	0.02	0.12
	KIN-53	2.9	0.63	0.00	0.00	0.00	0.06	1.52	0.00	0.08	0.44	0.00	0.16
	KIN-57	22.7	1.40	0.00	0.00	6.10	0.00	8.37	0.00	0.23	4.18	0.00	2.42
	KIN-59	26.0	1.43	0.00	0.00	20.29	0.00	1.13	0.00	0.02	0.01	0.26	2.88
Backreef - Mid	KIN-05	7.4	1.74	0.00	0.00	3.91	0.00	0.45	0.00	0.16	0.81	0.00	0.29
	KIN-08	3.3	1.22	0.00	0.00	0.00	0.00	0.61	0.00	0.19	0.51	0.45	0.35
	KIN-12	2.7	1.20	0.00	0.00	0.00	0.00	0.04	0.00	0.05	0.09	0.04	1.24
	KIN-14	4.2	0.05	0.00	0.00	2.19	0.00	0.26	0.00	0.13	1.15	0.07	0.30
Backreef - Shallow	KIN-16	1.6	0.27	0.00	0.00	0.00	0.00	0.73	0.00	0.12	0.01	0.00	0.49
	KIN-51	20.2	0.75	0.00	0.00	15.28	0.03	0.94	0.00	0.25	0.38	0.15	2.47
	KIN-54	2.8	1.59	0.00	0.00	0.00	0.07	0.00	0.00	0.26	0.07	0.25	0.56
	KIN-58	6.5	2.06	0.00	0.00	0.00	0.00	0.65	0.00	0.32	2.27	0.37	0.83
	KIN-60	3.8	1.00	0.00	0.00	0.00	0.00	0.96	0.00	0.09	0.13	0.43	1.20
Forereef - Deep	KIN-52	12.3	2.35	0.00	0.00	5.01	2.09	1.23	0.00	0.32	0.15	0.39	0.74
	KIN-56	24.6	0.36	0.03	0.00	6.30	9.67	0.31	0.00	0.52	0.39	0.77	6.20
Forereef - Mid	KIN-11	48.0	1.55	0.16	0.00	39.08	0.22	3.08	0.00	0.42	2.00	0.08	1.35
	KIN-13	8.7	0.63	0.60	0.00	0.00	0.53	0.41	0.00	0.54	0.21	0.59	5.23
	KIN-23	62.0	1.10	0.36	0.00	52.39	0.09	2.34	0.00	0.22	4.49	0.24	0.74
Forereef - Shallow	KIN-55	15.1	0.44	0.00	0.07	12.61	0.00	0.14	0.00	0.38	0.00	0.12	1.32
	KIN-61	5.6	1.51	0.07	0.00	0.00	0.16	0.29	0.00	0.31	2.38	0.33	0.55
Lagoon - Mid	KIN-03	2.0	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.54	0.00	0.14
	KIN-07	4.6	1.43	0.00	0.00	0.00	0.00	0.83	0.00	0.05	1.66	0.00	0.67
	KIN-10	2.4	0.51	0.00	0.00	0.00	0.00	0.85	0.00	0.22	0.24	0.25	0.31
Average		12.7	1.1	0.1	0.0	7.1	0.6	1.1	0.0	0.2	1.0	0.2	1.3

Table D.4.1.2.--Coral reef fish biomass (kg 100m⁻²) at sites around Kingman Atoll as measured by nSPC.

Stratum-Depth	Site	Total	Acanth.	Anthias	Carangid	Carch.	Holocentrid	Lutjanid	Myliobatid	Pomacentrid	Scarid	Serranid	Others
Backreef - Deep	KIN-50	5.8	0.17	0.02	0.00	2.51	0.00	0.91	0.00	0.40	1.29	0.06	0.48
	KIN-53	3.2	0.12	0.00	0.00	0.00	0.00	2.43	0.00	0.06	0.10	0.02	0.44
	KIN-57	8.9	0.79	0.00	0.00	1.57	0.00	3.39	0.00	0.07	0.76	0.07	2.27
	KIN-59	13.2	1.26	0.00	0.00	7.25	0.00	1.18	0.00	0.04	0.13	0.11	3.24
Backreef - Mid	KIN-05	46.3	0.51	0.00	0.00	25.20	0.00	0.93	18.53	0.11	0.38	0.13	0.50
	KIN-08	3.7	1.11	0.01	0.00	0.00	0.05	0.62	0.00	0.26	0.74	0.36	0.54
	KIN-12	2.5	0.52	0.00	0.11	0.00	0.00	0.72	0.00	0.05	0.56	0.16	0.41
	KIN-14	16.3	0.53	0.02	0.00	11.76	0.06	0.84	0.00	0.20	1.32	0.34	1.19
Backreef - Shallow	KIN-16	1.4	0.26	0.00	0.00	0.00	0.00	0.47	0.00	0.12	0.00	0.16	0.34
	KIN-51	5.8	0.75	0.00	0.00	2.21	0.00	0.67	0.00	0.14	0.88	0.28	0.90
	KIN-54	9.2	1.37	0.00	0.00	4.81	0.08	1.07	0.00	0.19	0.63	0.12	0.88
	KIN-58	15.7	1.33	0.00	0.00	10.81	0.00	1.32	0.00	0.12	1.03	0.19	0.89
	KIN-60	4.7	1.10	0.00	0.00	0.00	0.00	0.97	0.00	0.09	0.19	0.28	2.06
Forereef - Deep	KIN-52	28.0	1.32	0.00	0.38	20.50	3.41	0.82	0.00	0.39	0.15	0.56	0.51
	KIN-56	48.7	0.57	0.00	0.00	18.16	9.05	1.67	0.00	0.51	0.74	1.00	16.97
Forereef - Mid	KIN-11	10.0	0.75	0.15	0.00	6.42	0.19	0.86	0.00	0.25	0.82	0.15	0.37
	KIN-13	14.3	0.58	0.51	0.00	8.23	0.56	1.13	0.00	0.50	1.47	0.40	0.93
	KIN-23	42.3	0.74	0.13	0.00	33.36	0.22	1.54	0.00	0.18	5.08	0.12	0.92
Forereef - Shallow	KIN-55	10.8	0.10	0.00	0.00	4.81	0.00	0.03	0.00	0.20	0.27	0.18	5.22
	KIN-61	7.3	2.09	0.10	0.00	0.00	0.17	1.22	0.00	0.32	1.43	0.45	1.57
Lagoon - Mid	KIN-03	4.0	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.11	2.33	0.22	0.46
	KIN-07	5.1	0.91	0.00	0.00	0.00	0.00	1.26	0.00	0.07	2.43	0.16	0.28
	KIN-10	4.3	0.50	0.00	0.00	0.87	0.00	0.77	0.00	0.23	0.65	0.09	1.18
Average		13.5	0.8	0.0	0.0	6.9	0.6	1.1	0.8	0.2	1.0	0.2	1.9

D.4.2 Towed-diver Fish Surveys

During the 2008 RAMP mission, the CRED Towboard team completed 21 surveys at Kingman Reef covering 54 km (54 ha) of ocean floor (Table D.4.2.1). Mean survey length was 2.6 km with a maximum length of 2.9 km and a minimum of 2.0 km. Mean survey depth was 14.2 m with a maximum depth of 18.7 m and a minimum of 2.1 m. Mean temperature on these surveys was 26.8 °C with a maximum temperature of 27.1 °C and a minimum of 26.7 °C. The first year in which the towboard team was able to survey the western margin of Kingman, completing 13.4 km of new survey coverage, was 2008.

Table D.4.2.1.--Survey statistics for towboard sampling during HI0803.

Island	#	Length (km)					Depth (m)				Temperature (°C)			
		Sum	Mean	Max	Min	SD	Mean	Max	Min	SD	Mean	Max	Min	SD
Jarvis	18	43	2.4	3.4	1.6	0.5	14.6	23.4	7.5	3.9	24.6	24.9	24.3	0.2
Palmyra	24	61	2.5	3.1	1.9	0.3	14.4	20.7	5.2	2.9	26.6	26.8	26.4	0.1
Kingman	21	54	2.6	2.9	2	0.3	14.2	18.7	2.1	4.3	26.8	27.1	26.7	0.1

During surveys at Kingman, 24 species of fish greater than 50 cm total length (> 50 cm TL) were observed. Overall numeric density for the island was 21.91 individuals per hectare. Overall biomass was 0.16 T/Ha. The five most common species in decreasing order of abundance were: *Lutjanus bohar*, *Carcharhinus amblyrhynchos*, *Caranx sexfasciatus*, *Chlorurus microrhinos*, and *Sphyrna helleri* (Table D.4.2.2). In terms of biomass, the five greatest contributors were: *Manta birostris*, *Carcharhinus amblyrhynchos*, *Lutjanus bohar*, *Sphyrna lewini*, *Caranx sexfasciatus* (Table D.4.2.3).

Table D.4.2.2.--All species of fishes > 50 cm TL encountered at Kingman Reef in decreasing order of abundance.

Species	Total (#)	Density (#/Ha)
<i>Lutjanus bohar</i>	366	6.78
<i>Carcharhinus amblyrhynchos</i>	229	4.24
<i>Caranx sexfasciatus</i>	176	3.26
<i>Chlorurus microrhinos</i>	142	2.63
<i>Sphyrna helleri</i>	110	2.04
<i>Caranx melampygus</i>	40	0.74
<i>Triaenodon obesus</i>	27	0.5
<i>Naso hexacanthus</i>	26	0.48
<i>Variola louti</i>	11	0.2
<i>Chanos chanos</i>	11	0.2
<i>Manta birostris</i>	9	0.17
<i>Aprion virescens</i>	7	0.13
<i>Sphyrna lewini</i>	6	0.11
<i>Monotaxis grandoculis</i>	6	0.11
<i>Caranx ignobilis</i>	3	0.06

Species	Total (#)	Density (#/Ha)
<i>Aulostomus chinensis</i>	2	0.04
<i>Fistularia commersonii</i>	2	0.04
<i>Caranx lugubris</i>	2	0.04
<i>Epinephelus polyphekadion</i>	2	0.04
<i>Epinephelus lanceolatus</i>	1	0.02
<i>Scarus rubroviolaceus</i>	1	0.02
<i>Scarus sp</i>	1	0.02
<i>Naso vlamingii</i>	1	0.02
<i>Naso annulatus</i>	1	0.02
<i>Aluterus scriptus</i>	1	0.02
Kingman Total	1183	21.91

Table D.4.2.3.--All species of fishes > 50 cm TL encountered at Kingman Reef in decreasing order of biomass.

Species	Total (T)	Density (T/Ha)
<i>Manta birostris</i>	3.055	0.06
<i>Carcharhinus amblyrhynchos</i>	2.256	0.04
<i>Lutjanus bohar</i>	0.900	0.02
<i>Sphyrna lewini</i>	0.646	0.01
<i>Caranx sexfasciatus</i>	0.532	0.01
<i>Chlorurus microrhinos</i>	0.369	0.01
<i>Chanos chanos</i>	0.313	0.01
<i>Triaenodon obesus</i>	0.231	0
<i>Epinephelus lanceolatus</i>	0.129	0
<i>Sphyrna helleri</i>	0.083	0
<i>Caranx melampygus</i>	0.081	0
<i>Naso hexacanthus</i>	0.055	0
<i>Caranx ignobilis</i>	0.035	0
<i>Aprion virescens</i>	0.023	0
<i>Variola louti</i>	0.023	0
<i>Monotaxis grandoculis</i>	0.019	0
<i>Caranx lugubris</i>	0.005	0
<i>Epinephelus polyphekadion</i>	0.004	0
<i>Naso vlamingii</i>	0.004	0
<i>Scarus rubroviolaceus</i>	0.003	0
<i>Scarus sp</i>	0.003	0
<i>Naso annulatus</i>	0.002	0

Species	Total (T)	Density (T/Ha)
<i>Aulostomus chinensis</i>	0.000	0
<i>Aluterus scriptus</i>	0.000	0
<i>Fistularia commersonii</i>	0.000	0
Kingman Total	8.770	0.16

Numeric distribution of fishes around Kingman was generally uniform with slightly higher numbers in the southern portion of the reef and higher numbers on the forereef compared with the backreef and lagoonal areas (Fig. D.4.2.1). Large schools of *Sphyrna helleri* were found near the southeastern tip of the reef while schools of *Caranx sexfasciatus* were found along the eastern margin. *Carcharhinus amblyrhynchos* abundance was highest along the southern portion of the forereef. *Lutjanus bohar* were commonly found in all areas of the atoll.

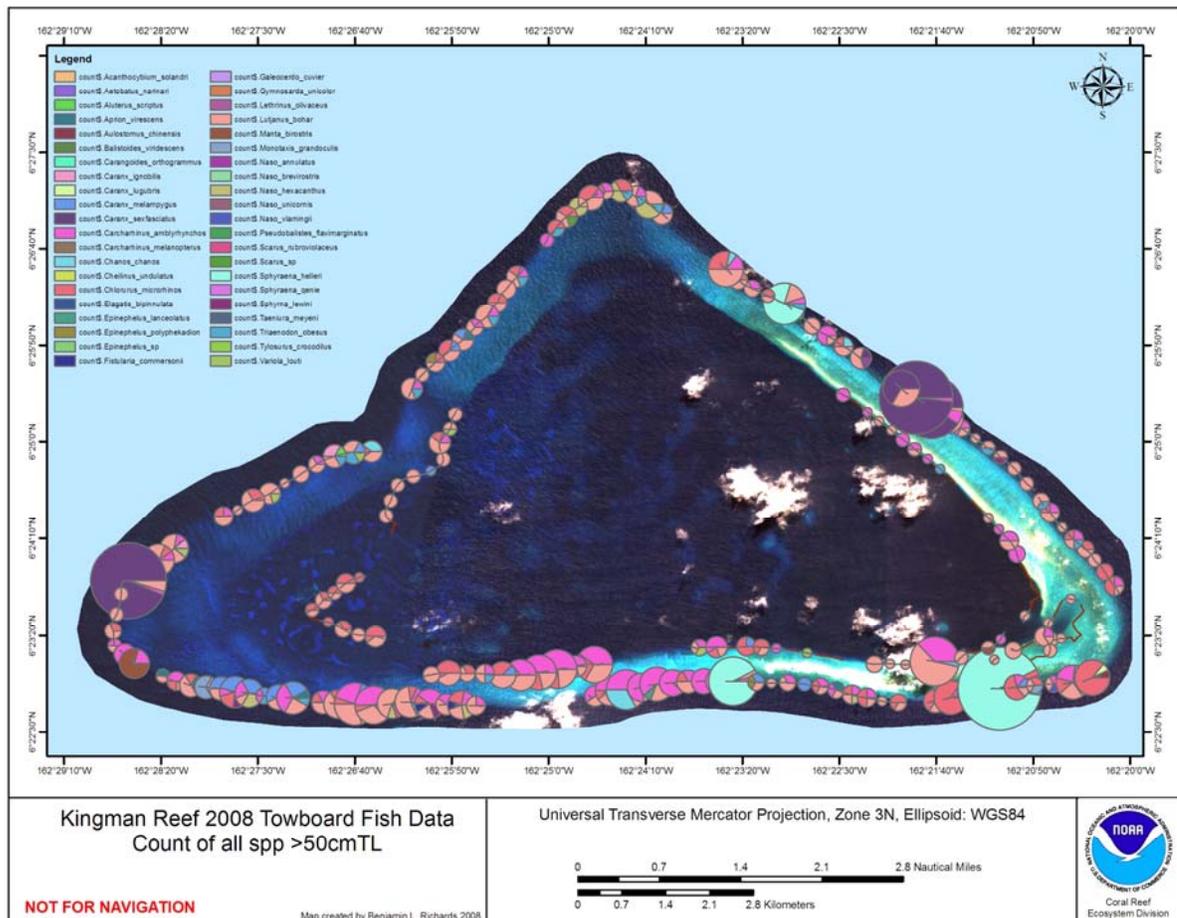


Figure D.4.2.1.--Numeric distribution of all fishes > 50 cm TL around Kingman Reef.

The distribution of biomass at Kingman Reef was dominated by the observation of eight large *Manta birostris* at the southwestern tip of the reef (Fig. D.4.2.2). Removing this species, biomass appears to be evenly distributed around the southern and eastern

portions of the reef with lower biomass levels along the western boundary. Biomass levels were higher on the forereef when compared to the backreef or lagoon areas. Along the southern portion of the forereef biomass is highest in the middle and western portions and is largely composed of *Carcharhinus amblyrhynchos*, *Chanos chanos*, and *Sphyrna lewini* as well as a single observation of *Epinephelus lanceolatus*. Along the eastern portion of the forereef, high biomass levels were due primarily to *Caranx sexfasciatus*, *Sphyrna lewini*, and *Carcharhinus amblyrhynchos*. Biomass levels along the western portion of the reef were lower and were largely due to *Lutjanus bohar*. In the backreef or lagoon area biomass was highest along the southern portion and was dominated by *Carcharhinus amblyrhynchos* and *Lutjanus bohar*.

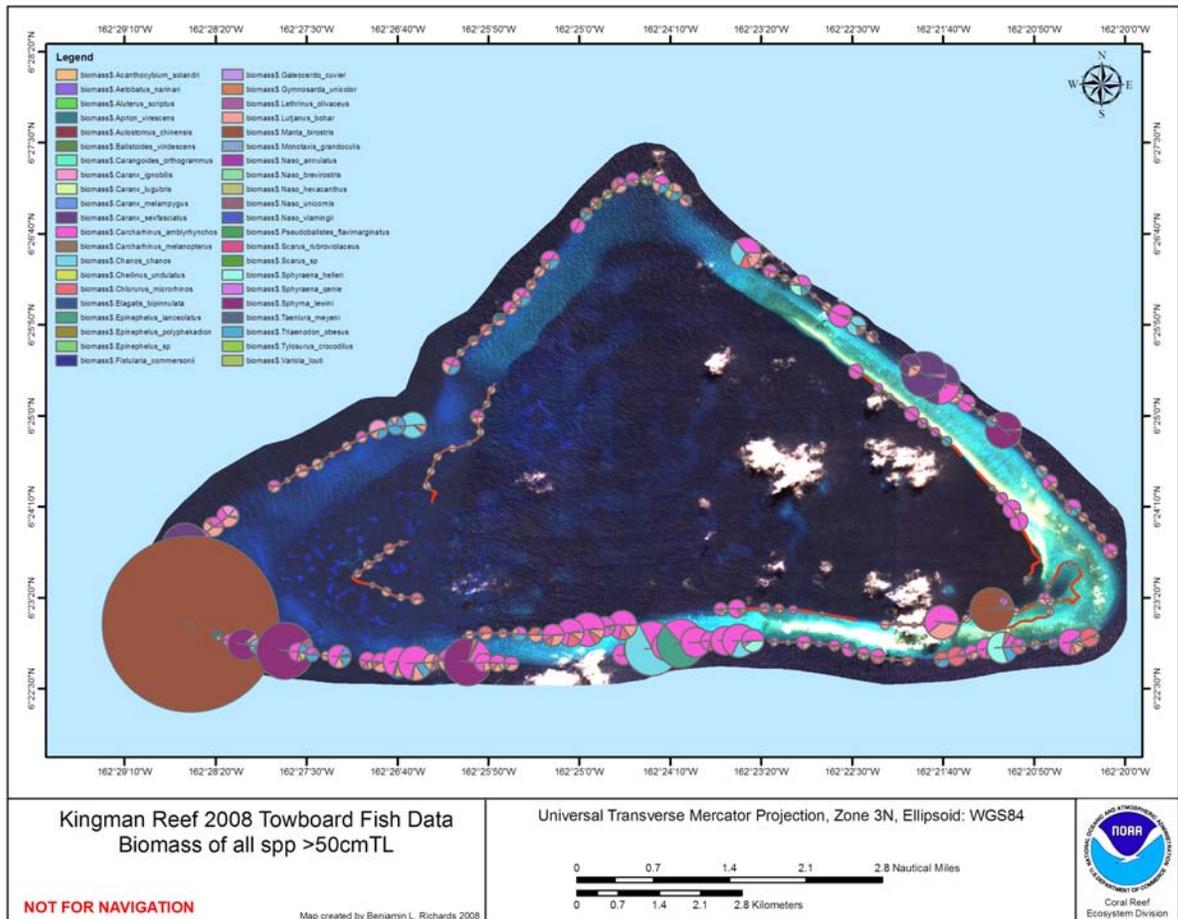


Figure D.4.2.2.--Biomass distribution of all fishes > 50 cm TL around Kingman Reef.

D.5. Kingman Reef Shipwreck Survey

Prepared by Bernardo Vargas-Angel and Scott Godwin

On April 5, 2008, the REA team conducted a qualitative survey around the shipwreck site on the reef flat of the northwest arm of the atoll. This qualitative survey was conducted at 1300 h, mid-tide, and consisted of a snorkel dive in the vicinity of the grounded vessel, aimed at identifying any major impacts resulting from the wreck itself as well as potential secondary effects from the metallic debris scattered around the wreck.

The wreck is located in approximately 1-1.5 m of water; the wooden hull remains upright on the reef flat, emerging approximately 1.5–2.0 m out the water. Approximately 60% of the hull remains in relatively stable condition; however the ship's main decks, engine room, and house appear missing. The qualitative survey did not identify any clear markings on the remains of the ship's hull (stern destroyed) that would provide an indication of provenance. In addition, the presence of charred wood remains on the bow keel, as well as on the port and starboard hull suggest that fire may have been implicated or associated in some, which may have caused abandonment. Metallic components of the ship mainly included piping, anchors, and engine parts.



Figure D.1.--External appearance of the wreck; bow and port hull views. Note the burnt wood on the bow keel and port hull (black arrows). Kingman Reef, April 5, 2008 (Photos: Bernardo Vargas-Angel)

Underwater inspection of the wreck site using mask and fins indicated relatively localized physical damage to the reef structure. A gouged groove in the reef framework, approximately 30–50 cm deep, and several extending for approximately 10–15 m was apparent; most likely formed as waves and winds forced the ship's keel and hull onto the shallow bank reef and reef flat. The observed scatter debris field extended approximately 0.25–0.5 ha around all sides of the ship and consisted of wooden planks, metallic engine parts, piping, and cookware, as well as fiberglass (Fig. D.2). Secondary effects of the wreck, including the proliferation of cyanophytes on the coralline pavement due to iron leaching from the metallic debris, were spread across an area of approximately 0.5 ha, fanning out east-northeast from the wreck site, with the greatest development of

cyanophytes in the area immediately adjacent of the ship's bow hull, on the shallow backreef and the reef flat (Fig. D.3).

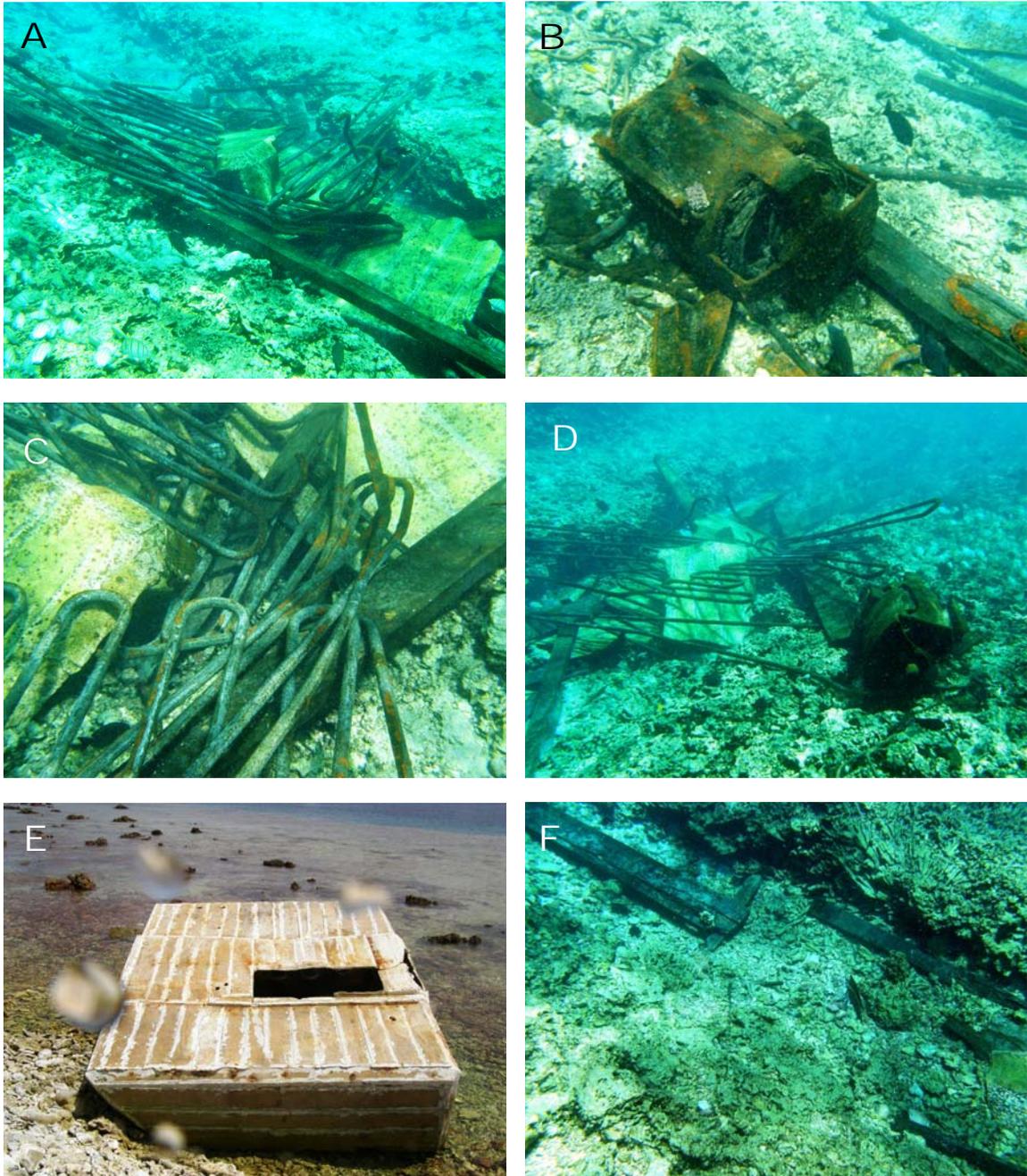


Figure D.2.--A–E. Wood, metallic, and fiberglass debris observed within the scatter field of the shipwreck. F. Bottom scouring and wooden debris on shallow forereef, Kingman Reef, April 5, 2008 (Photos: Bernardo Vargas-Ángel).



Figure D.3.--A–B. Underwater views of the backreef and reef flat adjacent to the wreck; note the thick, prolific development of cyanophytes growing over the coral pavement, and rubble. C–D. Cyanophytes overgrowing the pavement around live corals and dead coral surfaces (*Porites* micro-atoll). E–F Comparative view of the reef flat within and outside the area of impact; note the prolific development of brown-colored cyanophytes growing around pocilloporid corals on panel E, compared to the ‘clean’, coralline algae-covered pavement on panel F. Kingman Reef, April 5, 2008 (Photos: Bernardo Vargas-Ángel).

No observable cyanophyte growth was noted directly on live coral surfaces. Most of the cyanobacterial development occurred on the coralline pavement and rubble; however dead coral surfaces, like those on *Porites* micro-atolls, exhibited substantial cyanophyte colonization (Fig. D.3.D). Although large schools of the covict tang (*Acanthurus triostegus*) were observed, no clear indication of changes to the fish communities could be elucidated at this moment.