CRUISE REPORT[1]

VESSEL: *Hi`ialakai*, Cruise 08-01 (Fig. 1)

CRUISE PERIOD: 24 January–14 February 2008

AREA OF OPERATION: Johnston Atoll, U.S. Phoenix 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 reef assessment/monitoring studies in waters surrounding Johnston Atoll and Howland and Baker Islands. 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:

24 January — Start of cruise. Embarked Marc Nadon (fish), Paul Ayotte (fish), Marie Ferguson (fish), Kara Osada (fish), Jason Helyer (coral), Bernardo Vargas Angel (coral), Peter Vroom (algae), Bonnie De Joseph (algae), Molly Timmers (invertebrates), Tony Perry (invertebrates), Stephane Charette (towed diver fish), Kevin Lino (towed diver fish), Edmund Coccagna (towed diver benthic), Kevin O'Brien (towed benthic diver), Oliver Vetter (oceanography), Frank Mancini (oceanography), Noah Pomeroy (oceanography), Michael Quisenberry (oceanography), Haiying Wang (data manager), Beth Flint (terrestrial), and Chris Depkin (terrestrial). Departed Ford Island at 1000 and began transit to Johnston Atoll (~ 710 nmi). An introductory meeting was held for new scientific personnel and new crew members at 1200, followed by fire, abandon ship, and man-overboard drills.

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[1] PIFSC Cruise Report CR-08-004
Issued 31 March 2008

25 January	Transit day. All scientists' dive gear were checked and medical evaluations given. Teams working off the HI-1 and HI-2 were given introductions to the boats, injured diver drills were performed, and members of the scientific party interested in participating in a "chamber dive" were given the opportunity. A dive safety meeting was held.
26 January	Transit day. The Chief Scientist and Team Leads met to discuss upcoming dive operations at Johnston Atoll. Beth Flint held a meeting to answer questions from crew and scientists interested in going ashore at Johnston Island. The ship's officers, Chief Scientist and Team Leads had a Risk Assessment meeting.
27 January	Arrived at Johnston Atoll and launched small boats at 0830. The oceanography team dropped off Quisenberry on Johnston Island to fix the tide recorder, swapped four subsurface temperature recorders (STRs), conducted nine shallow water conductivity-temperature-depth (CTDs), and picked up Quisenberry at the end of the day. The tow team completed six tows on the forereef working from the western to northern sides of the atoll. The Rapid Ecological Assessment (REA) teams completed three multidisciplinary REA surveys at sites JOH-01, JOH-18, and JOH-19. Three additional fish surveys were completed at sites JOH-50, JOH-51, and JOH-52. HI-5 was used to transport Flint and Depkin to Johnston Island where they planned to camp and conduct bird and botanical surveys.
28 January	Weather day. Sustained winds of 25–30 knots with gusts up to 40 knots. Large swells from the NE and S making for confused seas.
29 January	Weather day. Sustained 30–40 knot winds and 10 foot swells.
30 January	Weather day. Sustained 25–35 knot winds.
31 January	Weather day. Sustained 25–35 knot winds. Conducted deepwater CTDS from the *Hi`ialakai*.
1 February	Continued operations at Johnston Atoll. HI-2 was used to bring Quisenberry and a crewman to Johnston Island to finish installation of the new tide gauge and to transport Flint and Depkin from Johnston Island to Sand Island to conduct bird and botanical surveys. HI-2 transported U.S. Fish and Wildlife Service (USFWS) supplies from Johnston Island to the *Hi`ialakai* and picked up Nadon and O'Brien who conducted fish REA surveys at sites JOH-53, -54, and -55. The oceanography team swapped sea surface temperature (SST) anchors and replaced the missing SST

buoy, and swapped one STR also located at the same site. They also swapped the wave and tide recorder (WTR) and accompanying anchor south of Johnston Island and completed 17 shallow water CTDs. The tow team completed three tows on the southern forereef, one tow south of Johnston Island, and one tow inside the lagoon. The REA teams completed three multidisciplinary REA surveys at sites JOH-10P, JOH-13, and JOH-12. Departed for Howland Island.

2 February	Transit day. Shellsbacks met at 0930 to discuss possible Equator crossing ceremonies. Dive gear was soaked in a bleach solution.
3 February	Transit day. Crew and scientists watched the SuperBowl.
4 February	Transit day. Fire and abandon ship drills were held.
5 February	Transit day.
6 February	Arrived at Howland Island and launched small boats at 0800. The integrated REA team completed three full surveys at HOW-14P, HOW-16, and HOW-05P. Artifical reef matrix structures (ARMS) were installed at HOW-14P and HOW-05P. The fish REA team completed an additional three surveys at HOW-50, HOW-51, and HOW-52. The oceanography team swapped 2 STRs, completed 22 shallow water CTDs spaced at 500-m intervals around the entire island, and collected water samples for nutrient analyses and chlorophyll analyses at 4 depths from 4 sites. The towed-diver team circumnavigated the island twice and completed two calibration dives to check data quality between observers. The terrestrial team was dropped off on Howland Island for an overnight stay to conduct bird counts and botanical surveys.
7 February	Continued field operations at Howland Island. The integrated REA team completed one full survey at HOW-11P and installed ARMS. A deep qualitative dive occurred at HOW-05P. The fish REA team completed three REAs at HOW-53, HOW-54 and HOW-55. The oceanography team swapped out one STR and deployed a new STR at REA site HOW-14P. The towed-diver team circumnavigated the island, recovered an STR along the northeast side of the island, and conducted two invertebrate collection dives. The terrestrial team was picked up from Howland Island. Dive gear was soaked in a bleach solution. Departed for Baker Island.
8 February	Arrived at Baker Island. Sustained 30+ knot winds prevented launch of small boats in the morning, so operations began after

	lunch. Weather conditions prevented the launch of HI-1, so a reduced REA team consisting of two fish divers, two coral divers, and two ARMS deployment divers surveyed BAK-11P and installed three ARMS. The oceanography team swapped two STRs on the west side of the island, collected one water sample profile, and conducted five shallow water CTDs. The towed-diver team completed one full tow along the west side, and two 30-min tows along the north and south sides of the island before challenging water and wind conditions forced them to turn around. The terrestrial team conducted bird surveys from the flying bridge of the *Hi`ialakai*.
9 February	Continued work at Baker Island. HI-1 was not operable because of engine problems. Two fish divers, two coral divers, and the ARMS/invertebrate divers comprised the morning REA team that was launched in HI-2. Fish and coral surveys were completed at BAK-14 and a set of ARMS installed. Fish, coral, and invertebrate surveys were completed at BAK-04. After an afternoon tank and personnel swapout, fish, coral, and algal surveys were completed at BAK-05P. The towed-diver team circumnavigated the island 1.5 times. The oceanography team swapped the Ocean Data Platform (ODP) and two STRs.
10 February	Transit day.
11 February	Transit day.
12 February	Transit day. Cleaned wetlab and drylab. Post-cruise meeting held at 1500.
13 February	Transit day. A fire drill was held in the morning, and room inspections for departing scientists occurred at 1500.
14 February	Docked in Pago Pago and cleared customs at 1100. Disembarked Vroom, DeJoseph, Flint, Depkin, Osada, Wang, Quisenberry, Vargas Angel, and Perry.

Table 1.--Cruise statistics for HI0801.

	Johnston Atoll	Howland Island	Baker Island
Towed-diver Habitat/Fish Surveys	11	7	8
Combined tow lengths (km)	22.18	23.91	20.45
Fish Rapid Ecological Assessments	12	10	4
Benthic Rapid Ecological Assessments	6	4	4
Wave and Tide Recorders (WTR) Recovered	1	0	0
Wave and Tide Recorders (WTR) Deployed	1	0	0
Ocean Data Platforms (ODP) Recovered	0	0	1
Ocean Data Platforms (ODP) Deployed	0	0	1
SST buoys recovered *anchor recovered without SST buoy	1*	0	0
SST buoys deployed	1	0	0
STRs recovered	5	4	4
STRs deployed	6	4	4
Coral Reef Early Warning System (CREWS) buoys recovered *anchor recovered without CREWS buoy	0	0	0
CREWS buoys deployed	0	0	0
Open ocean 75 m CTD Casts w/ dissolved inorganic carbon (DIC) water profiles (2 depth samples per profile)	4	0	0
Deep NUT & CHL water profiles collected (5 depth samples per profile)	3	7	6
Deepwater CTDs (from *Hi`ialakai*)	7	6	6
Shallow (30m) CTD Casts (from small boats)	27	22	5
Shallow NUT & CHL water profiles collected (1-4 depth samples per profile as depth allows)	0	4	1
SCUBA dives	78	78	55

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 Johnston Atoll and the U.S. Phoenix Islands (Howland Island and Baker Island).

B. Deploy an array of Coral Reef Early Warning System (CREWS) buoys, SST buoys, subsurface ODPs, subsurface WTRs, STRs and environmental acoustic recorders (EARs) to allow remote long-term monitoring of oceanographic and environmental conditions affecting coral reef ecosystems of Johnston Atoll and the U.S.Phoenix Islands (Howland and Baker Islands).

C. Collect water samples for analysis of nutrient and chlorophyll levels.

D. Conduct shipboard CTDs to a depth of 500 m and CTDs to a depth of 75 m, shallow water CTDs from small boats to a depth of ~ 30 m, and shipboard acoustic Doppler current profiler (ADCP) surveys around reef ecosystems to examine physical and biological linkages supporting and maintaining these island and atoll ecosystems.

E. Conduct two separate shipboard water sampling schemes, 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 opean ocean in the vicinity of reefs. Shallow water sampling from small boats to a depth of ~ 30 m around reef ecosystems will be used to complement both 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. Collect ADCP data during all transits. The ADCP unit shall be configured to collect narrow-band data in 16-m bins (deepwater mode).

RESULTS:

See Appendices B Through D.

SCIENTIFIC PERSONNEL:

Peter Vroom, PhD, Chief Scientist, Benthic Team – Algae, University of Hawaii (UH)-Joint Institute for Marine and Atmospheric Research (JIMAR), Pacific Islands Fisheries Science Center (PIFSC)-Coral Reef Ecosystems Division (CRED)

Bonnie De Joseph, Benthic Team - Algae, UH-JIMAR, PIFSC-CRED

Jason Helyer, Benthic Team – Coral Populations, UH-JIMAR, PIFSC-CRED
Bernardo Vargas Angel, PhD, Benthic Team – Coral Disease, UH-JIMAR, PIFSC-CRED
Molly Timmers, Benthic Team – Invertebrates, UH-JIMAR, PIFSC-CRED
Tony Perry, Benthic Team – Invertebrates/ARMS, NOAA-PIFSC-CRED
Marc Nadon, Fish Team, UH-JIMAR, PIFSC-CRED
Paula Ayotte, Fish Team, UH-JIMAR, PIFSC-CRED
Marie Ferguson, Fish Team, UH-JIMAR, PIFSC-CRED
Kara Osada, Fish Team, State of Hawaii, Division of Aquatic Resources
Stephane Charette, Towed Diver Team- Fish, UH-JIMAR, PIFSC-CRED
Kevin Lino, Towed Diver Team – Fish, UH-JIMAR, PIFSC-CRED
Edmund Coccagna, Towed Diver Team – Benthic, UH-JIMAR, PIFSC-CRED
Kevin O'Brien, Towed Diver Team – Benthic, UH-JIMAR, PIFSC-CRED
Oliver Vetter, Oceanography Team, UH-JIMAR, PIFSC-CRED
Frank Mancini, Oceanography Team, UH-JIMAR, PIFSC-CRED
Noah Pomeroy, Oceanography Team, UH-JIMAR, PIFSC-CRED
Michael Quisenberry, Oceanography Team, UH-JIMAR, PIFSC-CRED
Haiying Wang, Data Management, UH-JIMAR, PIFSC-CRED
Beth Flint, Terrestrial Team, United States Fish and Wildlife Service (USFWS)
Chris Depkin, Terrestrial Team, United States Fish and Wildlife Service (USFWS)

DATA COLLECTED:

Digital images from algal photoquadrats
Algal voucher specimens necessary for algal species identification
Algal field notes of species diversity and relative abundance
Videotransects of benthos and overall site character 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
Transect surveys of all fish 2 cm or larger in 600 m^2 – ID to species and estimate size
Stationary point count surveys of fish 25 cm and larger – ID to species and estimate size
Fish species presence checklists for community diversity estimates at each site
Digital images of rare or interesting fish species
Digital images of the benthic habitat from towboard surveys
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 estimations from towboard surveys

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
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 photosynethtic active radiation
ADCP transects

(/s/Peter S. Vroom)
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Peter S. Vroom, Ph.D.
Chief Scientist

(/s/David Kennedy)
Approved by: _____
David Kennedy
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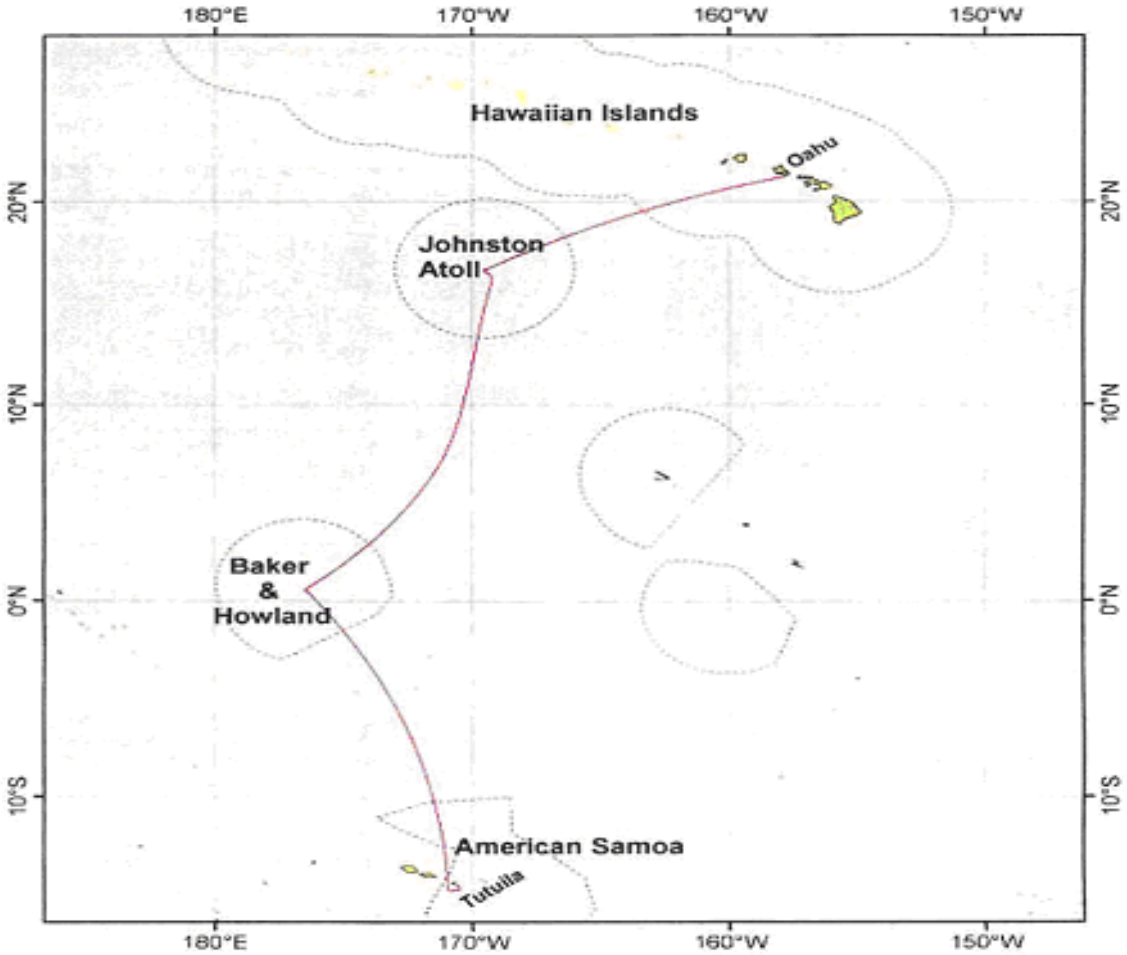

Figure 1.--Track of the *Hi`ialakai* HI-08-01, 24 January through 14 February 2008.

Appendix A: Methods

A.1 Oceanography & Water Quality Methods

(Oliver J. Vetter, Frank Mancini, Noah Pomeroy)

The Coral Reef Ecosystem Division has been conducting multidisciplinary research at Johnston Atoll since 2004 and around Howland and Baker 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 Atoll. During HI0801, 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.

- Ocean Data Platforms (ODP): Measure subsurface temperature, salinity, directional wave energy, tides and current profiles.

- 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.

- 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 fluorometer (Wetlabs Wetstar??). 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 75 m, complemented by water samples collected at 2- and 75-m depths are conducted at select locations for dissolved inorganic carbon (DIC) 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.

A.2 Rapid Ecological Assessment (REA) Methods

(Fish: Marc Nadon, Paula Ayotte, Kevin O'Brien, and Kara Osada; Corals: Bernardo Vargas Angel and Jason Helyer; Algae:Peter Vroom and Bonnie DeJoseph; Invertebrates: Molly Timmers and Tony Perry III)

The survey methodology for benthic data used during HI0801 is the same as previously used during REA surveys conducted in 2004 and 2006. 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 3–15 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 m^2) 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 (three 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 surrounding Johnston Atoll, three complimentary survey techniques were employed: coral population surveys, coral health and disease assessments, and benthic cover estimates using the line point intercept method. All three methods were conducted along two 25-meter transects at each site.

A.2.2.1 Coral Population Survey

Information on coral population structure was collected along two 25-meter 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 at Johnston.

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 meters on each side of the transect lines (approx. 300–500 m^2). 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), 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 of the affliction (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-meter 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, turfalgae, 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. The first team accompanied the Benthic REA team and surveyed previously visited sites while the second team was deployed on a separate boat and surveyed new, randomly chosen sites. Surveys were performed using a 25-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 < 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 SPCs (7.5-m radius). During the first 5 min of the SPC, the divers only recorded the presence of species within their survey areas. Afterwards, the divers proceeded down their respective species list, sizing and counting 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, with the nSPC conducted first followed by the BLT.

Fishes observed off transect or after the initial 5 min of the nSPC were recorded for presence data. No collection efforts were made by the fish team at Johnston during the survey period.

A.2.4 Macroinvertebrates

Quantitative counts and percent cover for specific target marine invertebrates are done along two separate 1 x 25 meter belt transects at 5-m intervals. Size frequency distribution of urchin species will be recorded for the first 25 individuals of each species. Based on data from previous rapid ecological assessments, 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-minute 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, Artifical Reef Matrix Structures (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 years enabling the recruitment and colonization of lesser known, cryptic marine invertebrates.

A.3. Towed-diver Survey Methods
(Stephane Charette, Edmund Coccagna, Kevin Lino, Marie Ferguson)
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 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 (GPS) 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.

A.4. Terrestrial Team Methods

(Beth Flint and Chris Depkin)

The terrestrial team consisting of Elizabeth Flint and Chris Depkin conducted pelagic bird and mammal transects 5 h per day during the transit to Johnston Atoll (25–26 January 2008). They recorded all birds and mammals sighted, as well as an index of flying fish density along the cruise track. Upon arrival at Johnston Atoll, Flint and Depkin went to shore and camped at the Point House peninsula for the next 5 nights in order to take advantage of early morning and late afternoon bird survey times, listen for nocturnal petrels that might come to the colonies after nightfall, and to minimize the burden to the small boat crews having to ferry them back and forth.They conducted counts of active nests (egg or chick) of Red-tailed Tropicbirds, Red-footed Boobies, Brown Boobies, Masked Boobies, Great Frigatebirds, Black Noddies, and White Terns at Johnston Island on 27–31 January and at North (Akau) Island and Sand Island on 1 February 2008. They also recorded breeding chronology of all breeding seabird species. They recorded and photographed all plant species sighted. They conducted a survey of all the seawalls at the islands visited, searching for areas where erosion or damage might increase the risk of a breach. They also surveyed for wildlife hazards such as open pits, drains, and chambers, and entanglement risks. In addition to regularly scheduled surveys, they recorded natural history notes on observations of insects, mammals, reptiles, and nearshore fish observed from shore.

Appendix B: Johnston Atoll

B.1. Oceanography and Water Quality

As a result of poor weather at Johnston Atoll during HI0801, operations were limited and priority was given to the replacement and deployment of moored instruments (STRs, WTR, SST, EAR). An effort was made to complete the circumnavigation of the atoll with equally spaced CTD casts at the 30-m contour. Time did not permit collection of shallow water DIC, NUT or CHL samples. Shipboard CTD casts were also hindered by weather, and an offshore transect for DIC sample collection was given priority over deepwater (500 m) CTD profiles, NUT and CHL sample collections.

A new SOSI-SST buoy was deployed at the established SST site. The previously deployed SST broke free from its mooring during Hurricane Ioke on approximately 22 August 2006. One WTR was recovered and replaced in the same location. An EAR mooring site was established on the south side of the Atoll, near the large boat channel. A total of five STRs were recovered and six were deployed; four independent moorings were conducted, one on the newly deployed SST anchor and one on the new EAR mooring (Fig. B.1.1. and Table B.1.1.).

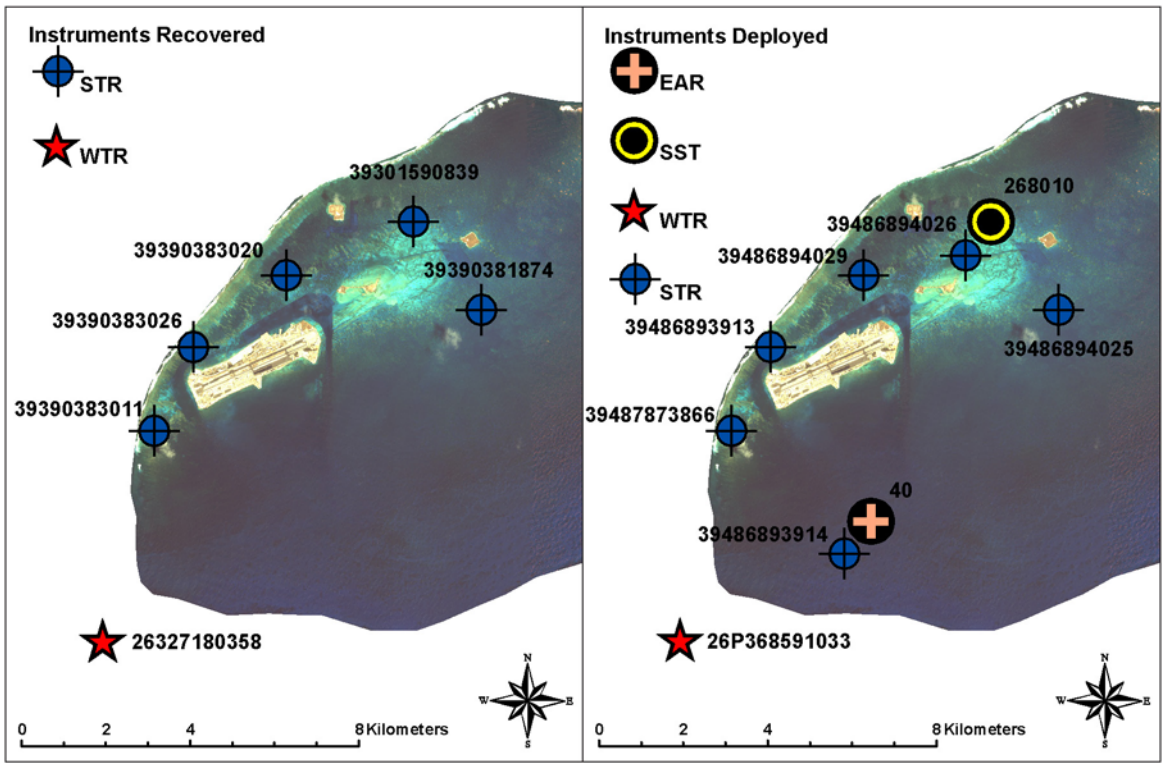

Figure B.1.1.--Moored Oceanographic Instrumentation Map. Moored oceanographic instruments, labeled by serial number, recovered and deployed at Johnston Atoll during HI0801.

Table B.1.1.--Moored Oceanographic Instrumentation Table. Moored oceanographic instruments recovered and deployed at Johnston Atoll during HI0801, instrument type, serial number, sensor depth, deployment and recovery dates (UTC)and data set start and end dates (UTC).

Instrument	Serial Number	Depth (m)	Deployed UTC	Recovered UTC	Data Start UTC	Data End UTC
WTR	26327180358	24.08	01/18/06 20:11	02/01/08 20:54	AWAITING DOWNLOAD	AWAITING DOWNLOAD
STR	39301590839	8.84	01/20/06 00:10	02/01/08 23:00	INSTRUMENT FAILED	INSTRUMENT FAILED
STR	39390381874	2.13	01/21/06 00:27	01/27/08 23:21	INSTRUMENT FAILED	INSTRUMENT FAILED
STR	39390383011	2.74	01/21/06 02:05	01/27/08 22:45	01/21/06 02:30	01/27/08 22:30
STR	39390383026	1.83	01/22/06 00:16	01/27/08 21:52	01/22/06 00:30	01/27/08 21:30
STR	39390383020	1.83	01/22/06 00:53	01/27/08 21:17	INSTRUMENT FAILED	INSTRUMENT FAILED
STR	39486894029	2.74	01/27/08 21:33	DEPLOYED	02/01/08 12:00	LOGGING
STR	39486893913	1.83	01/27/08 22:00	DEPLOYED	02/01/08 12:00	LOGGING
STR	39487873866	2.74	01/27/08 22:45	DEPLOYED	02/01/08 12:00	LOGGING
STR	39486894025	2.13	01/27/08 23:21	DEPLOYED	02/01/08 12:00	LOGGING
WTR	26P368591033	24.08	02/01/08 20:54	DEPLOYED	02/02/08 00:00	LOGGING
EAR	40	16.76	02/01/08 20:59	DEPLOYED	02/01/08 21:00	LOGGING
STR	39486893914	16.76	02/01/08 20:59	DEPLOYED	02/01/08 21:00	LOGGING
SST	268010	0	02/01/08 23:00	DEPLOYED	02/01/08 23:00	LOGGING
STR	39486894026	8.84	02/01/08 23:00	DEPLOYED	02/01/08 23:00	LOGGING

Twenty-seven shallow water CTDs were conducted at the 30-m contour. A complete circumnavigation of the atoll with CTD casts was not possible due to weather and time constraints. Worth noting, a potentially significant amount of time elapsed between CTD operations due to weather. Cast numbers 1-9 were conducted on 28 January 2008 and casts 10–27 were conducted on 2 February 2008 (Figs. B.1.3. and B.1.4.).

Seven shipboard CTD casts were conducted near Johnston Atoll (Fig. B.1.2.). CTD casts 1-3 were conducted on 28 January 2008 UTC to 500 m depth, and water samples were

collected at 3, 80, 100, 125 and 150 meters for NUT and CHL analysis. Casts 4-7 were conducted on 1 February 2008 UTC to 75 m depth and water samples collected at 2 and 75m for DIC analysis. NUT, CHL and DIC samples were processed and stored according to protocol and will be sent out for analysis following the cruise.

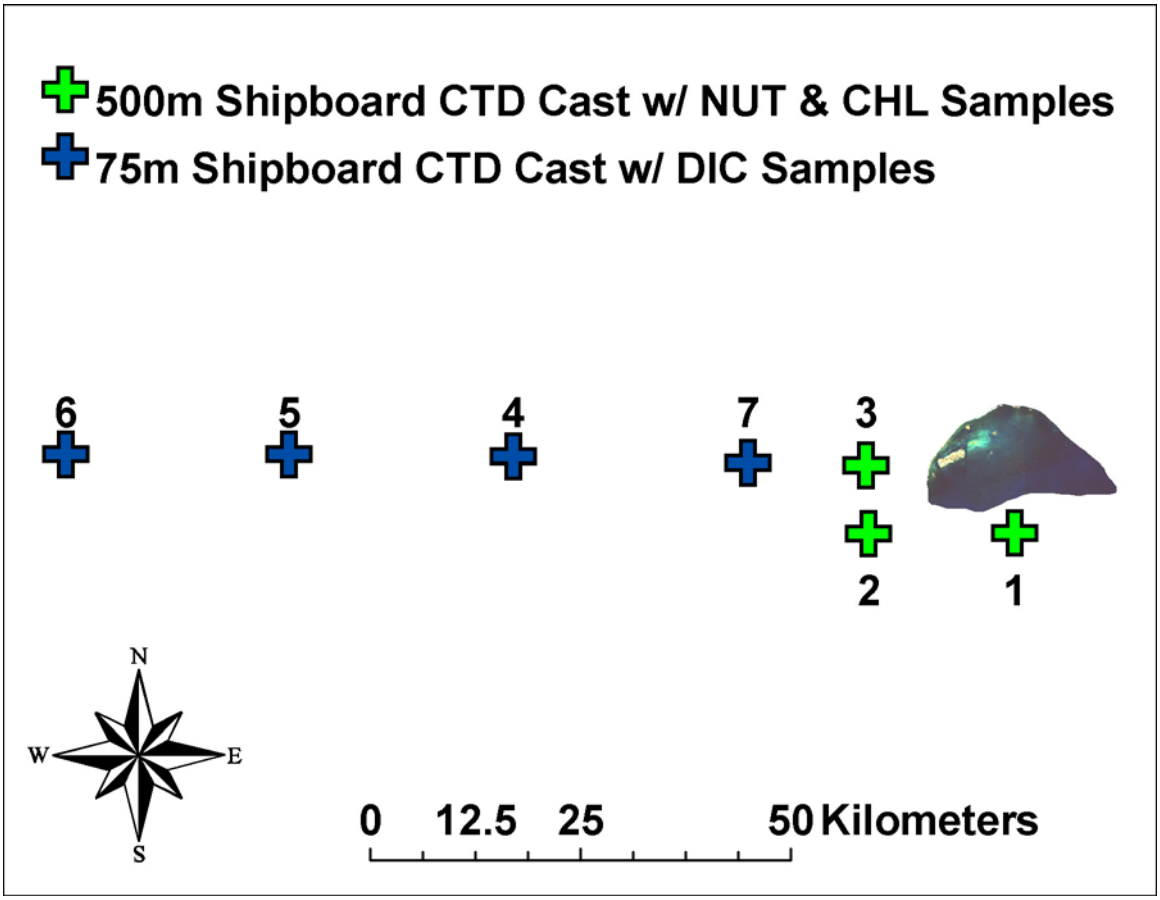

Figure B.1.2.--Shipboard CTD, DIC, NUT & CHL Operations. Deepwater shipboard CTD, DIC, NUT & CHL sites near Johnston Atoll during HI0801, labeled by cast number.

Preliminary Results

Due to the time delay between casts 1-9 and 10-27, we are hesitant to draw conclusions about water property variation in the shallow water CTD data. However, some trends can be recognized between casts conducted in succession. Water at 20 m depth was slightly cooler, denser, and more turbid on the western than on the southern side of the atoll (Fig. B.1.3.). Water on the east side of the atoll grew slightly warmer, fresher, less dense and more turbid at 20 m approaching the north point. The range of all measured variables at 20 m is quite small.

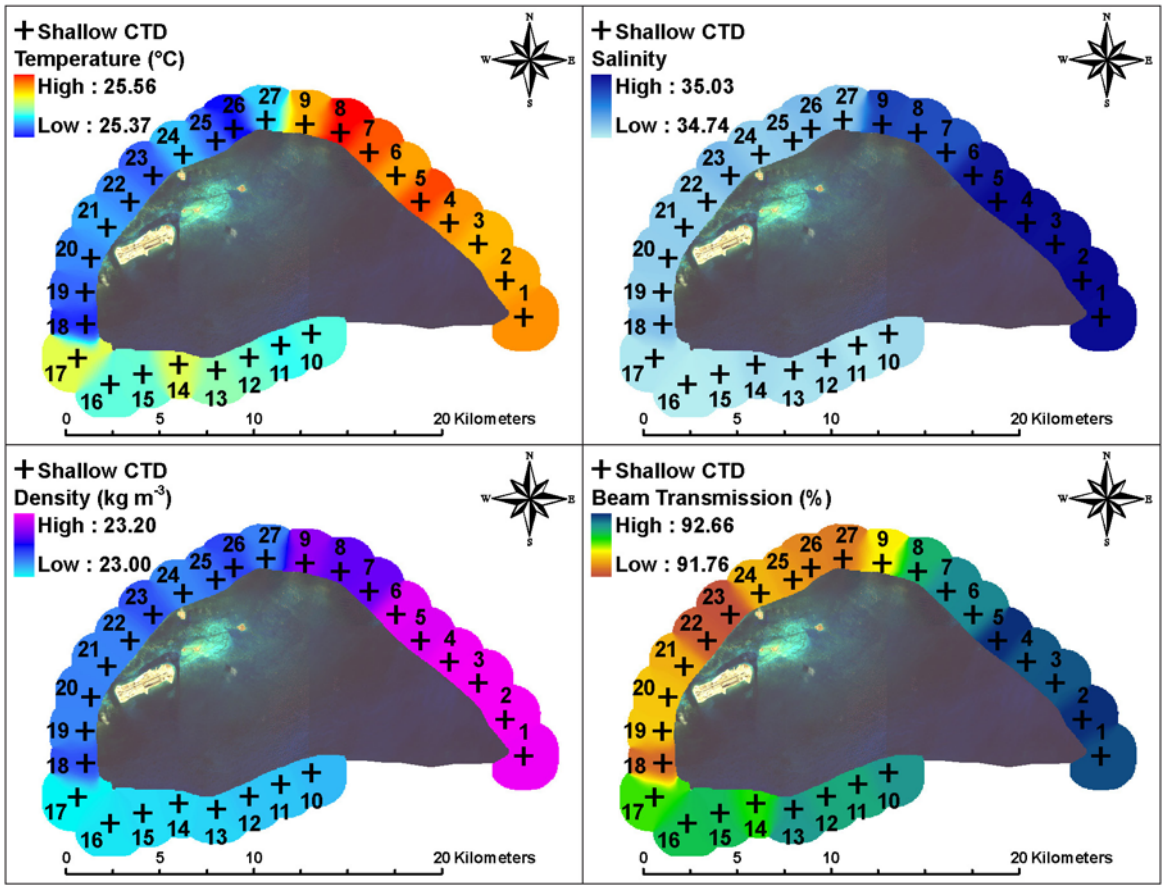

Figure B.1.3.--Shallow CTD Casts and 20m Data Interpolations. Shallow CTD cast locations and interpolations of temperature (upper left), salinity (upper right), density (bottom left) and beam transmission (bottom right) at 20 m depth. Casts 1-9 were conducted on 28 January 2008 UTC and casts 10-27 were conducted on 2 February 2008 UTC at Johnston Atoll during HI0801.

Temperature, salinity, density, and transmittance at the 30-m depth contour were relatively homogeneous with depth around the atoll (Fig. B.1.4). There was a full depth gradient in all properties measured by the CTD at the southwest corner. The southern shores (casts 10–17) showed warmer (+ 0.15 ^{0} C), slightly less saline (- 0.2), less dense and clearer water than the north and western shores. This is likely a product of deep water mixing on the northern and northwestern shores due to the high wave action observed during this time.

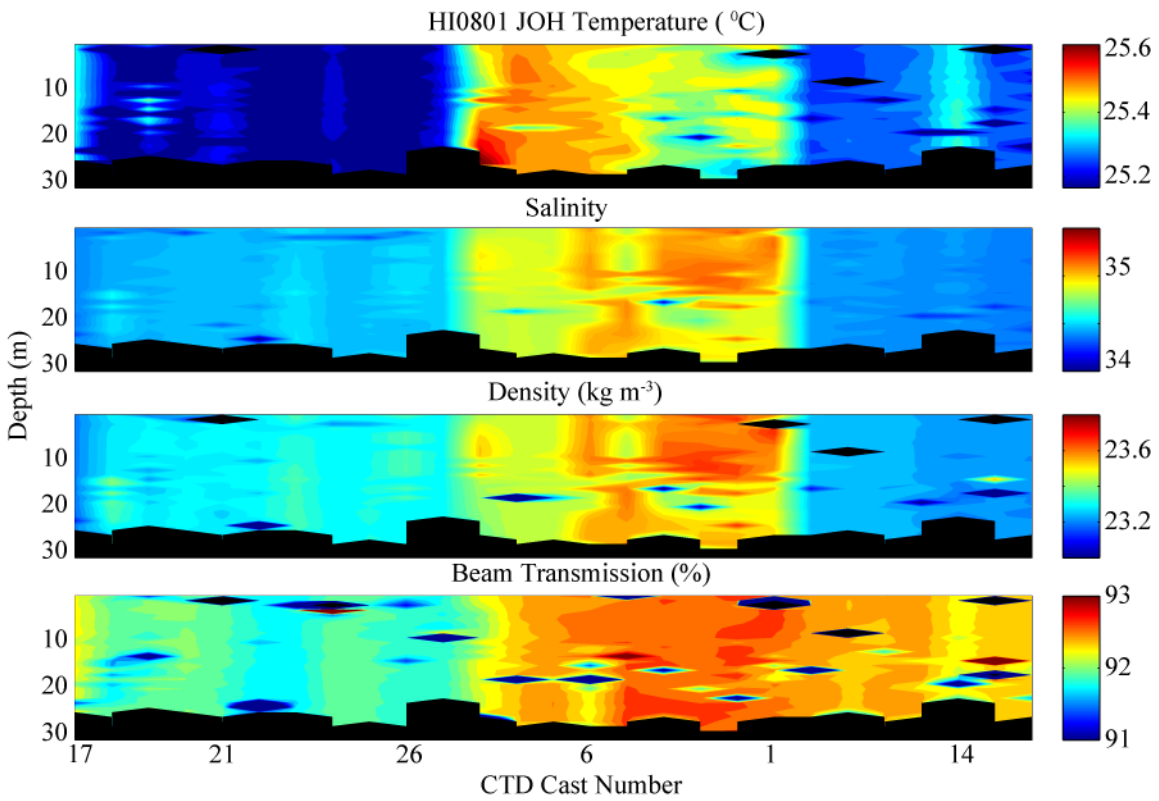

Figure B.1.4.--Shallow CTD Cross-section Plot. Cross-section plot of shallow water CTD data temperature, salinity, density and beam transmission collected at Johnston Atoll during HI0801. Refer to Figure B.1.2. for CTD cast locations.

Temperature data were obtained from two locations around Johnston Atoll (Fig. B.1.5). Intercomparison of the timeseries data shows similar seasonal temperature fluctuations, with the warmest temperatures occurring from August to September and the coolest from February to March. On 22 August 2006, Hurricane Ioke made landfall on Johnston Atoll causing a temperature drop of 1.5 ^{0}C in a matter of hours (Fig. B.1.5). This rapid cooling within the lagoon was likely due to freshwater input from rainfall and offshore mixing from large waves forcing water over the reef.

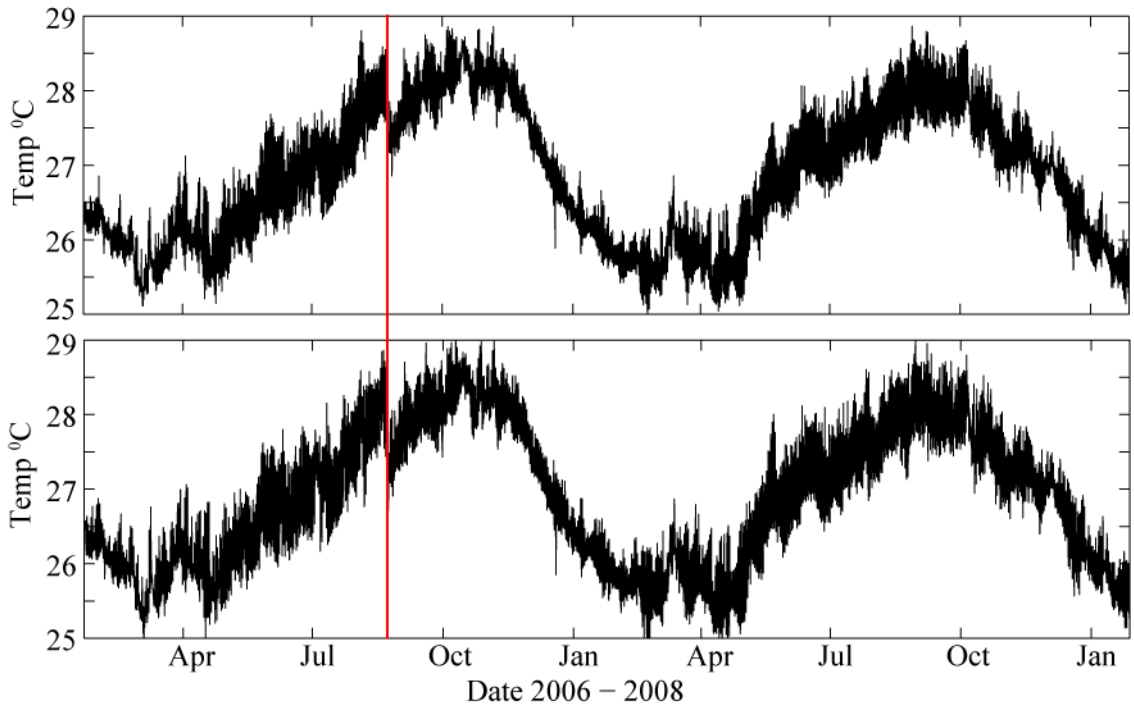

Figure B.1.5.--Temperature data obtained from two STR locations at Johnston Atoll. The red line shows when Hurricane Ioke made landfall on Johnston Atoll on 22 August 2006.

B.1.1. Tide Gauge Recorder Swap
(Michael Quisenberry)

Station Names	***Johnston Atoll, USA***
Date of Visit	1/24/08-2/15/08
Technician	Michael L Quisenberry
Travel Routing	Honolulu-Johnston Atoll-American Samoa-Honolulu
Local Accommodations	Aboard the NOAA Ship *Hi'ialakai*
Local Voltage	110V Standard
Communication	Internet and INMARSAT phone

Reason for visit:
The station was not working and needed to be upgraded with a Satlink 2 DCP, Vega Radar, SDR encoder, and Druck pressure sensor. Also, transportation became available.

Work Accomplished:

- Installed new:
    - Satlink 2 with sd card slot (1GB card)
    - Waterlog Yaggi antenna
    - Garmin Dome GPS antenna on pole mount
    - BP 40W Solar Panel
    - (2) 34Ah Sunextender batteries (12V)
    - (3) meter I-beam
    - (2) Witch switches on tide staff support
    - Druck pressure sensor in 1.25 in PVC
    - Druck PRS vent box
    - Vegapluse 62 radar on box beam with cover
    - Hart to SDI-12 conversion box for radar
    - Hoffman box backing plate
    - Sunsaver 6 solar regulator
    - SDR Encoder sensor with GPS antenna and 5W solar panel
    - Anchored the Encoder table to the floor
    - 2.5 in Aluminum pole with 3/8 in threaded rod through bolted to exterior tide house wall for mounting solar panel and antennas
- Removed:
    - 540 DCP
    - Old solar panel
    - Rusted pole for mounting antenna and solar panel
    - Old yagi antenna
    - Old batteries
- Took advantage of the existing ~20-40 W and ~5 W solar panel on the tower and wired them into the solar regulator for the DCP and SDR respectively
- Installed new BM1 benchmark at tide station
- Reestablished 3 benchmark locations after island wide deconstruction
- Recovered old NOAA records on all 10 benchmarks
- Conducted short survey
- Updated photo and written documentation

Further action recommended:

The station was left in haste due to time issues with the ship. Replace the SDR encoder since it wouldn't communicate with the Satlink. Bring a 4.5 m stainless steel tape to replace the existing one. Possibly mount the radar sensor higher since I mounted it to the deck because of time. Verify that the switches are at mean sea level; move accordingly if needed.

<u>B.2. Rapid Ecological Assessment (REA) Site Descriptions</u>

JOH-01 1/27/2008

N 16° 44.3776 W 169 ^{o}32.0695

Depth Range: 1.5–7.6 m

This west-northwest site was a lagoon patch reef north of Johnston Island near a dredged channel. Turf algae over pavement and dead coral dominated the benthos followed by

moderate coral cover and sand. Coral cover averaged 32% and dominant coral species in descending order were *Montipora capitata*, *M. patula*, and *Acropora cytherea*. Two cases of skeletal growth anomalies were observed on *Montipora* and one case of acute tissue loss (white syndrome) on *Acropora*. *Dictyosphaeria versluysii* and small amounts of crustose coralline red algae were the only macroalgae to occur in photoquadrats, although, *Caulerpa serrulata* was found close to transect lines. Macroinvertebrate presence was extremely low; only two *Tripneustes gratilla* and one *Actinopyga obsesa* were seen on the transect. However, vermetid mollucs and a green didenmid-like tunicate were abundant. Large fish (over 20 cm) were mostly absent, although a few that were present included *Aphareus furca*, *Chlorurus perspicillatus,* and *Oxycheilinus unifasciatus*. The juvenile parrotfish species *Chlorurus sordidus* and a lesser quantity of *Scarus psittacus* were dominant, found in roving schools throughout the complex coral habitat.

JOH-18 1/27/2008
N 16 ^{o} 43.8814 W 169 ^{o} 32.3693
Depth Range: 5.5–6.4 m
This north-northwest silty lagoon patch reef site was located adjacent to the northern edge of Johnston Island. Sand and turf over pavement and dead coral dominated the benthos. Live coral was low (10%) with *Montipora* sp. being the most abundant genus. One case of both skeletal growth anomaly and bleaching occurred on *Montipora.* The algal photoquadrats only contained turf and cyanophytes. *Caulerpa serrulata* was found during the random swim. No macroinvertebrates were recorded on the transect. However, during a random swim coralliophillas, *Quoyula madreporarum,* were observed. The overall survey area was depauperate of fish; however, one isolated patch of reef along the transect was high in fish biomass. Juvenile parrotfish dominated, especially in the depauperate areas. In the busier patch area, several species of larger fish, including *Sargocentron spiniferum*, *Acanthurus blochii*, *Oxycheilinus unifasciatus*, and *Caranx melampygus* were noted. An unusually large *Epibulus insidiator* was observed off transect; many yellow-phase individuals of this species were seen on and off transect. Also noted were large schools of goatfish.

JOH-19 1/27/2008
N 16 ^{o} 44.6945 W 169 ^{o} 32.1810
Depth Range: 2.4–6.3 m
This west-northwest lagoon patch reef site had high live coral (47%) and turf algae (37%) cover. The dominant corals were *Montipora capitata, Montipora patula,* and a small number of large *Acropora cytherea* colonies. Ten cases of skeletal growth anomalies and one case of bleaching were observed on *Montipora.* Macroalgae was relatively scarce. Photoquadrats contained turf algae, cyanophytes, and *Dictyosphaeria versluysii*. *Ventricaria ventricosa* was found abundantly during the random swim, as well as a few individuals of *Caulerpa serrulata.* The sea cucumber, *Holothuria atra*, was the dominant marcoinvertebrate. Sixty-seven *H. atra* were recorded off transect. Four species of urchins were seen, *Echinometra mathaei* being the dominant one. The eared sea hare, *Dolabella auriculaia*, and an unidentified synaptid sea cucumber resembling, *Polypectana kefersteini,* were observed during a random swim. A green didenmid-like

tunicate was abundant. A variety of butterflyfish including *Chaetodon auriga*, *C. ephippium*, *C. lunulatus*, *C. citrinellus*, *C. ornatissimus*, *C. unimaculatus*, and *C. trifascialis* were observed. *Fistularia commersonii* was seen off transect, as were two *Caranx melampygus*. Overall, there was a high variety of fish species, though no one species dominated.

JOH-10P 2/1/2008
N 16 ^{o} 45.8015 W 169 ^{o} 30.6767
Depth Range: 11.3–15.5 m
This north lagoon patch reef site, located east of Akau Island, has permanent transect pins and was visited during 2004 and 2006 surveys. Turf algae over pavement and dead coral dominated the benthos followed by moderately high live coral (36%). Montiporid corals were the most abundant coral observed within the transects followed by *Acropora cytherea* and *Pavona varians*. Fifteen cases of skeletal growth anomalies on *Montipora* spp. and three cases of white syndrome on *Acropora cytherea* were observed. Macroalgae were scarce, but a deep green tunicate that mimicked algae was fairly common. Turf algae, crustose coralline red algae, and a small *Ventricaria ventricosa* were found in the photoquadrat areas while *Caulerpa serrulata* and *Dictyosphaeria versluysii* were observed during the random swim. Holothurids dominated the macroinvertebrate fauna. Three species were seen on the transect: *Bohadishia paradoxa, Holouthuria edulis*, and *H. atra* totaling 12 sea cucumbers. In addition, *Actinopyga obesa* was seen off-transect. *Tripneustes gratilla* were observed in low numbers. Vermetid mollusks were prevalent. Compared to the other sites, juvenile parrotfish were lacking, as were overall large numbers of fish. Of the fish present, *Acanthurus nigroris* and *Chlorurus sordidus* were most abundant. However, a large school of *Chromis ovalis* were seen off transect. Of note, a small eagle ray was spotted.

JOH-05P 2/1/2008
N 16 ^{o} 45.6051 W 169 ^{o} 30.7022
Depth Range: 11.9–15.5 m
This north lagoon patch reef site on the east side of Akau Island has permanent transect pins and was visited during 2004 and 2006 surveys. Fifty percent of the benthic cover was turf algae over pavement and dead coral. Coral cover averaged 22% with *Montipora capitata, Montipora patula,* and *Acropora cytherea* being the dominant coral taxon found on belt transects. Seventeen cases of skeletal growth anomalies on *Montipora* spp. and one case of discoloration on *Montipora* was observed. Turf algae, crustose coralline red algae, *Peyssonnelia* sp., *Ventricaria ventricosa*, and a cobweb-like, green cyanophyte were found inside photoquadrats. *Caulerpa serrulata* and *Dictyosphaeria versluysii* were observed during the random swim. No macroinvertebrates were found along the transect. However, *Holothuria difficilus* and *Holothuria atra* were observed during the random swim. A green didenmid tunicate was seen throughout the site. Surgeonfish and parrotfish once again dominated, and boxfish were seen in higher quantities than typically observed. A possible hybrid of *Thalassoma lutescens* and *T. duperrey* was seen. Seen off transect was a single *Sphyraena barracuda*.

JOH-12 2/1/2008
N 16 ^{o} 44.8697 W 169 ^{o} 31.4460
Depth Range: 9.1–11.9 m
This lagoon patch reef site, located directly north of the navigational channel had moderately low live cover (23%) and was composed predominantly of *Montipora* spp. and *Acropora cytherea*. Turf algae over pavement and dead coral represented nearly 61% of benthic cover, and sand represented 17%. One case of white syndrome was noted on *Acropora cytherea*. Macroalgae were scarce. Turf algae, crustose coralline red algae, *Lobophora variegata*, *Ventricaria ventricosa*, *Dictyosphaeria versluysii*, and a purplish, pillowy cyanophyte were observed in the photoquads. Three known species of holothuroids were observed, *Holothuria atra, H. edulis,* and *Actinopyga obesa,* and one undescribed *Holothuria spp.* known commonly as the chocolate chip sea cucumber was seen. *Tripneustes gratilla* were observed in low numbers. Although macroinvertebrate numbers were low along the transect, holothurids were prevalent off transect. During the roving swim, over 20 *Holothuria atra,* 10 *B. paradoxa*, 10 *A. obesa*, and 5 *H. edulis* were observed. Parrotfish juveniles easily dominated this site, with schools made up of individuals ranging from 2 to 20 cm. *Naso literatus* juveniles were found in high quantities, often associated with the parrotfish schools. Seen off transect were *Caranx melampygus* and *Aphareus furca*.

JOH-50 1/27/2008
N 16 ^{o} 45.484 W 169 ^{o} 31.485
Depth Range: 3–7 m
This site is located northwest of Johnston Island, inside the lagoon. It was established by the REA fish team as a new sampling location in the lagoon-shallow stratum. The general area is a high complexity, high coral cover acropora reef, typical of the Johnston lagoon. The reef is almost entirely aggregated with few sand patches. Chaetodontids dominated this site, comprising 51% of total fish biomass recorded on the nSPC survey. *Chaetodon ephippium* was particularly numerous, found in large schools on both the belt and nSPC surveys. Labrids were also common, as were Scarids.

JOH-51 1/27/2008
N 16 ^{o} 43.123 W 169 ^{o} 33.220
Depth Range: 5–6 m
This site is located southwest of Johnston Island, inside the lagoon. It was established by the REA fish team as a new sampling location in the lagoon-shallow stratum. The general area is a high complexity, high coral cover acropora reef, typical of the Johnston lagoon. The reef is patchy with about 60% aggregated substrate and the rest composed of sand channels. Small Scarids were the most common fish encountered at this site. Chaetodontids were also numerous, with five species, *C. trifascialis, C. unimaculatus, C. multicinctus, C. lunulatus, and C. auriga* represented. These were followed closely in biomass by the ubiquitous acanthurids.

JOH-52 1/27/2008
N 16 ^{o} 41.787 W 169 ^{o} 30.388
Depth Range: 13–20 m
This site is located east of Johnston Island, in the unprotected side of the lagoon. It was established by the REA fish team as a new sampling location in the lagoon mid depth stratum. The general area is a medium complexity, low coral cover reef with lower visibility than at other sites. We noticed a lot of overturned acropora plates, probably due to the recent hurricane that passed by Johnston in August 2006. The reef is very patchy with mostly sand substrate with a few large patches of aggregated reef. Acanthurids by far comprised the most biomass at this site. *Ctenochaetus strigosus, Acanthurus nigroris, Zebrasoma flavescens, and Naso literatus* dominated here. Of particular interest were large schools of *N. literatus*, estimated at > 50 individuals, varying in size from 14 to 22 cm. Five large individuals of the species *Aprion virescens* were recorded both on and off transect, making Lutjanids the second most common family present at this site in terms of total biomass. Also notable was a sighting of one 150-cm *Carcharinus amblyrhynchus* (off transect), and one *Thallassoma duperrey*/*lutescens* hybrid.

JOH-53 2/1/2008
N 16 ^{o} 44.918 W 169 ^{o} 32.368
Depth Range: 11–12 m
This site is located on the western forereef reef of Johnston Atoll. It was established by the REA fish team as a new sampling location in the forereef mid depth stratum. The general area is a high complexity, low coral cover reef with high *Millepora* cover (firecoral, ~ 30%). The reef is completely aggregated, with little sandy area. Balistids were common here on the forereef, particularly *Melichthys niger*, which was seen in large numbers. The species *Acanthurus nigroris* and *Ctenochaetus strigosus* were numerous as well.

JOH-54 2/1/2008
N 16 ^{o} 44.232W 169 ^{o} 32.974
Depth Range: 9–14 m
This site is located on the western forereef reef of Johnston Atoll. It was established by the REA fish team as a new sampling location in the forereef mid depth stratum. The general area is a high complexity, low coral cover reef with high *Millepora* cover (firecoral, ~ 30%). The reef is completely aggregated, with little sandy area. Acanthurids, Balistids and Labrids were common here. Notable were larger numbers of Holocentrids located there than in previous sites, as well as one large individual of the species *Gymnothorax javanicus*, which alone represented more biomass than all the Acanthurids, Balistids, and Labrids recorded on the same nSPC survey combined.

JOH-55 2/1/2008
N 16 ^{o} 43.411 W 169 ^{o} 33.505
Depth Range: 9–12 m
This site is located on the western forereef reef of Johnston Atoll. It was established by the REA fish team as a new sampling location in the forereef mid depth stratum. The

general area is a high complexity, low coral cover reef with high *Millepora* cover (firecoral, ~ 30%). The reef is characterized by very large spurs and grooves about 30–50 m wide. Holocentrids comprised a large proportion of the biomass here, along with the Acanthurid species *Ctenochaetus strigosus* and *Acanthurus nigroris*. Also very common were the smaller chromis species *C. acares* and *C. agilis*. Notable were several individuals of the species *Scombroides lysan* that were seen off-transect at this site.

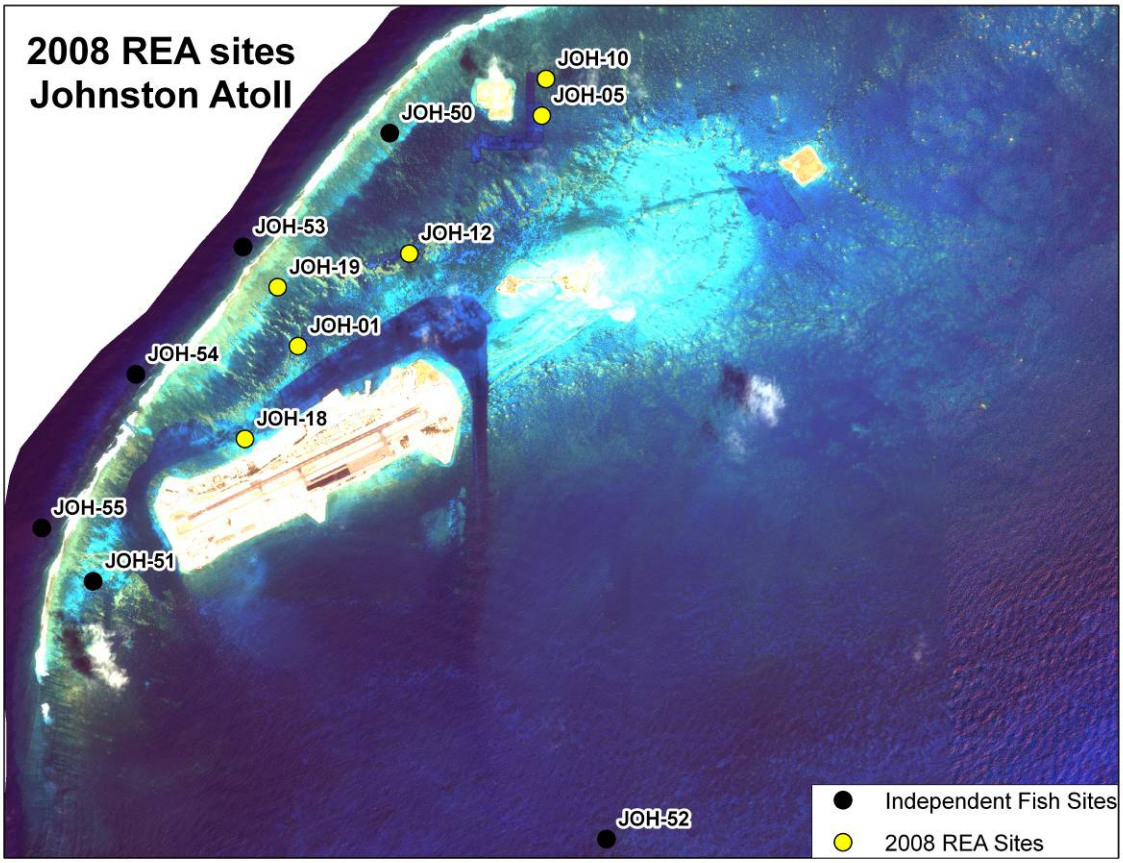

Figure B.2.1.--Map of Johnston Atoll REA sites surveyed in 2008.

B.3. Benthic Environment

B.3.1. Algae

Quantitative algal surveys were conducted at six quiet water lagoonal sites at Johnston Atoll. All sites except for JOH-18 exhibited high Acroporid and Monitoporid coral cover with relatively little macroalgae (Table B.3.1.1). Macroalgal diversity was low and consistent across the lagoon. Five species of macroalgae were recorded along survey lines: three species of green algae, one species of red algae, and one species of brown algae, as well as crustose coralline red algal, turf algal, and cyanophyte functional groups.

Table B.3.1.1--Algal genera or functional groups recorded in photoquadrats at Johnston Atoll. 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.

	JOH-01	JOH-05P	JOH-10P	JOH-12	JOH-18	JOH-19
GREEN ALGAE						
Caulerpa serrulata	*	*	*		*	*
Dictyosphaeria versluysii	8.333333	*	*	8.333333		8.333333
Ventricaria ventricosa		25	25	8.333333		*
RED ALGAE						
crustose coralline red algae	41.66667	16.66667	33.33333	33.33333		
Peyssonnelia sp.		8.333333				
OCHROPHYTA						
Lobophora variegata				8.333333		
FUNCTIONAL GROUPS						
turf algae	91.66667	100	100	100	100	83.33333
Cyanophyte		8.333333		16.66667	8.333333	16.66667

B.3.2. Corals

Coral REA surveys were conducted at six sites (JOH-01, JOH-05P, JOH-10P, JOH-12, JOH-18, and JOH-19) around Johnston Atoll between January 27, 2008 and February 1, 2008 (Fig. B.2.1.). Coral population surveys were conducted by Jason Helyer (CRED), and coral disease and health assessments were conducted by Dr. Bernardo Vargas Angel (CRED). Poor weather conditions prohibited diving operations during January 28-31, 2008 and limited the REA team to working in shallow lagoon habitats protected from the large swells hitting the atoll. Survey depths ranged between 4 and 14 m for all locales visited. Two permanent sites (JOH-10P and JOH-05P) were surveyed with transect pins being located at both sites.

B.3.2.1 Percent Benthic Cover

The line-point intercept (LPI) methodology quantified a total of 612 points along 300 m of lagoon coral communities. Patterns of intra-island variability in percent benthic cover, derived from the six independent REA surveys in 2008, are reflected in Figure B.3.2.1.1. Point-count surveys indicated that the mean percent live coral cover for all sites combined was intermediate: 31.9 ± 5.7% (mean ± SE). Coral cover in excess of 40% was encountered at sites JOH-19 and JOH-12 in the northwestern lagoon, north of Johnston Island. Contrastingly lower percent coral cover (9.8%) was detected at JOH-18, off the north-facing shore of Johnston Island. Of the nearly 10 scleractinian genera recorded by Jim Maragos during the 2006 benthic REA surveys, a total of 3 were enumerated along the 2008 LPI transects, with *Montipora* being the most numerically abundant (82.9 ± 5.6%), followed by *Acropora* (15.4 ± 5.4%), and *Pavona* (2.0 ± 1.0%). No additional coral genera were enumerated along the LPI transects.

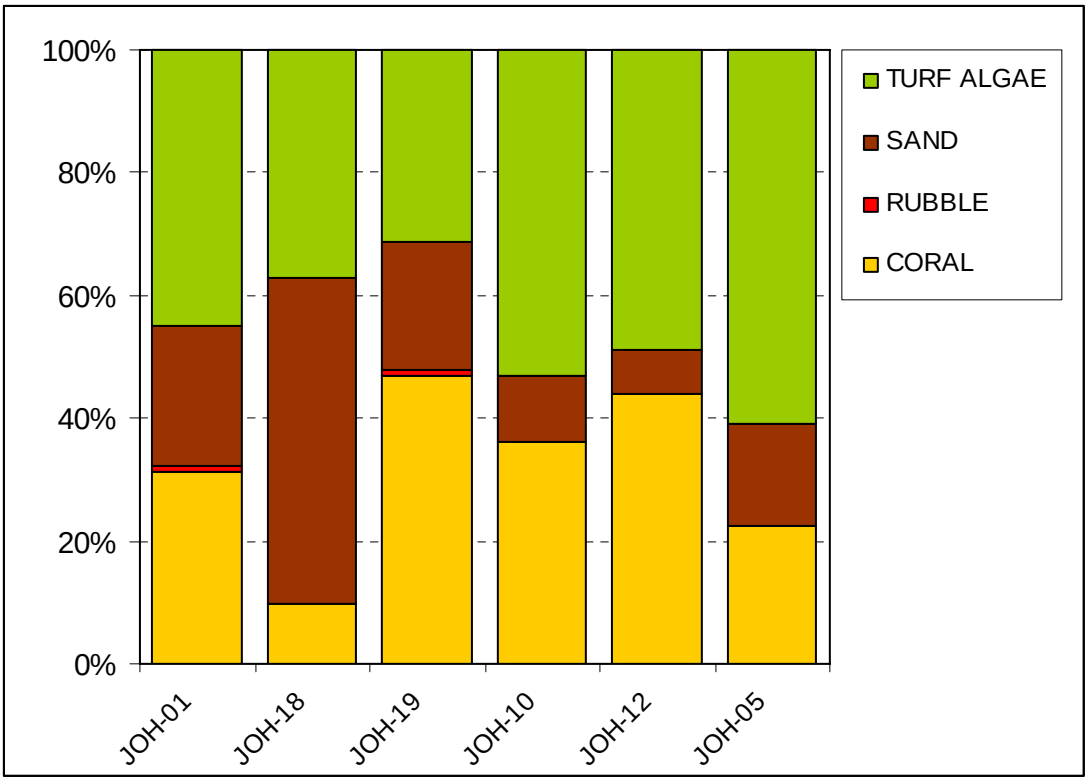

Figure B.3.2.1.1.--Mean percent cover of selected benthic elements derived from six independent REA surveys at Johnston Atoll, Equatorial Pacific Cruise 2008 (January 27 and February 1, 2008). CORAL: live scleractinian and hydrozoan stony corals; RUBBLE: coral rubble (including recent and old coral rubble covered with turf-algae); SAND: sand; and TURF ALGAE: turf algae growing over dead coral and coral pavement.

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 January 2006 and 2008 is illustrated in Figure B.3.2.1.2. Differences in mean coral cover between years amounted to nearly 16% for all sites combined. However, because Pacific Typhoon Ioke crossed over Johnston Atoll from the southeast on 22 August 2006 as a category 2, it is plausible that the storm effects may be implicated in the differences observed in percent live coral cover among years.

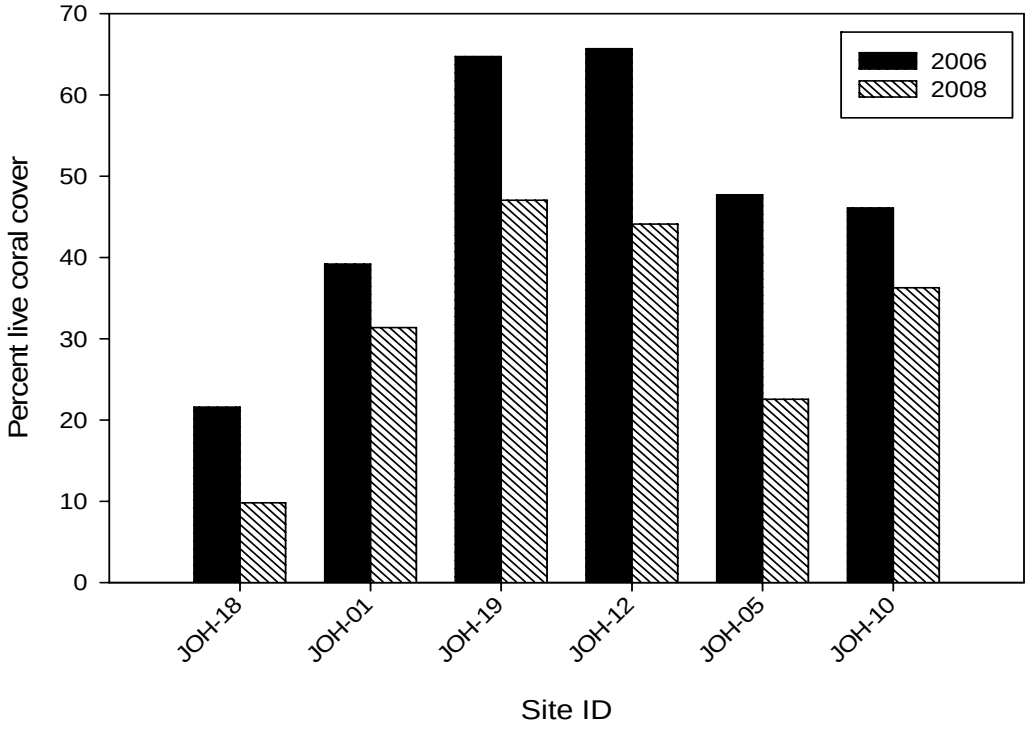

Figure B.3.2.1.2.--Percent live coral cover for six REA sites at Johnston Atoll contrasted for survey years 2006 and 2008.

B.3.2.2. Coral Populations

A total of 2,426 colonies belonging to 4 anthozoan taxon were enumerated within 300 m^2 of reef surveyed at Johnston. Montiporid corals and large table corals, *Acropora cytherea*, dominated sites inside the lagoon accounting for 92.3%and 5.8% of colonies found within belt transects, respectively (Table B.3.2.2.1). *Monitpora capitata* and *Montipora patula* were the most common of the montiporid corals encountered with several other *Montipora* species being present as well. Generic diversity of corals within Johnston lagoon was extremely low with only four genera present within belt transects.

Table B.3.2.2.1.--Number of anthozoans enumerated within belt transects at Johnston Atoll during 2008 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Genus	# of Colonies	Percent of Total
Acropora	152	6.3
Montipora	**2240**	**92.3**
Pavona	22	0.9
Pocillopora	12	0.5

Size-class distributions of all corals enumerated within belt transect are shown in Figure B.3.2.2.1. Of the 2,426 colonies, 51.4% had a maximum diameter < 10 cm, and 95.1% had a maximum diameter > 40 cm. It is important to note, however, the subjectivity of discerning colony boundaries of many of the montiporid corals found within the lagoon which constituted an overwhelming percentage of the corals counted at Johnston Atoll. For this reason, size-class and density data should be interpreted with caution.

It appears that Pacific Typhoon Ioke, a category 2 storm which crossed over Johnston Atoll from the southeast on 22 August 2006, might have impacted some of the larger table corals, *Acropora cytherea* within the lagoon. Large overturned colonies were observed off transect at five of six REA sites. Figure B.3.2.2.1. illustrates the size-class distribution of table corals found at four REA sites within the lagoon that were visited in 2004, 2006, and 2008. While there seems to be a decreasing trend in *Acropora cytherea* density in most of the size-classes, a significant increase in colonies in the 0–5-cm size class suggest that larval resources are still present in the lagoon.

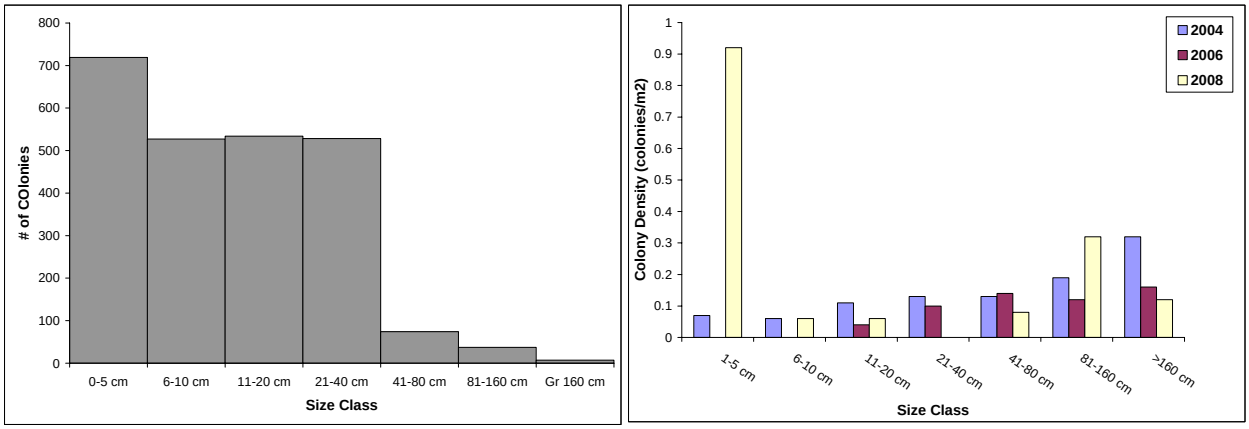

Figure B.3.2.2.1.--Size-class distribution of 2,426 coral colonies enumerated within belt transects at Johnston Atoll in 2006 (left) and temporal comparison of size class distribution of *Acropora cytherea* at sites JOH-01,-05,-10, and -12 from 2004 to 2008.

B.3.2.3 Coral Health and Disease

In 2008, the coral disease REA surveyed a total area of ~ 1430 m^2 at six different sites. Due to time constraints, only 56 m^2 were surveyed for disease at site JOH-12. A summary of disease occurrence is presented in Table B.3.2.3.1. Overall, occurrence was relatively high, with a total of 53 cases within the total area surveyed (~ 4 cases/100 m^2 of reef area). Skeletal growth anomalies were the most abundant disease state (85% cases) and affected corals in the genus *Montipora*, followed by the white syndrome, (9%), which was observed affecting the tabular *Acropora cytherea* only. Among sites, JOH-10P and JOH-12 in the northern lagoon, exhibited the greatest occurrence of disease with over 34% of cases each, compared to 2% for site JOH-05. Disease conditions were registered on two different coral genera, with *Montipora* (*Montipora capitata*, *M.* cf *peltiforms*; *M*. cf. *patula*, and *M*. cf. *hoffmeisteri*) exhibiting 90% of cases, followed by *Acropora* (10%).

Table B.3.2.3.1.--Number of cases of coral disease and diminished health states at Johnston Atoll REA sites during 2008 surveys.

Site	BLE	SGA	WSY	DIS	Grand Total
JOH-01		2	1		3
JOH-18	1	1			2
JOH-19	1	10			11
JOH-10P		15	3		18
JOH-12		17		1	18
JOH-05P			1		1
Grand Total	2	45	5	1	53

B.3.3. Macroinvertebrates

All reef areas surveyed were located within the northern lagoon patch reef habitat. Being primarily dominated by coral, all surveyed sites were low in non-cryptic macroinvertebrate abundance with the exception of echinoderms at JOH-19 and JOH-10P. Both holothuroids and echinoids were prevalent at JOH-19 with densities of 0.20 m² and 0.14 m², respectively. The dominant holothuroid species was *Holothuria atra* (95%), and the dominant echinoid species was *Echinometra mathaei* (50%). Only holothuroids were common at JOH-10P with a density of 0.12 m². Unlike JOH-019, the dominant holothuroid was *Bohadschia paradoxa* (83%) at JOH-10P. Overall, nine species of holothuroids were observed: *Holothuria atra, H. edulis, H. dificilus, H. whitmaei, Bohadschia paradoxa, Actinopyga obsesa, Euapta godeffroyi, Polyplectana kefersteini,* and an unidentified *Holothuria* spp. commonly called the "chocolate chip" sea cucumber. Seven species of echinoids were observed: *Echinometra mathaei, Echinothrix calamaris, Echinothrix diadema, Tripneustes gratilla, Diadema paucispinum, Heterocentrotus mammilatus,* and *Eucidaris metularia*. No asteroids were seen. Mollusks from the family Vermetidae were present in great abundance throughout all sites. A green didemnid tunicate was noted at the majority of sites to be overgrowing over some *Acropora* and *Montipora* coral colonies.

B.3.3.1. Urchin and Giant Clam Measurements

Figure B.3.3.1.1. reveals the average test diameter of species encountered at each site. Only sites where ≥ 5 measurements were recorded for a species are represented.

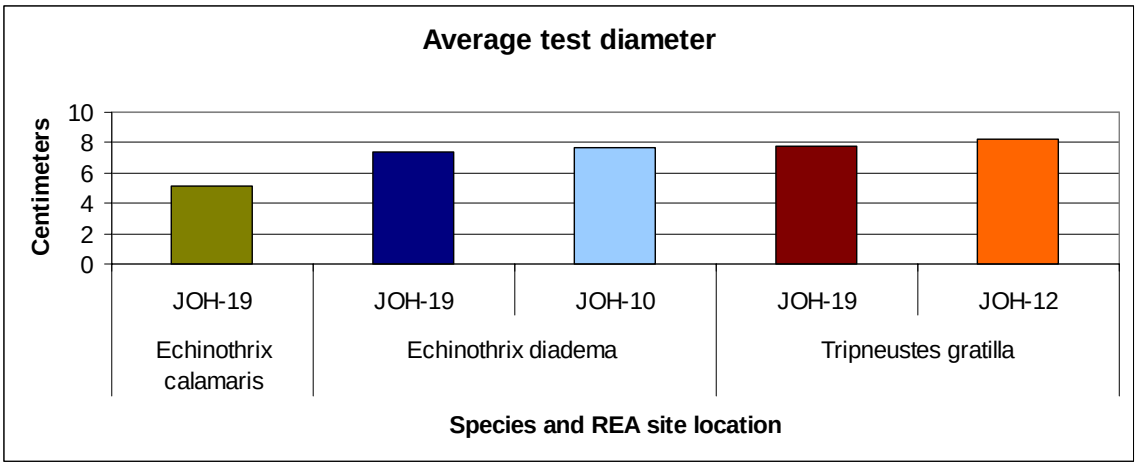

Figure B.3.3.1.1.--Average urchin test diameter.

No giant clams were measured for they are not present at Johnston Atoll.

B.3.3.2. ARMS Deployment

Due to weather constraints, no ARMS were deployed on the forereef habitat at Johnston Atoll.

B.3.3.3. Invertebrate Collections

An unidentified *Holothuria* spp., commonly called the "chocolate chip" sea cucumber was collected and preserved.

B.3.4 Towed-diver Benthic Surveys

A total of 11 towed-diver surveys covering 23.05 kilometers of habitat were completed along the forereef and lagoon strata of Johnston Atoll (Fig. B.3.4.1). Along the forereef, bottom complexity ranged from low to medium-low in the southwest to medium in the western and northwestern reefs. The bottom complexity within the lagoon ranged from medium-high along the southern side of Johnston Island to medium in the large boat channel.

The dominant habitat of the nine forereef surveys was continuous reef interspersed by pavement, with the exception of an area of high-relief spur and groove to the west of Johnston Island. Hard coral cover averaged 15.7% and was largely dominated by *Millepora* and *Pocillopra*, with small *Distichopora* colonies present in most surveys. *Acropora* colonies were noted along the northwestern and southwestern surveys, but overall *Acropora* numbers remained low. Stressed hard coral numbers also remained low with the exception of one area along the southwestern forereef where up to 30% of *Pocilloporas* were affected.

Algal coverage of forereef surveys remained relatively low throughout all surveys. Macroalgae accounted for 5.9% of benthic composition with the *Halimeda* genus being

the most frequently observed, and coralline algae accounted for 12.5% of overall composition.

The dominant habitat of the two lagoon surveys was patch reef amongst sand or rubble. *Acropora* and *Montipora* accounted for the majority of the hard corals, which averaged 33.8% of the benthic composition. Macroalgae coverage averaged 16.7%, with *Bryopsis* blooms reaching as high as 40% of coverage in certain areas to the south of Johnston Island. Coralline algae presence was relatively low, averaging 3.4% of total coverage.

High counts of free-living sea urchins were recorded along the forereef surveys (average 68.2 free-living urchins per forereef strata surveyed) where, comparatively, small counts were recorded along lagoon habitats (average 0.5 free-living urchins per lagoon strata surveyed). Additionally, boring sea urchin counts were higher along the forereef areas surveyed (average 1.3 boring urchins per forereef strata) compared to lagoon areas surveyed (average 0.06 boring urchins per lagoon strata). A total of 264 *Acanthaster planci* (COTs) were recorded at Johnston Atoll, all recorded along the forereef strata. COT numbers recorded were higher at the west and northwest section of the atoll (average 4.1 COTs per west and northwest forereef strata surveyed) and decreased along the southwestern portion of the atoll (average 0.5 per southwest forereef strata surveyed). Sea cucumber counts were also greatest along forereef strata (average 12.01 sea cucumbers per forereef strata) compared to lagoon habitats surveyed (average 0.17 sea cucumbers per lagoon strata). For forereef habitats, sea cucumber numbers were significantly greater along the southwest forereef (average 25.2 sea cucumbers per southwest forereef strata) than forereef habitats along the northwest and west section of the atoll.

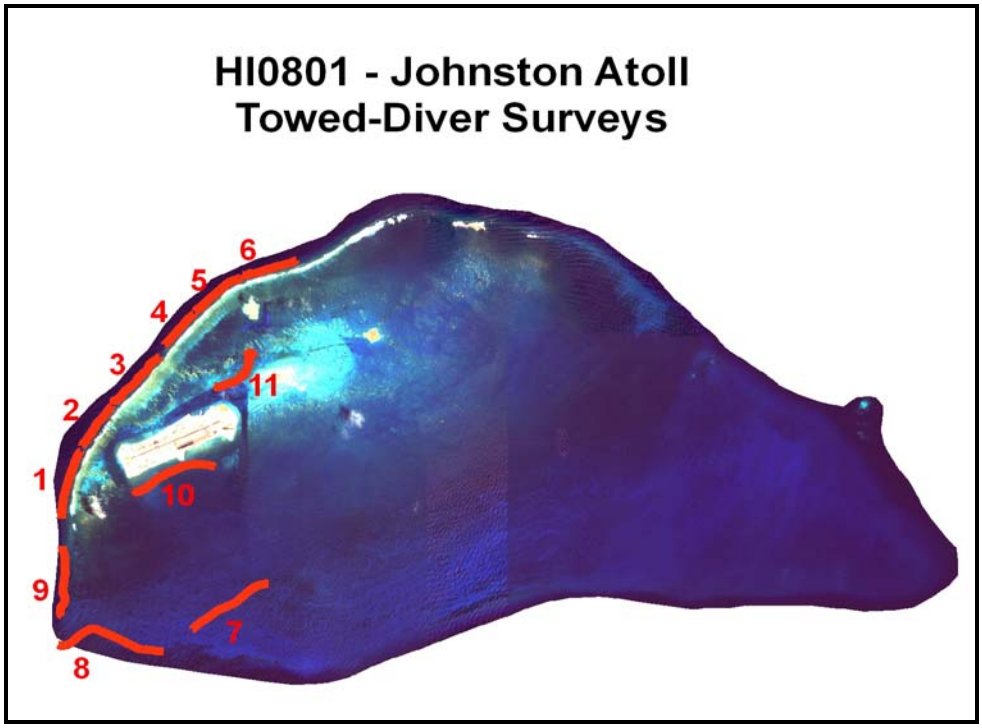

Figure B.3.4.1.--Towed-diver tracks at Johnston Atoll, 2008.

B.4 Fish

B.4.1 REA Fish Surveys

Stationary Point Count data (new methodology)
A total of 24 individual nSPC surveys were conducted at 12 sites around Johnston Atoll (3 forefeef/mid depth, 4 lagoon/mid depth, 5 lagoon/shallow depths). Surgeonfishes (Acanthuridae) were the largest contributor to biomass with 0.99 kg 100 m^{-2}. Parrotfishes (Scaridae) and triggerfishes (Balistidae) were also common, each with a biomass of ~ 0.50 kg 100 m^{-2} (Table B.4.1.1., Fig. 4.1.1.).

Belt transect data
During the survey period, 22 belt transect surveys were conducted at 12 sites around Johnston Atoll. Surgeonfishes and parrotfishes were the primary contributors to biomass with 1.03 kg 100 m^{-2} and 1.14 kg 100 m^{-2}, respectively (Table 4.1.2.).

Overall observations
A total of 101 species were observed during the survey period by all divers. The average total fish biomass at the sites in Sarigan during the survey period was 0.36 ton ha^{-1} for the nSPC surveys (Table 4.1.1.), and the average fish biomass was 0.41 ton ha^{-1} for the belt transect surveys (Table 4.1.2.).

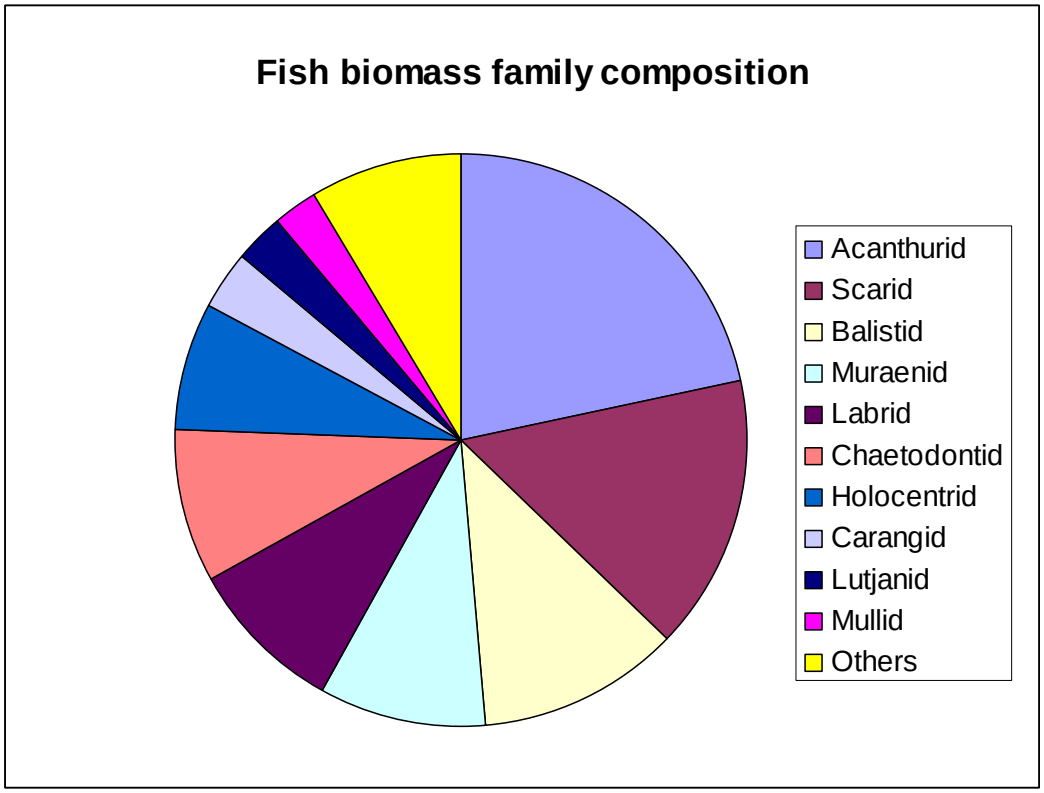

Figure 4.1.1.--Fish biomass family composition at Johnston Atoll, 2008.

Table 4.1.1.--Coral reef fish biomass (kg 100 m^{-2}) at sites around Johnston as measured by stationary point counts.

Stratum-Depth	Site	Grand Total	Acanthurid	Balistid	Carangid	Chaetodontid	Holocentrid	Labrid	Lutjanid	Mullid	Muraenid	Scarid	Others
Forereef – Mid	JOH-53	5.22	0.81	2.10	0.51	0.01	0.04	0.52	0.28	0.03	0.29	0.16	0.48
	JOH-54	6.63	1.02	0.83	0.00	0.08	0.34	0.68	0.01	0.08	2.81	0.40	0.37
	JOH-55	2.85	1.12	0.08	0.00	0.02	0.89	0.33	0.02	0.06	0.00	0.13	0.21
	Average	**4.90**	**0.99**	**1.00**	**0.17**	**0.04**	**0.42**	**0.51**	**0.11**	**0.05**	**1.03**	**0.23**	**0.35**
Lagoon – Mid	JOH-05	3.78	0.81	0.03	0.00	0.85	0.09	0.27	0.00	0.11	0.00	0.57	1.06
	JOH-10	3.22	0.60	0.02	0.00	0.43	0.02	0.16	0.05	0.01	0.00	1.45	0.48
	JOH-12	2.69	0.37	0.04	0.31	0.29	0.01	0.24	0.00	0.02	0.00	1.33	0.08
	JOH-52	4.09	2.05	0.43	0.00	0.07	0.23	0.14	0.68	0.20	0.00	0.19	0.11
	Average	**3.45**	**0.96**	**0.13**	**0.08**	**0.41**	**0.09**	**0.20**	**0.18**	**0.08**	**0.00**	**0.88**	**0.43**
Lagoon - Shallow	JOH-01	3.32	0.46	0.15	0.00	0.37	0.33	0.29	0.05	0.06	0.00	1.32	0.30
	JOH-18	3.96	1.09	0.05	0.55	0.10	0.93	0.24	0.00	0.49	0.00	0.37	0.14
	JOH-19	1.70	0.20	0.00	0.00	0.29	0.10	0.14	0.00	0.01	0.00	0.82	0.14
	JOH-50	2.73	0.11	0.26	0.00	1.41	0.02	0.38	0.00	0.02	0.05	0.33	0.14
	JOH-51	1.43	0.30	0.02	0.00	0.43	0.00	0.27	0.06	0.13	0.00	0.19	0.03
	Average	**2.63**	**0.43**	**0.09**	**0.11**	**0.52**	**0.28**	**0.26**	**0.02**	**0.14**	**0.01**	**0.61**	**0.15**
All strata	**Average**	**3.66**	**0.79**	**0.41**	**0.12**	**0.32**	**0.26**	**0.32**	**0.10**	**0.09**	**0.35**	**0.57**	**0.31**

Table 4.1.2.--Coral reef fish biomass (kg 100 m^{-2}) at sites around Johnston as measured by betl transects.

Stratum-Depth	Site	Grand Total	Acanthurid	Balistid	Carangid	Chaetodontid	Holocentrid	Labrid	Lutjanid	Mullid	Muraenid	Scarid	Others
Forereef – Mid	JOH-53	2.55	0.65	0.49	0.12	0.00	0.06	0.00	0.04	0.00	0.50	0.24	0.45
	JOH-54	2.97	1.33	0.18	0.00	0.12	0.31	0.00	0.11	0.06	0.00	0.10	0.76
	JOH-55	3.61	0.84	0.11	0.00	0.05	1.10	0.00	0.06	0.02	0.00	0.11	1.32
	Average	**3.04**	**0.94**	**0.26**	**0.04**	**0.06**	**0.49**	**0.00**	**0.07**	**0.03**	**0.17**	**0.15**	**0.84**
Lagoon – Mid	JOH-05	5.79	1.14	0.00	0.00	0.87	0.16	0.03	0.00	0.34	0.00	2.02	1.24
	JOH-10	5.57	1.43	0.02	0.00	0.60	0.03	0.00	0.00	0.07	0.00	2.27	1.16
	JOH-12	5.90	1.01	0.00	0.19	0.84	0.00	0.00	0.00	0.02	0.00	2.97	0.86
	JOH-52	3.49	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.12	0.12
	Average	**5.19**	**1.70**	**0.00**	**0.05**	**0.58**	**0.05**	**0.01**	**0.00**	**0.12**	**0.00**	**1.84**	**0.85**
Lagoon - Shallow	JOH-01	6.43	0.48	0.79	0.00	0.30	0.04	0.00	0.00	0.00	0.00	4.08	0.74
	JOH-18	2.36	0.40	0.00	0.00	0.11	0.91	0.00	0.00	0.33	0.00	0.33	0.27
	JOH-19	6.47	0.89	0.10	0.00	0.96	0.47	0.00	0.00	0.09	0.00	1.76	2.20
	JOH-50	3.42	0.26	0.10	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.29	0.53
	JOH-51	1.89	0.28	0.00	0.00	0.38	0.00	0.00	0.00	0.11	0.00	0.74	0.39
	Average	**4.11**	**0.46**	**0.20**	**0.00**	**0.80**	**0.28**	**0.00**	**0.00**	**0.11**	**0.00**	**1.44**	**0.82**
All strata	**Average**	**4.11**	**1.03**	**0.16**	**0.03**	**0.48**	**0.27**	**0.00**	**0.00**	**0.08**	**0.00**	**1.14**	**0.84**

B.4.2 Towed-diver Fish Surveys

Table 4.2.1. HI0801 Towed-Diver Survey Report for Johnston Atoll.

		Survey Length					Mean Depth
		N	**Min**	**Max**	**Median**	**Sum**	**Average**
Johnston Atoll	**01/27/2008**	6	1.24	2.12	1.71	10.18	-14.62
	02/01/2008	5	1.92	3.22	2.56	12.87	-13.41
	All	11	1.24	3.22	1.97	23.05	-14.07

N = number of surveys conducted.

Survey Length is given in kilometers.

Depth readings are taken at 5-s intervals during each 50-min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of 11 species of large fishes (> 50 cm TL) representing 9 families were observed at Johnston Atoll during the survey period (01/27/08-02/01/08). The mean number of fishes (all species pooled) observed by divers was 16.6 fish ha^{-1}. The 11 species recorded are shown in Figure B.4.2.1. The Grey Reef shark (*Carcharhinus amblyrhynchos*) was the most abundant species observed during the quantitative surveys along the forereef with a mean number of 5.5 fishes observed per hectare. The Bluefin Trevally (*Caranx melampygus*) was the second most abundant fish species encountered during the survey period and the most abundant species inside the lagoon with a mean numeric density of 1.66 fishes per hectare.

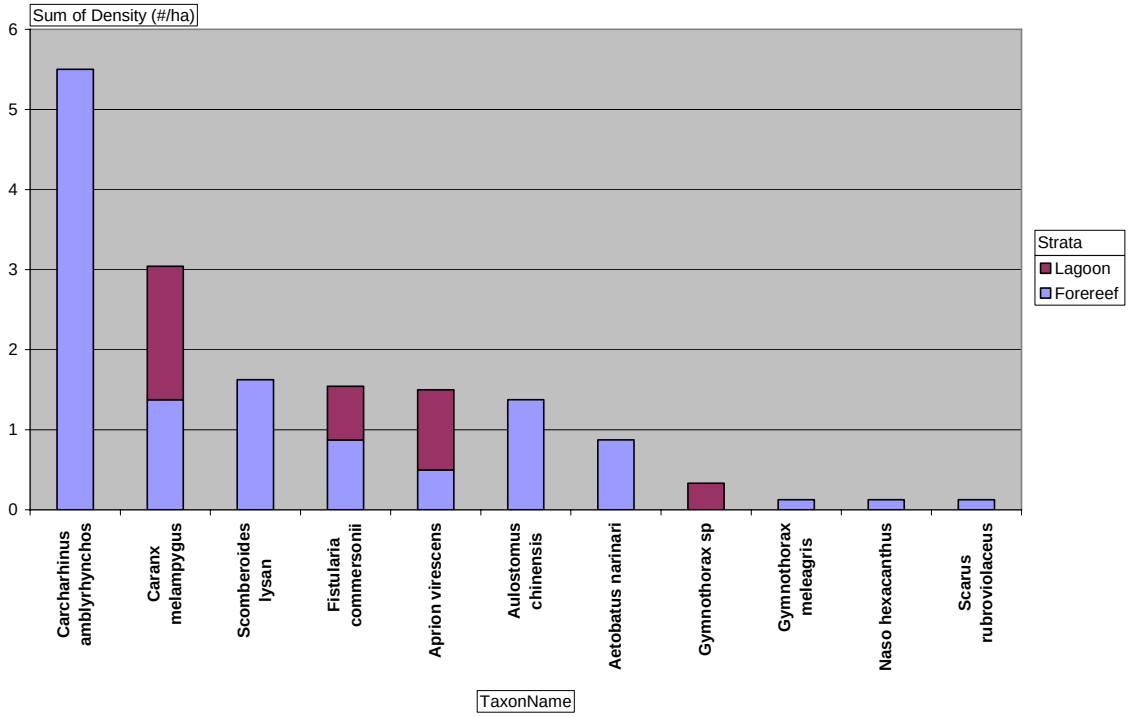

Figure B.4.2.1.--Graph showing density of large fish on the forereef and Lagoon at Johnston Atoll.

The grand mean biomass density of fishes observed on the shallow reefs (< 30 m) at Johnston Atoll during the survey period was 0.089 t ha^{-1}. The Grey Reef Shark (*Carcharhincus amblyrhynchos*) accounted for more than 79% of the total mean biomass of large fishes (Fig. B.4.2.2.). The total biomass density for the Grey Reef Shark was 0.070 t ha^{-1}. One school of 30 sharks was observed on a survey of the forereef. This incident, combined with the limited number of survey area covered, corresponds with the high biomass and density of Grey Reef Shark..

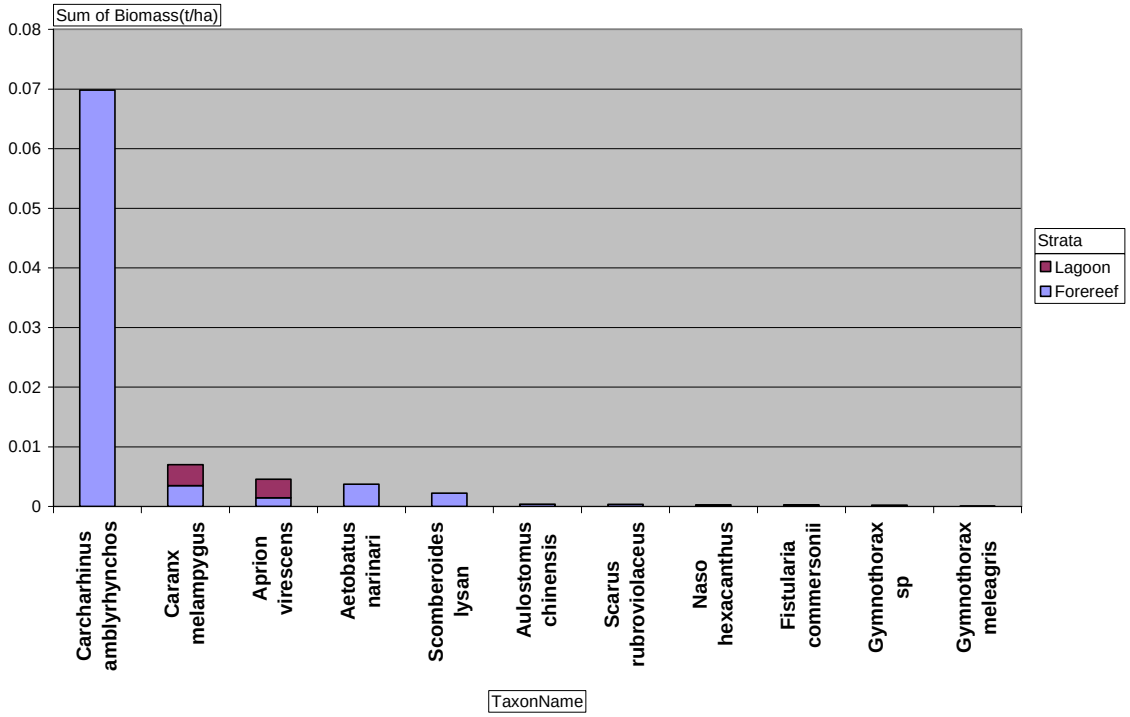

Figure B.4.2.2.--Graph showing biomass of large fish on the forereef and lagoon at Johnston Atoll.

B.5. Terrestrial Team

Johnston Island National Wildlife Refuge is one of the most unusual Refuges in the system. The atoll was designated as a National Wildlife Refuge in 1926 and is of enormous importance to marine wildlife because of its extreme isolation and location in the central tropical Pacific. The Refuge had resident managers and biologists stationed there until 2004 when military activities were complete and the island was vacated. Now visits are made at least biennially to monitor populations, habitats, wildlife hazards and signs of trespass. The last visit by U.S. Fish and Wildlife Service staff to Johnston Atoll occurred in 2006 when two Service biologists aboard the *Hi'ialakai* visited from 17 to 23 January.

Bird density and diversity were low during the transit to Johnston Atoll, however, peaking on the first day (10 birds/hour and 7 different species). The index of flying fish density increased as the ship moved south from 5.2 flying fish per hour on 25 January to 16 flying fish per hour on 26 January.

The camping gear performed admirably and the tents (Eureka Timberline) stood up to high winds (gusts as high as 45 knots clocked on ship) on the first and subsequent nights.

Nine of the fifteen species of seabirds that typically breed at Johnston Atoll were attending their eggs or chicks during our visit. An additional two species (Grey-backed Tern, *Onychoprion lunata*, and Christmas Island Shearwater, *Puffinus nativitatis*) were

exhibiting courtship and may have started breeding activities as well. One notable bird was a Laysan Albatross (*Phoebastria immutabilis*) sighted flying by the north side of Johnston Island. Another interesting vagrant was a female Northern Harrier or Marsh Hawk (*Circus cyaneus*). Table B.5.1. lists numbers of active nests for each species in the atoll breeding at the time of our visit. In general, numbers are higher than historically counted at this time of year. For instance, Red-footed Boobies with a total of 828 nests is a count nearly twice as high as that made in January 2001 and is almost as many birds as the high count in April of that year. Possible explanations are that Red-footed Boobies chose to breed earlier this year or that the opening up of new nesting opportunities on Johnston Island where they did not previously breed and where nest sites are not as limited has allowed more birds to initiate breeding. Other seabird species that have moved to Johnston Island only since the human population left in 2004 include Great Frigatebird, and for the first time this year, Brown Booby, and Brown Noddy. Migrant shorebirds wintering at Johnston Atoll included Pacific Golden Plover (27 seen), Bristle-thighed Curlew (16 seen), Ruddy Turnstone (50 seen), Wandering Tattler (5 seen), and Sanderling (1 seen).

The only land mammal found at Johnston Atoll is the house mouse, *Mus musculus*, and this species was seen active during daylight hours in all sectors of Johnston Island and on Sand Island. Two humpback whales (*Megaptera novaeangliae*) were seen by crew and scientists on the first day at Johnston near the *Hi'ialakai*.

At least 62 species of vascular land plants were observed on Johnston Island and appeared as if they had received abundant water this year. Trees most preferred by the large numbers of Red-footed Boobies that have moved onto Johnston Island from the outer islands include *Coccoloba uvifera,* Sea Grape, *Cordia subcordata*, Kou, *Tournefortia argentea*, Tree Heliotrope, and *Casuarina equisetifolia*, Ironwood, and a species that seems to be spreading, *Acacia farnesiana*. This native of tropical America is quite common along the north side of the runway and has abundant sharp spines. It is not yet as widespread as the *Leucaena leucocephala*, haole koa, but could become a problem. Many of the ornamental plants imported to Johnston continue to thrive in the absence of humans but a series of dry years will doubtless reduce the number of species occurring there. Sand and North Islands had scant vegetation and many fewer species but these instances may represent the future condition of Johnston Island.

Wildlife entrapment hazards were identified and mitigated at Johnston and North Islands. These included sewer access structures and electrical boxes with open covers and drains that had lost their grates. Damage to seawalls and landfills caused from a direct hit by Hurricane Ioke (August 2006) and other storms and high wave events since then were evident all around Johnston Island with a particularly large break in the seawall (100 m long) discovered in the southwest quadrant of the island. The large Joint Operations Center (JOC) building located at the east end of Johnston Island was missing two doors on the 4th floor. The absence of these doors may imperil wild birds entering the building causing the JOC to be a hazard to wildlife and accelerating the decay of the building. Some of the metal ductwork on the roof of the JOC blew off during Hurricane Ioke and the remaining material will continue to be a danger to wildlife when there are

high winds. At North Island, the staff found two fish aggregating device (FAD) transmitters that washed up. Depkin disconnected the antennae on the newer one, but the battery remains as a contamination hazard there.

Table B.5.1.--Number of Active Nests (containing an egg or chick) by Species and Island at Johnston Atoll, January 2008.

Island Species	Johnston – Sectors 1-5,7,8	Sand - all	North - all	Total Johnston Atoll
Red-footed Booby (*Sula sula*)	624	19	185	828
Brown Booby (*Sula leucogaster*)	1	16	4	21
Masked Booby (*Sula dactylatra*)	0	1	12	13
Great Frigatebird (*Fregata minor*)	52	2	0	54
Red-tailed Tropicbird (*Phaethon rubricauda*)	1601	69	56	1726
White Tern (*Gygis alba*)	217	0	0	217
Brown Noddy (*Anous stolidus*)	1	1	4	6
Black Noddy (*Anous tenuirostris*)	78	0	0	78
Sooty Tern (*Onychoprion fusc*ata)	0	0	~ 200	200

Appendix C: Howland Island

C.1. Oceanography and Water Quality

Due to technical problems with the small boat HI-2, Howland Island operations during HI0801 were limited to 1.5 days of work. In this time four STRs were recovered and four STRs were deployed. The full three STR array on the west side was swapped out, and a new deployment was established on the northwest corner near REA site 14P and a newly deployed ARMS station. The STR on the east side of the atoll could not be recovered, and the STR on the northern site was recovered but not replaced, both due to sea and weather conditions (Fig. C.1.1.). The new site was established because of the repeated difficulty of reaching the northern and eastern STR sites.

A total of seven open ocean (500 m) CTD casts and water samples (3, 80, 100, 125 and 150 m) were conducted in a four cast array to the west and a three cast array to the east (Fig. C.1.2.).

Twenty-two shallow water CTDs were performed around the atoll at 500-m intervals. Four shallow water, 4-depth (1, 10, 20 and 30 m) water samples for chlorophyll and nutrients were performed, one at each cardinal point around the island (Figs. C.1.3. and C.1.4.).

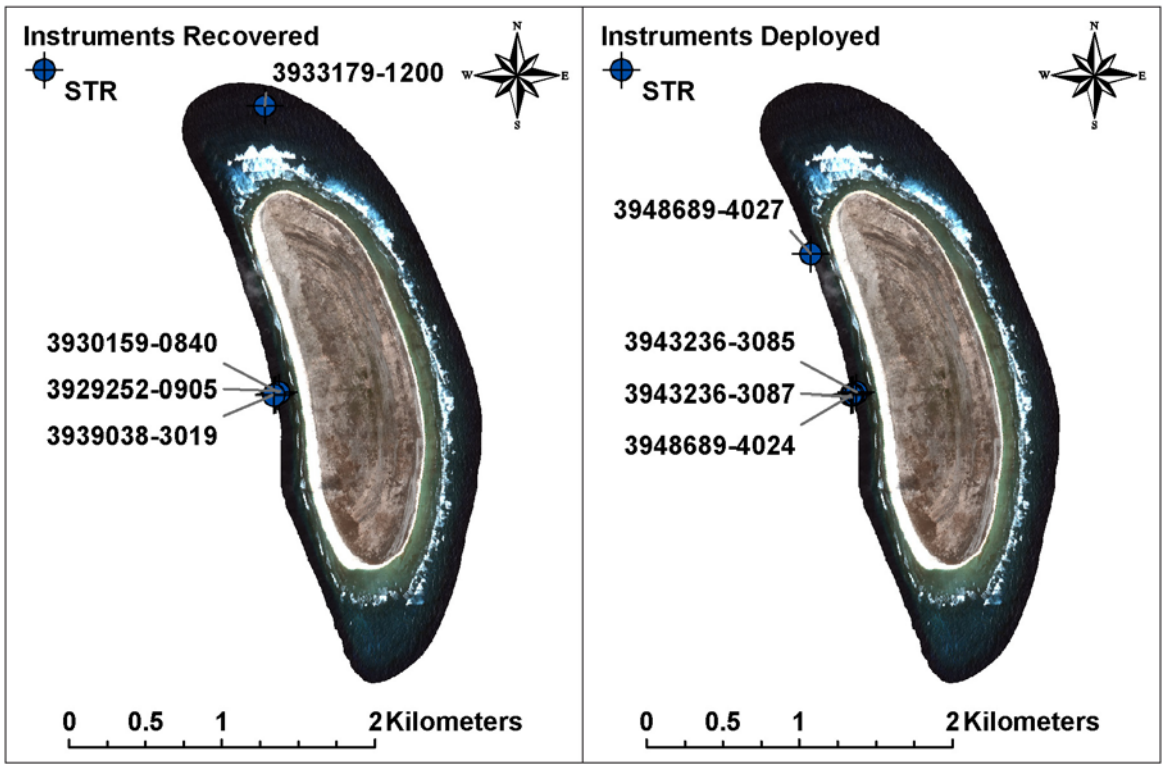

Figure C.1.1.--Moored Oceanographic Instrumentation Map. Moored oceanographic instruments, labeled by serial number, recovered and deployed at Howland Island during HI0801.

Table C.1.1.--Moored Oceanographic Instrumentation Table. Moored oceanographic instruments recovered and deployed at Howland Island during HI0801, instrument type, serial number, lat/long of mooring, sensor depth and data set start and end dates (UTC).

Instrument	Serial Number	Latitude	Longitude	Depth (m)	Data Start	Data End
STR	3933179-1200	00 49.4106 N	176 37.3296 W	18.9	1/22/04 23:00	2/26/06 15:30
STR	3930159-0840	00 48.3965 N	176 37.2805 W	3.05	INSTRUMENT FAILED	
STR	3929252-0905	00 48.3916 N	176 37.2900 W	17.98	1/28/06 22:00	2/5/08 23:30
STR	3939038-3019	00 48.3880 N	176 37.2980 W	37.19	10/28/06 22:00	2/7/08 23:30
STR	3943236-3087	00 48.3916 N	176 37.2900 W	17.98	LOGGING DATA	
STR	3943236-3085	00 48.3965 N	176 37.2805 W	3.05	LOGGING DATA	
STR	3948689-4027	00 48.8880 N	176 37.4408 W	14.63	LOGGING DATA	
STR	3948689-4024	00 48.3880 N	176 37.2980 W	37.19	LOGGING DATA	

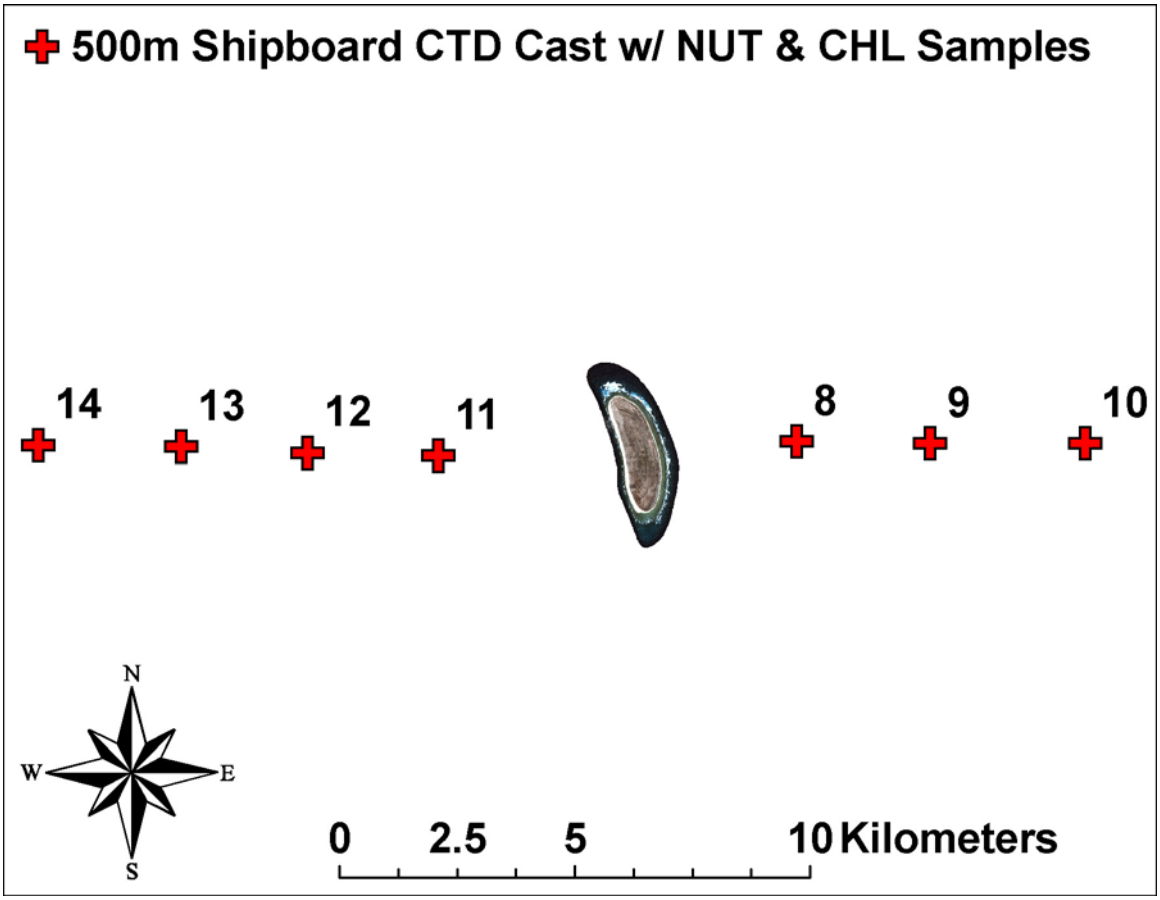

Figure C.1.2.--Shipboard CTD, NUT & CHL Operations. Deepwater shipboard CTD, NUT & CHL sites near Howland Island during HI0801, labeled by cast number.

Preliminary Results

Water at the 20-m depth bin was slightly cooler, more saline, denser and clearer on the western side of the atoll, with strong gradients on the north, casts 004-005, and south, casts 012-013, points (Fig. C.1.3.). While the range of all measured variables at this contour was quite small, the data suggests upwelling of deep water on the west side of the atoll.

Temperature, salinity, density and transmittance throughout the 30-m water column were relatively homogeneous with depth on the east and slightly stratified on the western side of Howland Island (Fig. C.1.4.). The east side showed warmer, fresher, less dense, and more turbid water than that found on the west. The strong spatial gradients noted at the northern and southern points propagated through the water column. Cooler deep water and a slightly stratified water column at casts 009–013 also suggest upwelling on the west side.

Subsurface temperature data was recovered from three different locations at Howland Island (Fig. C.1.5.). Water temperature at Howland Island lacked the usual diurnal fluctuation of seasonal warming and cooling. Over the past 15 months there has been a consistent cooling of the water on the west side of the Island, with a 5 ^{0}C reduction (31 ^{0}C–25 ^{0}C) from January 2007 to January 2008. This temperature drop shows in both deep (STR 3019 in 38 m) and intermediate (STR 0905 in 20 m) water depths. La Niña conditions could explain this relatively long-term cooling of the coastal waters around Howland.

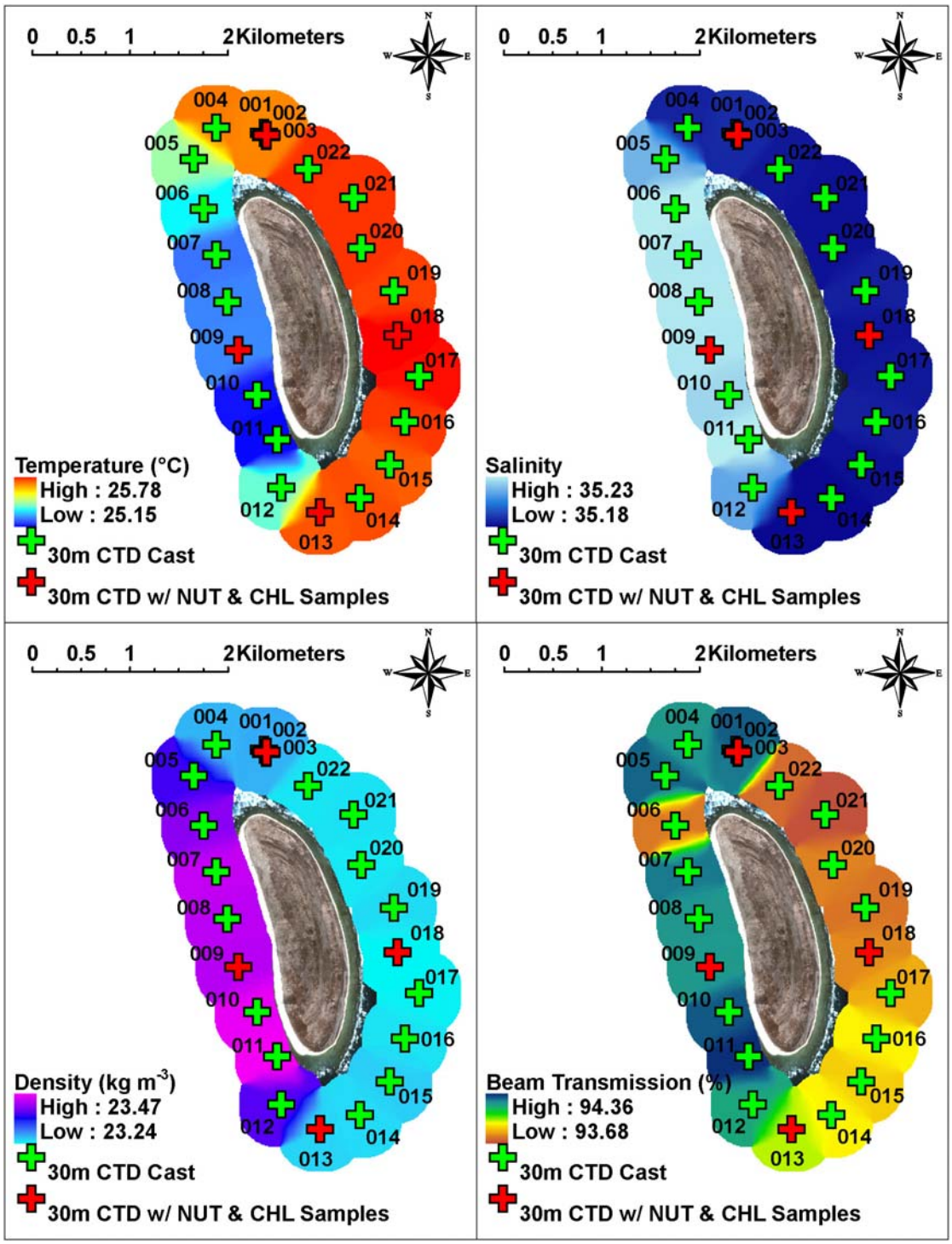

Figure C.1.3.--Shallow CTD Casts and 20-m Data Interpolations. Shallow CTD cast locations and interpolations of temperature (upper left), salinity (upper right), density (bottom left) and beam transmission (bottom right) at 20-m depth. All casts were conducted on 6-7 Feb 2008 UTC at Howland Island during HI0801.

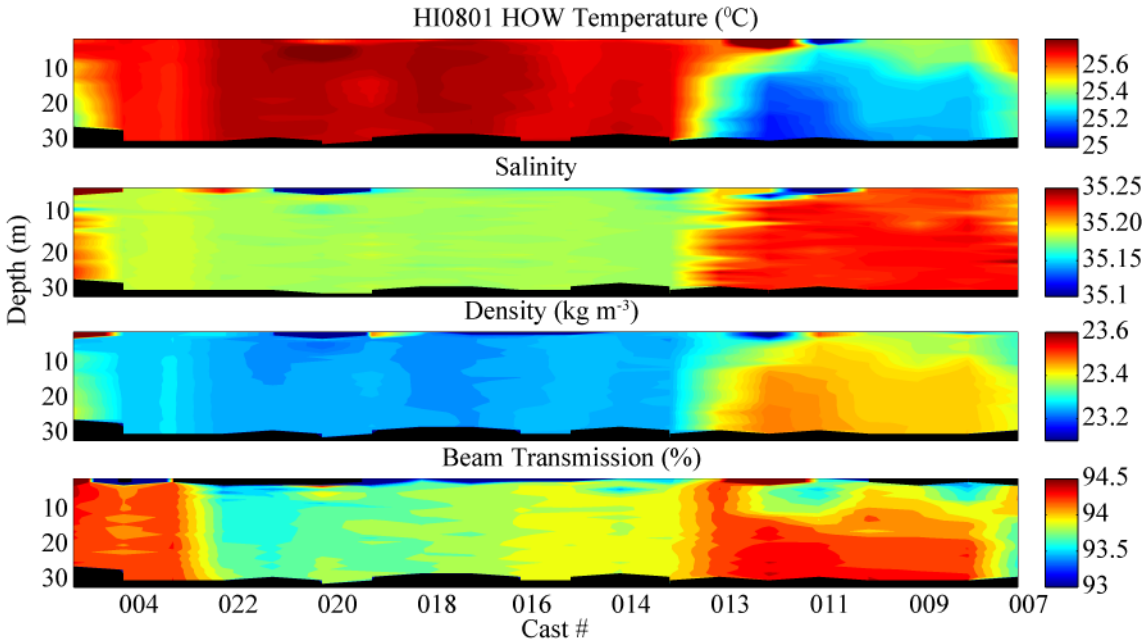

Figure C.1.4.--Shallow CTD cross-section from Howland Island. Cross-section plot of shallow water CTD data temperature, salinity, density and beam transmission collected at Howland Island during HI0801. Refer to Figure C.1.3. for CTD cast locations.

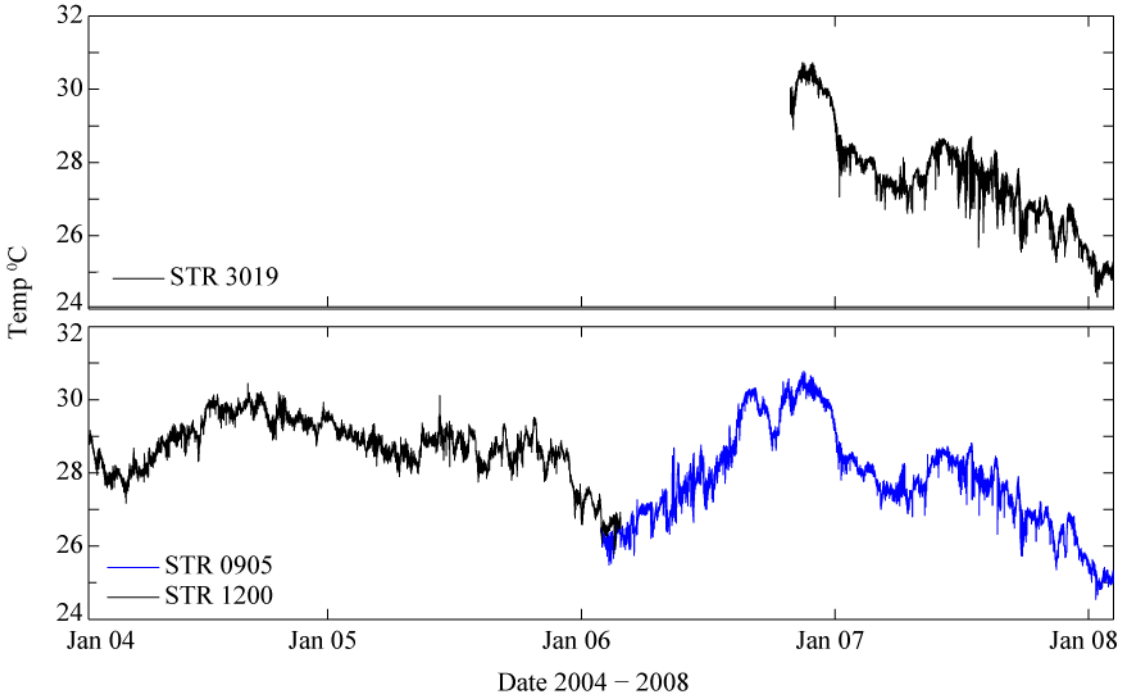

Figure C.1.5.--Subsurface Temperature Timeseries. Temperature data obtained from three STR moorings at Howland Island. Refer to Figure C.1.1. and Table C.1.1. for mooring location, depth and dataset information.

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

HOW-05P 2/6/08
N 0 º 48.343 W 176 º 37.287
Depth Range: 8–9.5 m
This site was located on the steep fringing forereef slope on the west side of Howland. Benthic transects were deployed along permanent transect pins installed by Jim Maragos in 2001/2002. Moderate percent live coral cover (33%) dominated by platy *Montipora* sp. and crustose coralline algae over dead coral, pavement, and rubble (39%) were the dominant components of the benthos. Also of note was the presence of the corallimorphan *Rhodactis* which represented nearly 20% of the live benthos. Other coral genera present along the transect line included: *Fungia*, *Pavona, Pocillopora, Hydnophora, Acropora, Porites,* and *Leptastera.* No coral diseases were detected within the survey area. Crustose coralline red algae was the dominant algae recorded. Additionally, *Wrangelia anastomosans*, *Halimeda fragilis*, *Lobophora variegata*, *Dictyosphaeria cavernosa*, turf algae, and a red/rust colored cyanophyte occurred in the photoquads. *Avrainvillea lacerata, Dictyosphaeria versluysii*, and *Caulerpa serrulata* were found during the random swims. Non-cryptic macroinvertebrates were low. The dominant macroinvertebrate was the urchin, *Diadema savignyi*. An unidentified black palythoa and bryozoan were common throughout the survey. In addition to biological surveys, three ARMS were deployed. Besides a large number of *Cephalopholis miniata* observed, this site's fish population was unremarkable and carried a similar assemblage of species as other Howland sites. An unusual sighting was a large school of *Naso caesius.* Off transect, a veritable freeway of *Pterocaesio tile* motored past.

HOW-20 2/7/2008
N 0 º 48.335 W 176 º 37.285
Depth Range: 10–29 m
This was a deep site located on the steep fringing forereef slope on the west side, directly offshore from site HOW-05. Only one transect was deployed which was videotaped and surveyed using the LPI protocol. Moderate percent live coral cover (33%) was present and the site was dominated by an amalgam of *Pachyseris speciosa* (40%) and *Pavona varians* (~30%). Other coral genera present along the transect line included, *Cyphastrea*, Leptastrea, Pocillopora, and Psammocora. Of note was the presence of several colonies of *Mycedium* along the transect line. Crustose coralline algae over dead coral, pavement, and rubble represented over 20% of benthic cover, and the corallimorpham *Rhodactis* represented nearly 9% of the live benthos. A qualitative survey of algal species showed turf algae and crustose coralline red algae to be the dominant algal functional groups. *Wrangelia anastomosans*, *Lobophora variegata*, a species of *Dictyota*, *Halimeda fragilis*, and a reddish cyanophyte were also recorded. *Halimeda fragilis* was much less abundant than at shallower depths.

HOW-11P 2/7/2008
N 0 º 47.936 W 176 º 37.229
Depth Range: 7.6–10.1 m
This site was located on the southwest side of Howland. Benthic transects were deployed along permanent transect pins installed by Jim Maragos in 2001/2002; however, two pins

were missed. The benthos consisted of moderately high live coral (49%) and crustose coralline algae over dead coral, pavement, and rubble (36%). The coral community was dominated by an amalgam of *Montipora* spp. (~52%) and *Pocillopora* (32%). Other coral genera present along the transect line included: *Acropora*, *Pavona*, *Porites*, and *Cyphastrea*. A coral disease and health assessment survey found one case of bleaching detected on a colony of tabular *Acropora*, and one case of hyperpigmented response on *Porites.* The crustose coralline red alga was the dominant algae present at the site. Additionally, *Lobophora variegata*, *Halimeda fragilis*, and turf algae occurred in the photoquads. *Wrangelia anastomosans*, *Caulerpa serrulata*, a reddish cyanophyte, and a species of *Laurencia* were found during the random swim. In addition, three ARMS were deployed and no invertebrate survey was conducted. Although schools of *Pseudanthias bartlettorum*, *Luzonichthys whitleyi* with smaller numbers of *Pseudanthias olivaceus* and *Lepidozygus tapeinosoma* were present, no schools of larger fish were observed. One large *Caranx ignobilis* and a few large Scarids did swim through the transect area. Overall, this site had a fair number of species, but no large numbers of any given species other than the schools of anthias.

HOW-14P, 2/6/2008
N 0 º 48.894 W 176 º 37.446
Depth Range: 13–15 m
This site was located on the steep fringing forereef slope on the west side. Permanent transect pins installed by Jim Maragos in 2001/2002 were not found. Crustose coralline algae over dead coral, pavement, and rubble represented over 45% of the benthos. Coral cover was moderately high (36%), dominated by an amalgam of *Porites* spp. (~36%), *Leptastrea* (15%), *Pavona* (15%), and *Acropora* (15%). The coral disease and health assessment survey found two cases of hyperpigmented responses on *Porites.* The dominant alga was crustose coralline red algae. Additionally, *Wrangelia anastomosans*, *Halimeda fragilis*, *Lobophora variegata*, *Dictyosphaeria cavernosa*, turf algae, and a red/rust colored cyanophyte occurred in the photoquads. *Avrainvillea lacerata, Dictyosphaeria versluysii*, and *Caulerpa serrulata* were found during the random swims. In addition, three ARMS were deployed and no invertebrate survey was conducted. The most abundant fish species were the anthias *Pseudanthias bartlettorum* and *Luzonichthys whitleyi*. Large species recorded were *Caranx lugubris*, *C. melampygus, Aphareus furca, Lutjanus bohar, Naso literatus*, and *Chlorurus microrhinos*. A variety of groupers, including *Cephalopholis miniata, C. urodeta, C. argus*, *Gracila albomarginata*, and *Aetheloperca rogaa* were indentified. *Carcharhinus amblyrhynchos* were seen on transect. Of note, *Elegatis bipinnulata, Gymnosarda nuda*, and *Scombroides lysan* were seen off transect.

HOW-16 2/6/2008
N 0 º 48.660 W 176 º 37.368
Depth Range: 14–16.5 m
This site was located on the steep fringing forereef slope on the west side. Crustose coralline algae over dead coral, pavement, and rubble represented over 45% of the substrate, and macroalgae represented 20% of the live benthos. Coral cover was moderately high (29%); dominated by an amalgam of *Porites* spp. (~36%), *Pavona*

(30%), *Pocillopora* (17%), and *Leptastera* (17%). No coral diseases were detected within the survey area. The dominant alga was crustose coralline red algae. Additionally, *Wrangelia anastomosans*, *Halimeda fragilis*, *Lobophora variegata*, *Dictyosphaeria cavernosa*, turf algae, and a red/rust colored cyanophyte occurred in the photoquads. *Avrainvillea lacerata, Dictyosphaeria versluysii*, and *Caulerpa serrulata* were found during the random swims. One case of coralline lethal disease on crustose coralline algae was reported. Non-cryptic macroinvertebrates were low. The dominant macroinvertebrates were trapezid crabs. Although not quantified, the Christmas tree worm, *Spirobranchus gigantus*, was widespread. The corallimorpharian, *Rhodactis hawsei*, was present. An unidentified black palythoa and bryozoan were common throughout the survey. Again, anthias were observed in large numbers, as was a large school of *Caesio teres*. Large midwater surgeons were seen at the SPC periphery, while a few large *Lutjanus bohar* ventured nearer. Smaller fishes, such as *Centropyge loricula, paracirrhites arcatus,* and *Cirrhitichthys oxycephalus* were prevalent in the more sheltered benthic climes. A single gray reef shark was seen during the nSPC; a large manta was seen off transect.

Site HOW-50
N 00° 48.475’ W 176° 37.304’
Depth Range: 2–3 m
This site is located on the leeward forereef of Howland Island. It was established by the REA fish team as a new sampling location in the forereef shallow depth stratum. The site had medium coral cover with medium structure. For the shallow nature of this site, fish biomass was very high. The area surveyed was a cleaning station which was visited by three manta rays (*Manta birostris*). A small gray reef (*Carcharhinus amblyrhynchos*) was also observed in the area. The area lacked the schools of anthias that dominated other sites. Instead, schools of *Chromis vanderbilti* and *Chromis acares* were present. Also abundant were *Thalassoma quinquevittatum* and *Thalassoma amblycephalum*.

Site HOW-51
N 00° 48.547’ W 176° 37.331’
Depth Range: 19–21 m
This site is located on the leeward forereef of Howland Island. It was established by the REA fish team as a new sampling location in the forereef deep depth stratum. The site was located on a fairly sheer wall with medium coral cover and low structure. Areas within the nSPCs ranged in depth by as much as 15–20 ft. Large schools of *Elagatis bipinnulata*, *Pterocaesio tile*, *Pseudanthias bartlettorum* and *Luzonichthys whitleyi* frolicked throughout the site. Groups of *Myripristis berndti* with *Myripristis vittata* were also found at this depth. Large snappers were observed on transect, while *Manta birostris* and *Carcharhinus amblyrhynchos* were only observed at a distance.

Site HOW-52
N 00° 47.824’ W 176° 37.171’
Depth Range: 22–24 m
This site is located on the southern end of the leeward forereef of Howland Island. It was established by the REA fish team as a new sampling location in the forereef deep depth

stratum. Unlike other steeper sites around Howland Island, this site had a sloping dropoff with medium coral cover and low structure. The shallower slope of the dropoff lead to fewer large fish presence but a greater number of *Myripristis berndti* and species not observed at other locations were present. A new species of angelfish for Howland was observed (*Paracentropyge multifasciata*) and a species of spadefish (*Platax boersii*). At this depth, *Cephalopholis spiloparaea* became one of the dominant species of grouper.

Site HOW-53
N 00° 48.136' W 176° 37.262'
Depth Range: 3–4 m
This site is located on the leeward forereef of Howland Island. It was established by the REA fish team as a new sampling location in the forereef shallow depth stratum. The site had medium coral cover with medium complexity. Fish biomass was low but this was partly due to the highly variable visibility encountered in the morning. Site was similar to HOW-50.

Site HOW-54
N 00° 48.879' W 176° 37.446'
Depth Range: 21–23 m
This site is located on the northern end of the leeward forereef of Howland Island. It was established by the REA fish team as a new sampling location in the forereef deep depth stratum. This site is characterized by a steep wall dropping quickly to substantial depths. Coral cover and complexity is medium. *Pseudanthias bartlettorum* and *Luzonichthys whitleyi* constituted the greatest number of fishes; the other species seen in larger numbers were *Myripristis berndti* and *M. amaena*, which were found congregating under ledges.

Site HOW-55
N 00° 47.699' W 176° 37.112'
Depth Range: 3–4 m
This site is located on the southern portion of the leeward forereef of Howland Island. It was established by the REA fish team as a new sampling location in the forereef shallow depth stratum. As evident by other Howland sites, anthias were ubiquitous. There also appeared to be high numbers of recruit *Thalassoma amblycephalum*. Six gray reef sharks patrolled the shallow depths outside of the transect, while *Carangoides ferdau* and *C. orthogrammus* were seen both in the shallows and deeper areas.

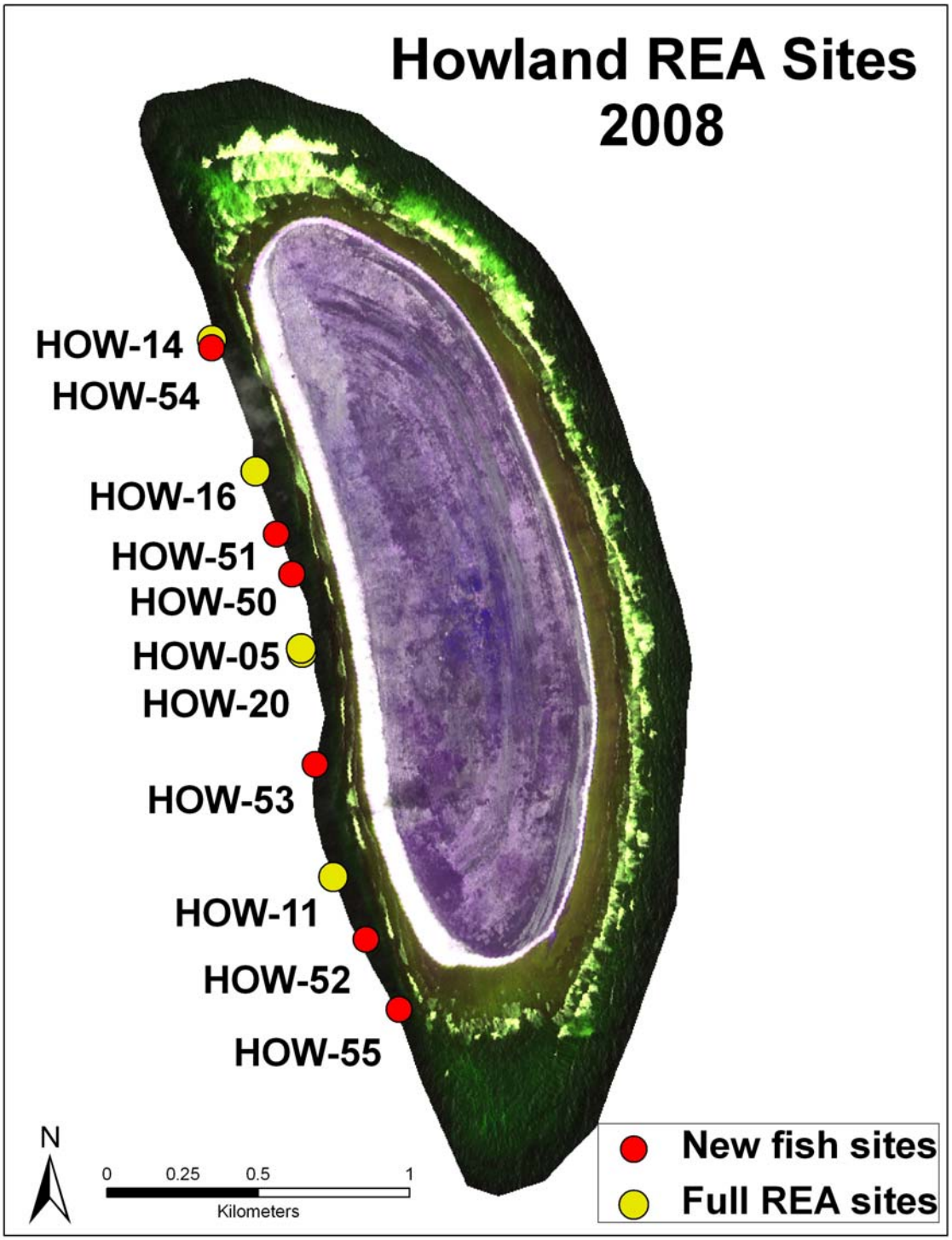

Figure C.2.1.--REA sites at Howland Island in 2008.

C.3. Benthic Environment

C.3.1. Algae

Quantitative algal surveys were conducted at four sites along the west side of Howland Island. An additional qualitative survey was conducted at 30 m at REA site HOW-05P. All sites exhibited extremely high crustose coralline red algal cover (Table C.3.1.1). Macroalgal diversity was low and consistent. Five species of macroalgae were recorded along survey lines: five species of green algae, two species of red algae, and two species of brown algae, as well as crustose coralline red algal, turf algal, and cyanophyte functional groups.

Table C.3.1.1.--Algal genera or functional groups recorded in photoquadrats at Howland 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.

	HOW-05P	HOW-5P deep	HOW-11P	HOW-14P	HOW-16
GREEN ALGAE					
Avrainvillea lacerata	*				
Caulerpa serrulata	*		*		*
Dictyosphaeria cavernosa				*	8.3
Dictyosphaeria versluysii					*
Halimeda fragilis	8.3	*	75.0	41.7	50.0
RED ALGAE					
crustose coralline red algae	83.3	*	100	100	91.7
Laurencia sp.			*		
Wrangelia anastomosans	8.3		*	*	*
OCHROPHYTA					
Dictyota sp.		*			
Lobophora variegata	66.7	*	50.0	91.7	100
FUNCTIONAL GROUPS					
turf algae	83.3	*	100	100	50.0
Cyanophyte		*	*	16.7	8.3

C.3.2. Corals

Four coral REA surveys (HOW-05P, -11P, -14P, and 16) were conducted along the western forereef at Howland Island between February 6 and 7, 2008 (Fig. C.2.1.). In addition, a partial REA survey/qualitative dive was completed at a depth of 29 m directly offshore of site HOW-05P (HOW-20). Three sites (HOW-05P, -11P, and -14P) had permanent transects established by Jim Maragos in 2000–2002; however transect pins were not found at HOW-05P. Dive depths ranged from 7.6 to 16.5 m. Coral population surveys were conducted by Jason Helyer (CRED), and coral disease and health assessments were conducted by Dr. Bernardo Vargas Angel (CRED).

C.3.2.1 Percent Benthic Cover

The line-point intercept (LPI) methodology quantified a total of 459 points along 250 m of forereef coral communities. Survey transects depth ranged between 8 and 16 m for all locales visited, except for site HOW-20, where a deep dive was conducted (25–26 m deep), and only one 25-m transect surveyed. Patterns of intra-island variability in percent benthic cover, derived from the five independent REA surveys in 2008, are reflected in Figure C.3.2.1.1. Point-count surveys indicated that the mean percent live coral cover for all sites combined was intermediate: 37.2 ± 3.3% (mean ± SE). Relatively high live coral cover (49%) was documented at site HOW-11P on the southwestern portion of the island. For all sites combined, crustose coralline algae on coral rubble and pavement represented over 40% of the benthic cover; interestingly, turf algae only amounted to over 1% of the live benthos. Of note, was the presence of the anthozoan *Rhodactis* sp. at all sites visited, as well as the scleractinian species *Pachyseris speciosa* and *Mycedium elephantotus* at site HOW-20. Of the 12 scleratinian genera enumerated along the line transects, *Montipora* and *Porites* were the most numerically abundant (26% and 20%, respectively). Below, Table C.3.2.1.1. provides an itemized analysis of relative contribution of the different scledractinain taxa to the total percent live coral cover.

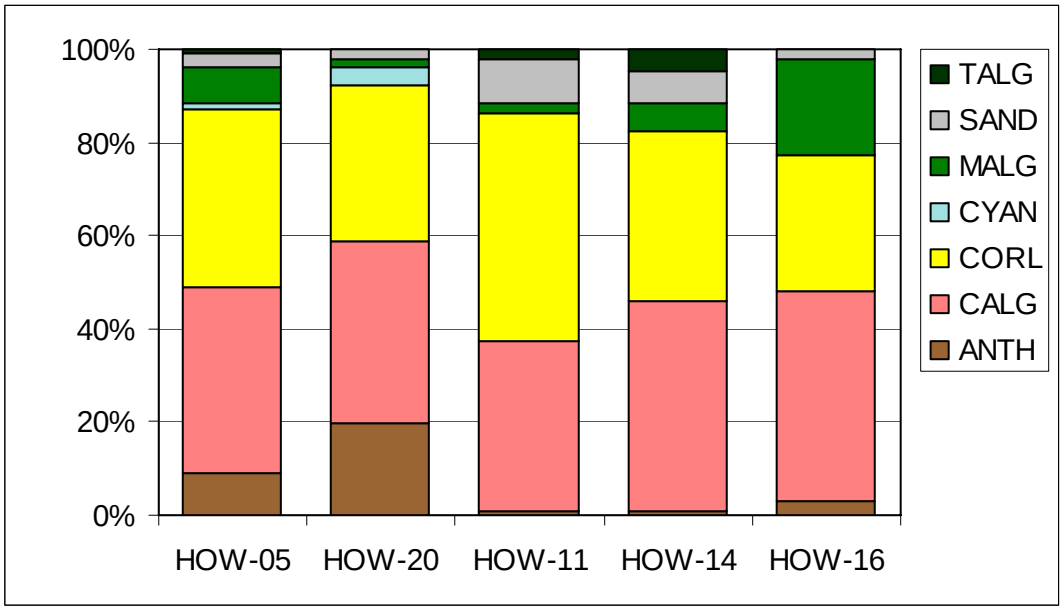

Figure C.3.2.1.1.--Mean percent cover of selected benthic elements derived from five independent REA surveys at Howland Island, Equatorial Pacific Cruise 2008 (Feb. 6–7, 2008). TALG: Turfalgae (on pavement, rubble, and dead coral); SAND: sand; MALG: macroalgae; CYAN: cyanophytes; CORL: live coral; CALG: crustose coralline algae (on pavement, rubble, and dead coral); ANTH: *Rhodactis* sp.

Table C.3.2.1.1.--Percent contribution of the different slceractinan genera to the total live coral cover; Howland Island, 2008.

Taxon	Relative abundance (%)
Montipora	26.01
Porites	20.23
Pocillopora	15.03
Pavona	14.45
Acropora	8.09
Leptastrea	7.51
Pachyseris	4.05
Psammocora	1.73
Cyphastrea	1.16
Favia	0.58
Hydnophora	0.58
Mycedium	0.58

C.3.2.2. Coral Populations

A total of 1,602 colonies belonging to 20 anthozoan taxon were enumerated within 187 m^2 of reef surveyed at Howland Island in 2008. *Pocilloporid, Montiporid, Porites*, and *Pavona* corals were the most abundant corals accounting for 18%, 15%, 15%, and 14% of colonies found within belt transects, respectively (Table C.3.2.1.2.). Of particular interest is the colonization of the red corallimorpharian, *Rhodactis howsii*. In 2006, *Rhodactis* was only reported within belt transects at HOW-05P. In 2008, it was present at all four REA sites and appeared to be overgrowing numerous corals including large plates of *Montipora*, large *Porites* heads, and *Favids*.

Genus	# of Colonies	% of Total
Acropora	136	8
Astreopora	1	0
Cycloseris	5	0
Cyphastrea	3	0
Favia	40	2
Favites	19	1
Fungia	**197**	**12**
Hydnophora	41	3
Leptastrea	22	1
Leptoseris	38	2
Montipora	**242**	**15**
Palythoa	15	1
Pavona	**231**	**14**
Pocillopora	**293**	**18**
Porites	**247**	**15**
Psammocora	19	1
Rhodactis	43	3
Sinularia	8	0
Symphillia	1	0
Tubastrea	1	0

Surveys conducted in 2006 showed an increase in the frequency of corals (number of corals per m^2) and a shift from larger to smaller corals from 2004 surveys. Coral densities decreased at all sites in 2008 except for HOW-11P which appeared to be elevated by a high settlement of *Porites* recruits. The smallest size-class of corals was relatively similar between 2006 and 2008 while the intermediate coral sizes (6-40 cm in diameter) decreased, with notable losses of *Pocillopora* and *Pavona* colonies. Large corals (> 80 cm in diameter) showed a slight increase with the majority of the increase coming from *Monitporid* and *Acroporid* corals.

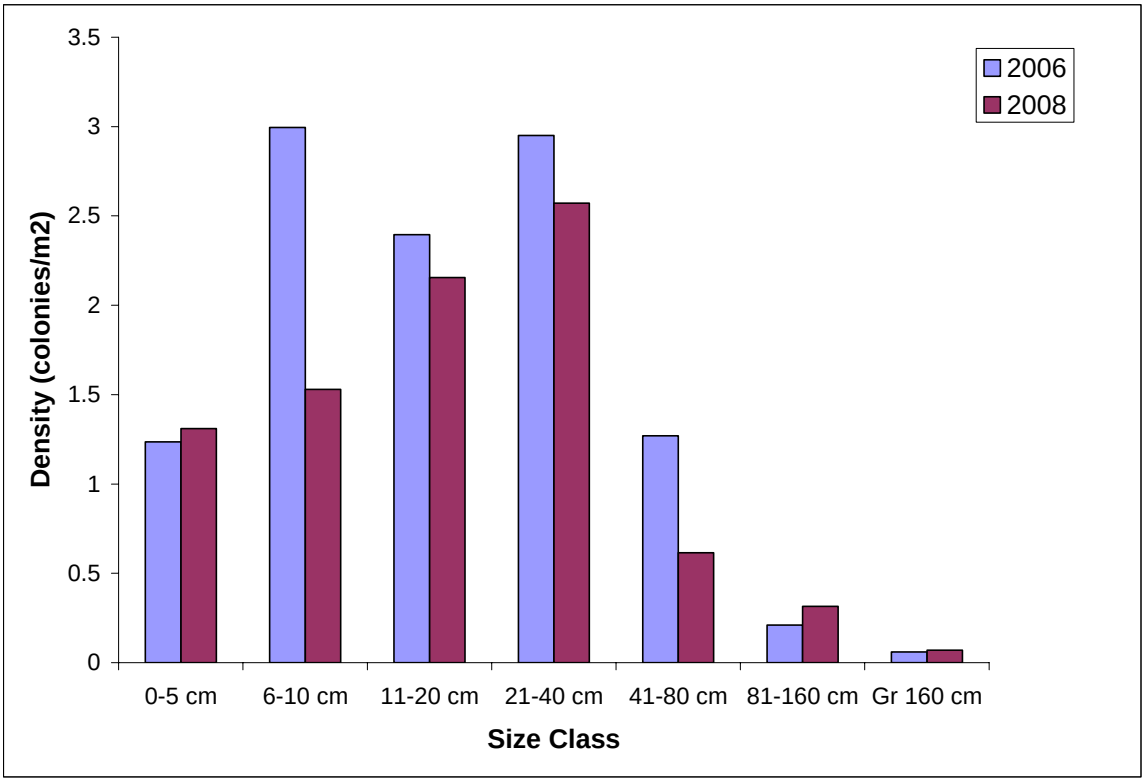

Figure C.3.2.1.2.--Temporal comparison of size-class distribution of all coral colonies enumerated within belt transects at HOW-05P, -11P, -14P, and 16 in 2006 and 2008.

C.3.2.3 Coral Health and Disease

In 2008, the coral disease REA surveyed a total area of ~ 1800 m^2 at four different sites. No diseases were documented at site HOW-05P, and no systematic disease survey was conducted at deep site HOW-20. A summary of disease occurrence is presented in Table C.3.2.1.3. Over 60% cases were noted on *Porites*.

Table C.3.2.1.3.--Cumulative number of cases of disease enumerated for all survey areas combined Howland Island, 2008. BLE: bleaching; HYP: hyperpigmented responses (purple-ring); TLS: sub-acute tissue loss, and CLD: coralline algae lethal disease.

DZCode	HOW-11P	HOW-14P	HOW-16	Grand Total
BLE	1			1
CLD			1	1
HYP	1	2		3
TLS			1	1
Grand Total	2	2	2	6

C.3.3. Macroinvertebrates

Due to ARMS deployment and weather constraints, quantitative invertebrate assessments were limited to only two sites at Howland Island. Overall, non-cryptic macroinvertebrates were low. Only one urchin species, *Diadema savignyi,* was observed on transect. However *Echinostrephus articulatus* and scattered spines of *Heterocentrotus mammillatus* were seen off transect at HOW-05P. In addition, small piles of empty *Turbo ?argyrostoma* shells were seen at this same location.

Diadema savignyi was the dominant macroinvertebrate at HOW-05P with a density of 0.08 m². Trapezid crabs were the dominant macroinvertebrate at HOW-16 with a density of 0.27 m². The corallimorph, *Rhodactis howseii*, was observed at both sites. A black zooanthid from the genera *Palythoa* and a black bryozoan was abundant at both sites. The sea cucumber, *Holothuria atra* and the seastar, *Linckia multifora,* were present.

C.3.3.1 Urchin and Giant Clam Measurements

Figure C.3.3.1.1. reveals the average test diameter of species encountered at each site.. Only sites where ≥ 5 measurements were recorded for a species are represented.

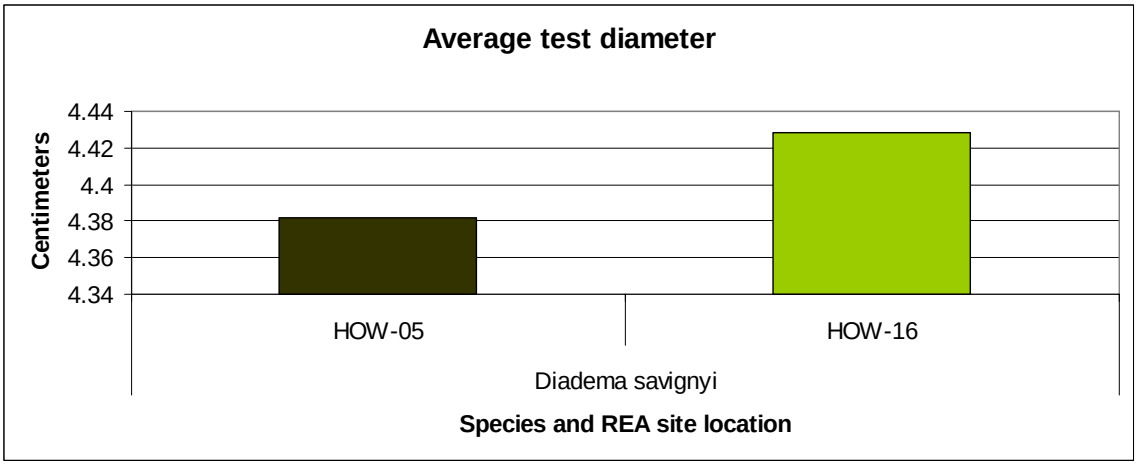

Figure C.3.3.1.1.--Average urchin test diameter.

Figure 3.3.1.2. reveals the average maximum shell length of giant clams observed from two sites at Howland Island. The text boxes represent the number of giant clams measured.

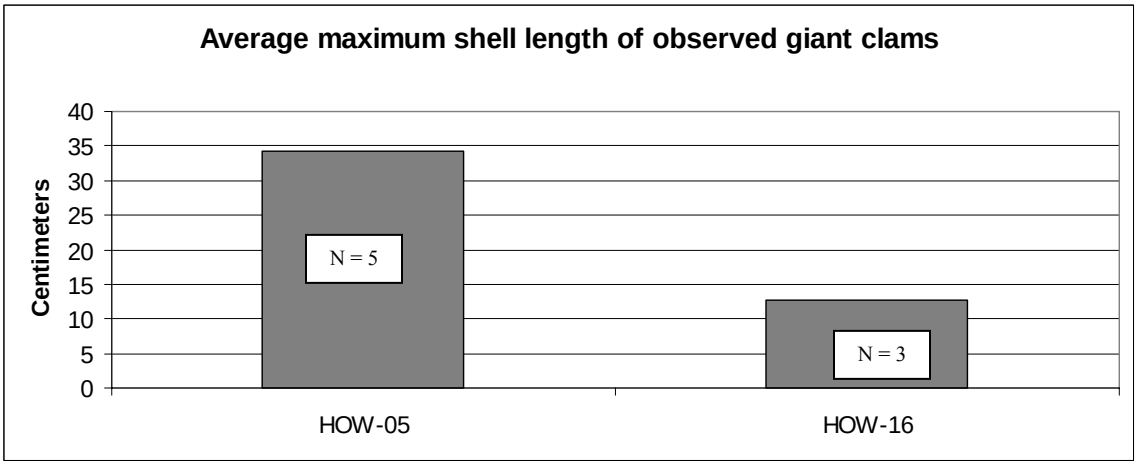

Figure 3.3.1.2.--Average maximum shell length of giant clams.

C.3.3.2 ARMS Deployment

Three were installed at Howland Island. The table below lists their site locations. All were positioned within close proximity of the REA survey sites.

	REA Sites		
Howland Island	HOW-11P	HOW-5P	HOW-14P

C.3.3.3. Invertebrate Collections

The following specimens were collected for the Hawaii Institute of Marine Biology for their molecular analyses investigating the connectivity of marine invertebrates in the central Pacific.

Species	Number	REA site	Latitude	Longitude
Linckia multifora	7	HOW-05P	00’ 48.3430	176’37.2870
Linckia multifora	1	HOW-11P	00’47.9360	176’37.2290
Holothuria atra	4	HOW-11P	00’47.9360	176’37.2290
? *Telesto*? soft coral	2	HOW-05P	00’ 48.3430	176’37.2870
Linckia multifora	3	N/A	00’48.415	176’37.293
Linckia multifora	1	N/A	00’48.638	176’37.350
Calcinus sp.	3	N/A	00’48.638	176’37.350
Ophiocoma sp.	1	N/A	00’48.415	176’37.293

C.3.4 Towed-diver Benthic Surveys

A total of nine towed-diver surveys covering 23.91 kilometers of habitat were completed along the forereef of Howland Island. Benthic habitat complexity ranged from medium in the north and east to high and medium-high in the west and southern reefs, respectively. The habitat was classified as continuous reef in all surveys, ranging from

steep walls on the west and south sides of the island, to moderately steep-sloped reefs in the east, and reef flats in the north.

The overall hard coral cover averaged 42.3% of the total benthic substrate of Howland Island, whereas soft coral accounted for 1.3% of the cover. The dominant coral species was Staghorn coral (*Acropora* sp.), especially on the east side of the island where there were large areas of up to 100% coverage. Other *Acroporas* and *Pocilloporas* were also observed frequently along the eastern side of the island. The western side of the island hosted a mixture of the above hard corals with *Fungia* and *Montipora*, as well as large areas of *Rhodactis* sp., the primary soft coral observed.

The overall averages for macro and coralline algae were 5.8% and 23.0%, respectively. Macro algal presence remained consistent throughout all surveys, primarily species of *Halimeda.* Coralline algae also remained relatively consistent throughout all surveys, although along the west side a slight increase was noted.

Free-living sea urchins were the highest macroinvertebrate counts recorded at Howland Island (total average 3.31 free-living urchins per hectare surveyed). The highest free-living urchin counts were observed along the southeastern and eastern sides of the island where an average of 2.85 urchins were recorded per hectare surveyed. Sea cucumbers were the second most abundant macroinvertebrate observed at Howland (total average 1.38 sea cucumbers per hectare surveyed). Similar to sea urchin distribution, the highest sea cucumber counts were recorded along the southeastern, eastern, as well as northeastern reef habitats (average 1.74 sea cucumbers per hectare surveyed). Giant clams were also observed at Howland with a total average of 0.43 recorded per hectare surveyed. Additionally, the highest counts were noted along the southeastern reef habitat (average 0.57 per hectare surveyed). Only one Crown-of-Thorns sea star was recorded at Howland Island.

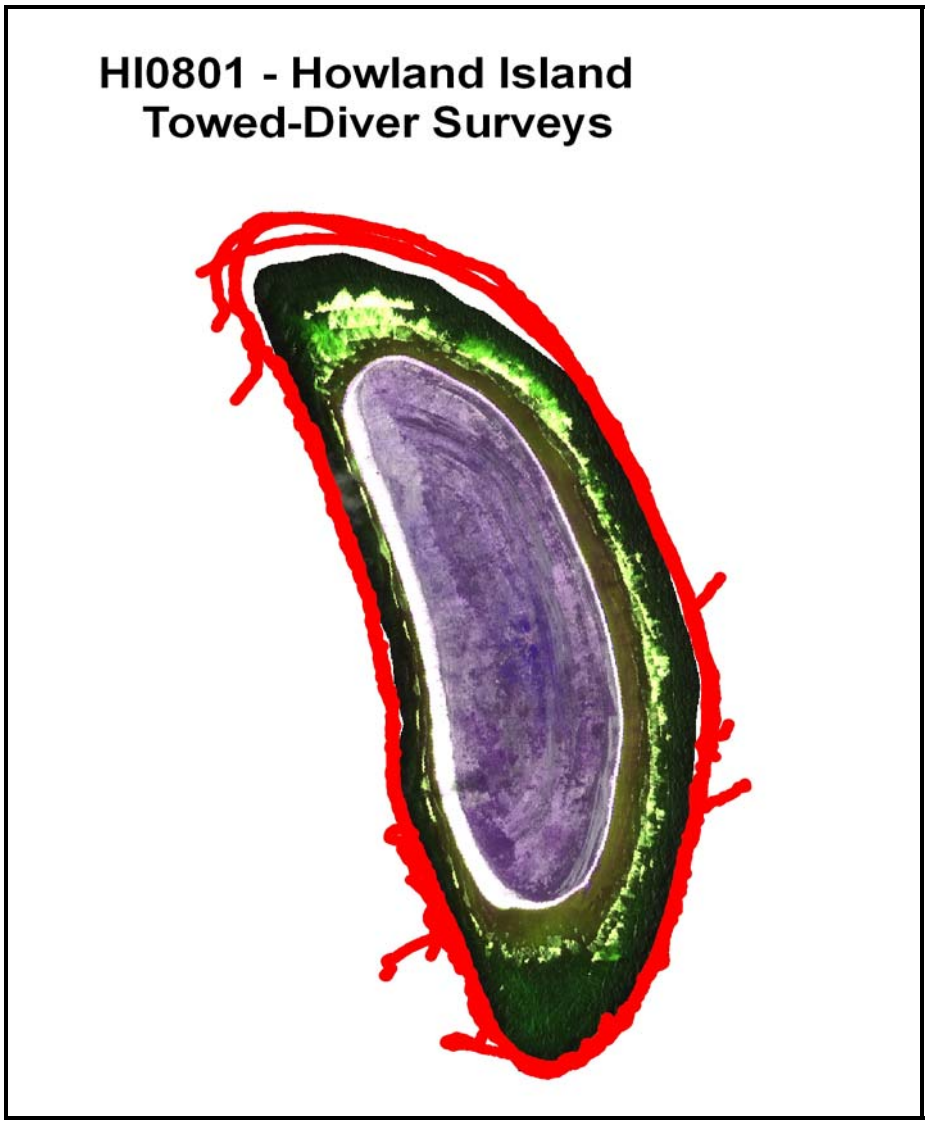

Figure 3.4.1.--Towed-diver survey tracks at Howland Island.

C.4 Fish

C.4.1 REA Fish Surveys

Stationary Point Count data (new methodology)

A total of 11 individual nSPC surveys were conducted at 10 sites around Howland Island (4 forefeef/mid depths, 3 forereef/deep, 3 forereef/shallow depths). Surgeonfishes (Acanthuridae) were the largest contributor to biomass with 3.4 kg 100 m^{-2}. Sharks (Carcharhinidae) and soldierfishes (Holocentridae) were also common, each with a biomass of ~3.0 kg 100 m^{-2} (Table C.4.1.1., Fig. C.4.1.1.). Rare manta ray sightings at HOW-50 were responsible for the high biomass at this site on both nSPC and BLT.

Belt transect data
During the survey period, 11 BLT surveys were conducted at 12 sites around Howland Island. Soldierfishes and surgeonfishes were the primary contributors to biomass with 4.4 kg 100 m^{-2} and 3.1 kg 100 m^{-2}, respectively (Table C.4.1.2.).

Overall observations
A total of 180 species were observed during the survey period by all divers. A range extension and new sighting for Howland Island were described for the golden spadefish, *Platax boersii*. The average total fish biomass at the sites at Howland Island during the survey period was 3.6 ton ha^{-1} for the nSPC surveys (Table C.4.1.1.), and the average fish biomass was 4.8 ton ha^{-1} for the BLT surveys (Table C.4.1.2.). These values take the manta ray sightings into account.

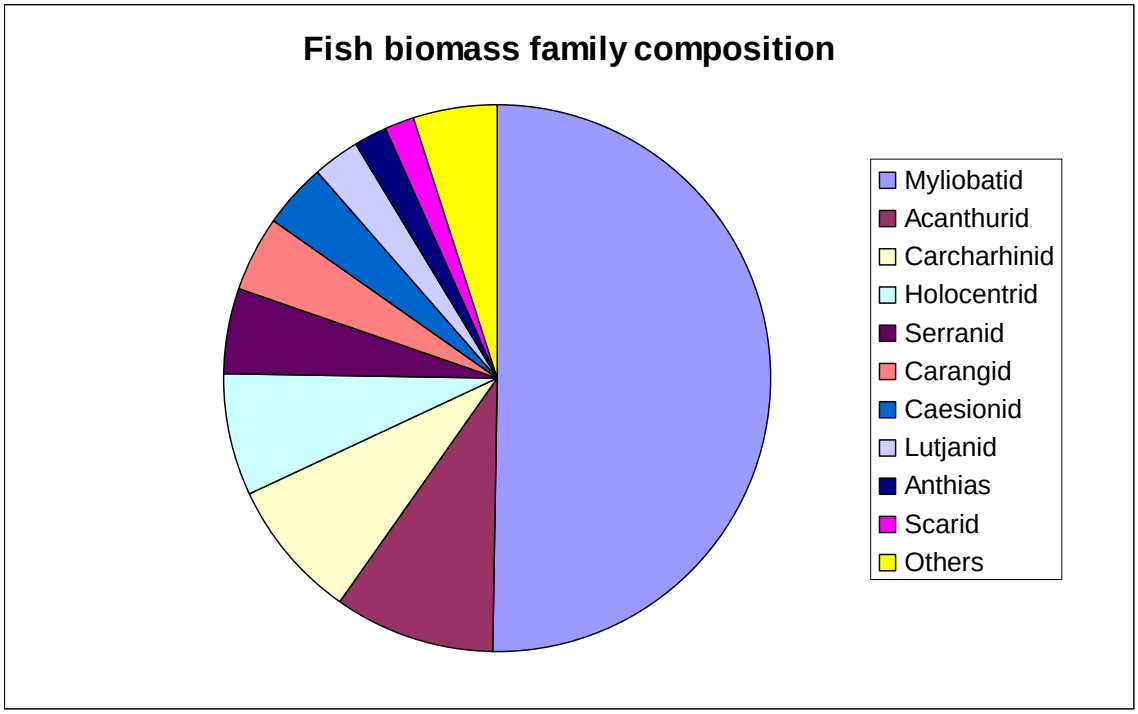

Figure C.4.1.1.--Total fish biomass broken down by family, as measured on nSPC.

Table. 4.1.1. -- Summary of total fish biomass around Howland Island, as measured on nSPC (kg 100 m^{-2})

Stratum-Depth	Site	Total	Myliobatid	Acanthurid	Carcharhinid	Holocentrid	Serranid	Carangid	Caesionid	Lutjanid	Anthias	Scarid	Others
Forereef - Deep	HOW-51	20	0.00	6.53	0.00	3.05	2.09	0.94	3.42	0.82	0.30	0.00	2.35
	HOW-52	16	0.00	2.76	0.00	7.18	2.00	0.92	0.00	1.06	0.62	0.00	1.22
	HOW-54	24	0.00	1.09	0.00	6.27	1.96	2.59	7.94	1.80	1.50	0.00	1.02
	Average	**20**	**0.0**	**3.5**	**0.0**	**5.5**	**2.0**	**1.5**	**3.8**	**1.2**	**0.8**	**0.0**	**1.5**
Forereef – Mid	HOW-05	19	0.00	11.03	0.00	1.56	2.74	0.67	0.00	0.75	0.98	0.00	1.72
	HOW-11	11	0.00	1.00	0.00	3.94	0.71	2.78	0.00	0.42	0.63	1.06	0.80
	HOW-14	36	0.00	2.25	23.06	1.15	3.50	1.80	0.00	0.86	1.70	0.59	0.83
	HOW-16	18	0.00	4.73	3.38	2.01	1.55	0.96	1.22	1.20	0.68	1.22	1.25
	Average	**21**	**0.0**	**4.8**	**6.6**	**2.2**	**2.1**	**1.6**	**0.3**	**0.8**	**1.0**	**0.7**	**1.2**
Forereef - Shallow	HOW-50	176*	162.15	2.73	7.12	0.08	0.39	0.00	0.00	0.50	0.00	1.30	2.05
	HOW-53	6	0.00	1.49	0.00	0.08	1.08	0.00	0.00	0.08	0.05	1.30	2.23
	HOW-55	17	0.00	1.79	0.00	0.63	1.54	5.72	0.00	2.44	0.50	1.09	3.71
	Average	**67**	**54.0**	**2.0**	**2.4**	**0.3**	**1.0**	**1.9**	**0.0**	**1.0**	**0.2**	**1.2**	**2.7**
Total		**36**	**18.0**	**3.4**	**3.0**	**2.6**	**1.7**	**1.6**	**1.4**	**1.0**	**0.7**	**0.6**	**1.8**

*High value due to manta ray sightings.

Table C.4.1.2.--Summary of total fish biomass around Howland Island, as measured on belt transects (kg 100 m^{-2})

Stratum-Depth	Site	Grand Total	Myliobatid	Holocentrid	Acanthurid	Carangid	Serranid	Anthias	Lutjanid	Scarid	Pomacentrid	Others
Forereef – Deep	HOW-51	22	0.00	10.11	0.99	2.97	1.22	1.52	1.91	0.00	0.11	3.64
	HOW-52	28	0.00	18.77	3.42	0.78	2.71	1.05	0.50	0.00	0.16	0.34
	HOW-54	16	0.00	3.45	1.74	0.43	2.04	3.82	1.56	0.29	0.08	2.20
	Average	**22**	**0.0**	**10.8**	**2.1**	**1.4**	**2.0**	**2.1**	**1.3**	**0.1**	**0.1**	**2.1**
Forereef – Mid	HOW-05	18	0.00	2.37	0.74	4.37	2.05	2.09	0.37	2.60	0.72	2.58
	HOW-11	16	0.00	2.08	8.07	0.72	0.82	0.67	0.23	1.73	0.27	0.99
	HOW-14	10	0.00	2.69	1.32	0.55	1.35	2.91	0.65	0.20	0.08	0.62
	HOW-16	13	0.00	0.84	1.69	0.27	1.36	1.27	5.50	0.00	0.18	1.72
	Average	**14**	**0.0**	**2.0**	**3.0**	**1.5**	**1.4**	**1.7**	**1.7**	**1.1**	**0.3**	**1.5**
Forereef - Shallow	HOW-50	298*	287.00	0.18	3.52	0.00	1.33	0.00	0.00	0.00	2.51	2.75
	HOW-53	12	0.00	0.12	7.08	0.00	0.43	0.02	0.14	2.21	0.90	0.78
	HOW-55	17	0.00	0.66	2.71	6.92	1.01	0.60	0.16	2.73	0.81	1.41
	Average	**109**	**73.8**	**0.3**	**4.4**	**2.3**	**0.9**	**0.2**	**0.1**	**1.6**	**1.4**	**1.6**
Total		**48**	**24.6**	**4.4**	**3.1**	**1.7**	**1.4**	**1.4**	**1.0**	**1.0**	**0.6**	**1.7**

*High value due to manta ray sightings.

C.4.2 Towed-diver fish surveys

Table C.4.2.1.--HI0801 Towed-Diver Survey Report for Howland Island.

			Survey Length				Mean Depth
		N	**Min**	**Max**	**Median**	**Sum**	**Average**
Howland Island	**02/06/2008**	6	1.60	3.39	2.59	15.97	-13.63
	02/07/2008	3	2.25	3.29	2.40	7.94	-15.15
	All	9	1.60	3.39	2.59	23.91	-14.14

N = number of surveys conducted.

Survey Length is given in kilometers.

Depth readings are taken at 5-s intervals during each 50-min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

A total of 31 species of large fishes (> 50 cm TL) representing 16 families were observed at Howland Island during the survey period (02/06/08-02/07/08). The mean number of fishes (all species pooled) observed by divers was 73.8 fish ha^{-1}. The eight most frequently recorded species are shown in Figure A. The Rainbow runner (*Elagatis bipinnulata*) was the most abundant species observed during the quantitative surveys with a mean number of 25.6 fishes observed per hectare. The Blackfin Barracuda (*Sphyraena qenie*) was the second most abundant fish species encountered during the survey with 15.8 fishes recorded per hectare. These species were seen in large aggregations which accounts for their high densities.

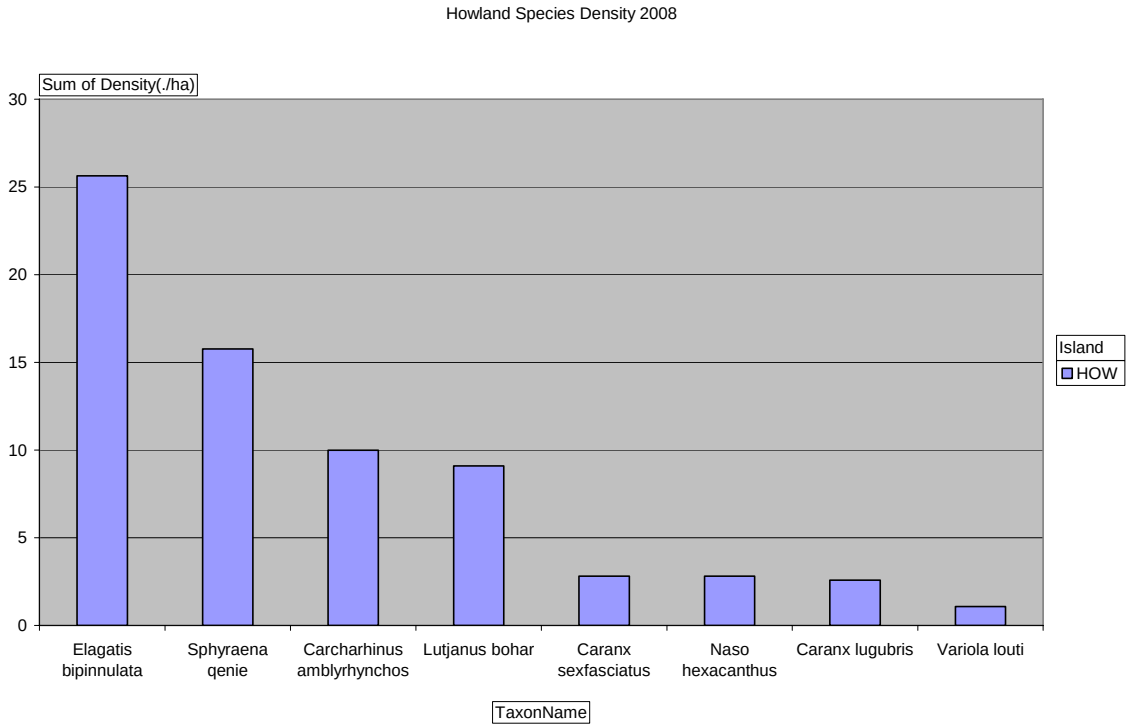

Figure C.4.2.1.--Density of eight most frequently recorded species at Howland Island.

The grand mean biomass density of fishes observed on the shallow reefs (< 30 m) at Howland Island during the survey period was 0.44 t ha^{-1}. The Manta Ray (*Manta birostris*) accounted for more than 45% of the total mean biomass of large fishes (Fig. B). The total biomass density for the Grey Reef Shark (*Carcharhinus amblyrhynchos)* was 0.11 t ha^{-1}, putting it second in terms of largest biomass at Howland.

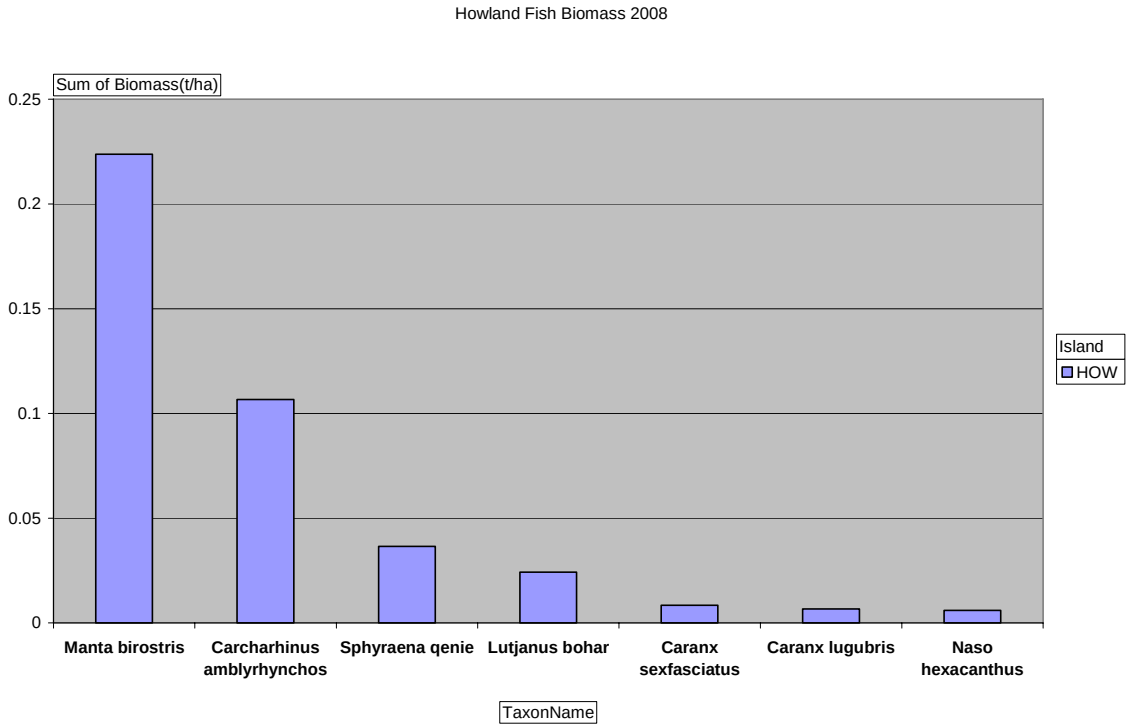

Figure C.4.2.2.--Seven species representing highest biomass at Howland Island.

C.5. Terrestrial Team

Background: Howland Island National Wildlife Refuge (NWR), along with nearby Baker Island NWR are the most remote Refuges in the system. The two small islands and the territorial sea at the time of establishment (3 miles out from the shoreline) were designated National Wildlife Refuges in 1973 and stand as some of the last best examples of Central Tropical Pacific coral reef ecosystems due to their extreme isolation and relative lack of anthropogenic activity. The Refuges are rarely visited due to their great distance from inhabited areas. The most recent previous monitoring visit at Howland occurred from 4 to 6 March 2007 when Fish and Wildlife Service biologist Steve Barclay visited aboard the USCG Cutter *Kukui* during their annual cruise to maintain Aids to Navigation throughout the U.S. Central Pacific Islands. The inception of the biennial American Samoa Reef Assessment Monitoring Program trips that bring biologists to systematically survey the marine environment every other year has also improved the Refuge's ability to monitor the terrestrial environment more regularly and more safely.

Results: Bird density and diversity were moderate during the transit from Johnston Atoll to Howland, peaking on the second day (37 birds/hour and 12 different species). The index of flying fish density decreased as the ship moved south from 135 flying fish per hour on 2 February to 23 flying fish per hour on 4 February. The value rose on 5 February to 117 per hour.

Nine of the twelve species of seabirds that typically breed at Howland Island were attending eggs or chicks during our visit. An additional three species of tern (Black Noddy, White Tern, and Blue Noddy) were present and may have had nests that were not found. Night searches for *Procellariform* species did not result in any detections on this visit. Table C.5.1. lists numbers of active nests for each species at Howland Island breeding at the time of our visit. The irregularity of monitoring visits to these remote sites and the relative aseasonality of these breeding colonies on the equator makes conclusions drawn from population size comparisons between trips unreliable. Even changes in presence or absence on any particular visit may just mean the oceanographic conditions are not favorable for breeding attempts by that species at that time. Seabird species listed for Baker were those observed flying to or from the island. Those species for which birds in juvenile plumage were observed were assumed to be breeding there.

Previous estimates of Sooty Tern nesting at Baker (Flint and Horvath, 2000) were 800,000 pairs. On this visit, large numbers of Sooty Terns swirled over most of the island and streams of individuals came in each day at sunset. There was certainly no less area covered with tern nests than on that previous visit. The magnitude of the infusion of nutrients being imported to the reef ecosystem from the guano being produced by as many as 2 million birds in residence is no doubt significant to the energy and biogeochemical dynamics of the Baker (and Howland) reef ecosystems.

Table C.5.2. lists species and counts of migratory shorebirds observed at Howland in 2008. Baker Island typically has a wider variety of species of migrants present because of a small wetland at the northeast end of the island, but we were unable to survey there.

There were no land mammals found at Howland Island. Feral cats were eradicated there in 1987 and numbers of bird species breeding has increased ever since. Cats were eliminated from Baker in the 1960s, so the smaller seabird species resumed breeding there earlier than they did at Howland. Upon arrival at Howland a large group of small cetaceans greeted the vessel and spent time around the small boats. Later a smaller group of Pacific Bottlenosed Dolphins (*Tursiops truncatus*) also was observed. At Baker Island, as the vessel departed, it was accompanied by a *Tursiops* pod, including a female with a calf. Depkin saw one small lizard, presumably the snake-eyed skink (*Cryptoblepharus poeciloptleurus*) foraging and sunning on the island. Many green sea turtles (*Chelonia mydas*) were seen by the divers in the area; however, there was no sign of them on land during this visit. During the night survey most plants had at least one resident jumping spider perched in the foliage. These animals were detected by their bright eyeshine when a flashlight was aimed at them. Specimens were collected in 2007 and identification is pending. Throughout the interior of the island there are large numbers of small burrow entrances approximately 3 to 6 centimeters in diameter leading biologists, on past visits, to worry about the presence of mice or rats. On this trip, Depkin was able to photograph a small land crab that emerged from one of these holes. The photograph (in Howland Island photo folder) was sent to Scott Godwin who gave a preliminary identification of the Genus *Geograpsus.* Species identification will require a specimen.

Nine species of vascular land plants were observed on Howland Island during this visit and the previous three trips. The island was green but looked as if there had been a dry period until recently. Table C.5.3. lists the species seen in February 2008. The kou (*Cordia subcordata*) grove in the center of the island appeared mostly dead but had active growth and blooming around the edges and down low in the patch. This shrub continued to show evidence of active herbivory by some insect that we did locate on the leaves.

Wildlife entrapment hazards were identified and mitigated at Howland Island. Very little shore debris was present, but one broken FAD was seen. The two water cisterns that historically have been an entrapment hazard were much improved by the addition of rock ramps added during the visit of Barclay et al. in 2007. No large pieces of debris on Baker's beaches were visible, and the divers did not report any hazards observed under water at either site. The temperature recording buoy at Baker was lost from its mooring prior to this visit, but since we were unable to land, we do not know whether it came ashore there.

The Earhart Light had some cracks in its surface and not much paint left. The Baker day beacon looked as if it were in good condition.

Table C.5.1.--Number of active seabird nests (containing an egg or chick) by species at Howland Island and presence and breeding status observed from offshore at Baker Island, February 2008.

Species	Howland Island	Baker Island
Red-footed Booby *(Sula sula)*	47 nests	Present, breeding
Brown Booby (*Sula leucogaster*)	20 nests	Present, breeding
Masked Booby **(***Sula dactylatra***)**	818 nests	Present, breeding
Great Frigatebird (*Fregata minor*)	24 nests	
Lesser Frigatebird (*Fregata ariel*)	2484 nests	Present, breeding
Red-tailed Tropicbird (*Phaethon rubricauda*)	9 nests	Present, breeding
White Tern (*Gygis alba*)	Present	
Brown Noddy (*Anous stolidus*)	23 nests	Present, breeding
Black Noddy (*Anous tenuirostris*)	Present	
Blue Noddy (*Procelsterna cerulea*)	Present	
Sooty Tern (*Onychoprion fuscata*)	~100,000 nests	Present, breeding
Gray-backed Tern (Onychoprion lunata)	3 nests	Present, breeding

Table C.5.2.--Number of migratory shorebirds by species counted at Howland Island, February 2008.

Species	# counted
Pacific Golden Plover (*Pluvialis fulva*)	2
Wandering Tattler (*Tringa incanus*)	3
Bristle-thighed Curlew (*Numenius tahitiensis*)	18
Ruddy Turnstone (*Arenaria interpres*)	50

Table C.5.3.--Plant species and their phenology observed at Howland Island, February 2008.

Species	Phenology
*Digitaria stenotaphrodes (*Pacific crabgrass*)*	older seedheads
Lepturus repens	not flowering or seeding
Tribulus cistoides	flowering
Boerhavia repens	flowering
Portulaca lutea	flowering
Cordia subcordata (kou)	flowering
Scaevola taccada	flowers and seeds
Tournefortia argentea (tree heliotrope)	flowering
Suriana maritima	not flowering or seeding

Appendix D: Baker Island

D.1. Oceanography and Water Quality

Of the 2 sea days allotted for work at Baker Island, sea and weather conditions limited the first day's operations to the west (leeward) side of the island. Mooring operations totalled four STRs and one ODP plate recovered and replaced at Baker Island (Fig. D.1.1., Table D.1.1.). Five shallow water CTDs were performed on the west side of the island at 500-m intervals, and one shallow water, 4-depth (1, 10, 20 and 30 m) water sample cast was performed on the west side of the island (Fig. D.1.3.). A total of six open ocean (500 m) CTD casts and water samples (3, 80, 100, 125 and 150 m) were conducted in a 4-cast array to the west and a 2-cast array to the east (Fig. D.1.2.).

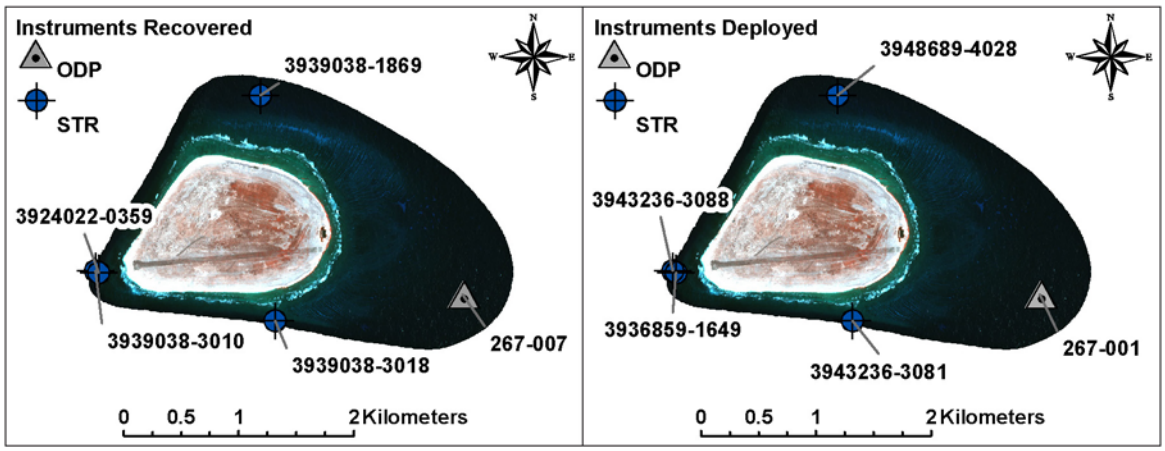

Figure D.1.1.--Moored Oceanographic Instrumentation Map. Moored oceanographic instruments, labeled by serial number, recovered and deployed at Baker Island during HI0801.

Table D.1.1.--Moored Oceanographic Instrumentation Table. Moored oceanographic instruments recovered and deployed at Baker Island during HI0801, instrument type, serial number, lat/long of mooring, sensor depth and data set start and end dates (UTC).

Instrument	Serial Number	Latitude	Longitude	Depth (m)	Data Start	Data End
ODP	267-007	00 11.3961 N	176 27.6071 W	19.81	1/31/06 8:00	2/8/08 16:00
STR	3939038-3018	00 11.2734 N	176 28.4847 W	4.57	1/31/06 1:30	2/9/08 22:00
STR	3939038-3010	00 11.5067 N	176 29.3252 W	17.37	1/31/06 2:30	2/9/08 1:00
STR	3924022-0359	00 11.4991 N	176 29.3081 W	4.27	1/31/06 3:00	2/9/08 1:00
STR	3939038-1869	00 12.3257 N	176 28.5526 W	16.76	2/2/06 0:00	2/10/08 1:00
STR	3936859-1649	00 11.4991 N	176 29.3081 W	4.27	LOGGING DATA	
STR	3943236-3088	00 11.5067 N	176 29.3252 W	17.37	LOGGING DATA	
STR	3943236-3081	00 11.2734 N	176 28.4847 W	4.57	LOGGING DATA	
ODP	267-001	00 11.3961 N	176 27.6071 W	19.81	LOGGING DATA	
STR	3948689-4028	00 12.3257 N	176 28.5526 W	16.76	LOGGING DATA	

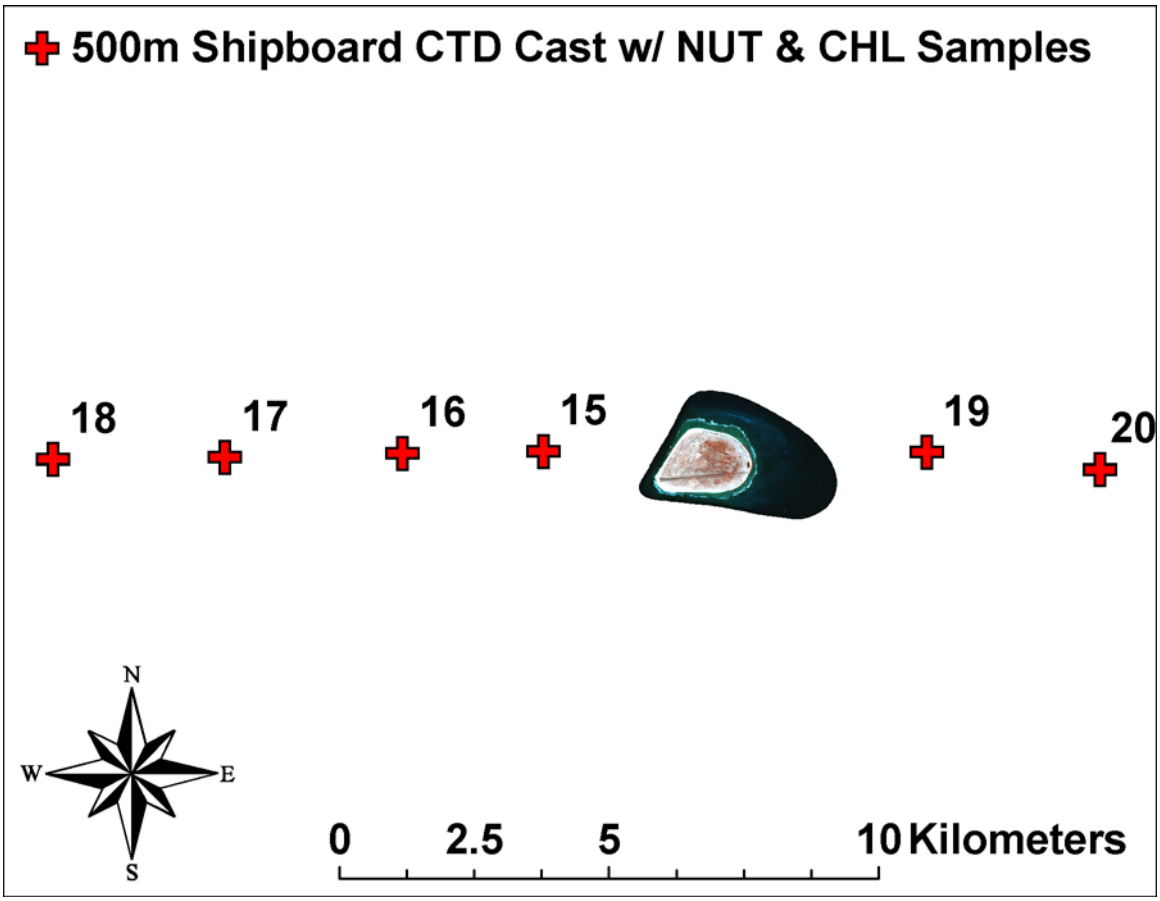

Figure D.1.2.--Shipboard CTD, DIC, NUT & CHL Operations. Deepwater shipboard CTD, NUT & CHL sites near Baker Island during HI0801, labeled by cast number.

Preliminary Results

Because CTDs and water samples were only conducted on the western leeward side of Baker Island (Fig. D.1.3.), any comparisons made between these data must be general. There was slightly warmer water, more saline, low density, more turbid water on the southern point (cast 001) than the north (cast 005); however the relative changes were very slight in all of these properties.

Temperature, salinity, density and transmittance throughout the 30-m water column were relatively homogeneous with depth on the west side, with a thin warmer, more saline, denser and relatively clear surface lens (Fig. D.1.4.). This lens was possibly formed by warming of the surface water by the sun. The properties measured by the shallow water CTD did not change appreciably through the water column on the western side of Baker Island during this period.

Temperature data were obtained from four locations around Baker Island (Figs. D.1.1. and D.1.5.). Subsurface temperatures recording each Baker Island mooring location were similar and followed a similar pattern to those recorded at nearby Howland Island for the same time period. Over the past 15 months there has been a consistent cooling of the water with a 5^0C reduction (31 ^{0}C - 25 ^{0}C) in temperature from January 2007 to January 2008. A similar event between islands suggests a large scale phenomenon, supporting La Niña effects, opposed to local forcing.

The wave field on the eastern side of Baker Atoll shows typical seasonal variability in swells for the northern hemisphere with intermittent ground and wind swell (Fig. D.1.6.). The eastern side is open to wind waves as well as long-distance, long-period swells from the north and south. Since Baker is close to the equator, there is relatively little annual difference in swell heights due to exposure from both main sources of waves in the Pacific. Prevailing currents in the area were from the east and more southerly directions (V velocities positive toward the north and U velocities positive toward the east). Mean current velocities were likely forced by wind and wave conditions which prevail from the east.

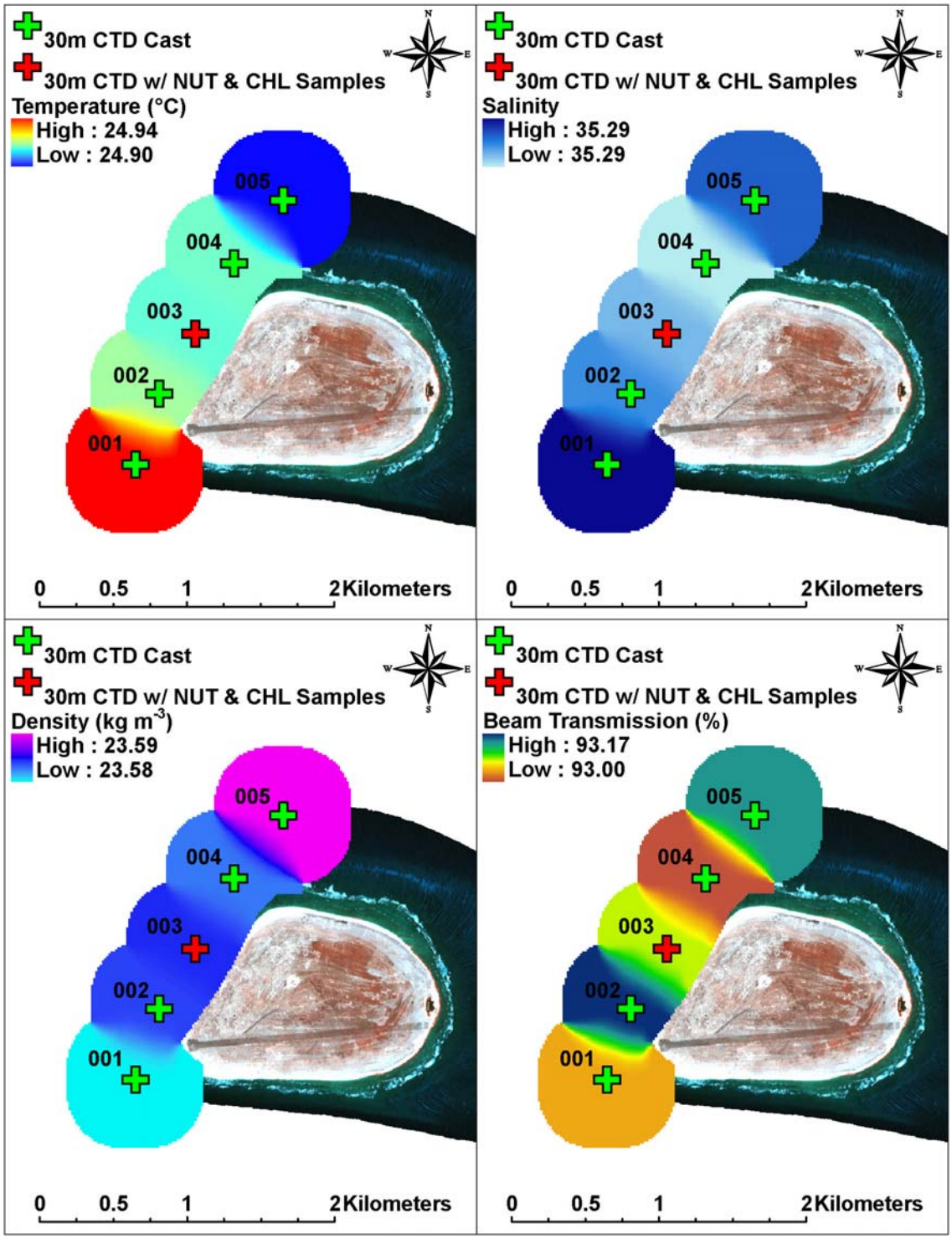

Figure D.1.3.--Shallow CTD Casts and 20m Data Interpolations. Shallow CTD cast locations and interpolations of temperature (upper left), salinity (upper right), density (bottom left) and beam transmission (bottom right) at 20-m depth. All casts were conducted on 9 Feb 2008 UTC at Baker Island during HI0801.

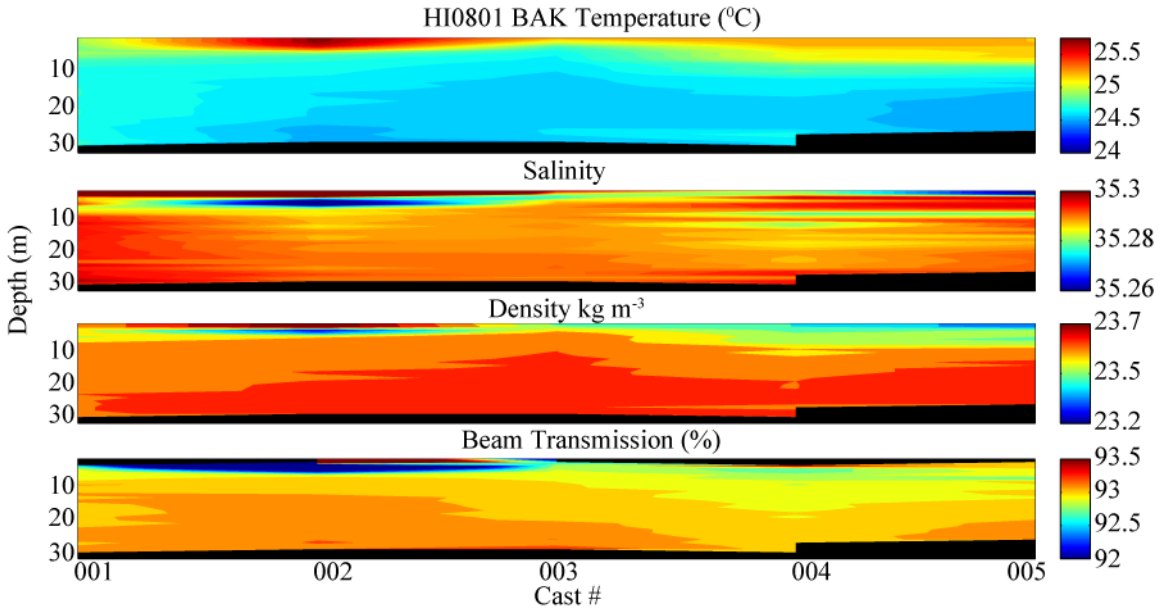

Figure D.1.4.--Shallow CTD Cross-section Plot. Cross-section plot of shallow water CTD data temperature, salinity, density and beam transmission collected at Baker Island during HI0801. Refer to Figure 3 for CTD cast locations.

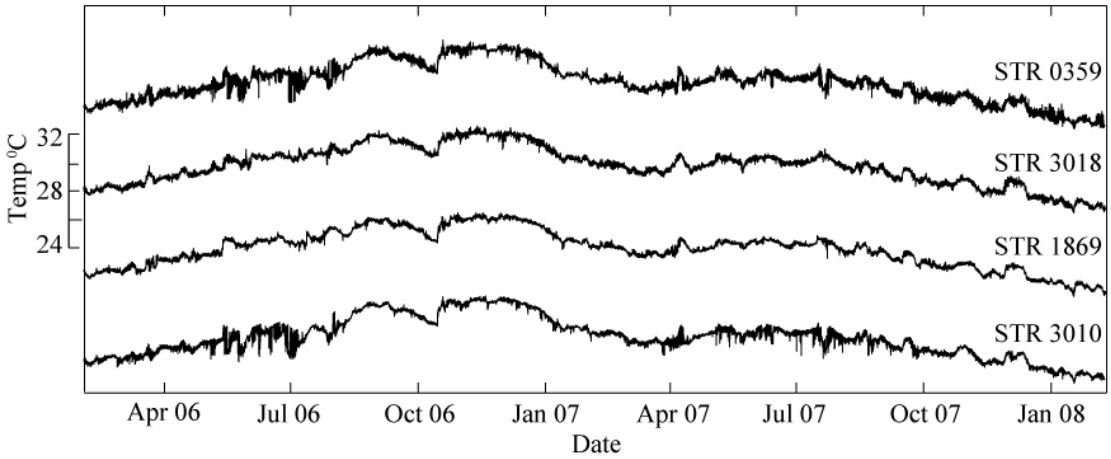

Figure D.1.5.--Subsurface Temperature Timeseries. Temperature data obtained from four STR locations at Baker Island. Refer to Figure 1 and Table 1 for mooring location, depth and dataset information.

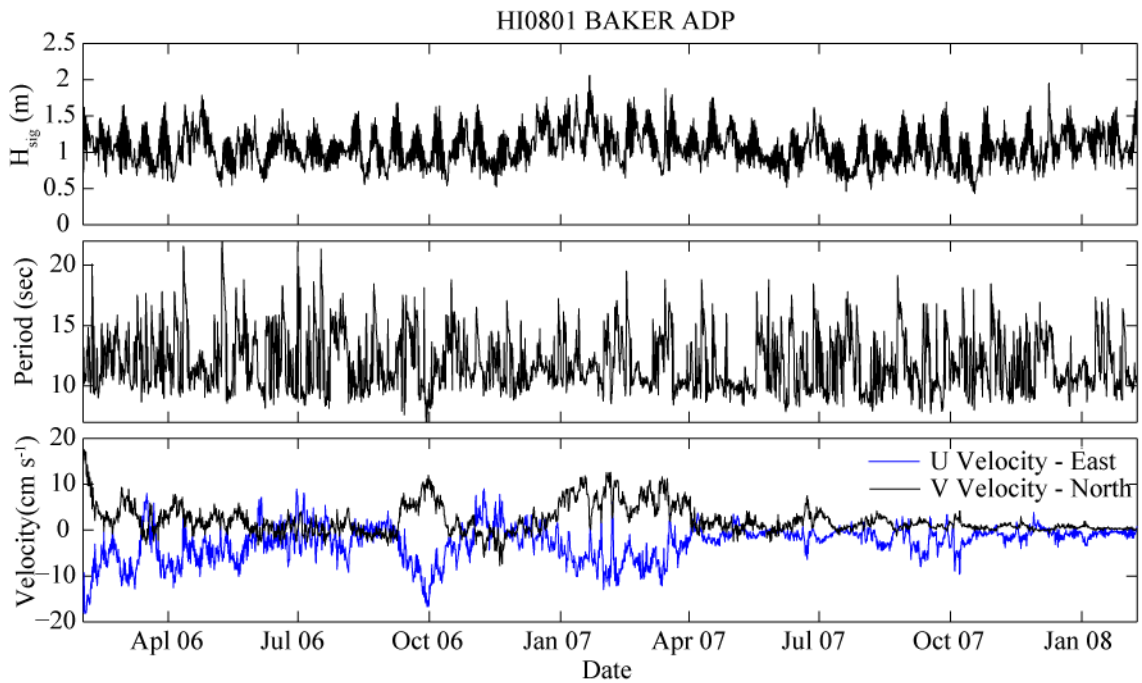

Figure D.1.6.--Wave & Current Timeseries. Wave burst (15 min) means of Significant wave height (m), dominant period (sec) and East and North current velocities. Data collected by ODP at Baker Island. Refer to Figure 1 and Table 1 for mooring location, depth and dataset information.

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

BAK-11P 2/8/2008
Depth Range: 8.2–14.3 m
N 0 º 11.955 W 176 º 29.073

This site was on the western fringing forereef slope of Baker Island. Only one transect pins installed by Jim Maragos in 2001/2002 were found. Expansive patches of dead *Acropora nobilis* skeletons and rubble overgrown with turf algae represented nearly 63% of the benthos. Coral cover was moderately high (25.5%), dominated by thickets of the staghorn coral *Acropora nobilis*. Other corals present along the transect line included *Pavona varians*, *Favia stelligera*, and the corallimorphan R*hodactis*. The coral disease and health assessment survey found one case of focal, bleaching detected on *Acropora.* No algae or invertebrate surveys were conducted while three artificial reef matrix structures (ARMS) were deployed. Only a single fish dive was conducted due to high seas and winds. Surge was intermediately strong during the dive. Several large carpets of anemones filled with *Amphirion chrysopterus* and juvenile *Dascyllus auripinnis* were present. Schools of *Pseudanthias bartlettorum*, *Luzonichthys whitleyi* with smaller numbers of *Pseudanthias olivaceus* and *Lepidozygus tapeinsoma* were present, being fed upon by *Caranx lugubris*. A large school of *Caesio teres* was also present. Surgeons dominated the mid-range fish, feeding on the lush algae-covered dead coral.

BAK-14 2/9/2008
Depth Range: 14–17 m
N 0 º 12.339 W 176 º 28.758
This site was on the northern fringing forereef slope. Coralline algae over rubble, dead coral, or coral pavement represented nearly 39% of the live benthos, and turf algae represented ~ 27% of the live benthos. Coral cover was moderately high (29%), dominated by an amalgam of staghorn and tabular acroporids (~80%). Other corals present along the transect line included *Pocillopora*, *Favia*, and *Psammocora*. Relatively high species diversity was present; 13 different scleractinian genera were recorded within the general survey area. Coral population surveys did not pick up several large thickets of *Acropora* which were present along the transect but whose centers did not lie within the belt. The coral disease and health assessment survey found one case of focal, bleaching and discoloration on *Pocillopora.* Overall, non-cryptic macroinvertebrates were low. The dominant and only macroinvertebrate observed along transects was *Linckia multifora.* No roving survey was done while three ARMS were deployed. No algae surveys were conducted. The large snappers *L. bohar* and *L. monostigma* dominated at this site. It was interesting to note that *Scarus oviceps* and *Scarus tricolor* were seen, as well as a few large *Naso ceasius*. Both *Plectroglyphidon dikii* and *johnstonianus*, most commonly associated with branching corals, were present in very large numbers. *Myripristis berndti* were very common here, aggregating in large numbers under plate and table corals.

BAK-04 2/9/2008
Depth Range: 16–18 m
N 0 º 12.311 W 176 º 28.472
This site was located on the northern fringing forereef slope. Crustose coralline algae over rubble (mainly staghorn coral) represented nearly 50% of the live benthos, and turf algae over coral rubble represented ~ 20% of the substrate. Coral cover was relatively low (9.8%), mainly composed of interspersed staghorn coral and tabular *Acropora* (~80%). Coral population surveys did not pick up several large thickets of *Acropora* which were present along the transect but whose centers did not lie within the belt. Relatively high generic diversity was recorded within the general survey area with 17 different scleractinian genera recorded. A coral disease and health assessment survey found one case of multifocal, tissue loss on a colony of *Acropora nobilis.* Overall, non-cryptic macroinvertebrates were low. The dominant macroinvertebrate observed along the transects was *Linckia multifora* followed by Trapezid crabs. Several top and turban shells were observed. Half were either occupied by *Dardanus* sp. or empty with evidence of predation. The *Phyllidiella* sp. nudibranch was common. No algae surveys were conducted. The dominant characteristic of this site was the high number of large fish. *Lutjanus bohar*, *Chlorurus microrhinos*, *Aphareus furca*, and *Caranx lugubris* were the most common. Of note was one individual of *Lethrinus xanthochilus*, and two large *manta birostris* that were present during the nSPC survey. A portion of this site's substrate was composed primarily of coral rubble. In this area, schools of *P. bartlettorum* mixed with many juvenile *Cirrhilabrus exquisitus* were found in relatively high numbers. One individual of *Heniochus monoceros* was observed as well. *Myripristis berndti* were everywhere, accounting for plenty of biomass.

BAK-05P 2/9/2008
Depth Range: 9.0–10.6 m
N 0 º 11.781 W 176 º 29.176
This site was located on the western fringing forereef slope of Baker Island. Only two transect pins installed by Jim Maragos in 2001/2002 were found. Expansive patches of dead *Acropora nobilis* skeletons and rubble overgrown with turf algae represented nearly 80% of the benthos. Live coral cover was moderately low (20%), mainly composed of interspersed staghorn and tabular *Acropora* (~80%). The coral disease and health assessment survey detected two cases of growth anomalies on tabular *Acropora* cf. *clathrata.* High surge prevented qualitative algae photoquadrat sampling, so a qualitative assessment was conducted. Crustose coralline red algae, turf algae, *Lobophora variegata*, *Hypnea pannosa*, *Dictyota* ceylanica, Dictyota friabilis, *Bryopsis pennata* were recorded. No invertebrate survey was conducted. A large school of *Acanthurus triostegus* was seen feeding on the algae-covered dead coral rubble that dominated the area. High numbers of various species of juvenile wrasses hugged the rubble, while thick schools of *Pseudanthias bartlettorum*, *Luzonichthys whitleyi* with smaller numbers of *Pseudanthias olivaceus* and *Lepidozygus tapeinsoma* circled above. As with BAK-11, midsized fish populations were dominated by surgeonfish. Of note *Carcharhinus amblyrhynchos* and *Aetobatus narinari* were observed on transect with a *Triaenodon obesus* seen off transect.

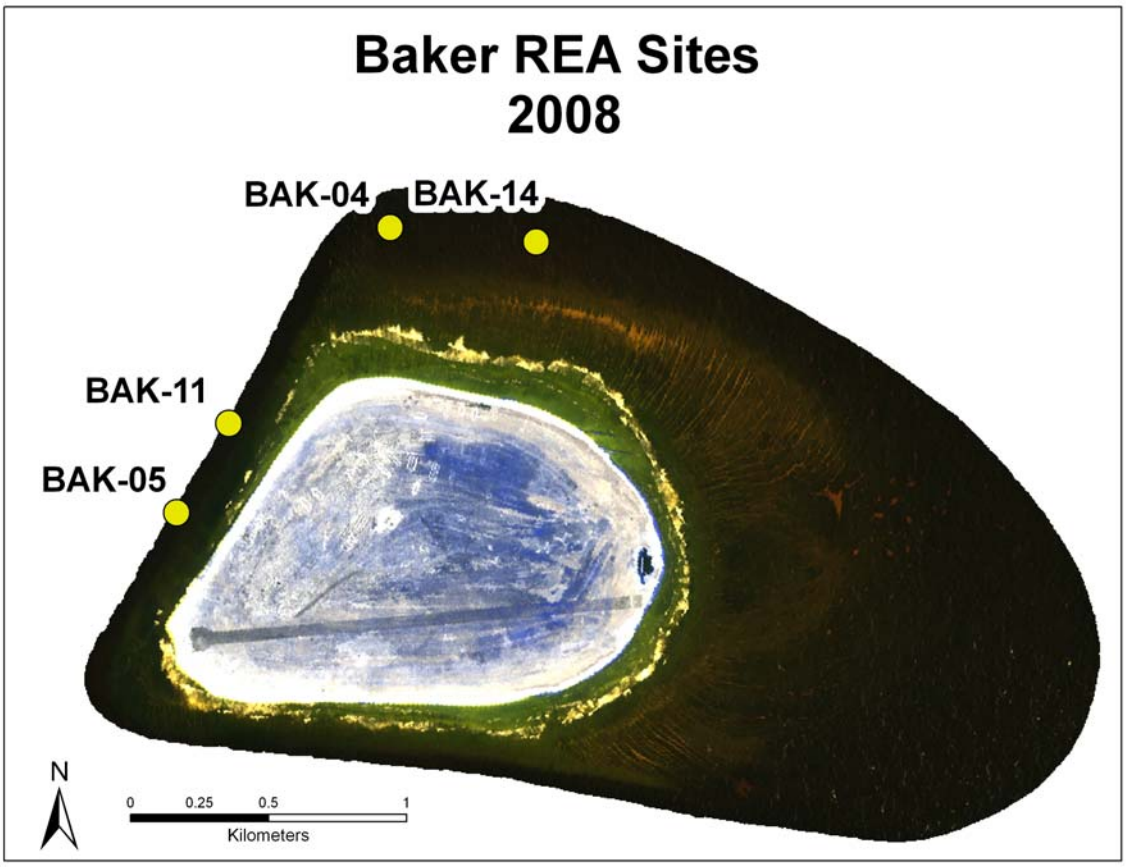

Figure D.2.1.--REA sites at Baker Island in 2008.

D.3. Benthic Environment

D.3.1. Algae

Because of weather and logistical difficulties, only one qualitative algal survey was conducted at REA site BAK-05P. The invertebrate team also collected two species of *Halimeda* at BAK-14. Five species of macroalgae were recorded along survey lines: one species of green algae, one species of red algae, and three species of brown algae, as well as crustose coralline red algal, turf algal, and cyanophyte functional groups (Table D.3.1.1).

Table D.3.1.1--Algal genera or functional groups recorded in photoquadrats at Baker 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.

	BAK-05P	BAK-14
GREEN ALGAE		
Bryopsis pennata	*	
Halimeda fragilis		*
Halimeda heteromorpha		*
RED ALGAE		
crustose coralline red algae	*	
Hypnea pannosa	*	
OCHROPHYTA		
Dictyota ceylanica	*	
Dictyota friabilis	*	
Lobophora variegata	*	
FUNCTIONAL GROUPS		
turf algae	*	
Cyanophyte	*	

D.3.2. Corals

Four coral REA surveys (BAK-04, -05P, -11P, and -14) were conducted along the western and northern forereefs at Baker Island between February 8 and 9, 2008 (Fig. D.2.1.). Two sites (BAK-05P and -11P) had permanent transects established by Jim Maragos in 2000–2002; however not all transect pins were found at both sites. Sites BAK-04 and -14 were last surveyed in 2000 and 2001, respectively, at which time quantitative surveys were not part of the coral survey protocol. Dive depths ranged from 8.2 to 18 m. Coral population surveys were conducted by Jason Helyer (CRED), and coral disease and health assessments were conducted by Dr. Bernardo Vargas Angel (CRED).

D.3.2.1 Percent Benthic Cover

The line-point intercept (LPI) methodology quantified a total of 408 points along 200 m of forereef coral communities. Survey transects depth ranged between 8 and 18 m for all locales visited. Patterns of intra-island variability in percent benthic cover, derived from the five independent REA surveys in 2008, are reflected in Figure D.3.2.1.1. Point-count

surveys indicated that the mean percent live coral cover for all sites combined was relatively low: 21.6 ± 4.2% (mean ± SE). Turf algae growing over rubble, pavement, or dead coral were an important component of the live benthos and represented nearly 50% of the benthic cover. In addition, crustose coralline algae represented 26% of the live benthos. Of the six scleractinian genera enumerated along the line transects, *Acropora* was the most abundant, representing 84%. Below, Table D.3.2.1.1. provides an itemized analysis of relative contribution of the different scleractinian taxa to the total percent live coral cover.

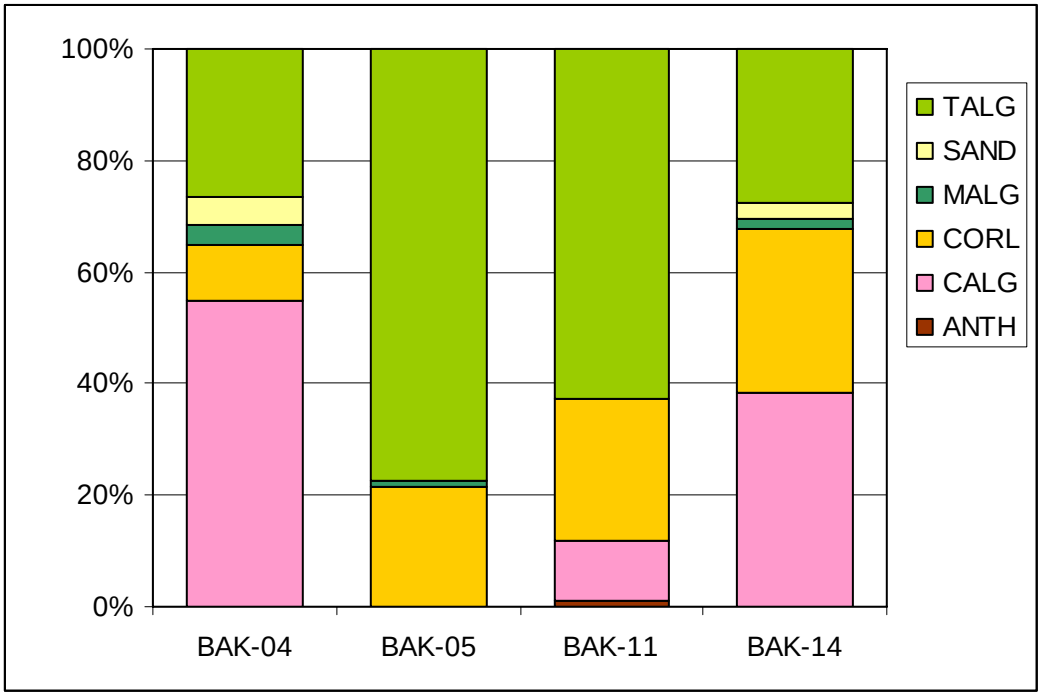

Figure D.3.2.1.1.--Mean percent cover of selected benthic elements derived from four independent REA surveys at Baker Island, Equatorial Pacific Cruise 2008 (Feb. 8–9, 2008). TALG: Turfalgae (on pavement, rubble, and dead coral); SAND: sand; MALG: macroalgae; CORL: live coral; CALG: crustose coralline algae (on pavement, rubble, and dead coral); ANTH: *Rhodactis* sp.

Table D.3.2.1.1.--Percent contribution of the different slceractinan genera to the total live coral cover, Baker Island, 2008.

Taxon	Relative abundance (%)
Acropora	74
Pocillopora	5
Pavona	4
Favia	3
Montipora	1
Psammocora	1

D.3.2.2. Coral Populations

A total of 933 colonies belonging to 16 anthozoan taxon were enumerated within 174 m^2 of reef surveyed at Baker. *Acropora and Pocillopora* were the most abundant corals accounting for 31.5% and 10.5% of colonies found within belt transects, respectively (Table D.3.2.1.2.). Mushroom corals of the *Fungid* family were also abundant on northern forereef sites. A number of *Acropora* species were encountered including: two species with tabular morphologies (*Acropora clathata* and *hyacinthus*), staghorn acropora (*Acropora nobilis*) and several digitate and corymbose species.

Genus	# of Colonies	% of Total
Acropora	**294**	**31.5**
Entacmaea	2	0.2
Favia	37	4.0
Favites	3	0.3
Fungia	**350**	**37.5**
Halomitra	3	0.3
Hydnophora	2	0.2
Leptastrea	2	0.2
Leptoseris	29	3.1
Montipora	13	1.4
Palythoa	5	0.5
Pavona	33	3.5
Pocillopora	**98**	**10.5**
Porites	25	2.7
Psammocora	32	3.4
Rhodactis	5	0.5

Figure D.3.2.1.2.--Number of anthozoans enumerated within belt transects at Baker Island during 2008 surveys. Taxa contributing more than 10% of the total number of colonies are in bold.

Because of weather conditions, only two sites from the recent time series of data (2004 and 2006) were revisited, limiting any conclusions that could be made from temporal comparisons. Further hindering the ability to detect temporal change in coral populations at Baker Island is the lack of permanent transects. Although BAK-05P and -11P both have permanent transect pins, many of the pins were missing and transect lines were likely not deployed in the same location as previous years. This problem becomes apparent when comparing the abundance of the corallimorph *Rhodactis* at site HOW-05 between 2006 and 2008. In 2006, 70 colonies of *Rhodactis* were found within the belt transect, none were found in 2008, although large expanses of the substrate were covered by *Rhodactis*, just 20 m north of where transects were laid.

Sites BAK-05P and BAK-11P along the western forereef, had extensive thickets of healthy staghorn coral (*Acropora nobilis* and *robusta*) in 2004, before a significant die-off occurred before the 2006 surveys which is thought to be partially due to a bleaching event (Jim Maragos, 2006 Cruise Report). It is hard to comment on the degree of

recovery of staghorn coral at these sites. Quantitative data only exists for 2006, so there is no reference point before the die-off took place. Further complicating the issue are difficulties that arise in estimating colony boundaries when branch densities increase and begin to form extensive thickets and the possibility that different areas of the reef were surveyed in each year. Figure D.3.2.1.2. shows size-class distributions of *Acropora* (staghorn, tabular, corymbose, and digitate, combined) at sites BAK-05P and -11P in 2006 and 2008.

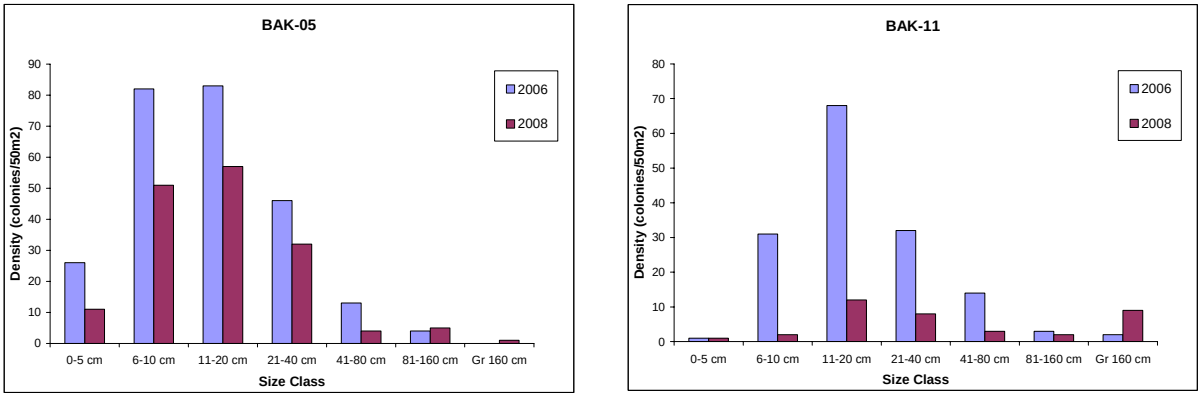

Figure D.3.2.1.2.--Temporal comparison of size-class distributions of all coral colonies enumerated within belt transects at BAK-05 and BAK-11 in 2006 and 2008.

D.3.2.3 Coral Health and Disease

In 2008, the coral disease REA surveyed a total area of ~ 900 m^2 at four different sites. Disease occurrence and abundance were overall low; a summary of disease occurrence is presented in Table D.3.2.1.3. Over 80% of cases were noted on *Acropora*.

Table D.3.2.1.3.--Cumulative number of cases of disease enumerated for all survey areas combined Howland Island, 2008. BLE: bleaching; SGA: skeletal growth anomaly; and TLS: subacute tissue loss.

DZCode	BAK-04	BAK-05P	BAK-11P	BAK-14	Grand Total
BLE			1	1	2
SGA		2			2
TLS	1				1
Grand Total	1	2	1	1	5

D.3.3. Macroinvertebrates

Due to ARMS deployment and weather constraints, quantitative invertebrate assessments were limited to only two sites at Baker Island. Overall, non-cryptic macroinvertebrates were low. Neither urchins nor sea cucumbers were observed at Baker. The seastar, *Linckia multiora,* was the dominant macroinvertebrate at BAK-04 with a density of 0.25 m^2 followed by Trapezid crabs with a density of 0.11 m^2. *Linckia multiora* was the only macroinvertebrate recorded at BAK-14 with a density of 0.06 m^2.

D.3.3.1. Urchin and Giant Clam Measurements

Neither urchins nor giant clams were observed at these two sites; therefore, no measurements were made.

D.3.3.2. ARMS Deployment

Two were installed at Baker Island. Table 3.3.2.1 lists their site locations. All were positioned within close proximity of the REA survey sites.

Table 3.3.2.1.--ARMS site locations at Baker Island.

	REA Sites		
Baker Island	BAK-14	BAK-11P	

D.3.3.3. Invertebrate Collections

The following specimens were collected for the Hawaii Institute of Marine Biology for their molecular analyses investigating the connectivity of marine invertebrates in the central Pacific.

Species	Number	REA site	Latitude	Longitude
Linckia multifora	2	BAK-11P	00'11.9550	176'29.0730
Linckia multifora	29	BAK-04	00'12.339	176'28.756
Linckia multifora	9	BAK-14	00'11.781	176'29.176

D.3.4 Towed-diver Benthic Surveys

Eight towed-diver surveys covering 19.46 kilometers of habitat were completed along the forereef of Baker Island. Benthic habitat complexity ranged from medium in the north, to medium-high in the eastern and southern reefs, and high along the western reefs. The habitat was classified as continuous reef in all surveys, ranging from steep walls on the west and south sides of the island, to reef crests and reef flats in the north and northeast.

The overall hard coral cover averaged 38.5% of the total benthic substrate of Baker Island, whereas soft coral accounted for 0.6% of the cover. The dominant coral species was Staghorn coral (*Acropora* sp.), especially on the north and northeastern sides of the island where there were large areas of up to 100% coverage. Other *Acroporas, Pocilloporas, Porites, Faviidaes, Symphyllias, and Fungia* were present throughout many of the surveys. The rubble component of all reefs, particularly the western and southern reefs where an increase was observed, are worth noting, as 21.1% of all substrate at Baker was classified as such.

The overall averages for macro and coralline algae were 6.2% and 22.0%, respectively. Macro and coralline algae presence remained relatively consistent throughout all surveys, with the exception of an increase in macro noted along the southern reefs. The macro algae component of bottom cover was dominated by *Halimeda*.

At Baker Island, free-living sea urchins, sea cucumbers and giant clams were the only macroinvertebrates recorded. Free-living sea urchins were the most abundant macroinvertebrate observed at Baker, averaging a total of 4.29 urchins per hectare surveyed. The highest free-living sea urchin counts were observed along the western and southern sides of the island (average 5.81 free-living urchins per hectare surveyed). Sea cucumbers were the second most abundant macroinvertebrate recorded at Baker where a total average of 0.35 sea cucumbers were noted per hectare surveyed. Parallel to sea urchin distribution, the highest sea cucumber counts were recorded along the western and southern reef habitats (average 0.70 sea cucumbers per hectare surveyed). Giant clams were also observed at Baker Island with a total count of seven individuals recorded.

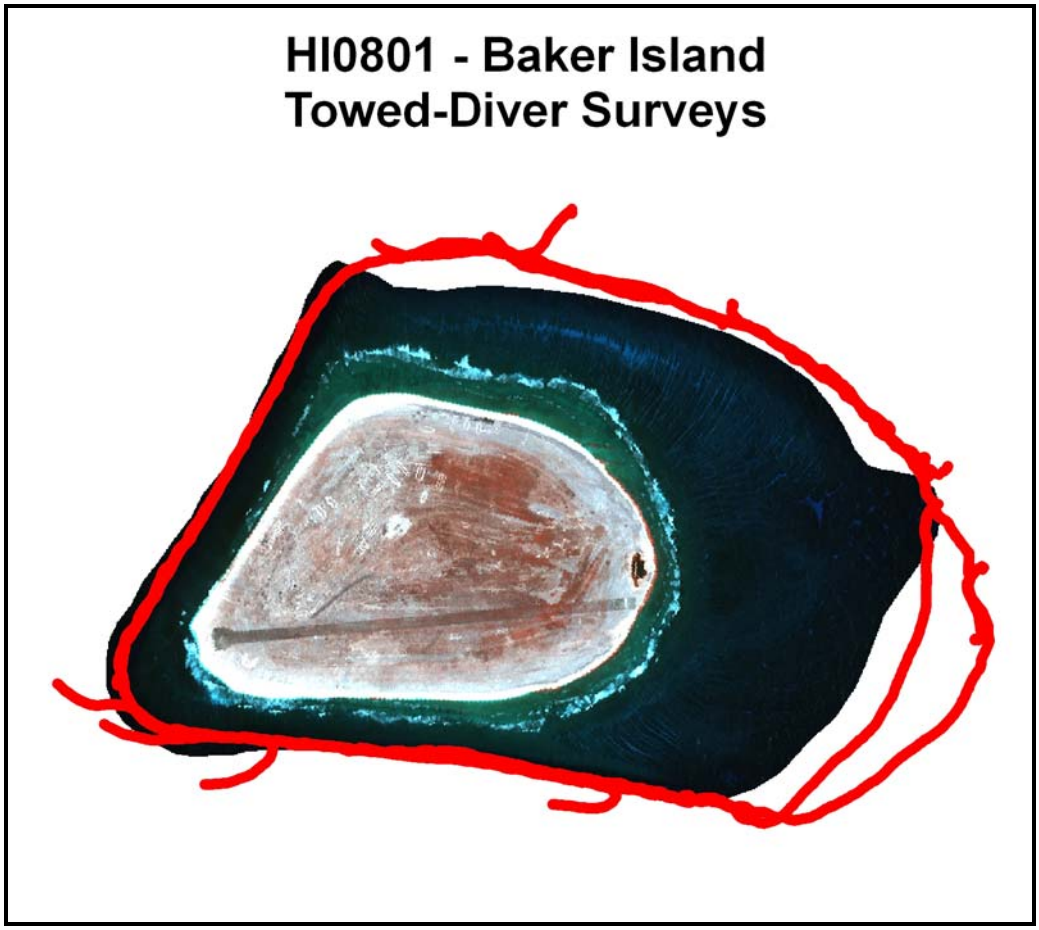

Figure D.3.4.1.--Towed-diver tracks around Baker Island, 2008.

D.4 Fish

D.4.1 REA Fish Surveys

Stationary Point Count data (new methodology)

Six individual nSPC surveys were conducted at four sites around Baker Island (four forefeef/mid depths). Surgeonfishes (Acanthuridae) were the largest contributor to biomass with 4.5 kg 100 m^{-2}. Snappers (Lutjanidae) and soldierfishes (Holocentridae)

were also common, each with a biomass of ~3.0 kg 100 m^{-2} (Table D.4.1.1., Fig. D.4.1.1.).

Belt transect data

During the survey period, seven belt transect surveys were conducted at four sites around Baker Island. Surgeonfishes and soldierfishes were the primary contributors to biomass with 4.8 kg 100 m^{-2} and 2.7 kg 100 m^{-2}, respectively (Table D.4.1.2.).

Overall observations

A total of 118 species were observed during the survey period by all divers. The average total fish biomass at the sites at Baker Island during the survey period was 2.0 ton ha^{-1} for the nSPC surveys (Table D.4.1.1.), and the average fish biomass was 1.9 ton ha^{-1} for the belt transect surveys (Table D.4.1.2.).

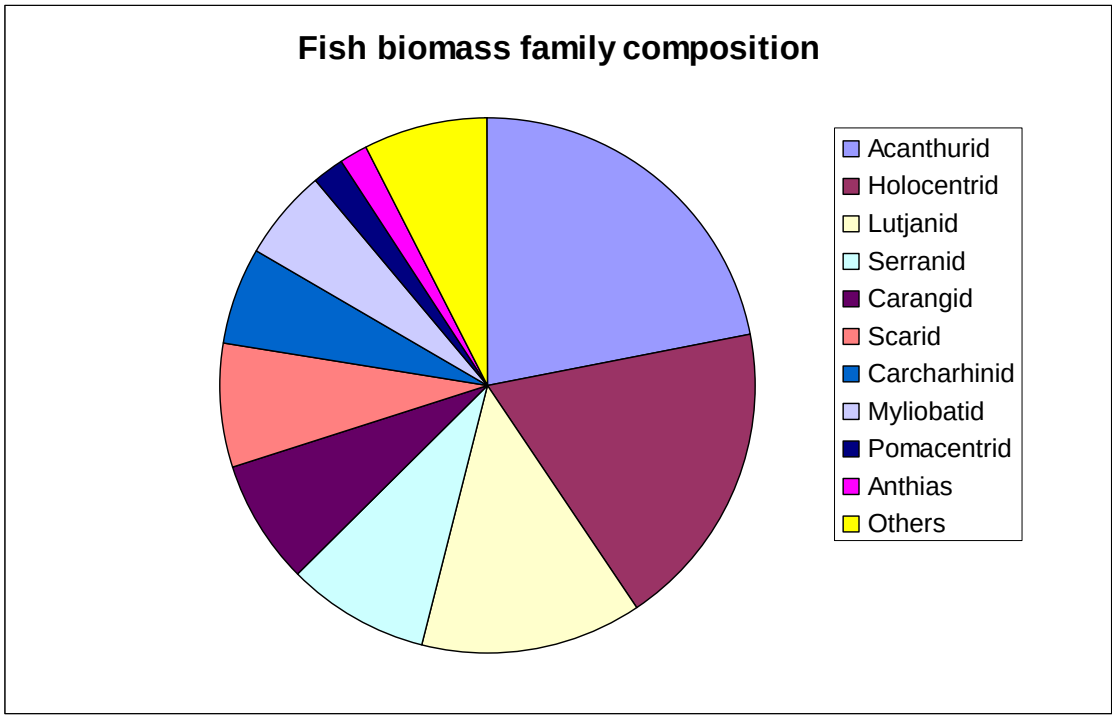

Figure D.4.1.1.--Total fish biomass broken down by family, as measured on nSPC.

Table D.4.1.1. --Summary of total fish biomass around Baker Island, as measured on nSPC (kg 100 m^{-2}).

Stratum-Depth	Site	**Total**	Acanthurid	Holocentrid	Lutjanid	Serranid	Carangid	Scarid	Carcharhinid	Myliobatid	Pomacentrid	Anthias	Others
Forereef - Mid	BAK-04	**21**	1.56	6.38	5.38	2.13	0.45	2.72	0.00	0.00	0.63	0.35	1.26
	BAK-05	**32**	10.19	2.96	0.89	1.13	2.71	1.52	4.83	4.57	0.37	0.53	2.23
	BAK-11	**14**	4.05	2.05	0.40	1.41	3.04	1.26	0.00	0.00	0.35	0.47	1.07
	BAK-14	**15**	2.28	3.71	4.35	2.34	0.00	0.63	0.00	0.00	0.20	0.02	1.59
Total		**20**	**4.5**	**3.8**	**2.8**	**1.8**	**1.5**	**1.5**	**1.2**	**1.1**	**0.4**	**0.3**	**1.5**

Table D.4.1.2.--Summary of total fish biomass around Baker Island, as measured on belt transects (kg 100 m^{-2}).

Stratum-Depth	Site	**Total**	Acanthurid	Holocentrid	Lethrinid	Carangid	Scarid	Lutjanid	Balistid	Pomacentrid	Serranid	Anthias	Others
Forereef - Mid	BAK-04	**15**	0.77	7.21	0.00	0.16	0.00	3.16	0.00	1.69	0.92	0.04	0.91
	BAK-05	**21**	10.29	2.33	0.30	2.74	1.92	0.16	0.31	0.67	0.57	0.92	1.06
	BAK-11	**30**	7.38	0.90	6.79	3.72	1.07	0.07	3.97	1.03	1.40	0.38	2.83
	BAK-14	**9**	0.71	0.53	0.00	0.00	3.36	1.88	0.24	0.54	0.15	0.19	1.52
Total		**19**	**4.8**	**2.7**	**1.8**	**1.7**	**1.6**	**1.3**	**1.1**	**1.0**	**0.8**	**0.4**	**1.6**

D.4.2 Towed-diver Fish Surveys

Table D.2.1.--HI0801 Towed-Diver Survey Report for Baker Island.

			Survey Length				Mean Depth
		N	**Min**	**Max**	**Median**	**Sum**	**Average**
Baker Island	**02/08/2008**	3	1.41	2.26	1.51	5.18	-15.04
	02/09/2008	5	1.68	4.22	2.57	14.28	-15.13
	All	8	1.41	4.22	2.15	19.46	-15.09

N = number of surveys conducted.
Survey Length is given in kilometers.
Depth readings are taken at 5-s intervals during each 50-min survey and are reported as a mean depth per survey. Median Mean Depth is the Median mean depth value for all surveys on a given day. Values are reported in meters.

Thirty species of large fishes (> 50 cm TL) representing 17 families were observed at Baker Island during the survey period (02/08/08-02/09/08). The mean number of fishes (all species pooled) observed by divers was 21.2 fish per ha^{-1}. The eight most frequently recorded species are shown in Figure A. The Red Snapper (*Lutjanus bohar*) was the most abundant species observed during the quantitative surveys with a mean number of 8.02 fishes observed per hectare. The Grey Reef Shark (*Carcharhinus amblyrhynchos*) was the second most abundant fish species encountered during the survey with 1.96 fishes recorded per hectare.

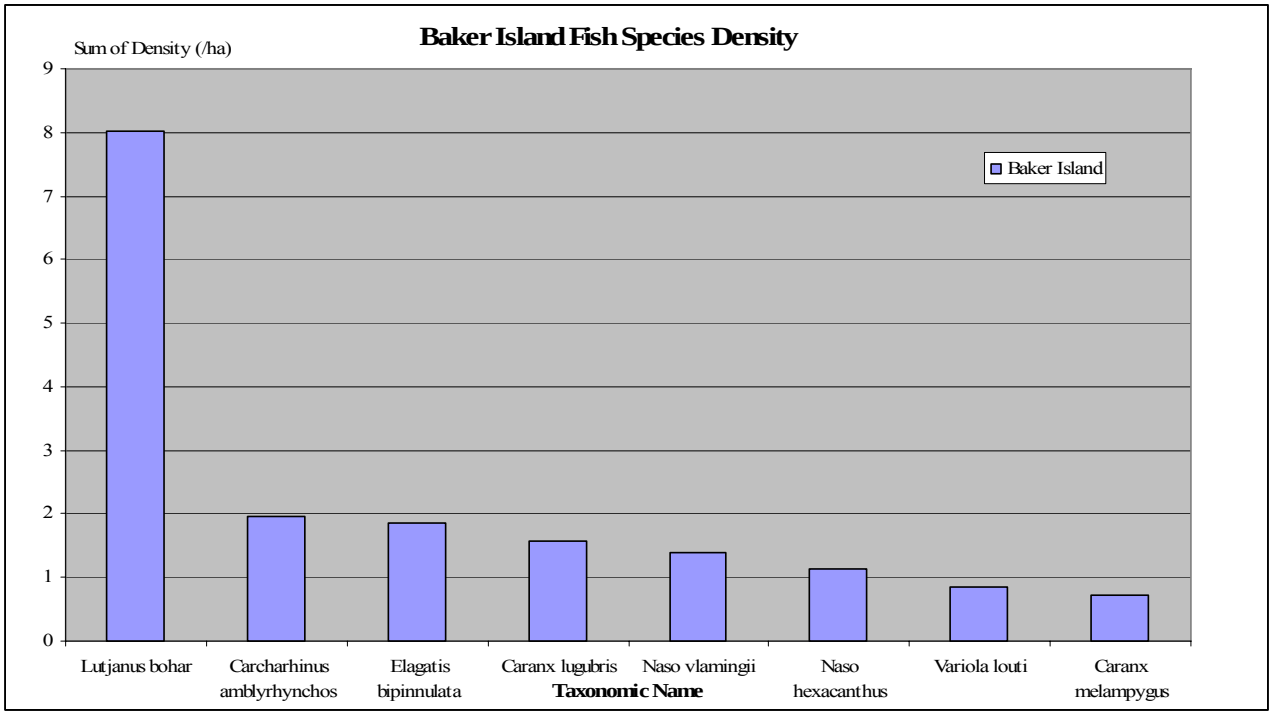

Figure D.4.2.1.--Density of large fish on the forereef at Baker Island.

The grand mean biomass density of fishes observed on the shallow reefs (< 30 m) at Baker Island during the survey period was 0.295 t ha^{-1}. The 12 species with the greatest biomass observed at Baker Island are listed in Figure B. The Manta Ray (*Manta birostris)* accounted for 45% of the total mean biomass of large fishes (Fig. B) with six rays being observed. The total biomass density for the Manta was 0.132 t ha^{-1}. The Scalloped Hammerhead Shark (*Sphyrna lewini*) accounted for 32% of the total mean biomass with a school of seven sharks being observed. In comparison, the Red Snapper (*Lutjanus bohar*) accounted for 7% of the total mean biomass of large fishes with 143 fish being sited. The total biomasses for the hammerhead sharks and red snappers observed was 0.095 t ha^{-1} and 0.021 t ha^{-1}, respectively.

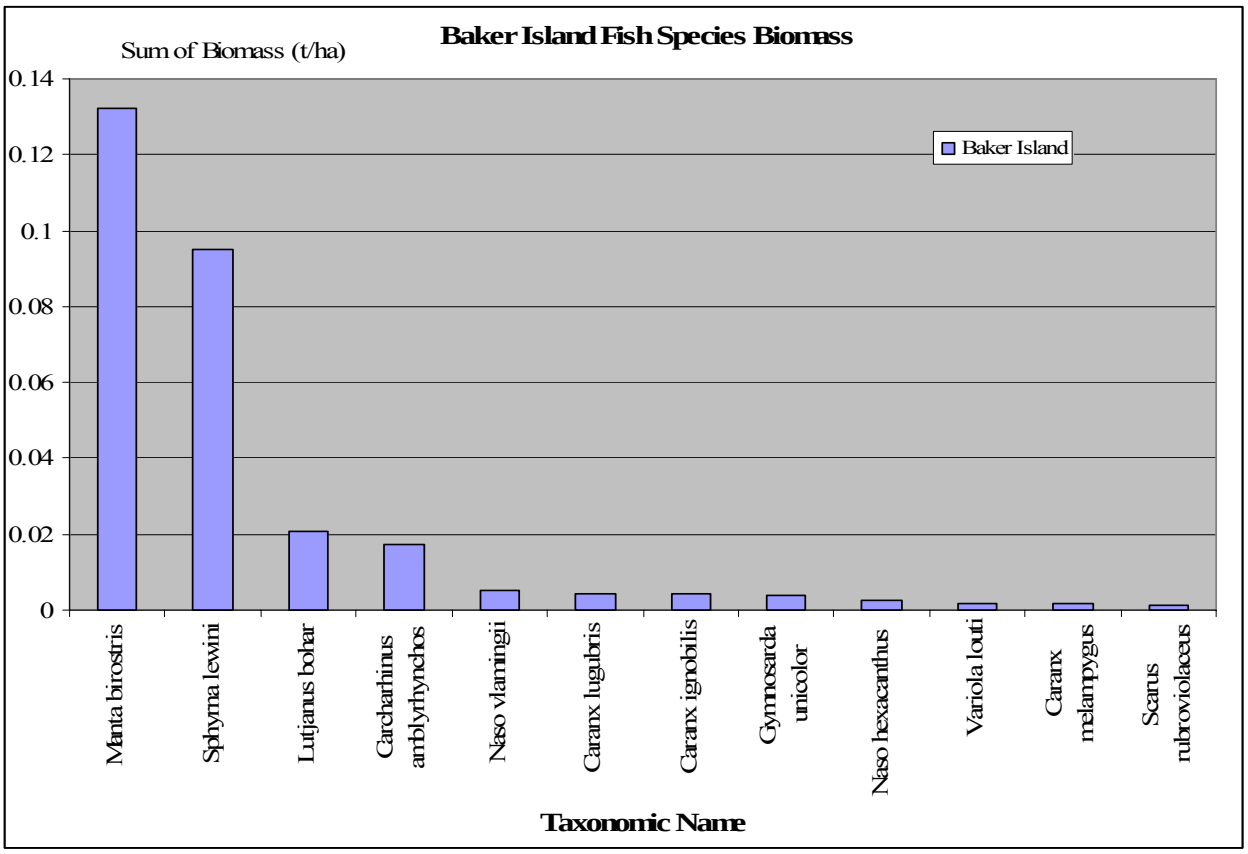

Figure D.4.2.2.--Biomass of large fish on the forereef at Baker Island.

D.5. Terrestrial Team

See Appendix C.5.