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CRUISE REPORT¹

VESSEL: NOAA Ship *Hi'ialakai*, Cruise HA-10-01, Leg 1

CRUISE PERIOD: 21 January–14 February 2010

AREA OF OPERATION: Johnston Atoll, Howland Island, and Baker Island of the Pacific Remote Islands Marine National Monument

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED) of the NOAA Pacific Islands Fisheries Science Center, the U.S. Fish and Wildlife Service (USFWS), and their partner agencies conducted interdisciplinary Pacific Reef and Assessment Program (Pacific RAMP) surveys in waters surrounding Johnston Atoll, Howland Island, and Baker Island. All activities described in this report were covered by Pacific Reefs National Wildlife Refuge Complex special-use permit number 12521-10001 (effective date: January 15, 2010; expiration date: May 30, 2010).

ITINERARY:

Note: Daily field operations included Rapid Ecological Assessment (REA) benthic surveys, REA fish surveys, and towed-diver surveys of both benthic and fish communities. Unless otherwise specified in the following daily summaries, these surveys occurred during each operational day.

- 21 January Start of cruise HA-10-01. Embarked all scientists. Departed Pearl Harbor, Hawai'i, at 1300 and began transit to Johnston Atoll.
- 22 January Transit day. Ship, small-boat, and dive safety drills were conducted.
- 23 January Transit day. Continued safety drills and dive preparations.
- 24 January Arrived at Johnston Atoll. Weather favorable. USFWS observers disembarked to this atoll. Conducted field operations, and deployed and retrieved the following types of instruments: subsurface temperature recorder (STR) and calcification acidification unit (CAU). Nearshore conductivity, temperature, and depth (CTD) profiles were conducted and water samples were collected

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from a small boat. Coral voucher samples were collected in support of the NOAA status review of several coral species for possible listing under the *Endangered Species Act* (ESA), and algal voucher specimens, non-coral invertebrate specimens, and microbial samples were collected. Plankton tows were conducted. During night shipboard operations east of Johnston Atoll, acoustic Doppler current profiler (ADCP) transects were performed but deepwater CTD casts were conducted unsuccessfully because of problems with the CTD instrument.

- 25 January Continued field operations at Johnston Atoll. Deployed and recovered the following types of instruments: sea-surface temperature (SST) buoy, wave-and-tide recorder (WTR), and ecological acoustic recorder (EAR). Nearshore CTD profiles were conducted and water samples were collected from a small boat. Coral voucher samples for the ESA status review, non-coral invertebrate specimens, and microbial samples were collected. Two ship personnel visited Johnston Atoll. ADCP transects and deepwater CTD casts deployed to a depth of 500 m were conducted west of Johnston Atoll during night shipboard operations.
- 26 January Continued field operations at Johnston Atoll. Deployed and recovered the following types of instruments: STR, CAU, and autonomous reef monitoring structure (ARMS). Nearshore CTD profiles were conducted and water samples were collected from a small boat. Coral voucher samples for the ESA status review and microbial samples were collected. ADCP transects and deepwater CTD casts deployed to a depth of 500 m were conducted east of Johnston Atoll during night shipboard operations.
- 27 January Continued field operations at Johnston Atoll. Deployed the following types of instruments: CAU and ARMS. Nearshore CTD profiles were conducted and water samples were collected from a small boat. Coral voucher samples for the ESA status review, voucher coral tissue samples for disease identification, and microbial samples were collected. ADCP transects and deepwater CTD casts deployed to depths of 500 m were conducted south of Johnston Atoll during night shipboard operations.
- 28 January Continued field operations at Johnston Atoll. Nearshore CTD profiles were conducted from a small boat. Coral voucher samples for the ESA status review, algal voucher specimens, and microbial samples were collected.
- 29 January Continued field operations at Johnston Atoll, but no oceanographic surveys were done. Coral voucher samples for the ESA status review,

fish specimens, voucher coral tissue samples for disease identification, algal voucher specimens, and microbial samples were collected. USFWS observers embarked from this atoll. Began transit to Howland Island.

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| 30 January | Transit day. |
| 31 January | Transit day. |
| 1 February | Transit day. |
| 2 February | Transit day. |
| 3 February | Arrived at Howland Island. USFWS observers disembarked to this island. Conducted field operations, and deployed and recovered the following types of instruments: STR, ARMS, and CAU. Nearshore CTD profiles were conducted and water samples were collected from a small boat. Coral voucher samples for the ESA status review and microbial samples were collected. Conducted 2 plankton tows. ADCP transects and deepwater CTD casts deployed to a depth of 500 m were conducted west of Howland Island during night shipboard operations. |
| 4 February | Continued field operations at Howland Island. Deployed and recovered the following types of instruments: STR, CAU, and ARMS. Nearshore CTD profiles were conducted and water samples were collected from a small boat. Coral voucher samples for the ESA status review and microbial samples were collected. |
| 5 February | Continued field operations at Howland Island. Coral voucher samples for the ESA status review and microbial samples were collected. USFWS observers embarked from Howland Island. ADCP transects and deepwater CTD casts deployed to a depth of 500 m were conducted during night shipboard operations on transit to Baker Island (~ 35 nmi distance). |
| 6 February | Arrived at Baker Island. USFWS observers disembarked to this island. Deployed and recovered the following types of instruments: ocean data platform (ODP), SST, STR, and ARMS. Coral voucher samples for the ESA status review, algal voucher specimens, and microbial samples were collected. ADCP transects and deepwater CTD casts deployed to a depth of 500 m were conducted east of Baker Island during night shipboard operations. |
| 7 February | Continued field operations at Baker Island. Deployed and recovered the following types of instruments: STR, CAU, and ARMS. Nearshore CTD profiles were conducted and water samples were collected from a |

small boat. Microbial samples were collected, and plankton tows were conducted. ADCP transects and deepwater CTD casts deployed to a depth of 500 m were conducted west of Baker Island during night shipboard operations.

- 8 February Continued field operations at Baker Island. Deployed and recovered the following types of instruments: STR, CAU, and ARMS. Nearshore CTD profiles were conducted and water samples were collected from a small boat. USFWS observers embarked from this island. Departed Baker Island en route to Pago Pago, American Samoa.
- 9–11 February Transit days.
- 12 February Remained at sea for additional days to wait out tropical cyclone Rene in lee of `Upolu Island, Western Samoa.
- 13 February Transit day.
- 14 February Arrived in port at Pago Pago, American Samoa. Disembarked scientists Ben Richards, Russell Moffitt, Kara Osada, Jonatha Giddens, Jim Maragos, Edmund Coccagna, Daniel Merritt, Beth Flint, and Lee-Ann Woodward. End of cruise HA-10-01, leg 1.

MISSIONS:

- A. Conducted ecosystem monitoring of the species composition, abundance, percentage of cover, size distribution, and general health of the fishes, corals, other invertebrates, and algae of the shallow-water (< 35 m) coral reef ecosystems of Johnston Atoll and Howland and Baker Islands.
- B. Deployed and retrieved an array of instruments—including SST buoys, STRs, WTRs, an ODP, EARs, and ARMS—to allow for remote, long-term monitoring of oceanographic, environmental, and ecological conditions affecting the coral reef ecosystems of Johnston Atoll and Howland and Baker Islands.
- C. Conducted shallow-water CTD casts and collected water samples to depths of ~ 30 m to examine physical and biological linkages supporting and maintaining these island and atoll ecosystems.
- D. Conducted shipboard oceanographic and meteorological observations, using CTD casts deployed to a depth of 500 m, collecting water samples to a depth of 150 m, collecting ADCP data around reef ecosystems, measuring SST and salinity, and collecting fundamental meteorological data, such as air temperature, wind speed and direction, barometric pressure, and relative humidity to examine physical and biological linkages supporting and maintaining these island and atoll ecosystems.
- E. Determined the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.
- F. Conducted terrestrial surveys of seabirds and vegetation on Johnston Atoll, Howland Island, and Baker Island (representatives of the U.S. Fish and Wildlife Service completed this mission).

RESULTS:

This section provides tallies of research activities (Table 1), a list of data collected during cruise HI-10-01, Leg 1, and a summary of important observations. For more information pertaining to the data collected, methodology employed, and preliminary findings at the islands and atoll visited, see Appendices A–E.

Table 1. Statistics for the Pacific RAMP 2010 cruise to Johnston Atoll and Howland and Baker Islands (cruise HA-10-01, Leg 1). The CAUs deployed during this cruise were the first such units deployed by CRED. Other instrument types included ARMS, ADCP, EAR, ODP, remote access sampler (RAS), SST buoy, STRs, and WTR. REA and towed-diver surveys were conducted on most days. Oceanographic surveys included CTD casts and ADCP transects. Water sampling collected data on nutrient, chlorophyll-*a* (Chl-*a*), and dissolved inorganic carbon (DIC) concentrations. The totals for scuba dives include all dives carried out for all activities at each island. Coral voucher samples were collected in support of the NOAA status review of several coral species for possible listing under the ESA. For information about biological sample collections by REA site, see Table E.1 in Appendix E: “Biological Collections.”

Research Activity	Total	Johnston Atoll	Howland Island	Baker Island
Scuba Dives	566	259	162	145
BIOLOGICAL SURVEYS				
Towed-diver Surveys: Benthic and Fish	47	22	14	11
Combined Length (km) of Towed-diver Surveys	93.4	43.9	25.8	22.8
Rapid Ecological Assessments: Benthic	32	16	8	8
Rapid Ecological Assessments: Fish	76	39	16	21
BIOLOGICAL SAMPLE COLLECTIONS				
Fish Specimens	25	25	0	0
Algal Voucher Specimens	9	7	0	2
Coral Tissue Samples for Disease Identification	17	17	0	0
Coral Voucher Samples for ESA Status Review	212	100	79	33
Non-coral Invertebrate Specimens	7	5	0	2
Plankton Tows	6	2	2	2
BIOLOGICAL MOORED INSTALLATIONS				
ARMS Retrieved	24	9	9	6
ARMS Deployed	24	9	9	6
CAUs Deployed	65	20	25	20
EAR Unit Retrieved	1	1	0	0
EAR Unit Deployed	1	1	0	0
OCEANOGRAPHIC MOORED INSTRUMENTS				
ODP Retrieved	1	0	0	1
ODP Deployed	0	0	0	0
SST Buoy Retrieved	1	1	0	0
SST Buoy Deployed	1	1	0	0
STRs Retrieved	13	5	4	4
STRs Deployed	16	6	5	5
WTR Retrieved	1	1	0	0
WTR Deployed	1	1	0	0
HYDROGRAPHIC SURVEYS				
Deepwater CTD Casts (from <i>Hi'ialakai</i>)	61	29	16	16
Shallow-water (≤ 30 m) CTD Casts (from small boats)	49	23	13	13
Total Length (km) of ADCP Transects	150	70	40	40
WATER-QUALITY SAMPLING				
Shallow-water sampling profiles	13	4	5	4
Shallow-water nutrient water samples collected	26	8	10	8
Shallow-water Chl- <i>a</i> water samples collected	26	8	10	8
Shallow-water salinity water samples collected	26	8	10	8

Research Activity	Total	Johnston Atoll	Howland Island	Baker Island
Shallow-water DIC water samples collected	26	8	10	8
Deepwater nutrient water samples collected	102	20	40	42
Deepwater Chl- <i>a</i> water samples collected	102	20	40	42
Microbial water samples collected	17	7	5	5

The coral reef ecosystems of the Pacific Remote Islands Marine National Monument are monitored biennially through CRED's Pacific RAMP. HA-10-01, Leg 1, was this program's fourth survey around Johnston Atoll (the first occurred in 2004) and the seventh survey around Howland and Baker Islands since 2000. Here, we present highlights of our observations during this latest expedition.

In the previous visit to Johnston Atoll (16°45' N, 169°31' W) in January and February 2008, adverse weather conditions limited the number of sites that could be safely surveyed, sacrificing 60% of the survey time allocated for that cruise. Fortunately, during this Pacific RAMP 2010 expedition, the weather was favorable, and scientific personnel were able to conduct all planned surveys.

Although Johnston Atoll is currently uninhabited, it previously had a relatively large population associated with military facilities there and anthropogenic pressures that impacted the surrounding ecosystems. As reported in *The State of the Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008* (Waddell and Clarke 2008), the coral reef ecosystem at Johnston Atoll is still relatively intact with a fairly large population of apex predators when compared to heavily populated areas in the Pacific and Caribbean, but coral disease is more prevalent and large-fish biomass and density of target species are lower than at other areas in the Pacific Remote Islands Marine National Monument: Baker, Howland, and Jarvis Islands, Kingman Reef, and Palmyra and Wake Atolls. Observations from this latest cruise were in line with data from previous years, including sightings of numerous grey reef sharks (*Carcharhinus amblyrhynchos*) and a higher level of coral disease than at other locations in the Pacific Remote Islands Marine National Monument.

Howland (0°48' N, 176°37' W) and Baker (0°12' N, 176°29' W) Islands are both affected by highly variable oceanographic conditions near the Equator, including upwelling from the Equatorial Undercurrent and the periodic effects of the El Niño-Southern Oscillation. Both islands have been inhabited briefly in the past, in the mid-1800s for guano mining and before WWII by colonists from Hawaii, but they have been uninhabited for the past 70 years and have been observed to have relatively pristine coral reef ecosystems. Six previous visits to these islands have helped to document the oceanographic variability and its effect on their coral reef ecosystems.

The surveys conducted during this Pacific RAMP 2010 cruise dramatically underlined the strong effect that the 2009 El Niño event has had on corals at Howland and Baker Islands. Water temperatures of 30°C recorded during scuba dives and from STRs over the

past 2 years showed that temperatures had been abnormally warm over 4 months since November 2009. Coral bleaching was widespread, affecting more than 30% of the colonies at both Howland and Baker Islands, with greater incidences on the eastern sides of these islands compared to their western reefs, where upwelling normally occurs. At the time of these observations, branching and table corals (e.g., *Acropora* sp.) appeared to be more affected by this bleaching episode than did massive corals.

The following data and samples were collected during this expedition:

REA Benthic Surveys:

- Digital still photos of overall site character and typical benthos
- Digital images of benthic organisms from photoquadrat surveys
- Quantitative assessments of benthic composition from line-point-intercept surveys
- Algal voucher specimens necessary for algal species identification
- Field notes of algal species diversity and relative abundance
- Number of coral colonies by genus, within belt transects of known area, and overall coral colony density
- Size-class metrics of corals within belt transects of known area
- Digital photographs of diseased corals and algae
- Field notes on signs of coral bleaching or disease
- Voucher coral tissue samples for disease identification and characterization
- Specimens of non-coral invertebrates collected at REA sites
- Coral voucher specimens for ESA status review

REA Fish Surveys:

- Number, species, and estimated sizes of all fishes observed within a 7.5-m radius from stationary-point-count (SPC) surveys
- Visual estimates of benthic cover, habitat type, and habitat complexity
- Digital still photographs to characterize benthic coral reef community cover
- Digital photographs of rare or interesting fish species
- Fish specimens were collected for contaminant analysis at the request of U.S. Fish and Wildlife Service
- Species presence checklists for estimates of fish community diversity

Towed-diver Surveys:

- Digital photographs of benthic habitats
- Counts of non-coral invertebrates, including giant clams, crown-of-thorns seastars, sea cucumbers, and sea urchins
- Quantitative assessments of large (≥ 50 cm in total length) reef fishes to species level
- Quantitative and qualitative assessments of key protected species and species of concern, including cetaceans, sea turtles, and rare fishes
- Benthic habitat characterization

Shipboard Oceanography:

- Deepwater CTD profiles to a depth of 500 m
- Chl-*a* and nutrient concentrations from water samples collected at variable depths
- Transects of profiles of ocean current velocity and direction collected using a shipboard ADCP unit
- Solar radiation, air temperature, barometric pressure, wind speed and direction

Nearshore Oceanography from Small Boats:

- Shallow-water CTD profiles to depths of ~ 30 m or the depths of REA sites
- Chl-*a* and nutrient concentrations from water samples collected in concert with shallow-water CTD casts
- DIC and salinity concentrations from water samples collected in concert with shallow-water CTD casts

Moored Biological Installations:

- Environmental acoustics of reefs, marine mammals, and boat traffic from EARs
- Assessment of taxonomic diversity of coral reef species by collection of invertebrate specimens from retrieved ARMS

Moored Oceanographic Instruments:

- Sea-surface and subsurface temperature at variable depths
- Sea-surface and subsurface salinity at variable depths
- Spectral wave and tidal elevation
- Single-point and directional ocean currents
- Surface air temperature, wind speed and direction, barometric pressure, and ultraviolet radiation

Reference:

Waddell, J. E., and A. M. Clarke (eds.).

2008. The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD. 569 p.

SCIENTIFIC PERSONNEL:

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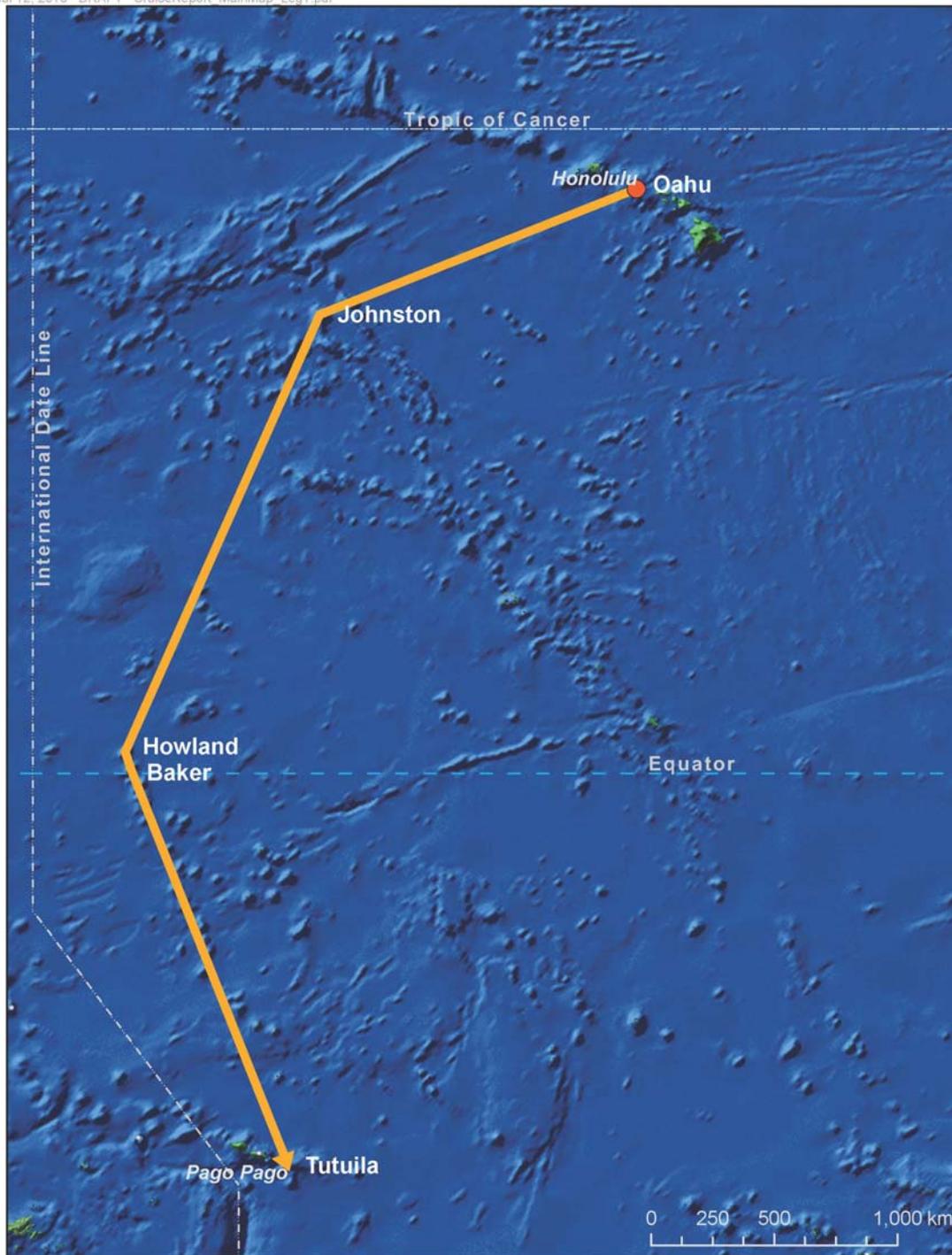


Figure 1.--Track of the NOAA Ship *Hi'ialakai* for the cruise HA-10-01, Leg 1, January 21–February 14, 2010, with Johnston Atoll, Howland Island, and Baker Island surveyed en route from Honolulu to American Samoa. Satellite image © 2002 Environmental Systems Research Institute Inc. (ESRI) and © 1998 WorldSat International Inc. All rights reserved.

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APPENDIX A: METHODS

This appendix describes the methods and procedures used by the Coral Reef Ecosystem Division (CRED) of the NOAA Pacific Islands Fisheries Science Center (PIFSC) during its Pacific Reef Assessment and Monitoring Program (Pacific RAMP) cruise HA-10-01, Leg 1, around Johnston Atoll and Howard and Baker Islands on the NOAA Ship *Hi'ialakai* during the period of January 21–February 14, 2010. The first PIFSC reef assessments around Howland and Baker Islands were conducted in 2000.

A.1. Oceanography and Water Quality

(Daniel Merritt, Oliver Vetter, Noah Pomeroy, Russell Reardon, and Katie Barott)

To assess and monitor the oceanographic and water-quality parameters influencing the coral reef ecosystems around Howard and Baker Islands and Johnston Atoll, CRED performed the following activities: (1) conducted deepwater oceanographic surveys characterizing prevailing water properties and ocean currents around these islands and atoll, (2) completed closely spaced, nearshore oceanographic and water-quality surveys, and (3) deployed and retrieved an array of surface and subsurface moored instruments designed to provide continuous, high-resolution time-series observations. In addition, shipboard meteorological observations, including wind speed and direction, relative humidity, air temperature, and barometric pressure, were recorded.

A.1.1. Moored Instruments for Time-series Observations

CRED accomplishes long-term oceanographic and bioacoustic assessment and monitoring through the deployment and retrieval of a variety of instrument platforms that internally record in situ observations and telemeter subsets of those data in near real time. The following types of instruments were retrieved or deployed during this cruise.

Ocean Data Platform (ODP): provided directional current profiles and wave spectra using a 3-beam-configured 1-MHz acoustic Doppler profiler (SonTek/YSI, San Diego, Calif., accuracy of 0.005 m s^{-1} in current and 0.1% in pressure) and high-resolution temperature and conductivity (SBE 37 MicroCAT temperature and salinity sensor, Sea-Bird Electronics Inc., Bellevue, Wash., accuracy of 0.002°C in temperature and 0.0003 S m^{-1} in conductivity). Sample intervals for current and wave data varied depending on duration of deployment. Temperature and salinity were sampled at 30-min intervals. This type of subsurface instrument was deployed at depths of 15–40 m.

Sea-surface Temperature (SST) Buoy: provides high-resolution SST (SBE 39 sensor, accuracy of 0.002°C). Data are sampled at 30-min intervals and internally recorded. Subsets of these data are transmitted daily via satellite telemetry.

Subsurface Temperature Recorder (STR): provides high-resolution temperature data (SBE 39 sensor). Data are internally recorded at 30-min intervals. This type of subsurface instrument is deployed at depths of 0.5–40 m.

Wave-and-tide Recorder (WTR): provides high-resolution wave and tide records (SBE 26*plus* Seagauge recorder, accuracy of 0.01% in pressure). Data are internally recorded and sample intervals vary depending on duration of deployment. This type of subsurface instrument typically is deployed at depths of 10–25 m.

A.1.2. Hydrographic Surveys

Detailed oceanographic and water-quality surveys were conducted using the following sampling techniques and equipment.

Shallow-water (Nearshore) Conductivity, Temperature, and Depth (CTD) Casts: a CTD profiler deployed from a small boat provided data on temperature; conductivity, which is related to salinity; and pressure, which is related to depth (SBE 19*plus* Seacat Profiler, accuracy of 0.005 S m⁻¹ in conductivity, 0.0002°C in temperature, and 0.1% in pressure). A transmissometer (C-Star, WET Labs, Philomath, Ore.) provided profiles of beam transmittance, which is related to turbidity. A dissolved oxygen sensor (SBE 43, accuracy of 2% of saturation) was also attached and measurements were made in concert with CTD measurements. A CTD cast was performed at each of the Rapid Ecological Assessment (REA) sites where calcification acidification units (CAUs) were deployed. In addition, a series of casts were completed at depths of ~ 30 m at regular horizontal intervals around each island. Data were collected by hand lowering this profiler off a small boat at descent rates of ~ 0.5–0.75 m s⁻¹ to the depths of REA sites or to depths of ~ 30 m at other nearshore locations.

Deepwater (Shipboard) CTD Casts: a ship-based CTD profiler provided high-resolution conductivity, temperature, and pressure data (Sea-Bird Electronics, SBE 911*plus* CTD, accuracy of 0.003 S m⁻¹ in conductivity, 0.001°C in temperature, and 0.015% in pressure). Measurements of dissolved oxygen (SBE43) and fluorescence and turbidity (*ECO* FLNTU, WET Labs, accuracy of 0.01 µg l⁻¹ in fluorescence and 0.01 NTU in turbidity) were performed in concert with CTD measurements. Data were collected at depths up to 500 m.

Shipboard Acoustic Doppler Current Profiler (ADCP): a ship-based sensor provided transects of directional ocean current data (75-kHz Ocean Surveyor, Teledyne RD Instruments Inc., Poway, Calif.). The system was configured with an 8-m pulse length, 16-m depth bins starting at 25 m and extending typically to 600 m (range depended on density and abundance of scatterers), and 15 min averaged ensembles. Data were continuously collected throughout this research cruise.

Water Chemistry: water samples for analyses of concentrations of chlorophyll-*a* (Chl-*a*), dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, and the nutrients phosphate, PO₄³⁻; silicate, Si(OH)₄; nitrate, NO₃⁻; and nitrite, NO₂⁻ were collected at select locales concurrently with shallow-water CTD casts. At each select CTD cast location, 4 water samples were taken at each of 2 depths (at the surface and near the reef), with 1 sample from each set of 4 analyzed for both DIC and TA. In concert with shipboard CTD casts, water samples were collected for analyses of Chl-*a* and nutrient concentrations.

A.2. Benthic Surveys and Biological Monitoring Installations and Sampling

(Edmund Coccagna, Jason Helyer, Erin Looney, James Maragos, Russell Moffitt, Cristi Richards, Molly Timmers, and Bernardo Vargas-Ángel)

CRED collected integrated information on the species composition (diversity), condition, abundance, and distribution of communities of corals, algae, and non-coral invertebrates and on benthic habitat complexity and substrates using 2 primary methodologies: Rapid Ecological Assessment (REA) surveys and towed-diver surveys. Performed at selected hard-bottom locations, REA benthic surveys include multiple methodologies that use two 25-m transect lines deployed at each REA site. Towed-diver surveys, which follow a depth contour of ~ 15 m and encompass various substrates, cover an area that is much broader than the area surveyed using fine-scale REA techniques. In addition, 2 types of moored installations, autonomous reef monitoring structures (ARMS) and calcification acidification units (CAUs), serve as mechanisms to quantify marine invertebrates that are not easily identifiable during REA surveys or to help determine accretion rates of coralline algae and scleractinian (hard) corals. Note that the REA sites selected for fish surveys are different from the sites where REA benthic surveys were conducted.

A.2.1. Benthic Composition

Using a line-point-intercept (LPI) method, hard corals, octocorals, macroalgae, crustose coralline red algae, and non-coral invertebrates, were identified to the highest possible taxonomic resolution and recorded, along with substrate types, at 20-cm intervals along two 25-m transect lines set in a single file row (separated by 5 m). These surveys generated data, 125 points per transect line (250 points per site), that can be used to estimate percentage of cover of benthic organisms at each REA site. Additionally, using the photoquadrat method, the benthos was recorded at predetermined points along the same 2 transect lines with a high-resolution digital camera mounted on a 1-m photoquadrat pole. These surveys generated 30 photographs per site that will be later analyzed by CRED staff and partners at Scripps Institution of Oceanography, University of California San Diego, using the computer program Coral Point Count with Excel extensions (CPCe), to determine the benthic composition at higher taxonomic levels for each REA site (photographs from similar surveys at REA sites surveyed by the fish team will also be analyzed at Scripps).

In addition to site-specific REA surveys, broad-scale towed-diver surveys were used to determine the benthic composition of shallow-water habitats around each island or atoll and to quantify the abundance of key conspicuous macroinvertebrates (crown-of-thorns [COTS] seastars, sea urchins, sea cucumbers, and giant clams). A pair of divers, by means similar to a manta-tow technique, were towed 60 m behind a small boat, a 6-m survey launch from SAFE Boats International (Port Orchard, Wash.), with one diver quantifying the benthos and the other quantifying fish populations. Each towed-diver survey lasted 50 min, broken into ten 5-min segments, and covered ~ 2 km. To georeference the survey launch's track, latitude and longitude coordinates were recorded at 5-s intervals using a Garmin GPSMap 76 global positioning system (GPS) unit on the boat. A custom algorithm was used to calculate the track of the divers based on speed and

course of the boat and depth of the diver. Each towed-diver platform, or towboard, was equipped with an SBE 39 temperature and depth recorder programmed to record at 5-s intervals. At the end of each day, data were downloaded, processed, and presented in ArcGIS and can be displayed in conjunction with IKONOS satellite imagery, NOAA chart data, or other spatial data layers.

Towed-diver benthic surveys recorded habitat type and complexity; percentages of cover of benthic fauna, including hard corals, stressed hard corals, soft corals, macroalgae, and crustose coralline red algae and of physical features, including sand and rubble; and counts of macroinvertebrates and marine debris. Towed divers classified percentage of cover using a system of 10 bins, ranging from 0%–100% cover of the benthos. Macroinvertebrates (COTS, urchins, sea cucumbers, and giant clams) were counted up to 25 individuals per segment and then binned into larger groups when exceeding 25. The benthic towboard was equipped with a downward-facing, high-resolution digital still camera. The camera took a photo of the substrate every 15 s. These photos, like the SBE 39 data, were linked spatially with GPS track files taken aboard the survey launch. Benthic photos can be analyzed later for community structure information.

A.2.2. Benthic Community Structure and Disease

At each REA site, the belt-transect method, with two 25-m transect lines as the focal point for surveys of coral communities, was used to quantitatively assess generic richness, colony density, and size class of coral colonies. On each transect, five 2.5-m² segments were surveyed (0–2.5 m; 5.0–7.5 m; 10–12.5 m; 15–17.5 m; 20–22.5 m), whereby all coral colonies whose center fell within 0.5 m of either side of each transect line were identified to the highest possible taxonomic resolution and measured using 2 planar size metrics: maximum diameter and diameter perpendicular to the maximum diameter.

For each coral colony identified during the belt-transect surveys, the extent of mortality, both recent and old, was estimated and signs of disease or compromised health were recorded, including type of lesion (bleaching, skeletal growth anomaly, white syndrome, tissue loss other than white syndrome, trematodiasis, necrosis, pigmentation responses, algal overgrowth, or other), extent (percentage of colony affected), severity (mild, moderate, marked, severe, or acute). Photographic documentation of affected corals was taken and opportunistic tissue samples were collected. Tissue samples were catalogued and fixed in buffered zinc-formalin solution for further histopathological analyses. Levels of predation of corals were also recorded. In tandem with these coral disease surveys at each REA site, the belt-transect method also was used to quantify coralline-algal disease and syndromes, including coralline lethal orange disease, coralline white band syndrome, and coralline cyanobacterial disease. Photographs of affected algae were taken at disease sites.

In separate REA surveys, using the belt-transect method but only performed at Johnston Atoll during this cruise, targeted macroinvertebrates that fell within 1 m on either side of two 25-m transect lines were enumerated. Targeted taxa included species from the

following groups: anemones, zoanthids, and other cnidarians; sea urchins, sea cucumbers, and other echinoderms; seastars of the family Asteroidea; spondylid oysters, pearl oysters, tridacnid (giant) clams; Triton's Trumpet (*Charonia* sp.), spider conches (*Lambis* sp.), and other gastropods; octopus; and hermit crabs, lobsters, large crabs, and other crustaceans.

Densities of the targeted macroinvertebrates were generated for each site at Johnston Atoll from the tallied transect counts. In addition, the test diameters of sea urchins were measured up to 25 individuals per species and the maximum shell lengths of giant clams were measured up to 25 individuals per site. Average test diameters and shell lengths were then generated from collected data at each REA site. Fortuitous non-invasive collections of targeted organisms to support research investigating gene flow and connectivity in the Pacific took place.

Time permitting at each REA site, roving-diver surveys were conducted, covering a swath of 3–5 m on either side of the transect lines to record algal species richness.

If algal species encountered during LPI, roving-diver, or photoquadrat surveys were not identifiable in the field, a single specimen of each species was collected for a voucher specimen and will be cataloged and critically analyzed in a CRED laboratory to ensure positive species identification. Provisions were made to ensure appropriate preservation and curation of each algal specimen. These voucher specimens along with the images from photoquadrat surveys form permanent historical records, the former of algal diversity and the latter of the composition of benthic communities at each REA site.

A.2.3. Moored Installations for Monitoring Marine Life

CRED accomplishes long-term monitoring of benthic biodiversity, the growth rates of corals and algae, and the sounds of marine animals through the use of the following types of installations that were retrieved or deployed during this cruise.

Autonomous Reef Monitoring Structure (ARMS): deployed at several sites at each island or atoll, ARMS provide a mechanism to monitor and quantify the biodiversity of cryptic invertebrates and algae that were not easily identifiable or accountable on the transect lines used for REA surveys. ARMS were installed on the benthos by pounding stainless steel rods by hand into bare substrate. They will remain on the benthos for 2 years, enabling the recruitment and colonization of lesser known, cryptic marine invertebrates, upon which time they will be collected and analyzed.

ARMS previously deployed during the 2008 RAMP cruise were retrieved. First, on the seafloor, the ARMS were covered in a mesh-lined lid to trap the contents, and then they were removed and transported to the ship. There, each unit was systematically disassembled and photo-documented, and all organisms contained in these structures were sorted by size and preserved in ethanol for later genetic and other molecular analysis.

Calcification Acidification Unit (CAU): Deployed at several sites at each island and atoll, CAUs provide a mechanism to quantify accretion rates by crustose coralline red algae and hard corals. Each CAU consists of 2 gray polyvinylchloride (PVC) plates (10 × 10 cm) separated by a 1-cm spacer. CAUs were installed on the benthos by pounding stainless steel rods by hand into bare substrate and then bolting the plate assembly to those rods. It has been demonstrated that PVC encourages growth of crustose coralline red algae and coral recruitment, and the net weight gain of calcium carbonate on the surfaces of the CAUs can be an indicator of net calcification. CAUs deployed during this cruise will remain on the benthos for 2 years, enabling the recruitment and colonization of crustose coralline red algae and hard corals, at which time they will be collected and analyzed. The data obtained via CAUs will enable a comparison of net calcification rates between islands and between archipelagos and form a baseline of accretion rates throughout the U.S. Pacific, allowing for future comparisons to determine possible consequences of increased ocean acidity and lowered aragonite saturation states.

Ecological Acoustic Recorder (EAR): an EAR is a passive acoustic device developed specifically for monitoring marine mammals, fishes, crustaceans, other sound-producing marine life, and human activity in marine habitats. An EAR is a digital, low-power system that records ambient sounds up to 30 kHz on a programmable schedule and can also respond to transient acoustic events that meet specific criteria, such as motorized vessels passing nearby or cetaceans. This type of subsurface instrument typically was deployed at depths of 5–25 m.

A.2.4. Microbial Communities and Water Chemistry

Microbes are a fundamental aspect of all marine ecosystems. The amount of energy from primary production remineralized within the microbial fraction determines the amount of energy available for the entire food web. The abundance and function of the microbial community on reefs may also play an important role in coral health.

Microbial and viral communities on coral reefs have been found to change along with coral reef health. Degraded coral reefs support microbial communities that are primarily heterotrophic and include a high abundance of potential pathogens, whereas near-pristine reefs support microbial communities that are balanced between heterotrophs and autotrophs and contain very few potential pathogens. A primarily heterotrophic and pathogenic microbial community in the water column could potentially lead to coral disease and death.

Microbial and viral communities on coral reefs have been found to change along with coral reef health. Degraded coral reefs support microbial communities that include a high abundance of potential pathogens and are primarily heterotrophic (a heterotrophic organism obtains food only from organic material, such as carbon and nitrogen, and is unable to use inorganic matter to form proteins and carbohydrates). In contrast, near-pristine reefs support microbial communities that are balanced between heterotrophs and autotrophs and contain very few potential pathogens (an autotrophic organism can synthesize food from inorganic material). A primarily heterotrophic and pathogenic

microbial community in the water column could potentially lead to coral disease and death.

Collection of Microbial Water Samples: At select REA sites, 20 L of water were collected daily from < 1 m above the benthos using 4–5 L diver-deployable Niskin bottles. These water samples were returned to the ship, where samples were collected first for analysis of dissolved organic carbon (DOC) and particulate organic carbon (POC) and then for determining microbial size and abundance, including bacteria and archaea (single-celled microorganisms). These samples are used for the analyses described in this section. Also, at one REA site at each island or atoll, ~ 70 L of water were collected at reef crevices and surfaces for more in-depth analysis on the microbial community.

Microscopy: It is well known that bacteriophages (bacterial viruses) are the most abundant form of life in the ocean, ranging from 1×10^6 virus-like particles (VLPs) per mL of seawater in the open ocean to 1×10^8 VLPs per mL in more productive coastal waters. The number of microbial and protistan cells in seawater is typically 1×10^6 and 1×10^3 cells per mL, respectively. Microbial and viral loading and the dominance of heterotrophic bacteria in reef water are linked to coral disease. Trophic-level interactions among bacteria, phages, and protists also affect global nutrient and carbon cycling. The most direct method for assessing and monitoring changes in the abundance of these microbiological components is by fluorescent microscopy using nucleic acid staining. *Enumeration of microbes and viruses.* Two replicate 5-mL samples were collected and fixed using paraformaldehyde and filtered through 0.2- μ m filters. These filters were stained using SYBR Gold (Molecular Probes Inc., Eugene, Ore.), a general nucleic acid stain, and mounted onto a microscope slide.

Enumeration of protists. 50-mL of water from each sample was fixed with glutaraldehyde; stained with 4',6-Diamidino-2-phenylindole (DAPI), a general nucleic acid stain for staining double-stranded DNA (dsDNA); and filtered onto a 0.8- μ m black polycarbonate filter.

Frequency of dividing cells. Two replicate 5-mL samples were fixed with glutaraldehyde and filtered through 0.2- μ m filters. These filters were then stained with DAPI and mounted onto a glass microscope slide.

The filters described above will be used to count the number and size of microbial components and quantify actively dividing microbial cells. This enumeration will be performed using fluorescent microscopy at San Diego State University. All filters will be stored at -20°C for archival purposes.

Water Chemistry (DOC/POC): Spatial assessment of microbial, viral, and protist components with respect to levels of DOC, nutrients, and particulate organics within coral reef ecosystems may identify important predictors of coral reef ecosystem degradation—information that will be essential for designing the most effective coral reef ecosystem monitoring strategy possible.

To assess dissolved organic carbon (DOC) concentrations, ~ 30 mL of seawater was filtered through pre-combusted glass fiber filters from each of the 4 Niskin bottles and the filtrate was collected in pre-combusted glass bottles. Hydrochloric acid was added to each bottle to remove DIC, and the bottles were stored upright at 4°C. To assess particulate organic carbon (POC), a total of 500 mL of seawater was filtered through a glass fiber filter, one for each Niskin bottle, and the filters were stored at -20°C. DOC and POC and stable isotopes of carbon and nitrogen were sent to San Diego State University to be analyzed via standard protocols after return to shore.

Microbial DNA Samples: The structure of the bacterial community will be assessed by metagenomic analysis, which involves collection of environmental DNA via filtration followed by 454 sequencing. Metagenomics is a powerful tool for studying environmental populations, as < 1% of all environmental microbial diversity is currently cultivable.

The remaining water in each Niskin bottle was pushed through a 20- μ m pre-filter to remove large eukaryotic organisms. This 20- μ m filtrate was then pushed through 0.22- μ m Sterivex filters to trap microbes (2 filters, each ~ 2.5 L). These filters were stored at -20°C and will be used to determine microbial community diversity and function. DNA isolation and metagenomic analysis will be completed at San Diego State University.

Flow Cytometry: Flow cytometry will be used primarily to characterize the size structure of microbial communities (e.g., autotroph vs. heterotroph abundance and viral abundance). This technique will also provide complementary data for abundance counts, metagenomic analysis, and Chl-*a* analysis.

Five 1-mL samples of water from each REA site were pushed through a 20- μ m filter. This filtrate was dispensed into cryovials (5 \times 1 mL) and fixed with glutaraldehyde. Vials were inverted to mix and incubated in the dark for 15 min. Glutaraldehyde-preserved samples were flash frozen in liquid nitrogen contained in a dry shipper to prevent damage to microbial cells. These samples were shipped upon return to Honolulu on dry ice to San Diego State University for flow cytometry analysis.

Large Water Samples at Reef Crevices: At one REA site per island, ~ 70 L of water were collected using a manual bilge pump, which fills four 20-L collapsible carboys with water from reef crevices. This sample was then pre-filtered through 100- μ m mesh upon return to the ship and then concentrated using tangential flow filtration, which concentrates the bacteria and viruses in the water. The initial ~ 70 L of water were brought to a final volume of ~ 500 mL. This concentrate was then filtered through 0.45- μ m filters to capture microbes (bacteria and archaea). These filters were then frozen. The DNA of the entire community will be extracted and sequenced at San Diego State University, and the diversity and function of the microbial communities on the sampled reefs will be analyzed. The filtrate from this sample was also kept and contains concentrated viruses. Chloroform was added to this filtrate to kill any small microbes, and then this sample was stored at 4°C. Once shipped to San Diego State University, viruses will be isolated from the viral concentrate, and community DNA will be extracted

and sequenced. This extracted and sequenced DNA will then be analyzed for viral community diversity and function.

Benthic Grabs: At the same REA site where the large water sample of ~70 L was collected, benthic samples were collected: 10 pieces of coral rubble and 10 pieces of macroalgae if present, and they were stored at -20°C . These samples are used to determine the microbial communities associated with the benthos.

Plankton Collection: At each island, 2 plankton tows were conducted from the surface water: one nearshore tow over the reef and one offshore tow ~ 0.8 km from shore. A bongo net with a 200- μm filter was pulled through the water for 15 min at a speed of ~ 1 kn. Upon return to the ship, samples were stored in ethanol at 4°C . These samples will be used to determine the abundance and diversity of planktonic communities.

A.2.5. Coral Diversity Surveys: Target Species Warranting Protection

The Pacific Ocean supports the largest and among the oldest habitat for coral reefs. During the past century, coral reefs have been increasingly threatened by anthropogenic activities, including human population growth, unmanaged fishing, and climate change. Stony (mostly scleractinian) corals are among the main organisms responsible for the biogenic growth and maintenance of reefs worldwide, yet we are only now beginning to focus attention regarding the status of threats to individual reef-building coral species and their habitats. The International Union for the Conservation of Nature has added more than 250 coral species to its Red List of Threatened Species, although the status of most of these species is still uncertain. During the past decade, the Center of Biological Diversity (CBD), based in Tucson, Ariz., proposed protecting a few stony corals as endangered species. In October 2009, the CBD petitioned NOAA to list an additional 83 coral species under the *Endangered Species Act*, and all but 8 of these species occur in the Indo-Pacific region. Sixty of these species have been observed in the central Pacific (J Maragos, pers. comm.), and 17 of them have been observed at Johnston Atoll and Howland and Baker Islands, based upon multiple surveys conducted at these islands over the past 3 decades. However, not all of these species were observed during the Pacific RAMP cruise to Johnston Atoll and Howland and Baker Islands in January–February, 2010, because some of them (including species of *Leptoseris* and *Turbinaria*) occur below dive depths that were accomplished during this cruise and an ongoing coral bleaching event reduced the abundance of others, especially species of *Acropora*.

Stony corals consist of several thin layers of cell tissues over a much larger, stony skeleton. Over the past 250 years, skeletal characters and morphology served as the basis for distinguishing coral species. However, most reef-building corals are colonial and dependent upon single-celled plants (zooxanthellae) that live in their tissues for growth and nutrition. These factors lead to many different growth forms for each species, complicating efforts to assign proper species names and determine which species are under threat and warrant special protection. Moreover, the large size of the Pacific Ocean isolates many archipelagoes and islands from one another, and this isolation likely leads to genetic drift and evolution of new species without obvious morphological changes. As

a result, there are likely many species of corals that still are not described. In addition, many of the species that have been recorded are likely to have been misidentified.

Thus, it is important to use supplemental approaches to define coral species more accurately, beyond just skeletal characters before considering them for endangered species status. Over the past several decades, taxonomic guidebooks with colored photographs of living corals taken during scuba dives have helped many scientists discern living coral species in their underwater habitats and in the process add “live tissue” characteristics to supplement skeletal characteristics. Also over the past several decades, coral taxonomists have grappled with additional approaches to differentiate individual species, including numerical taxonomy of morphological features and immunoassay techniques. However, these approaches have met with limited success and are difficult to apply and standardize for widespread use. More recently, molecular approaches that compare the DNA of different corals are showing great promise in determining which morphologically similar species have differing genomes and which corals with differing growth forms have the same genomes. As more useful “markers” are discovered on genes, there should be greater success in defining coral species and their phylogenetic relationships with other cnidarians.

Nevertheless, to resolve coral species assignments, there always will need to be a strong relationship between consistent observed morphological-anatomical characteristics and molecular characteristics determined via laboratory analyses. In turn, this dual approach would better define which species are in greater need of protection.

During this Pacific RAMP cruise, James Maragos collected coral samples focusing on species (1) included in the CBD petition, (2) other species closely related to the species in the petition, (3) undescribed species likely to be new to science, and (4) a selected number of common species of several genera to determine levels of genetic drift and connectivity. Maragos searched for these species during each dive, first taking an underwater photo and then collecting a small (1–3 cm²) sample of each species, and then placed and sealed each in a separate prenumbered Ziploc bag. Then, each species was recorded on an underwater sheet, listing its in situ identification, Ziploc bag number, and REA site number. Later, each of the underwater photos taken was labeled with the corresponding bag number, based on the sequence of digital photos taken during each dive.

Upon return to the ship after each dive day, samples were immediately taken to the wet lab for processing. Using a hammer and cold chisel, or a surgical bone cutter, small (< 1 cm) fragments of each sample were placed in a vial labeled with the bag number of their sample. A separate waterproof paper tag with the same bag number was also placed inside the vial and the contents filled with 98% ethanol and tightly sealed. To avoid contamination, after the processing of each sample, the chisel, hammer, and bone cutter were washed and each used bag was discarded. At the end of each field day and after sample processing, the day’s samples were added to a master spreadsheet of information about samples, including date, depth, site number, species, bag label number, island, etc.

A.3. Surveys of Reef Fishes

(Paula Ayotte, Emily Donham, Kevin Lino, Jonatha Giddens, Kara Osada, and Benjamin Richards)

Four divers conducted REA fish surveys using the stationary-point-count (SPC) method at preselected REA sites. Two separate teams performed these surveys. Each team consisted of 2 divers and conducted either 1 or 2 SPC surveys per site. All fish REA sites visited were selected using a stratified random sampling design in shallow (0–6 m), moderate (6–18 m), or deep (18–30 m) depth strata. Three habitat strata were surveyed, if available: forereef, backreef, and lagoon. Note that the REA sites selected for fish surveys are different from the sites where REA benthic surveys were conducted.

SPC surveys were performed using a 30-m transect line set along a single depth contour. Once a transect line was deployed, a team of 2 divers moved to positions at 7.5 and 22.5 m. Those marks served as the centers of visually estimated cylindrical survey areas with a radius of 7.5 m. During the first 5 min, divers only recorded the presence of species within their respective cylinders. On completion of that 5 min enumeration period, divers began the count period, in which they systematically go down the species lists created during the enumeration period, sizing and counting all individuals within their cylinder, one species at a time. Cryptic species missed during the initial 5 min of a survey were still counted, sized, and added to the original species list when divers believed that they had most likely been missed during the enumeration period. The presence of notable species (e.g., sharks, bumphead parrotfish, turtles, and cetaceans) observed at any time during a dive but not recorded during SPC surveys was noted as “presence” data.

After a survey was completed, divers estimated benthic habitat cover and structural complexity of their respective survey areas: habitat complexity on a 6-point scale and benthic habitat by percentage of cover for categories that included hard corals, soft corals, macroalgae, crustose coralline algae, sand, and other invertebrates. In addition, a photoquadrat survey was made along the 30-m reference line, with photographs taken every 2 m. These photographs will be later analyzed by CRED staff and partners at Scripps Institution of Oceanography.

If bottom time and air permitted, the 30-m transect line was moved to a location that was nearby (but not overlapping) and at the same depth level, and the SPC procedure was repeated.

In addition to these site-specific REA surveys, broad-scale towed-diver surveys were used to characterize the fish communities of shallow-water habitats around each island or atoll. A pair of divers was towed ~ 60 m behind a small boat, with one of the pair quantifying large-bodied fish populations and the other diver quantifying benthos. Each towed-diver survey lasted 50 min, with data grouped into ten 5-min segments, and covered ~ 2 km. To georeference the survey launch’s track, latitude and longitude coordinates were recorded at 5-s intervals using a Garmin GPSMap 76 GPS unit on the boat. A custom algorithm was used to calculate the track of the divers based on the track, speed, and course of the boat and depth of the diver. Each towed-diver platform, or

towboard, was equipped with an SBE 39 temperature and depth recorder set to record at 5-s intervals. At the end of each day, data were downloaded, processed, and presented in ArcGIS so that they can be displayed in conjunction with IKONOS satellite imagery, NOAA chart data, or other spatial data layers.

Towed-diver fish surveys record, to the lowest possible taxon, all fishes > 50 cm in total length (TL) along a 10-m swath in front of and centered on the diver. Species (or lowest possible taxon) and total length in centimeters were recorded for each fish counted. Sightings of species of particular concern (e.g., turtles, cetaceans, bumphead parrotfish, and Napoleon wrasse) observed outside the survey swath were noted and classified as presence/absence data.

At the end of each day, all fish survey data were transcribed from field data sheets into a centralized Microsoft Access database. The fish towboard was equipped with a forward-looking digital video camera that created a visual archive of the survey track.

APPENDIX B: JOHNSTON ATOLL

Johnston Atoll, located at 16°45' N, 169°31' W in the central Pacific, includes 4 islands and a small lagoon and is part of the Pacific Remote Islands Marine National Monument. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

In addition to the activities described in this appendix, a U.S. Fish and Wildlife Service field party went ashore to Johnston Atoll during HA-10-01, Leg 1, to conduct surveys of terrestrial flora and fauna.

B.1. Oceanography and Water Quality

Oceanographic operations during HA-10-01, Leg 1, at Johnston Atoll entailed numerous retrievals and deployments of oceanographic moored instruments, installation of calcification acidification units (CAUs), nearshore water sampling and conductivity, temperature, and depth (CTD) casts around this atoll to depths of ~ 30 m or to the depths of Rapid Ecological Assessment (REA) sites, shipboard water sampling and CTD casts offshore to a depth of 500 m, and acoustic Doppler current profiler (ADCP) transect lines.

For long-term monitoring, subsurface temperature recorders (STRs) were retrieved and deployed where possible, including 5 retrievals and 6 deployments (Fig. B.1.1). One STR was either buried by dead coral or moved by strong current and wave action. To replace this lost instrument, an STR was deployed in a similar position. An entire SST mooring, including buoy, line and anchor, was removed and replaced in the same location within the atoll. A Sea-Bird Electronics Inc. (Bellevue, Wash.) SBE 26 Seagauge wave-and-tide recorder (WTR) and an environmental acoustic recorder (EAR) were removed and replaced on their previously deployed anchors. Anchors were checked for integrity, fitted with new cathodes for protection against erosion, and found to be in good condition (Table B.1.1). For information about CAU deployments completed at Johnston Atoll, see Figure B.1.2 and Section B.2: “Benthic Environment.”

A total of 23 shallow-water CTD casts were performed at nearshore locations around Johnston Atoll (Fig. B.1.2), including a cast at each of the 4 REA sites where CAUs were installed and a series of casts around this atoll at depths of ~ 30 m at regular horizontal intervals. In concert with the CTD cast at each of those 4 REA sites, 2 water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), salinity, and nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 8 DIC, 8 salinity, 8 nutrient, and 8 Chl-*a* water samples were collected, 1 from the surface and 1 near the reef at each site.

Deepwater CTD casts were conducted from the NOAA Ship *Hi`ialakai* to a depth of 500 m around Johnston Atoll over 4 nights (Fig. B.1.3). CTD casts 1–5 were conducted on the east side on Jan. 24; however, because of problems with the SBE 911*plus* CTD on

these initial casts, east side casts were repeated with casts 14–18. Casts 6–13 were conducted on the west side of this atoll on Jan. 25, casts 14–21 were conducted on the east side on Jan. 27, and casts 22–29 were conducted on the south side on Jan. 28 (Fig. B.1.3). A total of 40 shipboard water samples, 20 nutrient and 20 Chl-*a*, were collected at Johnston. ADCP data were collected along transect lines for a total length of 70 km.

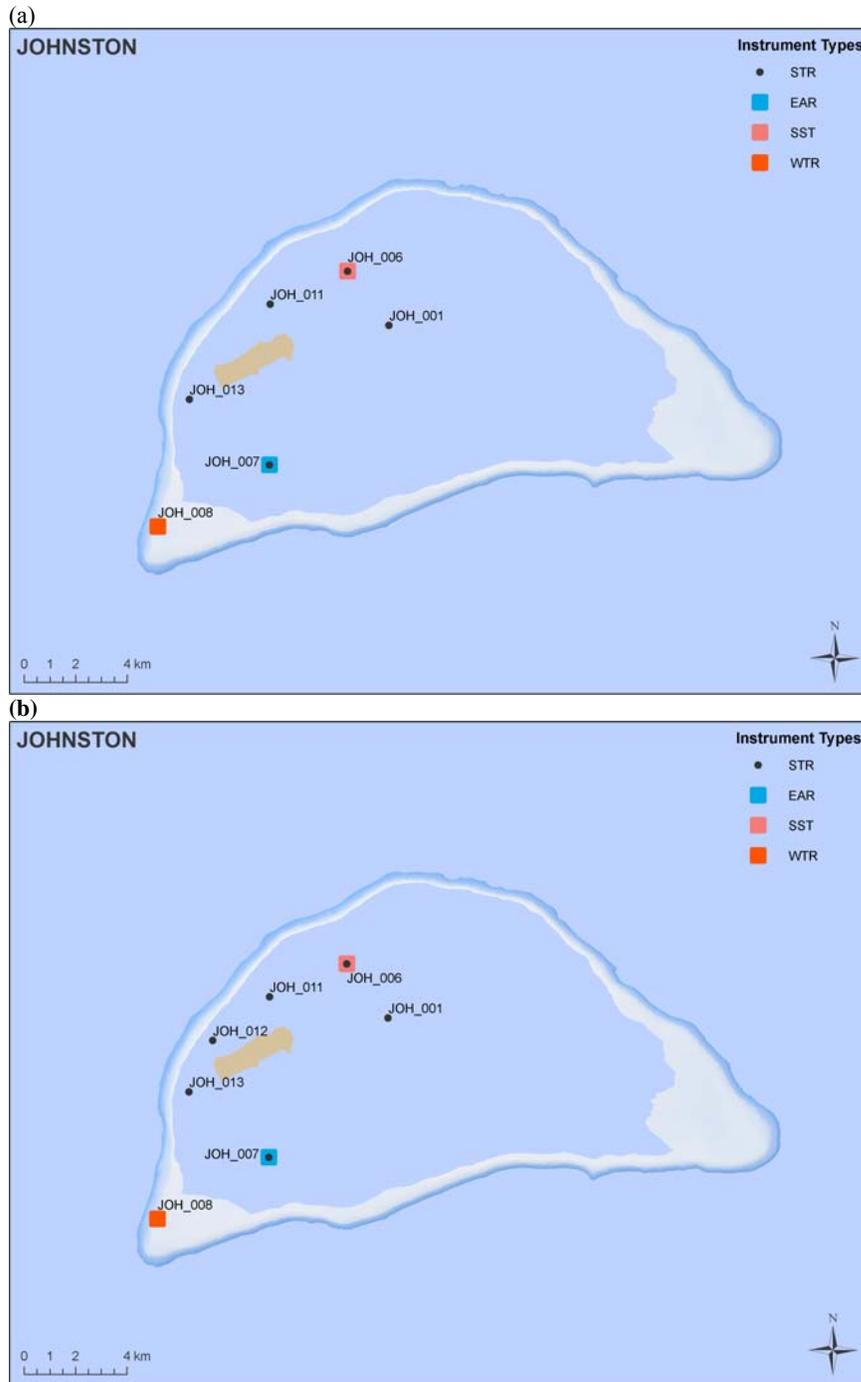


Figure B.1.1. Moored instruments (a) retrieved and (b) deployed at Johnston Atoll during cruise HA-10-01, Leg 1.

Table B.1.1. Geographic coordinates and sensor depths of the moored instruments that were retrieved or deployed at Johnston Atoll during cruise HA-10-01, Leg 1.

Mooring Site	Instrument Type	Latitude	Longitude	Sensor Depth (m)
Retrievals				
JOH-001	STR	16.74063918	-169.4852232	2.4
JOH-006	SST	16.75957222	-169.4996867	0.3
JOH-006	STR	16.75957222	-169.4996867	8.8
JOH-007	EAR	16.69184427	-169.5270211	17.1
JOH-007	STR	16.69184427	-169.5270211	17.1
JOH-008	WTR	16.6702514	-169.5660743	24.4
JOH-011	STR	16.74806572	-169.52672	2.7
JOH-013	STR	16.71479358	-169.5550272	3
Deployments				
JOH-001	STR	16.74063918	-169.4852232	2.4
JOH-006	STR	16.75957222	-169.4996867	8.8
JOH-006	SST	16.75957222	-169.4996867	0.2
JOH-007	STR	16.69184427	-169.5270211	17.1
JOH-007	EAR	16.69184427	-169.5270211	17.1
JOH-008	WTR	16.6702514	-169.5660743	24.4
JOH-011	STR	16.74806572	-169.52672	2.7
JOH-012	STR	16.73276204	-169.5466672	1.8
JOH-013	STR	16.71479358	-169.5550272	3



Figure B.1.2. Locations of shallow-water CTD casts performed at Johnston Atoll during cruise HA-10-01, Leg 1. Water samples were collected at 4 of these cast locations, each near an REA site where CAUs were deployed.

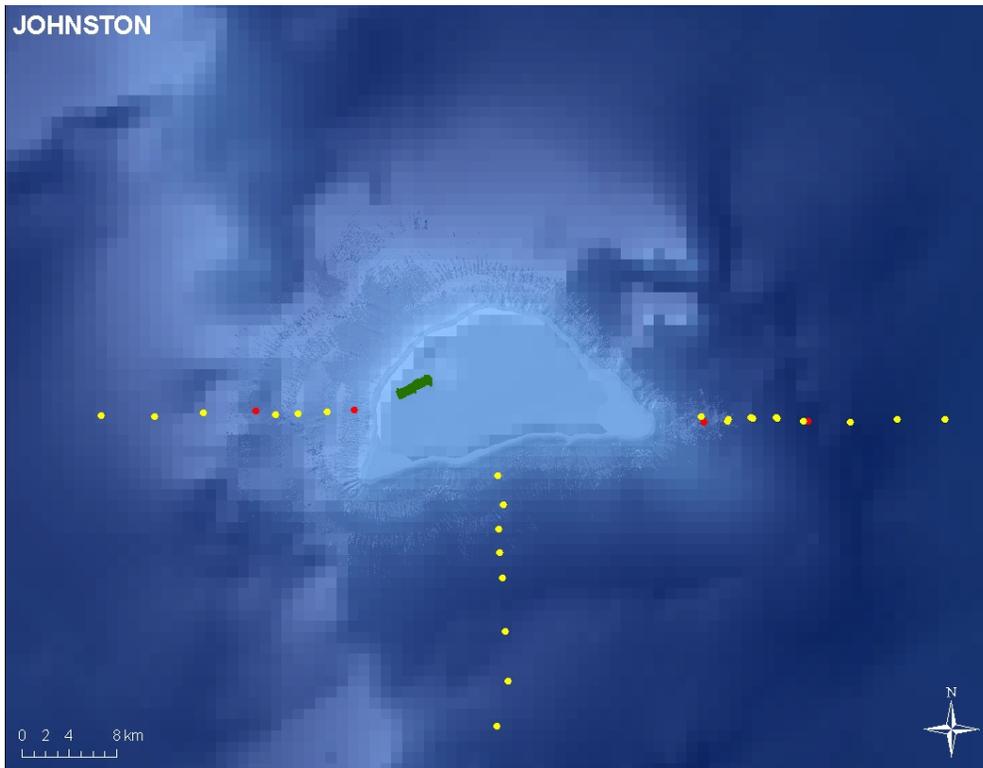


Figure B.1.3. Locations of deepwater CTD casts conducted at Johnston Atoll from the NOAA Ship *Hi'ialakai* to a depth of 500 m. Shipboard water samples for analyses of nutrient and Chl-*a* concentrations were collected in concert with the casts conducted at the 4 locations displayed in red. Satellite data: SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997). © 2008 The Regents of the University of California. All Rights Reserved.

Preliminary Results: Temperatures and Wave Heights

Temperature data from STRs at 5 locations inside and outside of Johnston Atoll (Fig. B.1.4) show typical seasonal fluctuations for the northern hemisphere, with the warmest temperatures occurring from August to September and the coolest from February to March. Diurnal temperature variability was greater within this atoll compared to the forereef because of rapid daytime warming of the shallow atoll water, but this diurnal variability was generally within 1°C. Summer temperatures were higher, by ~ 1°C, than temperatures recorded during other seasons and were more sustained at higher levels than were summer temperatures in 2008, a possible signature of the strong El Niño-Southern Oscillation conditions observed in 2009.

Large wave events in the northern Pacific are also higher and more frequent during periods of the El Niño climate pattern. Wave heights on the southwest corner of Johnston Atoll reached over 2 m more regularly and were generally larger during the fall and winter of 2009 compared to the same period in 2008 (Fig. B.1.5).

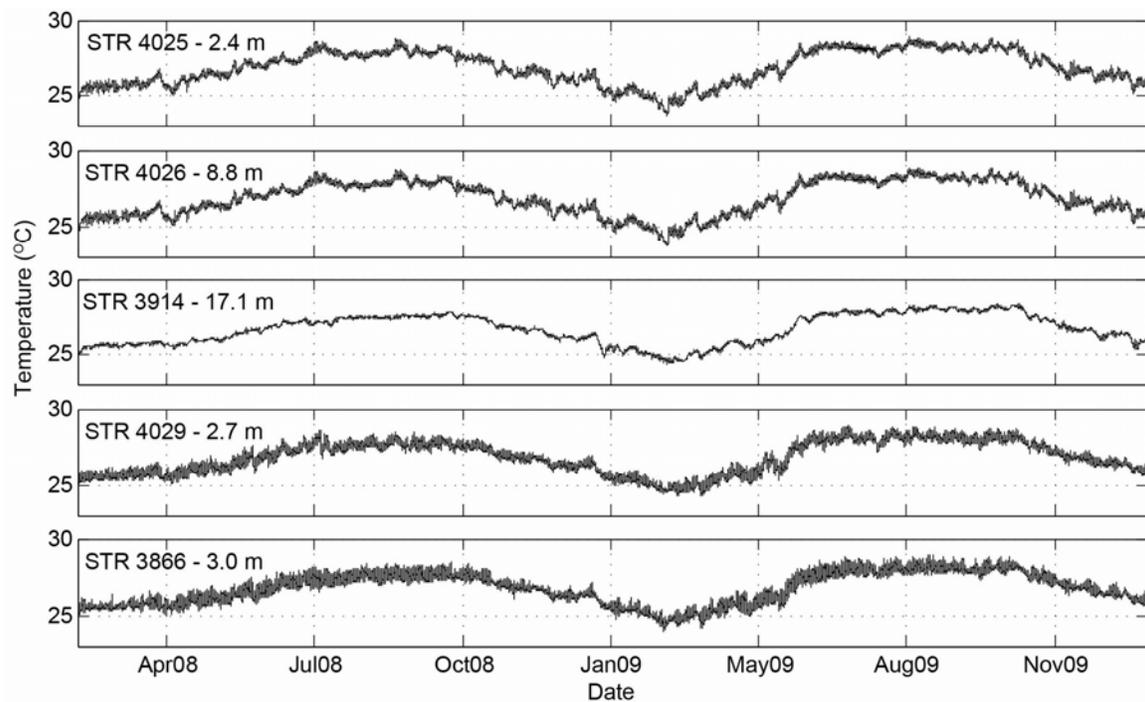


Figure B.1.4. Time-series observations of temperatures during the period from February 2008 to January 2010 collected from 5 STRs deployed at different locations and depths at Johnston Atoll.

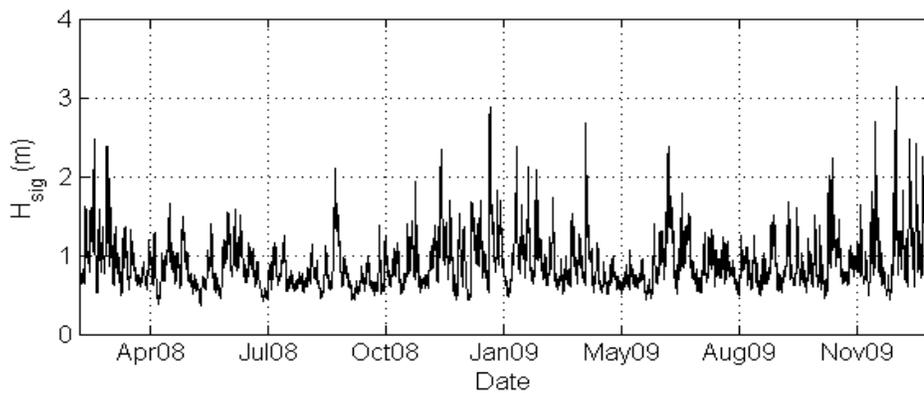


Figure B.1.5. Time-series observations of significant wave height during the period of February 2008 to January 2010 from a WTR deployed on the southwest corner of Johnston Atoll.

B.2. Benthic Environment

During cruise HA-10-01, Leg 1, CRED conducted Rapid Ecological Assessment (REA) benthic surveys, using the line-point-intercept and belt-transect methods, at 16 sites at Johnston Atoll to assess benthic composition, coral and algal community structure, coral and algal disease, and non-coral macroinvertebrate abundance and test diameters (Table B.2.1 and Fig. B.2.1). The benthic team conducted a total of 107 individual scuba dives around Johnston Atoll.

A total of 22 towed-diver surveys were completed at Johnston Atoll, covering 43.9 km of ocean floor (Fig. B.2.2). The mean survey length was 2.0 km with a range of 0.6–3.7 km. The mean survey depth was 11.9 m with a range of 2.8–21.2 m. The mean temperature from data recorded during these surveys was 26°C with a range of 25.8°C–26.3°C.

Various samples were collected at 16 REA sites: 7 total voucher specimens of algae at 4 REA sites, 17 total samples of coral diseases at 4 sites, 5 total collections of non-coral macroinvertebrates at 4 sites, and 7 total microbial water samples at 7 sites. Additional microbial collections included benthic grabs of coral rubble samples at 1 site and plankton tows at 2 locations. For a list of collections made at these REA sites, see Table E.1 in Appendix E: “Biological Collections.”

A total of 100 samples of 26 coral species were collected at the same 16 REA sites in support of the NOAA status review of 82 coral species in response to a petition by the Center of Biological Diversity (CBD) to list them under the *Endangered Species Act* (ESA). For an ESA collections list, see Table E.2 in Appendix E.

At each of the same 4 select REA sites where water samples were taken, an array of 5 CAUs was deployed for a total of 20 CAUs installed at Johnston Atoll (Fig. B.1.2 and Table B.2.1). These CAU arrays were the first deployed by CRED. CAUs deployed on the first day were revisited on the fourth day to check the epoxy and integrity of each deployment. Some variability in the strength of the epoxy was observed, but all CAU deployments appeared sound.

A total of 9 autonomous reef monitoring structures (ARMS) were installed near 3 of the 4 REA sites where CAUs were deployed.

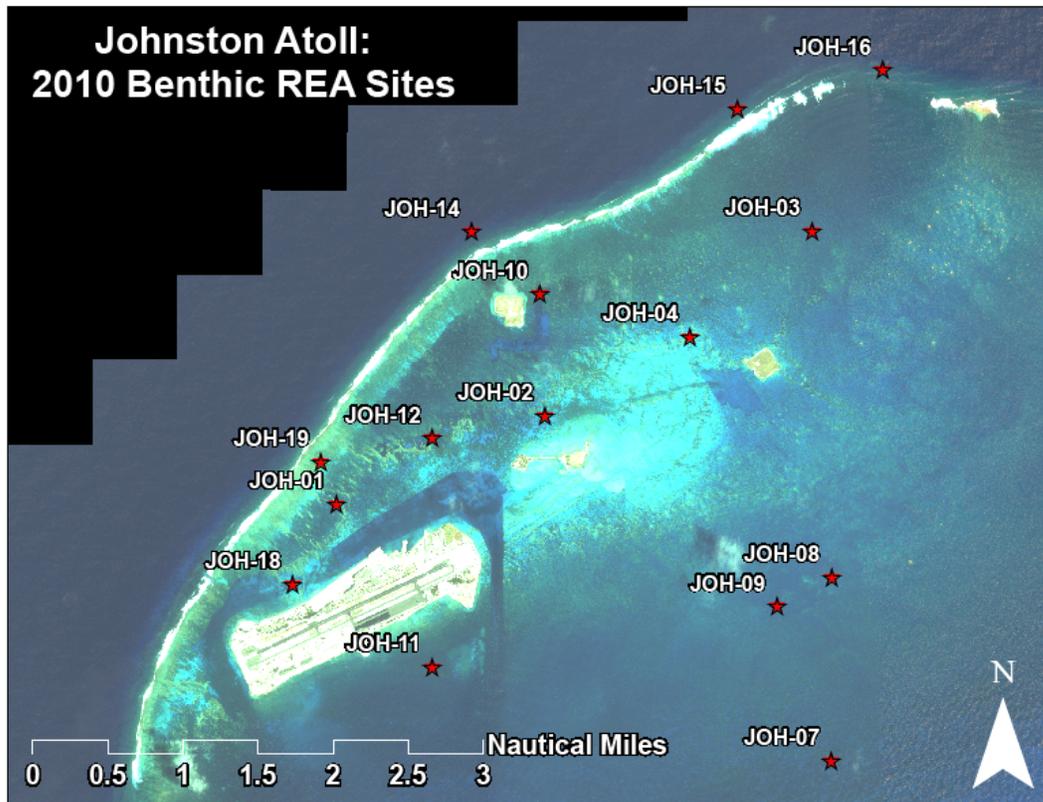


Figure B.2.1. Locations of REA benthic sites surveyed at Johnston Atoll during cruise HA-10-01, Leg 1 (IKONOS Carterra Geo Data, 2003).

Table B.2.1. Summary of REA benthic surveys, deployments and retrievals of moored biological installations, and sample collections performed at REA sites at Johnston Atoll during cruise HA-10-01, Leg 1. The line-point-intercept (LPI) method was used to estimate percentage of cover of algae, corals, and other invertebrates. Photoquadrat surveys (Photo) recorded digital images of benthos for later analysis of benthic cover. Roving-diver surveys of algae (Algae) were conducted if time permitted at the end of LPI surveys. Surveys of coral community structure and condition (Corals) were performed using the belt-transect method, as were separate surveys of other invertebrates (Inverts). This table does not include the coral specimens for taxonomic verification that were collected by U.S. Fish and Wildlife Service biologist James Maragos.

REA Site	Date	Latitude	Longitude	REA Surveys					Deployments and Retrievals		Sample Collections		
				LPI	Photo	Algae	Corals	Inverts	CAUs	ARMS	Algae	Coral Disease	Microbial Samples
JOH-09	24-Jan	16.72862	-169.4857	×	×	—	×	×	×	—	—	—	×
JOH-14	25-Jan	16.76994	-169.5190	×	×	—	×	×	—	—	—	—	—
JOH-15	25-Jan	16.78358	-169.49004	×	×	—	×	×	—	—	×	—	—
JOH-16	25-Jan	16.78760	-169.47322	×	×	×	×	×	—	—	—	—	×
JOH-01	26-Jan	16.73983	-169.53471	×	×	—	×	×	—	—	—	—	—
JOH-12	26-Jan	16.74753	-169.52397	×	×	×	×	×	×	×	—	—	×
JOH-18	26-Jan	16.73092	-169.53964	×	×	—	×	×	—	—	—	×	—
JOH-02	27-Jan	16.74990	-169.51147	×	×	—	×	×	—	—	—	—	—
JOH-10	27-Jan	16.76330	-169.51195	×	×	—	×	×	×	×	—	×	×
JOH-11	27-Jan	16.72154	-169.52432	×	×	×	×	×	×	×	—	×	×
JOH-03	28-Jan	16.77034	-169.48181	×	×	×	×	×	—	—	—	—	—
JOH-04	28-Jan	16.75849	-169.49529	×	×	×	×	×	—	—	—	—	—
JOH-06	28-Jan	16.69820	-169.48557	×	×	×	×	×	—	—	×	—	×
JOH-07	29-Jan	16.71155	-169.47972	×	×	×	×	×	—	—	×	×	×
JOH-08	29-Jan	16.73192	-169.47969	×	×	—	×	×	—	—	×	—	—
JOH-19	29-Jan	16.74483	-169.53593	×	×	—	×	×	—	—	—	—	—

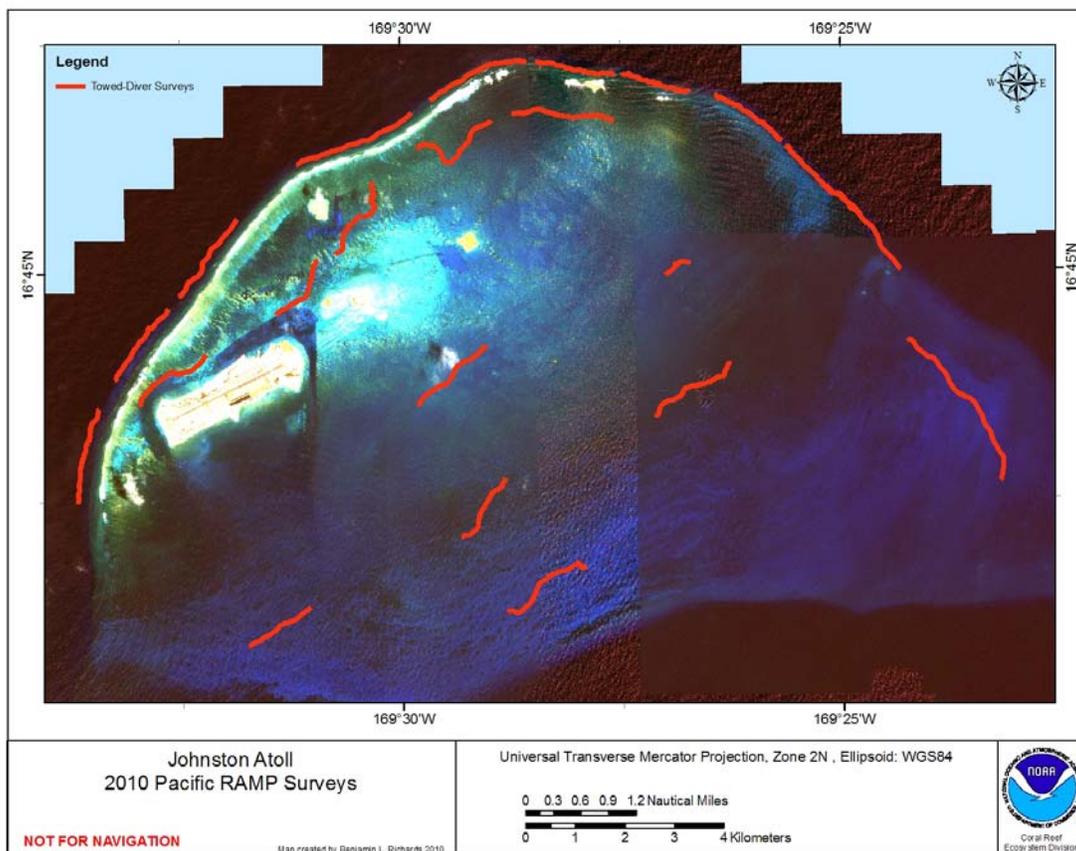


Figure B.2.2. Tracks of towed-diver surveys (fish and benthic) conducted at Johnston Atoll during cruise HA-10-01, Leg 1 (IKONOS Carterra Geo Data, 2003).

B.3. Reef Fish Community

During cruise HA-10-01, Leg 1, CRED conducted REA fish surveys, using a stratified random design and stationary-point-count method, at 39 REA sites at Johnston Atoll and among 7 different habitat strata: deep forereef, moderate forereef, deep backreef, moderate backreef, deep lagoon, moderate lagoon, and shallow lagoon (Fig. B.3.1 and Table B.3.1). A total of 25 individual fishes from 5 species were collected at 3 sites at Johnston Atoll as part of an effort by the U.S. Fish and Wildlife Service to test for toxic substances in the lagoon at this atoll. For a listing of collections made, see Appendix E: “Biological Collections.”

In addition, CRED completed a total of 22 towed-diver surveys at Johnston Atoll as described in Section B.2 of this report.

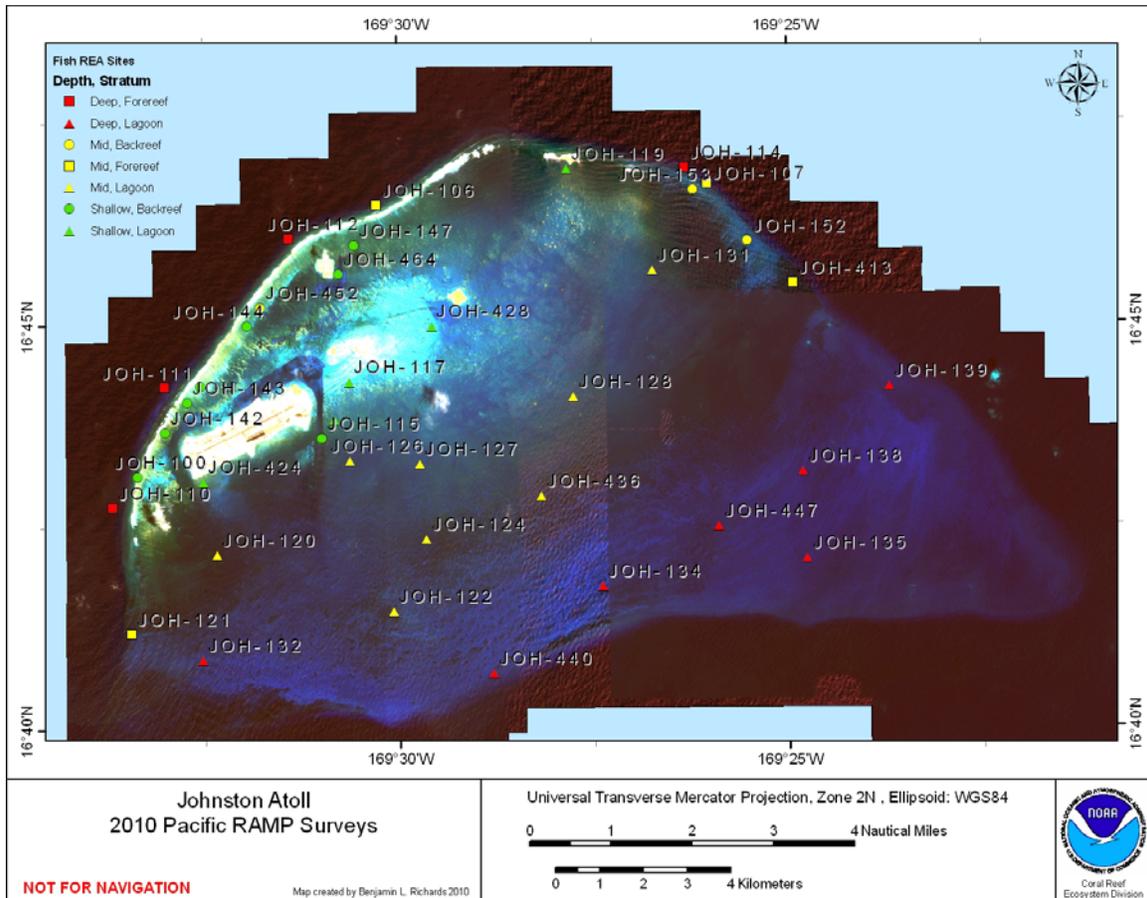


Figure B.3.1. Locations of REA fish sites surveyed around Johnston Atoll during cruise HA-10-01, Leg 1. All of these REA sites were selected using a stratified random design (IKONOS Carterra Geo Data, 2003).

Table B.3.1. Summary of sites where REA fish surveys were conducted around Johnston Atoll during cruise HA-10-01, Leg 1.

REA Site	Date	Depth, Stratum Descriptions	Depth (m)	Latitude	Longitude
JOH-110	24-Jan	Deep, Forereef	20	16.7124	-169.56126
JOH-120	24-Jan	Moderate, Lagoon	17	16.70251	-169.53903
JOH-126	24-Jan	Moderate, Lagoon	12	16.72178	-169.51051
JOH-100	25-Jan	Shallow, Backreef	4	16.71873	-169.55585
JOH-106	25-Jan	Moderate, Forereef	13	16.77455	-169.50465
JOH-111	25-Jan	Deep, Forereef	20	16.73732	-169.55008
JOH-112	25-Jan	Deep, Forereef	24	16.76768	-169.52347
JOH-119	25-Jan	Shallow, Lagoon	6	16.78178	-169.46387
JOH-121	25-Jan	Moderate, Forereef	15	16.68651	-169.55745
JOH-107	26-Jan	Moderate, Forereef	16	16.77859	-169.43379
JOH-114	26-Jan	Deep, Forereef	27	16.782	-169.43864
JOH-116	26-Jan	Shallow, Lagoon	4	16.7304	-169.5137

REA Site	Date	Depth, Stratum Descriptions	Depth (m)	Latitude	Longitude
JOH-124	26-Jan	Moderate, Lagoon	12	16.70556	-169.49425
JOH-127	26-Jan	Moderate, Lagoon	6	16.72109	-169.49561
JOH-131	26-Jan	Moderate, Lagoon	11	16.76082	-169.44568
JOH-134	26-Jan	Deep, Lagoon	19	16.69573	-169.4566
JOH-139	26-Jan	Deep, Lagoon	23	16.76081	-169.44568
JOH-115	27-Jan	Shallow, Backreef	5	16.7265	-169.51645
JOH-122	27-Jan	Moderate, Lagoon	12	16.69072	-169.50139
JOH-132	27-Jan	Deep, Lagoon	22	16.68097	-169.54224
JOH-142	27-Jan	Shallow, Backreef	5	16.72787	-169.55009
JOH-144	27-Jan	Shallow, Backreef	3	16.74967	-169.53238
JOH-440	27-Jan	Deep, Lagoon	24	16.67791	-169.48006
JOH-452	27-Jan	Moderate, Backreef	8	16.75345	-169.52954
JOH-128	28-Jan	Moderate, Lagoon	9	16.73486	-169.46269
JOH-143	28-Jan	Shallow, Backreef	4	16.73411	-169.5452
JOH-147	28-Jan	Shallow, Backreef	6	16.7662	-169.50941
JOH-436	28-Jan	Moderate, Lagoon	14	16.71442	-169.46956
JOH-447	28-Jan	Deep, Lagoon	21	16.708	-169.43166
JOH-450	28-Jan	Shallow, Backreef	4	16.7374	-169.54233
JOH-464	28-Jan	Shallow, Backreef	14	16.76044	-169.51276
JOH-117	29-Jan	Shallow, Lagoon	4	16.73808	-169.51056
JOH-135	29-Jan	Deep, Lagoon	23	16.70135	-169.41284
JOH-138	29-Jan	Deep, Lagoon	25	16.71932	-169.41367
JOH-152	29-Jan	Moderate, Backreef	9	16.76691	-169.42522
JOH-153	29-Jan	Moderate, Backreef	8	16.7774	-169.4368
JOH-413	29-Jan	Moderate, Forereef	13	16.7581	-169.41562
JOH-424	29-Jan	Shallow, Lagoon	6	16.71768	-169.54195
JOH-428	29-Jan	Shallow, Lagoon	2	16.74938	-169.4929

APPENDIX C: HOWLAND ISLAND

Howland Island is an uninhabited island located at 0°48' N, 176°37' W in the central Pacific and is part of the Pacific Remote Islands Marine National Monument. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

In addition to the activities described in this appendix, a U.S. Fish and Wildlife Service field party went ashore to Howland Island during HA-10-01, Leg 1, to conduct surveys of terrestrial flora and fauna.

C.1. Oceanography and Water Quality

Oceanographic operations during cruise HA-10-01, Leg 1, at Howland Island entailed retrievals and deployments of moored subsurface temperature recorders (STRs), installation of calcification acidification units (CAUs), nearshore water sampling and conductivity, temperature, and depth (CTD) casts around this island to depths of ~ 30 m or to the depths of Rapid Ecological Assessment (REA) sites, shipboard water sampling and CTD casts offshore to a depth of 500 m, and acoustic Doppler current profiler (ADCP) transect lines.

For long-term monitoring, 4 STRs were retrieved and 5 were deployed at Howland Island (Fig. C.1.1 and Table C.1.1). For information about CAU deployments completed at this island, see Figure C.1.2 and Section C.2: “Benthic Environment.”

A total of 13 shallow-water CTD casts were performed at nearshore locations around Howland Island (Fig. C.1.2), including a cast at each of the 5 REA sites where CAUs were installed and a series of casts around this island at depths of ~ 30 m at regular horizontal intervals. In concert with the CTD cast at each of those 5 REA sites, 2 water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), salinity, and nutrient and chlorophyll-*a* (Chl-*a*) concentrations. A total of 10 DIC, 10 salinity, 10 nutrient, and 10 Chl- *a* water samples were collected, 1 from the surface and 1 near the reef at each site.

Deepwater CTD casts were conducted from the NOAA Ship *Hi`ialakai* to a depth of 500 m at 16 locations around Howland Island over 2 nights (Fig. C.1.3). To the west of this island, 8 CTD casts were run on the first night, and 8 were run to the east on the next night, with ADCP lines run over the same transect line on the reciprocal course. Total length of ADCP transect lines was 40 km. Concurrently with every other CTD cast, a total of 40 shipboard water samples, 20 Chl-*a* and 20 nutrient, were collected at Howland Island.

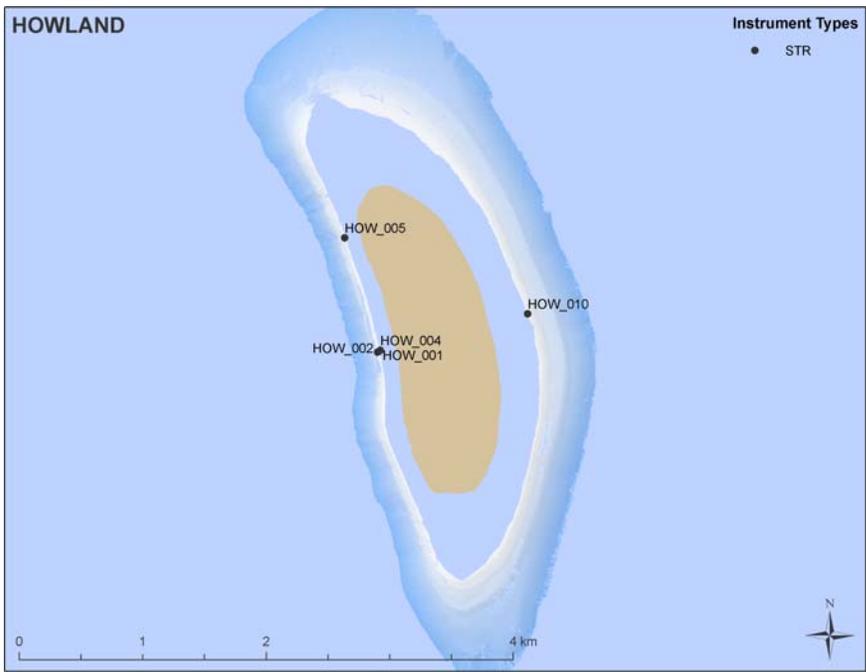
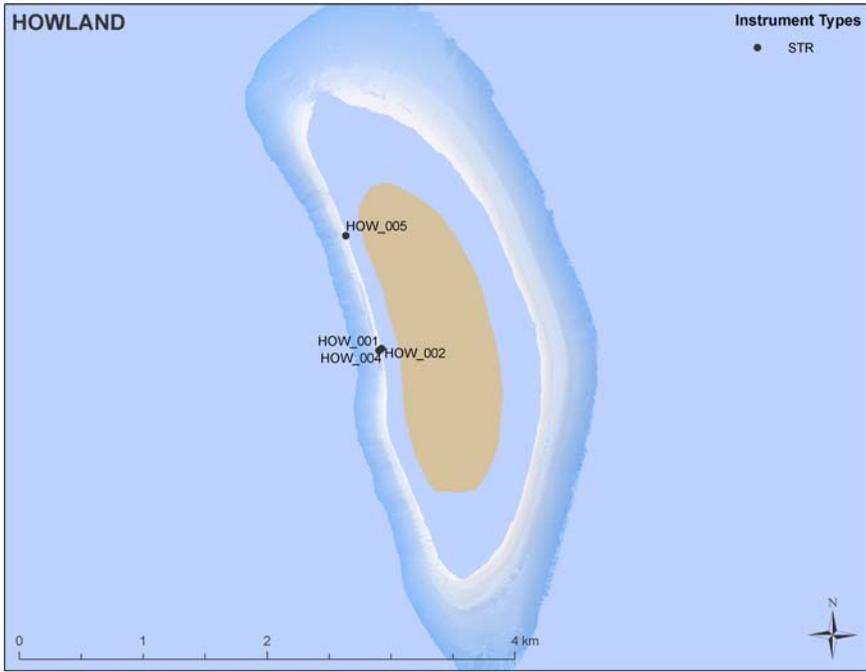


Figure C.1.1. Moored STRs (a) retrieved and (b) deployed at Howland Island during cruise HA-10-01, Leg 1.

Table C.1.1. Geographic coordinates and sensor depths of the moored STRs that were retrieved or deployed at Howland Island during cruise HA-10-01, Leg 1.

Mooring Site	Instrument Type	Latitude	Longitude	Sensor Depth (m)
Retrievals				
HOW-001	STR	0.80646238	-176.6215262	19.8
HOW-002	STR	0.80649382	-176.621483	38.4
HOW-004	STR	0.80660881	-176.6213444	4.3
HOW-005	STR	0.81481797	-176.6239249	15.2
Deployments				
HOW-001	STR	0.80646238	-176.6215262	19.8
HOW-002	STR	0.80649382	-176.621483	38.4
HOW-004	STR	0.80660881	-176.6213444	4.3
HOW-005	STR	0.81481797	-176.6239249	15.2
HOW-010	STR	0.80927535	-176.6105942	13.1

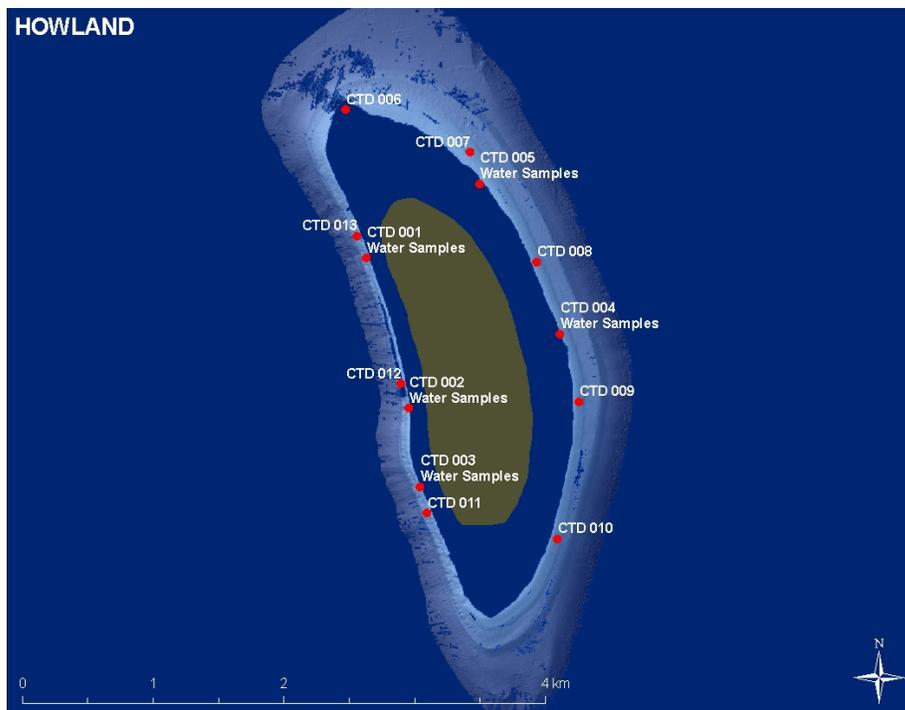


Figure C.1.2. Locations of shallow-water CTD casts performed at Howland Island during cruise HA-10-01, Leg 1. Water samples were collected at 5 of these cast locations, each near REA sites where CAUs were deployed.

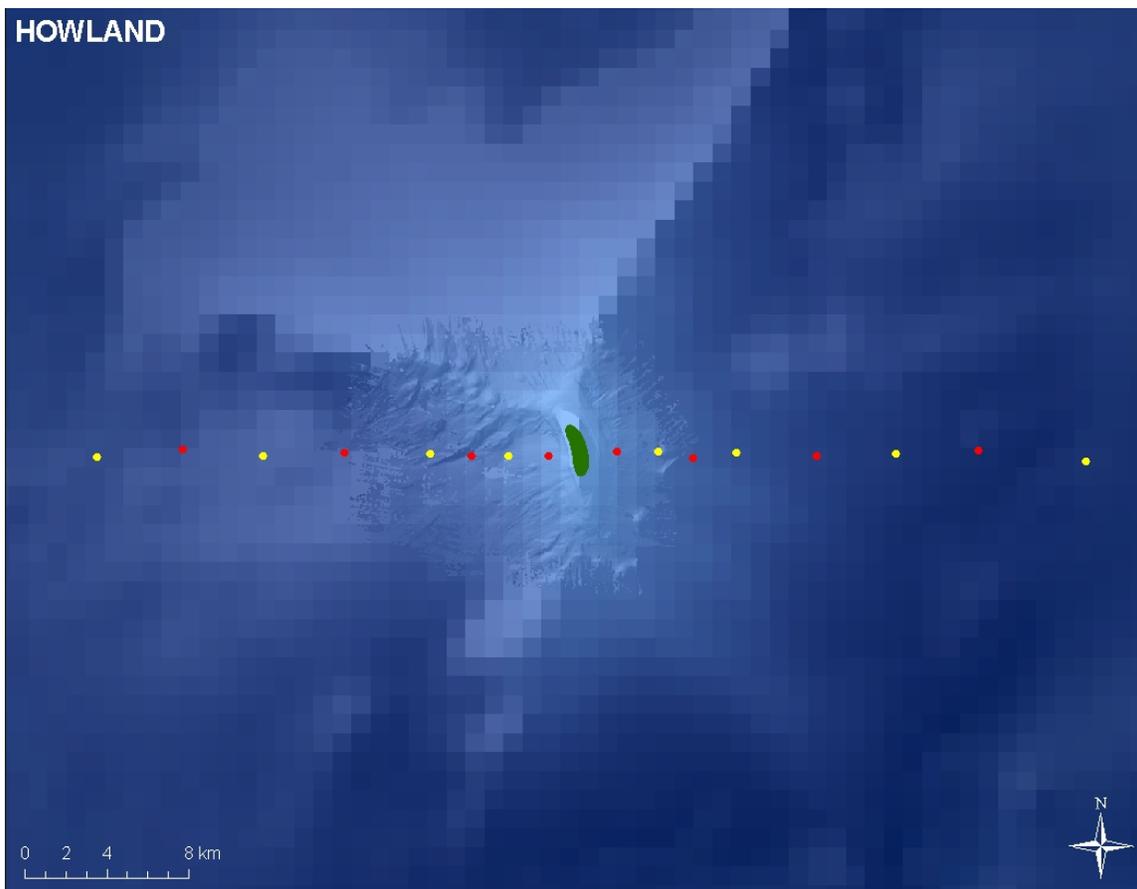


Figure C.1.3. Locations of deepwater CTD casts conducted at Howland Island from the NOAA Ship *Hi'ialakai* to a depth of 500 m. Shipboard water samples for analyses of nutrient and Chl-*a* concentrations were collected in concert with every other CTD cast; these casts are displayed in red. Satellite data: SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997). © 2008 The Regents of the University of California. All Rights Reserved.

Preliminary Results: Subsurface Temperatures

Temperature data from STRs at 4 locations around Howland Island show that the lowest water temperature in the last 2 years was recorded during February 2008 (Fig. C.1.4.). Since this time, temperatures have risen steadily from summer 2009 to winter 2010. Data from STRs deployed prior to 2008 show a temperature increase through the boreal summer and a typical low of $\sim 25^{\circ}\text{C}$ through January and February. The temperatures were consistently 5°C higher at each depth in 2010 than the previously recorded range for the same time in 2008. This anomalous temperature record likely is an indication of the strong conditions related to the 2009–2010 El Niño-Southern Oscillation climate pattern that reduces the upwelling of the subsurface equatorial countercurrent that typically decreases nearshore water temperatures at Howland Island. These warm temperatures were uncharacteristically consistent throughout the shallow water column (1–40 m), with daily mean temperatures recorded in waters at a depth of 37 m similar to values observed at a depth of 3 m.

Severe coral bleaching was seen at Howland Island (see next section for more on coral bleaching observations) during cruise HA-10-01, Leg 1. This bleaching likely was caused

by prolonged exposure of the corals to temperatures surpassing the bleaching threshold of 29.7°C and lowered salinity levels, which augmented the bleaching effects of high temperatures alone (Hoegh-Guldberg and Smith, 1989; Liu et al., 2005).

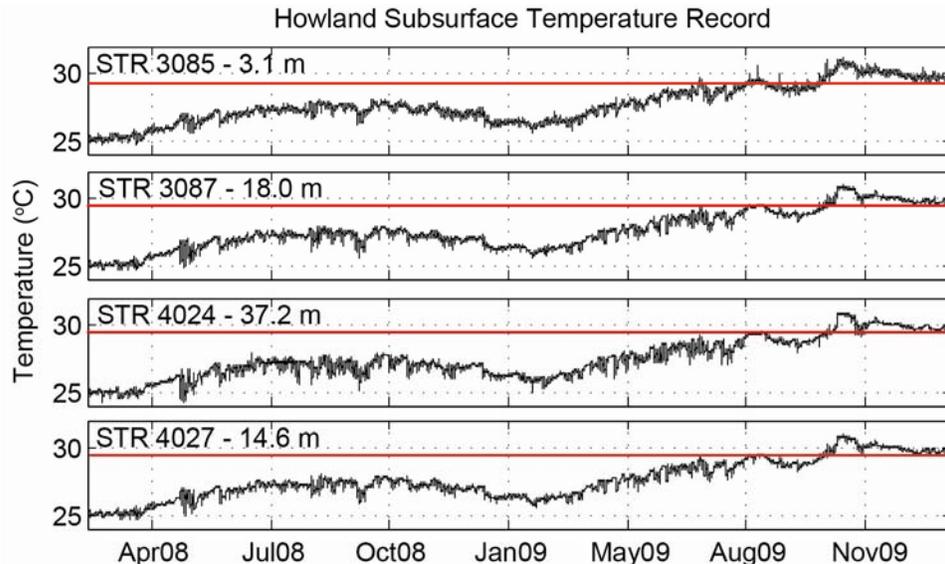


Figure C.1.4. Time-series observations of temperatures during the period from February 2008 to February 2010 collected from 4 STRs deployed at different locations and depths at Howland Island. The bleaching threshold, indicated by the red lines on this graph, was 29.7°C at Howland Island.

C.2. Benthic Environment

During cruise HA-10-01, Leg 1, CRED conducted Rapid Ecological Assessment (REA) benthic surveys, using the line-point-intercept and belt-transect methods, at 8 sites at Howland Island to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. C.2.1 and Table C.2.1). Microbial water and rubble samples were taken at 5 REA sites for a total of 6 microbial collections. The benthic team conducted a total of 48 individual scuba dives around Howland Island.

A total of 14 towed-diver surveys were completed at Howland Island, covering 25.8 km of ocean floor (Fig. C.2.2). Mean survey length was 1.8 km with a range of 1.5–2.6 km. The mean survey depth was 15.3 m with a range of 13.0–23.8 m. The mean temperature from data recorded during these surveys was 29.8°C with a range of 29.7°C–29.9°C.

At 5 REA sites, a total of 5 microbial water samples were taken. Additional microbial work included benthic grabs of coral rubble samples at 1 site and plankton tows at 2 locations. For a list of collections made at these REA sites, see Table E.1 in Appendix E: “Biological Collections.”

A total of 79 samples of 34 coral species were collected at 8 REA sites in support of the NOAA status review of 82 coral species in response to a petition by the Center of

Biological Diversity (CBD) to list them under the *Endangered Species Act* (ESA). For an ESA collections list, see Table E.2 in Appendix E.

At 5 select REA sites, an array of 5 CAUs was deployed for a total of 25 CAUs installed at Howland Island (Fig. C.1.2 and Table C.2.1). These CAU arrays, along with the units installed at Johnston Atoll and Baker Island during this cruise, were the first deployed by CRED. For more information about CAUs and the technique used to deploy them, see Appendix A: “Methods.”

A total of 9 autonomous reef monitoring structures (ARMS) were retrieved near 3 of the 5 REA sites where CAUs were deployed. In close proximity of each of these 3 sites, 3 new ARMS were deployed at the same (or nearly the same) positions occupied by the previous ARMS. For a list of REA sites, and their geographic coordinates, where ARMS were deployed at Howland Island, see Table C.2.1. Near one site, HOW-05, new ARMS were installed 100 m away from the location where the old ARMS were retrieved (new ARMS are located at REA site HOW-05, not HOW-05P).

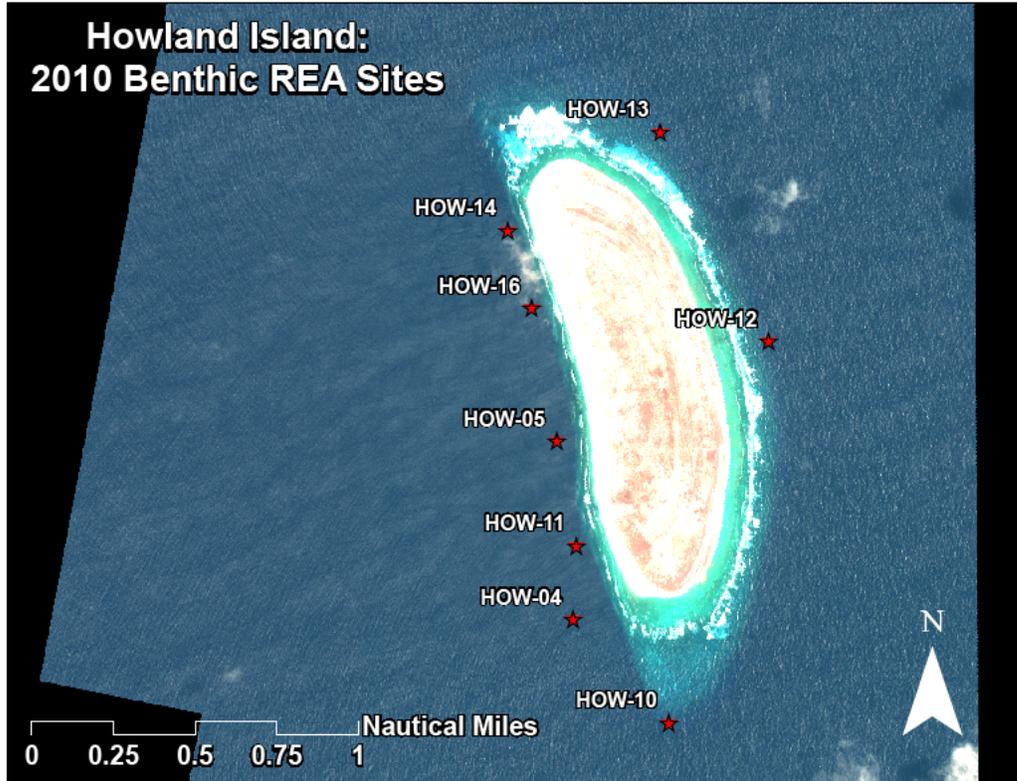


Figure C.2.1. Locations of REA benthic sites surveyed at Howland Island during cruise HA-10-01, Leg 1 (IKONOS Carterra Geo Data, 2000).

Table C.2.1. Summary of REA benthic surveys, deployments and retrievals of moored biological installations, and sample collections performed at REA sites at Howland Island during cruise HA-10-01, Leg 1. The line-point-intercept (LPI) method was used to estimate percentage of cover of algae, corals, and other invertebrates. Photoquadrat surveys (Photo) recorded digital images of benthos for later analysis of benthic cover. Roving-diver surveys of algae (Algae) were conducted if time permitted at the end of LPI surveys. Surveys of coral community structure and disease (Corals) were performed using the belt-transect method. Belt-transect surveys of other invertebrates were not conducted. This table does not include the coral specimens for taxonomic verification that were collected by U.S. Fish and Wildlife Service biologist James Maragos.

REA Site	Date	Latitude	Longitude	REA Surveys				Deployments and Retrievals		Sample Collections	
				LPI	Photo	Algae	Corals	CAUs	ARMS	Algae	Microbial Samples
HOW-14	3-Feb	0.81443	-176.62383	×	—	×	×	×	×	—	×
HOW-16	3-Feb	0.81098	-176.62285	×	×	×	×	—	—	—	—
HOW-11	4-Feb	0.79877	-176.62024	×	×	×	×	×	×	—	—
HOW-12	4-Feb	0.80918	-176.61066	×	×	—	×	×	—	—	×
HOW-13	4-Feb	0.81953	-176.61613	×	×	—	×	×	—	—	×
HOW-04	5-Feb	0.79513	-176.61870	×	×	—	×	—	—	—	×
HOW-05	5-Feb	0.80418	-176.62102	×	×	×	×	×	×	—	—
HOW-10	5-Feb	0.79000	-176.61597	×	×	×	×	—	—	—	×

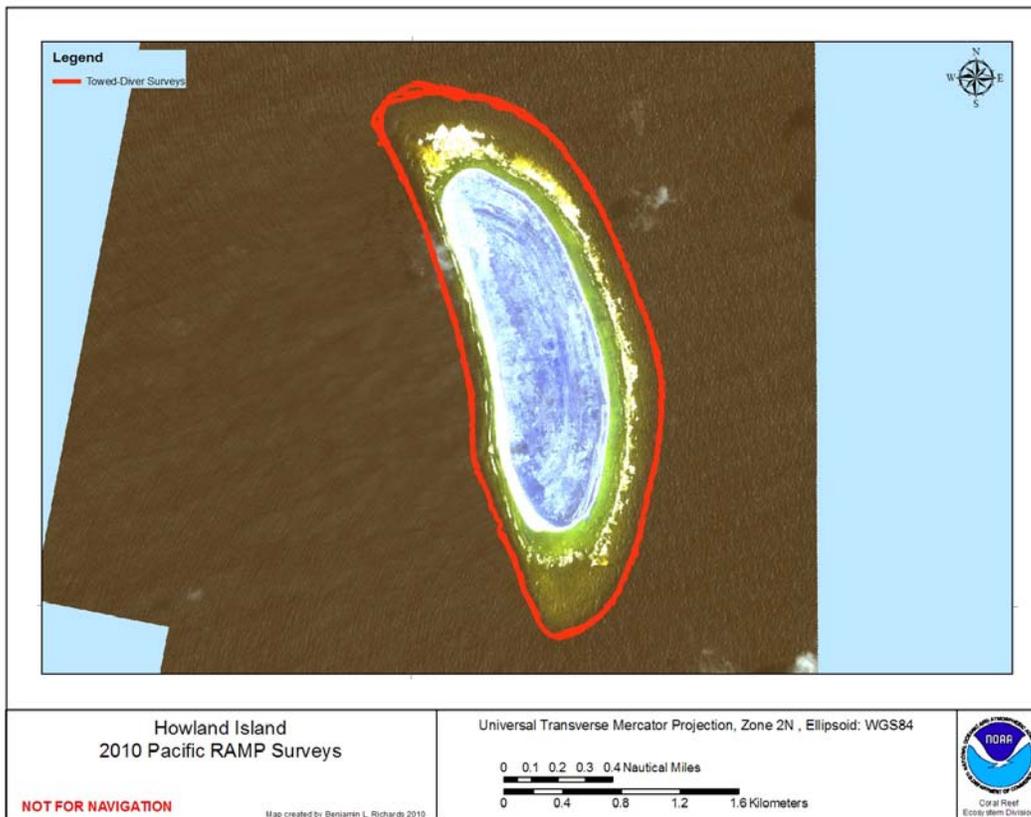


Figure C.2.2. Tracks of towed-diver surveys (fish and benthic) conducted at Howland Island during cruise HA-10-01, Leg1 (IKONOS Carterra Geo Data, 2000).

Preliminary Results: Coral Bleaching

Elevated water temperatures have severely impacted the coral reef communities surrounding Howland Island. CRED divers found widespread coral bleaching in excess of 33% at Howland Island, with greater prevalence values recorded along the north, east, and south shores compared to the western reefs. Overall, no substantial differences in bleaching patterns and prevalence were observed between Howland and Baker Islands. Branching and table corals (e.g., *Acropora* spp.) appeared to be more affected by this bleaching episode than did massive corals at the time of these observations.

C.3. Reef Fish Community

During cruise HA-10-01, Leg 1, CRED conducted REA fish surveys, using a stratified random design and stationary-point-count method, at 16 REA sites at Howland Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig. C.3.1 and Table C.3.1). The fish team made no collection efforts at Howland Island.

In addition, CRED completed 14 towed-diver surveys at Howland Island as described in Section C.2 of this report (Fig. C.2.2).

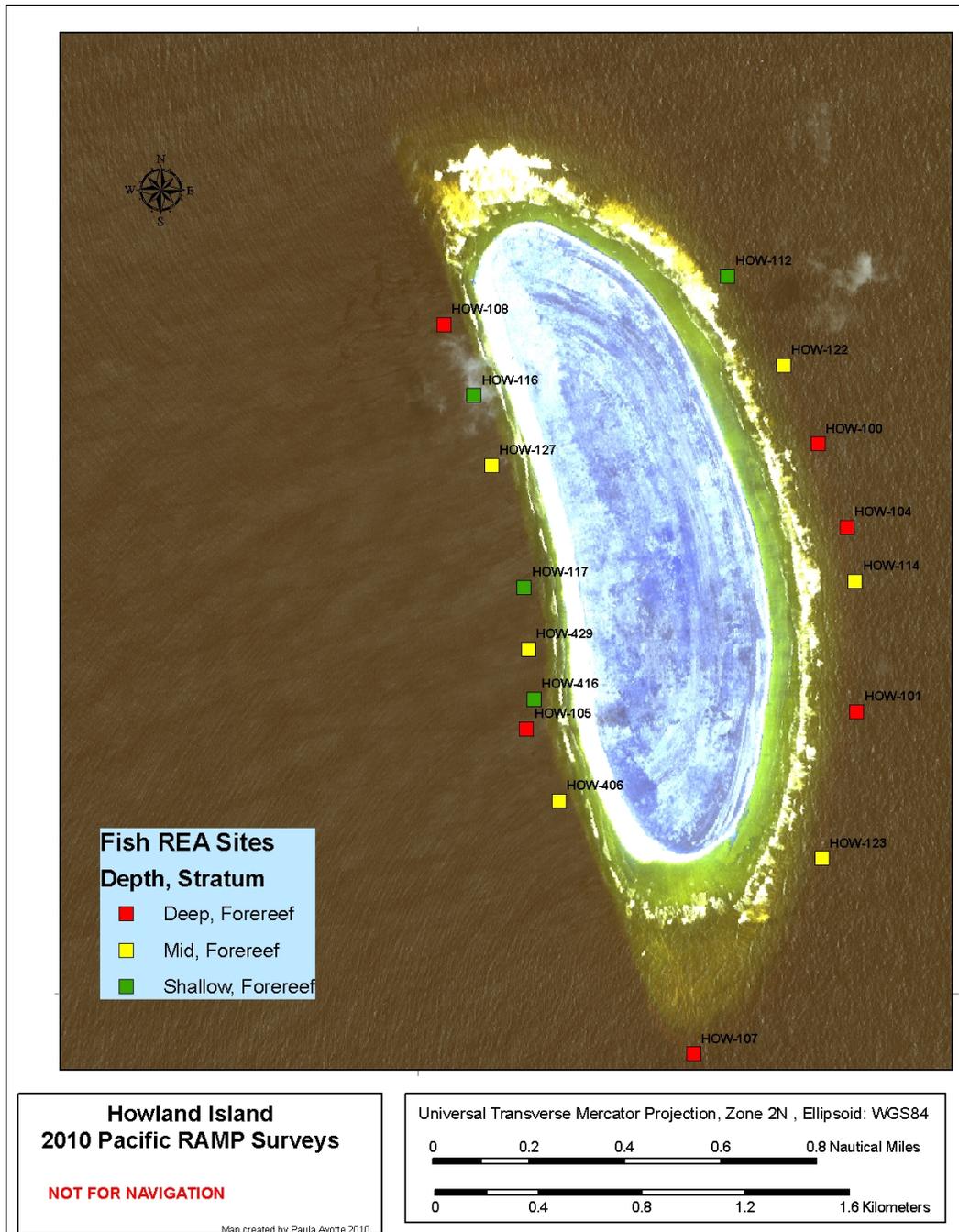


Figure C.3.1. Locations of REA fish sites surveyed around Howland Island during cruise HA-10-01, Leg 1. All of these REA sites were selected using a stratified random design (IKONOS Carterra Geo Data, 2000).

Table C.3.1. Summary of sites where REA fish surveys were conducted around Howland Island during cruise HA-10-01, Leg 1.

REA Site	Date	Depth, Stratum Descriptions	Depth (m)	Latitude	Longitude
HOW-100	04-Feb	Deep, Forereef	22	0.81117	-176.61102
HOW-101	05-Feb	Deep, Forereef	24	0.80149	-176.6097
HOW-104	04-Feb	Deep, Forereef	22	0.80846	-176.61009
HOW-105	03-Feb	Deep, Forereef	21	0.8009	-176.6212
HOW-107	05-Feb	Deep, Forereef	22	0.78957	-176.61537
HOW-108	03-Feb	Deep, Forereef	20	0.81498	-176.62407
HOW-112	04-Feb	Shallow, Forereef	5	0.81667	-176.61421
HOW-114	04-Feb	Moderate, Forereef	12	0.80604	-176.60976
HOW-116	05-Feb	Shallow, Forereef	3	0.81251	-176.62303
HOW-117	03-Feb	Shallow, Forereef	4	0.80582	-176.62128
HOW-122	04-Feb	Moderate, Forereef	14	0.81356	176.61226
HOW-123	04-Feb	Moderate, Forereef	13	0.79638	-176.61092
HOW-127	03-Feb	Moderate, Forereef	13	0.81008	-176.62241
HOW-406	03-Feb	Moderate, Forereef	12	0.79838	176.62007
HOW-416	05-Feb	Shallow, Forereef	4	0.80193	-176.62093
HOW-429	05-Feb	Moderate, Forereef	14	0.80368	-176.62112

C.4. References

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APPENDIX D: BAKER ISLAND

Baker Island is an uninhabited island located at 0°12' N, 176°29' W in the central Pacific and is part of the Pacific Remote Islands Marine National Monument. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

In addition to the activities described in this appendix, a U.S. Fish and Wildlife Service field party went ashore to Baker Island during HA-10-01, Leg 1, to conduct surveys of terrestrial flora and fauna.

D.1. Oceanography and Water Quality

Oceanographic operations during cruise HA-10-01, Leg 1, at Baker Island entailed numerous retrievals and deployments of oceanographic moored instruments, installation of calcification acidification units (CAUs), nearshore water sampling and conductivity, temperature, and depth (CTD) casts around this island to depths of ~ 30 m or to the depths of Rapid Ecological Assessment (REA) sites, shipboard water sampling and CTD casts offshore to a depth of 500 m, and acoustic Doppler current profiler (ADCP) transect lines.

For long-term monitoring, subsurface temperature recorders (STRs) were retrieved and deployed where possible around Baker Island, including 4 retrievals and 5 deployments (Fig. D.1.1). On the southeast side of Baker Island, CRED retrieved one ocean data platform (ODP), which included a Sea-Bird Electronics Inc. (Bellevue, Wash.) SBE 37 MicroCAT conductivity and temperature recorder and an acoustic Doppler profiler (ADP) from SonTek/YSI (San Diego, Calif.) for measuring full-depth current information. Additionally, the oceanography team retrieved 2 sea-surface temperature (SST) buoy anchors and associated mooring lines, which were left behind during past visits because of inclement weather (Fig. D.1.1 and Table D.1.1). For information about CAU deployments completed at Baker Island, see Figure D.1.2 and Section D.2: “Benthic Environment.”

A total of 13 shallow-water CTD casts were performed at nearshore locations around Baker Island (Fig. D.1.2), including a cast at each of the 4 REA sites where CAUs were installed and a series of casts around this island at depths of ~ 30 m at regular horizontal intervals. In concert with the CTD cast at each of those 4 REA sites, 2 water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), salinity, and nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 8 DIC, 8 salinity, 8 nutrient, and 8 Chl-*a* water samples were collected, 1 from the surface and 1 near the reef at each site.

Deepwater CTD casts were conducted from the NOAA Ship *Hi`ialakai* to a depth of 500 m, 8 to the east and 8 to the west of Baker Island (Fig. D.1.3), with shipboard ADCP lines run to the east and west of Baker Island over 2 nights. Total length of ADCP

transect lines was ~ 40 km. In conjunction with these shipboard CTD casts, a total of 84 water samples, 42 nutrient and 42 Chl-*a*, were collected near Baker Island. These water samples were collected concurrently with CTD casts 47, 49, 51, and 53 to the east of Baker Island and casts 55, 57, 59, and 61 to the west.

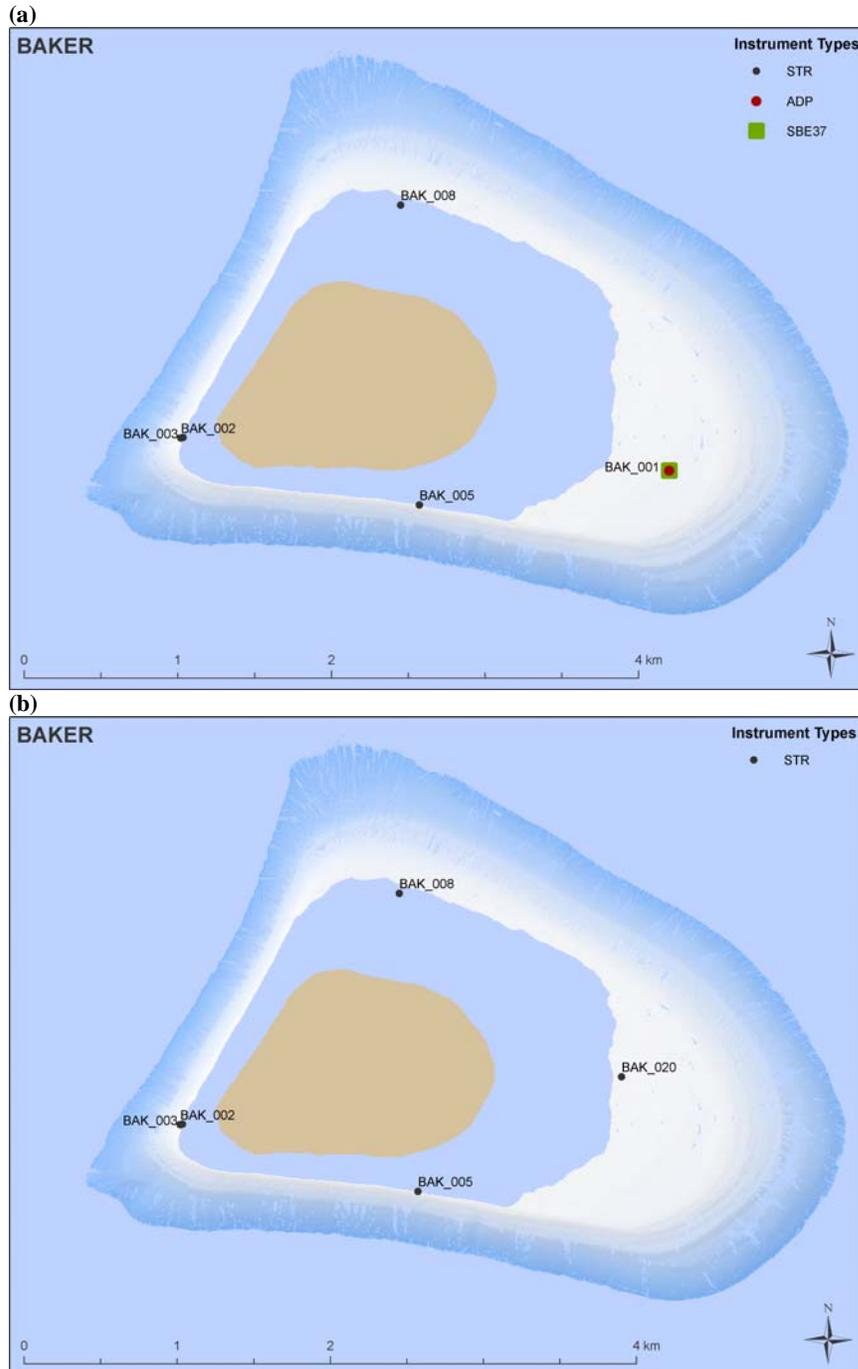


Figure D.1.1. Moored oceanographic instruments (a) retrieved and (b) deployed at Baker Island during cruise HA-10-01, Leg 1.

Table D.1.1. Geographic coordinates and sensor depths of the moored oceanographic instruments that were retrieved or deployed at Baker Island during cruise HA-10-01, Leg 1.

Mooring Site	Instrument Type	Latitude	Longitude	Sensor Depth (m)
Retrievals				
BAK-001	ADP	0.18985002	-176.4601508	20.1
BAK-001	SBE 37	0.18985002	-176.4601508	20.1
BAK-002	STR	0.19176328	-176.4887229	18.6
BAK-003	STR	0.19179731	-176.4885983	5.2
BAK-005	STR	0.18783443	-176.4747583	5.5
BAK-008	STR	0.20538504	-176.4758678	17.4
Deployments				
BAK-002	STR	0.19176328	-176.4887229	18.6
BAK-003	STR	0.19179731	-176.4885983	9.1
BAK-005	STR	0.18783443	-176.4747583	5.5
BAK-008	STR	0.20538504	-176.4758678	17.4
BAK-020	STR	0.19458773	-176.4628085	11.3

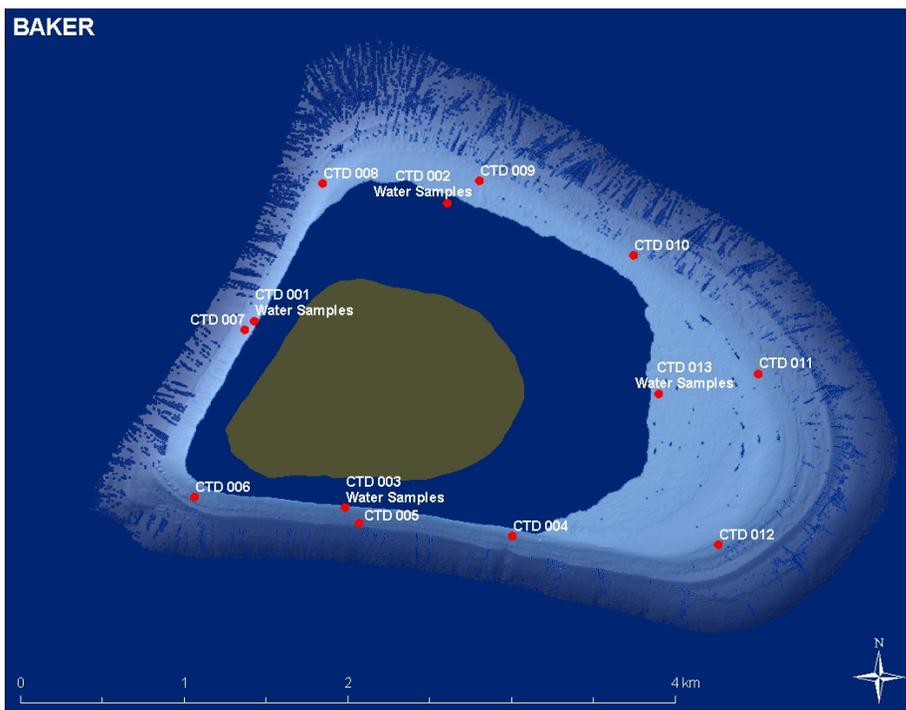


Figure D.1.2. Locations of shallow-water CTD casts performed around Baker Island during cruise HA-10-01, Leg 1. At 4 of these cast locations, water samples were collected and CAUs were deployed.

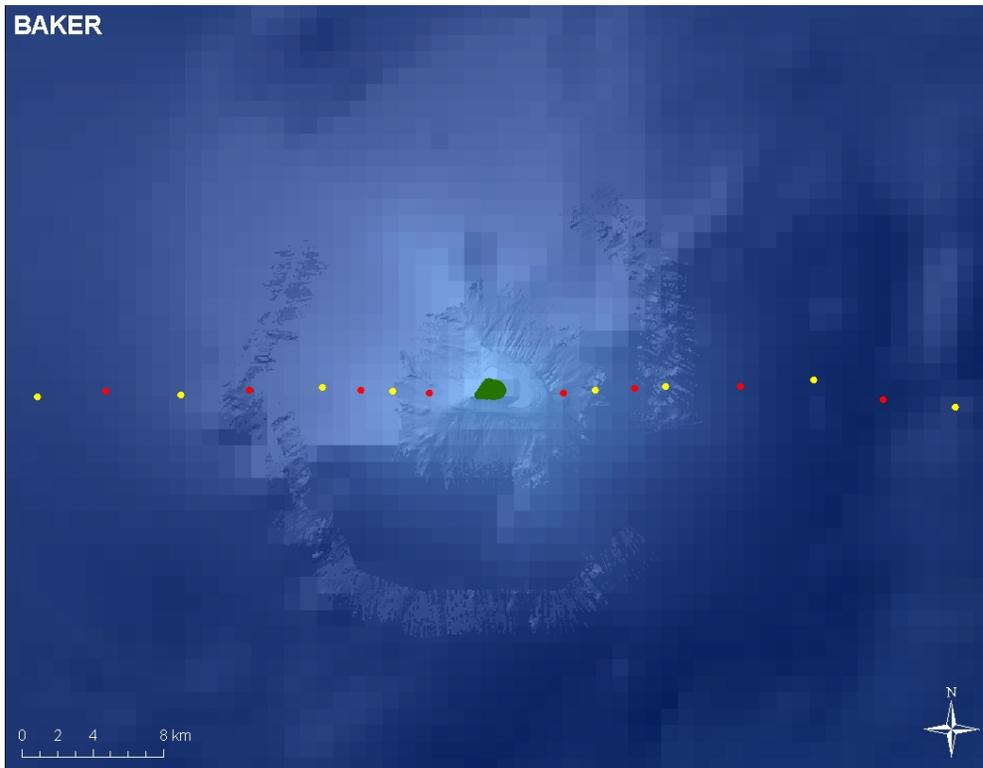


Figure D.1.3. Locations of deepwater CTD casts conducted at Baker Island from the NOAA Ship *Hi'ialakai* to a depth of 500 m. Shipboard water samples for analyses of nutrient and Chl-*a* concentrations were collected in concert with the casts conducted at the 8 locations displayed in red. Satellite data: SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997). © 2008 The Regents of the University of California. All Rights Reserved.

Preliminary Results: Temperature

Temperature data from 5 locations around Baker Island were obtained with 4 STRs and 1 ODP (Figs. D.1.4 and D.1.5). The lowest water temperature ($\sim 25^{\circ}\text{C}$) recorded in the last 2 years by the in situ temperature loggers on these instruments, was observed in February 2008. Since this time, temperatures have risen steadily through the summer of 2009 and winter of 2010. The in situ data from these 5 instruments shows that temperatures generally increase through the boreal summer and drop to a typical low of 25°C in January or February, although this island's location near the equator means that seasonal fluctuations are less obvious at Baker Island than at islands at higher latitudes. This year, however, temperatures around this island were consistently 5°C higher than the range recorded for the same month in 2009.

In addition, between October 27 and November 5, 2009, salinity values recorded by the ODP at Baker Island fell from 35.61 to 34.45 psu, coinciding with the peak in temperatures in October 2009. These uncharacteristic temperature and salinity records likely were directly related to the 2009–2010 El Niño-Southern Oscillation climate pattern, which reduced the upwelling of the subsurface equatorial countercurrent that typically decreases water temperatures at Baker Island. These warm temperatures were unusually consistent throughout the shallow water column (1–30 m), with daily mean temperatures recorded in waters at a depth of 20 m similar to values recorded at a depth

of 3 m. This pattern is consistent with observations from Howland Island, with similar temperatures measured as deep as 38 m.

Severe coral bleaching was seen at Baker Island (see next section for more on coral bleaching observations) during cruise HA-10-01, Leg 1. This bleaching likely was caused by prolonged exposure of the corals to temperatures surpassing the bleaching threshold of 29.7°C and lowered salinity levels, which augmented the bleaching effects of high temperatures alone (Hoegh-Guldberg and Smith, 1989; Liu et al., 2006).

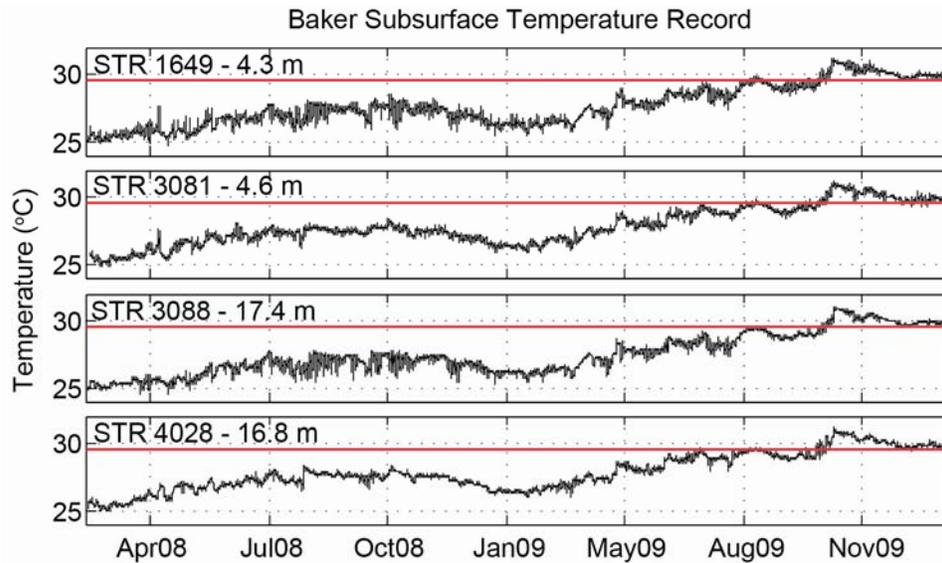


Figure D.1.4. Time-series observations of temperatures during the period from February 2008 to February 2010 collected from 4 STRs deployed at different locations and depths at Baker Island. The bleaching threshold, indicated by the red lines on this graph, was 29.7°C at Baker Island.

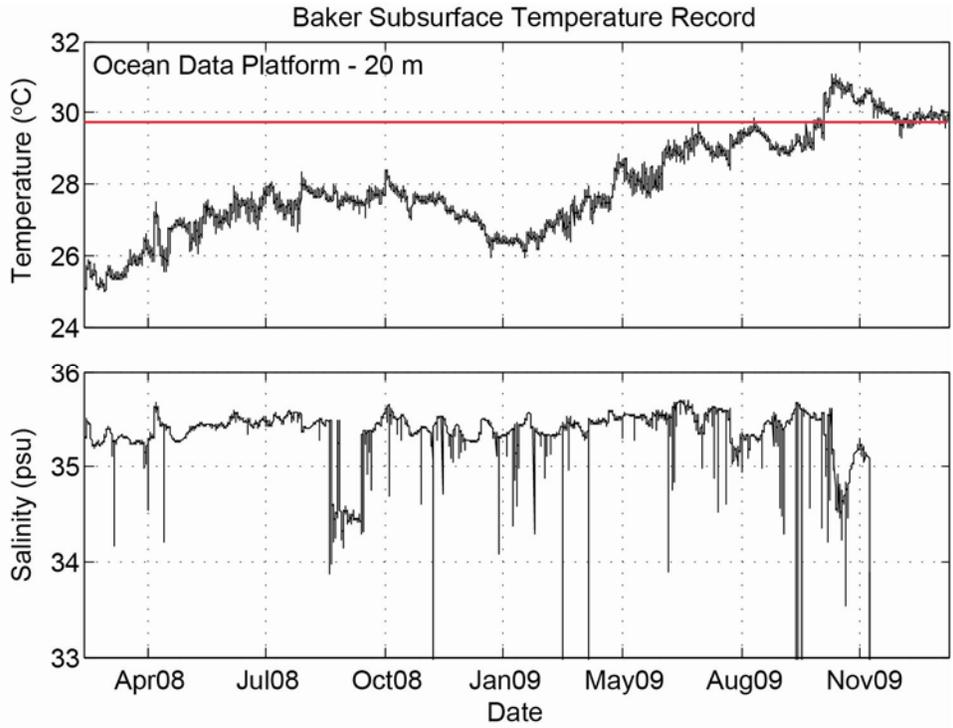


Figure D.1.5. Time-series observations of temperature and salinity values during the period from February 2008 to February 2010 collected from an ODP deployed at a depth of 20 m at Baker Island. The bleaching threshold, indicated by the red line on the top graph above, was 29.7°C at Baker Island.

D.2. Benthic Environment

During cruise HA-10-01, Leg 1, CRED conducted Rapid Ecological Assessment (REA) benthic surveys, using the line-point-intercept and belt-transect methods, at 8 sites at Baker Island to assess coral and algal community structure and disease, and benthic composition (Table D.2.1 and Fig. D.2.1). The benthic team conducted a total of 45 individual scuba dives around Baker Island.

A total of 11 towed-diver surveys were completed at Baker Island, covering 22.8 km of ocean floor (Fig. D.2.2). Mean survey length was 2.1 km with a range of 1.6–2.9 km. The mean survey depth was 13.7 m with a range of 8.3–16.6 m. The mean temperature from data recorded during these surveys was 29.8°C with a range of 29.8–29.9°C.

Various samples were collected at 8 REA sites: 2 voucher specimens of algae at 2 REA sites, 2 collections of non-coral macroinvertebrates at 2 sites, and 5 total microbial water samples at 5 sites. Additional microbial work included benthic grabs of coral rubble and macroalgal samples at 1 site and plankton tows at 2 locations. For a list of collections made at these REA sites, see Table E.1 in Appendix E: “Biological Collections.”

A total of 33 samples of 15 coral species were collected at 5 REA sites in support of the NOAA status review of 82 coral species in response to a petition by the Center of Biological Diversity (CBD) to list them under the *Endangered Species Act* (ESA). For an ESA collections list, see Table E.2 in Appendix E.

At each of 4 select REA sites, an array of 5 calcification acidification units (CAUs) were deployed for a total of 20 CAUs installed at Baker Island (Fig. D.1.2 and Table D.2.1). These CAU arrays, along with the units installed at Johnston Atoll and Howland Island during this cruise, were the first deployed by CRED. For more information about CAUs and the technique used to deploy them, see Appendix A: “Methods.”

A total of 6 autonomous reef monitoring structures (ARMS) were retrieved near 2 of the 4 REA sites where CAUs were deployed. Near one of these same REA sites, 3 new ARMS were deployed at the same positions occupied by previous ARMS. No ARMS were installed at the other ARMS retrieval site, BAK-14, which often suffers from heavy surge. Instead, 3 new ARMS were deployed near BAK-16, which was selected as a new ARMS location. For a list of REA sites, and their geographic coordinates, near where ARMS were retrieved and deployed at Baker Island, see Table D.2.1.

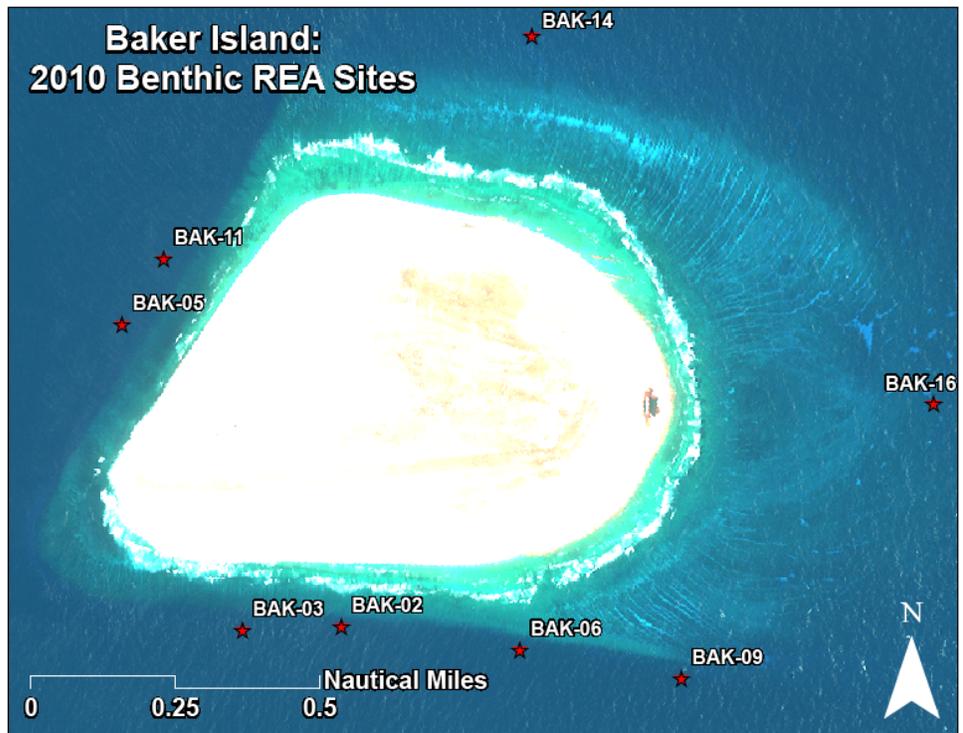


Figure D.2.1. Locations of REA benthic sites surveyed at Baker Island during cruise HA-10-01, Leg 1 (IKONOS Carterra Geo Data, 2000).

Table D.2.1. Summary of REA benthic surveys, deployments and retrievals of moored biological installations, and sample collections performed at REA sites at Baker Island during cruise HA-10-01, Leg 1. The line-point-intercept (LPI) method was used to estimate percentage of cover of algae, corals, and other invertebrates. Photoquadrat surveys (Photo) recorded digital images of benthos for later analysis of benthic cover. Roving-diver surveys of algae (Algae) were conducted if time permitted at the end of LPI surveys. Surveys of coral community structure and disease (Corals) were performed using the belt-transect method. Belt-transect surveys of other invertebrates were not conducted. This table does not include the coral specimens for taxonomic verification that were collected by U.S. Fish and Wildlife Service biologist James Maragos.

REA Site	Date	Latitude	Longitude	REA Surveys				Deployments and Retrievals		Sample Collections	
				LPI	Photo	Algae	Corals	CAUs	ARMS	Algae	Microbial Samples
BAK-02	6-Feb	0.18832	-176.48033	×	×	—	×	×	—	—	×
BAK-06	6-Feb	0.18768	-176.47472	—	×	—	×	—	—	—	×
BAK-14	6-Feb	0.20501	-176.47456	×	×	—	×	×	×	×	—
BAK-05	7-Feb	0.19688	-176.48590	×	×	—	×	—	—	—	—
BAK-03	7-Feb	0.18865	-176.48294	×	×	—	×	—	—	—	—
BAK-11	7-Feb	0.19913	-176.48465	×	×	—	×	×	×	—	×
BAK-09	8-Feb	0.18680	-176.47000	×	×	×	×	—	—	—	×
BAK-16	8-Feb	0.19458	-176.46278	×	×	—	×	×	×	—	×



Figure D.2.2. Tracks of towed-diver surveys (fish and benthic) conducted at Baker Island during cruise HA-10-01, Leg1 (IKONOS Carterra Geo Data, 2000).

Preliminary Results: Coral Bleaching

Elevated water temperatures have severely impacted the coral reef communities surrounding Baker Island. CRED divers found widespread coral bleaching in excess of 35% at Baker Island, with greater prevalence values recorded along the eastern shelf compared to the western and southern reefs. Overall, no substantial differences in bleaching patterns and prevalence were observed between Howland and Baker Islands. Branching and table corals (*Pocillopora* spp. and *Acropora* spp.) appeared to be more affected by this bleaching episode than did massive corals at the time of these observations.

D.3. Reef Fish Community

During cruise HA-10-01, Leg 1, CRED conducted REA fish surveys, using a stratified random design and stationary-point-count method, at 21 REA sites at Baker Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig. D.3.1 and Table D.3.1). The fish team made no collection efforts at Baker Island.

In addition, CRED completed 11 towed-diver surveys at Baker Island as described in Section D.2 of this report (Fig. D.2.2).

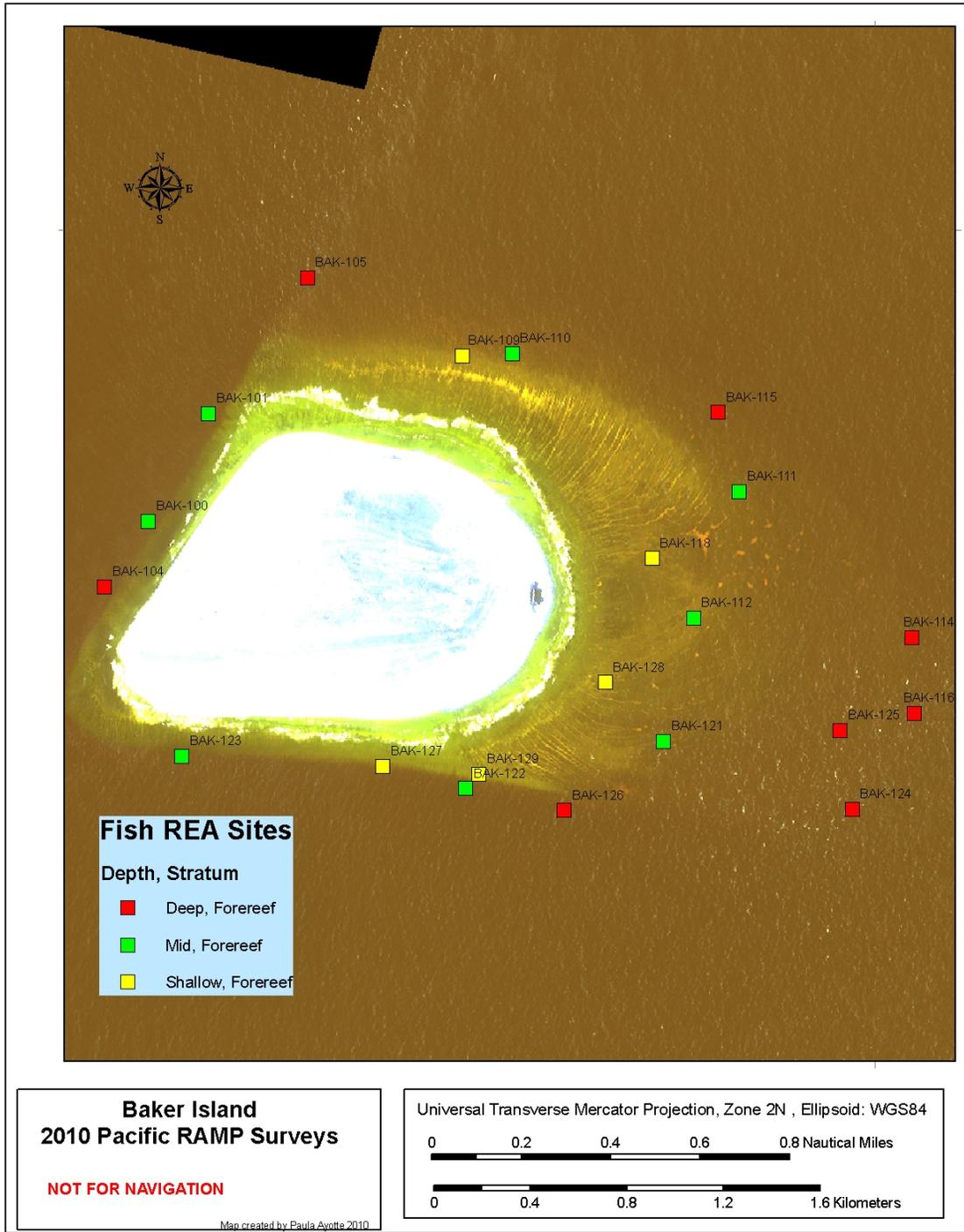


Figure D.3.1. Locations of REA fish sites surveyed around Baker Island during cruise HA-10-01, Leg 1. All of these REA sites were selected using a stratified random design (IKONOS Carterra Geo Data, 2000).

Table D.3.1. Summary of REA fish survey sites around Baker Island during cruise HA-10-01, Leg 1.

REA Site	Date	Depth, Stratum Descriptions	Depth (m)	Latitude	Longitude
BAK-100	08-Feb	Moderate, Forereef	14	0.19746	-176.4854
BAK-101	08-Feb	Moderate, Forereef	13	0.20148	-176.4832
BAK-104	08-Feb	Deep, Forereef	24	0.19501	-176.4871
BAK-105	07-Feb	Deep, Forereef	22	0.20655	-176.4795
BAK-109	07-Feb	Shallow, Forereef	5	0.20364	-176.4737
BAK-110	07-Feb	Moderate, Forereef	10	0.20372	-176.4719
BAK-111	06-Feb	Moderate, Forereef	10	0.19856	-176.4634
BAK-112	07-Feb	Moderate, Forereef	6	0.19385	-176.4651
BAK-114	07-Feb	Deep, Forereef	23	0.19311	-176.4569
BAK-115	07-Feb	Deep, Forereef	22	0.20153	-176.4642
BAK-116	06-Feb	Deep, Forereef	19	0.19029	-176.4569
BAK-118	07-Feb	Shallow, Forereef	6	0.19607	-176.4666
BAK-121	06-Feb	Moderate, Forereef	9	0.18924	-176.4662
BAK-122	07-Feb	Moderate, Forereef	13	0.18747	-176.4736
BAK-123	07-Feb	Moderate, Forereef	14	0.18868	-176.4842
BAK-124	06-Feb	Deep, Forereef	27	0.1867	-176.4592
BAK-125	06-Feb	Deep, Forereef	21	0.18964	-176.4596
BAK-126	06-Feb	Deep, Forereef	21	0.18666	-176.4699
BAK-127	06-Feb	Shallow, Forereef	3	0.18831	-176.4767
BAK-128	06-Feb	Shallow, Forereef	5	0.19144	-176.4684
BAK-129	06-Feb	Shallow, Forereef	4	0.18802	-176.4731

D.4. References

Hoegh-Guldberg, O., and G. J. Smith.

1989. The effect of sudden changes in temperature, light and salinity on the population-density and export of zooxanthellae from the reef corals *Stylophora pistillata* Esper and *Seriatopora hystrix* Dana. J. Exp. Mar. Biol. Ecol. 129:279–303.

Liu, G., A. E. Strong, W. Skirving, and L. F. Arzayus.

2006. Overview of NOAA Coral Reef Watch program's near-real time satellite global coral bleaching monitoring activities. Proceedings of the 10th International Coral Reef Symposium, June 28–July 2, 2004, Okinawa, Japan, Session Number 1:1783–1793.

APPENDIX E: BIOLOGICAL COLLECTIONS

Biological samples were collected at Johnston Atoll, Howland Island, Baker Island, and their surrounding waters for multiple research purposes. A complete listing of these collections are presented here in Table E.1, excluding targeted coral diversity collections by U.S. Fish and Wildlife Service biologist James Maragos; these coral samples are reported in this appendix in Table E.2.

Table E.1. Biological samples collected around Johnston Atoll, Howland Island, and Baker Island during cruise HA-10-01, Leg 1, January 21–February 14, 2010.

REA Site	Island	Date	Latitude	Longitude	Specimen Collected	Depth (m)
Algal Collections: Voucher Specimens						
JOH-15	Johnston	25-Jan	16.78358	-169.49004	<i>Halimeda taenicola</i>	13
JOH-15	Johnston	25-Jan	16.78358	-169.49004	<i>Chrysymenia</i> sp.	13
JOH-06	Johnston	28-Jan	16.69820	-169.48557	<i>Caulerpa racemosa</i>	17
JOH-08	Johnston	29-Jan	16.73192	-169.47969	<i>Caulerpa racemosa</i>	10
JOH-08	Johnston	29-Jan	16.73192	-169.47969	<i>Caulerpa cupressoides</i>	10
JOH-08	Johnston	29-Jan	16.73192	-169.47969	<i>Caulerpa serrulata</i>	10
JOH-07	Johnston	29-Jan	16.71155	-169.47972	<i>Caulerpa taxifolia</i>	18
BAK-14	Baker	6-Feb	0.20501	-176.47456	<i>Halimeda fragilis</i>	17
BAK-14	Baker	6-Feb	0.20501	-176.47456	<i>Halimeda</i> sp.	17
Non-coral Invertebrate Collections						
JOH-15	Johnston	25-Jan	16.78358	-169.49004	<i>Ophiocoma pica</i>	13
JOH-15	Johnston	25-Jan	16.78358	-169.49004	<i>Linckia multifora</i>	13
JOH-16	Johnston	25-Jan	16.78760	-169.47322	<i>Holothuria whitmaei</i>	15
JOH-18	Johnston	26-Jan	16.73092	-169.53964	<i>Linckia multifora</i>	10
JOH-06	Johnston	26-Jan	16.69820	-169.48557	<i>Holothuria</i> sp.	15
BAK-09	Baker	8-Feb	0.18680	-176.47000	<i>Linckia multifora</i>	34
BAK-16	Baker	8-Feb	0.19458	-176.46278	<i>Ophiocoma pica</i>	1
Microbial Collections: Water Samples, Coral Rubble, and Macroalgae						
JOH-09	Johnston	24-Jan	16.72862	-169.48570	20-L water sample	12
JOH-16	Johnston	25-Jan	16.78760	-169.47322	20-L water sample	15
JOH-12	Johnston	26-Jan	16.74753	-169.52397	coral rubble, ~ 70-L water sample	10
JOH-10	Johnston	27-Jan	16.76330	-169.51195	20-L water sample	15
JOH-11	Johnston	27-Jan	16.72154	-169.52432	20-L water sample	14
JOH-06	Johnston	28-Jan	16.69820	-169.48557	20-L water sample	16
JOH-07	Johnston	29-Jan	16.71155	-169.47972	20-L water sample	17
HOW-14	Howland	3-Feb	0.81443	-176.62383	coral rubble, ~ 70-L water sample	12
HOW-12	Howland	4-Feb	0.80918	-176.61066	20-L water sample	15
HOW-13	Howland	4-Feb	0.81953	-176.61613	20-L water sample	14
HOW-10	Howland	5-Feb	0.79000	-176.61597	20-L water sample	16
HOW-04	Howland	5-Feb	0.79513	-176.61870	20-L water sample	16
BAK-02	Baker	6-Feb	0.18832	-176.48033	20-L water sample	16
BAK-06	Baker	6-Feb	0.18768	-176.47472	20-L water sample	15
BAK-11	Baker	7-Feb	0.19913	-176.48465	coral rubble, ~ 70-L water sample, unidentified macroalgae	12

REA Site	Island	Date	Latitude	Longitude	Specimen Collected	Depth (m)
BAK-09	Baker	8-Feb	0.18680	-176.47000	20-L water sample	16
BAK-16	Baker	8-Feb	0.19458	-176.46278	20-L water sample	13
Coral Disease Collections						
JOH-18	Johnston	26-Jan	16.73092	-169.53964	<i>Montipora</i> sp	12
JOH-18	Johnston	26-Jan	16.73092	-169.53964	<i>Montipora</i> sp	12
JOH-18	Johnston	26-Jan	16.73092	-169.53964	<i>Montipora</i> sp	12
JOH-10	Johnston	26-Jan	16.76330	-169.51195	<i>Montipora</i> sp	44
JOH-10	Johnston	26-Jan	16.76330	-169.51195	<i>Montipora</i> sp	44
JOH-10	Johnston	26-Jan	16.76330	-169.51195	<i>Montipora</i> sp	44
JOH-10	Johnston	26-Jan	16.76330	-169.51195	<i>Montipora</i> sp	44
JOH-10	Johnston	26-Jan	16.76330	-169.51195	<i>Montipora</i> sp	44
JOH-10	Johnston	26-Jan	16.76330	-169.51195	<i>Montipora</i> sp	44
JOH-11	Johnston	26-Jan	16.72154	-169.52432	<i>Montipora</i> sp	40
JOH-11	Johnston	26-Jan	16.72154	-169.52432	<i>Montipora</i> sp	40
JOH-11	Johnston	26-Jan	16.72154	-169.52432	<i>Montipora</i> sp	40
JOH-11	Johnston	26-Jan	16.72154	-169.52432	<i>Montipora</i> sp	40
JOH-11	Johnston	26-Jan	16.72154	-169.52432	<i>Montipora</i> sp	40
JOH-11	Johnston	26-Jan	16.72154	-169.52432	<i>Montipora</i> sp	40
JOH-11	Johnston	26-Jan	16.72154	-169.52432	<i>Montipora</i> sp	40
JOH-07	Johnston	29-Jan	16.71155	-169.47972	<i>Montipora</i> sp	50
JOH-07	Johnston	29-Jan	16.71155	-169.47972	<i>Montipora</i> sp	50
Fish Collections						
JOH-08	Johnston	29-Jan	16.73182	-169.47962	<i>Ctenochaetus strigosus</i>	10
JOH-08	Johnston	29-Jan	16.73182	-169.47962	<i>Ctenochaetus strigosus</i>	10
JOH-08	Johnston	29-Jan	16.73182	-169.47962	<i>Ctenochaetus strigosus</i>	10
JOH-08	Johnston	29-Jan	16.73182	-169.47962	<i>Dascyllus albisella</i>	10
JOH-08	Johnston	29-Jan	16.73182	-169.47962	<i>Dascyllus albisella</i>	10
JOH-08	Johnston	29-Jan	16.73182	-169.47962	<i>Dascyllus albisella</i>	10
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Abudefduf sordidus</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Chaetodon auriga</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Chaetodon auriga</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Ctenochaetus strigosus</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Ctenochaetus strigosus</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Ctenochaetus strigosus</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Dascyllus albisella</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Dascyllus albisella</i>	13
JOH-10	Johnston	29-Jan	16.76375	-169.51203	<i>Dascyllus albisella</i>	13
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Chaetodon auriga</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Chaetodon auriga</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Chaetodon auriga</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Ctenochaetus strigosus</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Ctenochaetus strigosus</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Ctenochaetus strigosus</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Dascyllus albisella</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Dascyllus albisella</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Dascyllus albisella</i>	10
JOH-12	Johnston	29-Jan	16.74728	-169.52397	<i>Parupeneus multifasciatus</i>	10

Table E.2. Number of coral samples, by species and island, collected by U.S. Fish and Wildlife Service biologist James Maragos around Johnston Atoll, Howland Island, and Baker Island during cruise HA-10-01, Leg 1, January 21–February 14, 2010.

Sampled Coral Species	Johnston Atoll	Howland Island	Baker Island	Totals by Species
<i>Acropora cf. cerealis</i>	8	1	1	10
<i>Acropora cytherea</i>	2	–	2	4
<i>Acropora humilis-gemmifera</i>	4	1	1	6
<i>Acropora muricata</i>	–	1	5	6
<i>Acropora paniculata</i>	4	–	–	4
<i>Acropora retusa-samoensis</i>	1	–	–	1
<i>Acropora loripes (rosaria)</i>	1	1	–	2
<i>Acropora</i> sp. [Line and Phoenix]	–	6	–	6
<i>Acropora valida</i>	4	1	3	8
<i>Distichopora cf. violacea</i>	3	–	–	3
<i>Favia stelligera</i>	–	3	–	3
<i>Isopora brueggemanni</i>	3	–	–	3
<i>Leptoseris mycetoseroides</i>	–	3	–	3
<i>Leptastrea pruinosa</i>	–	3	–	3
<i>Leptastrea</i> sp.	–	1	–	1
<i>Millepora dichotoma</i>	3	–	–	3
<i>Montipora aequituberculata</i>	–	4	3	7
<i>Montipora caliculata</i>	–	–	1	1
<i>Montipora capitata</i>	4	–	–	4
<i>Montipora efflorescens</i>	–	4	–	4
<i>Montipora flabellata</i>	3	–	–	3
<i>Montipora hoffmeisteri</i>	4	–	–	4
<i>Montipora cf. incrassate</i>	7	–	–	7
<i>Montipora monasteriata</i>	–	1	–	1
<i>Montipora patula</i>	5	–	–	5
<i>Montipora verrilli</i>	3	–	–	3
<i>Pavona chiriquiensis</i>	–	2	2	4
<i>Pavona clavus</i>	–	2	–	2
<i>Pavona duerdeni</i>	4	–	–	4
<i>Pavona explanulata</i>	–	1	–	1
<i>Pavona maldivensis</i>	10	3	–	13
<i>Pavona minuta</i>	–	1	–	1
<i>Pavona varians</i>	3	1	–	4
<i>Pocillopora brevicornis</i>	–	1	–	1
<i>Pocillopora damicornis</i>	2	–	–	2
<i>Pocillopora eydouxi</i>	8	2	3	13
<i>Pocillopora eydouxi-meandrina</i>	1	–	–	1
<i>Pocillopora ligulata</i>	1	4	–	5
<i>Pocillopora meandrina</i>	3	2	5	10
<i>Pocillopora molokensis</i>	–	2	–	2
<i>Pocillopora verrucosa</i>	–	1	–	1
<i>Pocillopora zelli</i>	–	3	–	3
<i>Porites australiensis</i>	–	5	–	5

Sampled Coral Species	Johnston Atoll	Howland Island	Baker Island	Totals by Species
<i>Porites evermanni</i>	1	–	–	1
<i>Porites lobata</i>	8	3	2	13
<i>Porites lobata-stephensoni</i>	–	2	1	3
<i>Porites lutea</i>	–	3	–	3
<i>Porites stephensoni</i>	–	2	–	2
<i>Porites vauhani</i>	–	4	2	6
<i>Psammocora nierstraszi</i>	–	4	–	4
<i>Psammocora haimeana</i>	–	–	1	1
<i>Tubastraea</i> sp. 1	–	1	–	1
<i>Tubastraea</i> sp. 2	–	–	1	1
Totals by Island (53 species)	100	79	33	212