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CRUISE REPORT[1]

VESSEL: NOAA Ship *Hi`ialakai*, Cruise HA-12-01, Leg I

CRUISE PERIOD: 27 February–25 March 2012

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

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED) of the NOAA Pacific Islands Fisheries Science Center, NOAA Southeast Fisheries Science Center, San Diego State University and United States Fish and Wildlife Service conducted interdisciplinary Pacific Reef Assessment and Monitoring Program (Pacific RAMP) surveys in waters surrounding Johnston Atoll, Howland Island, Baker Island, Swains Island, and Tutuila Island. All activities described in this report were covered by the following permits: National Park of American Samoa research permit number NPSA-2012-SCI-001 and Pacific Reefs National Wildlife Refuge Complex special use permit number 12521-10001.

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.

27 February Start of cruise. Embarked all scientific crew. After fueling was complete, the *Hi'ialakai* departed Pearl Harbor, Honolulu, O`ahu Island, at 1600, and began transit to Johnston Atoll.

28 February Transit day.

29 February Transit day.

[1] PIFSC Cruise Report CR-12-010
Issued 1 December 2012

1 March Transit day.

2 March Arrived at Johnston Atoll and began field operations. Deployed and retrieved calcification acidification units (CAUs). Algae samples were collected for microbial and calcification analyses. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations.

3 March Continued field operations at Johnston Atoll. Deployed and retrieved the following types of instruments: sea-surface temperature (SST) buoy, subsurface temperature recorders (STR), Autonomous Reef Monitoring Structures (ARMS), and CAUs. Algae samples were collected for calcification analysis. Nearshore water samples were collected for Chl-*a*, nutrient, DIC, TA, and salinity analyses. Nearshore CTD profiles were collected and shipboard operations included deepwater CTD casts, ADCP transects, and water sampling for Chl-*a* and nutrient concentrations.

4 March Continued field operations at Johnston Atoll. Deployed and retrieved the following types of instruments: STR, ARMS. Nearshore water samples were collected for microbial community analyses. No shipboard water sampling or CTD casts were performed because of a malfunction of the electronic equipment.

5 March Continued field operations at Johnston Atoll. Deployed and retrieved the following types of instruments: STR, ARMS, Wave-and-tide Recorder (WTR) and environmental acoustic recorder (EAR). Nearshore water samples were collected for microbial community analyses. Nearshore CTD profiles were collected, and shipboard operations included only ADCP transects. No shipboard water sampling or CTD casts were performed because of a malfunction of the electronic equipment.

6 March Continued field operations at Johnston Atoll. No instruments were retrieved or deployed, and no benthic or fish REA surveys were performed, due to weather. Began transit to Howland Island.

7 March Transit day.

8 March Transit day.

9 March Transit day.

10 March Transit day.

11 March	Arrived at Howland Island. Began field operations. Deployed and retrieved the following types of instruments: STR, ARMS, and CAUs. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations.
12 March	Continued field operations at Howland Island. Deployed and retrieved the following types of instruments: STR, ARMS, and CAUs. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations.
13 March	Continued field operations at Howland Island. Deployed and retrieved the following types of instruments: STR and ARMS. Coral cores were collected for ocean acidification research. Coral rubble was collected for microbial analysis, and algae samples were collected for microbial, calcification and isotopic analyses. Nearshore water samples were collected for microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations.
14 March	Continued field operations at Howland Island. Coral cores were collected for ocean acidification research. Algae samples were collected for microbial, calcification and isotopic analyses. Nearshore water samples were collected for microbial community analyses. Shipboard operations included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations. Began transit to Baker Island.
15 March	Arrived at Baker Island. Began field operations. Deployed and retrieved the following types of instruments: STR, ARMS, and CAUs. Algae samples were collected for microbial, calcification and isotopic analyses. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations

included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations.

16 March — Continued field operations at Baker Island. Deployed and retrieved the following types of instruments: STR, ARMS, and CAUs. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations.

17 March — Continued field operations at Baker Island. Deployed CAUs, and collected a coral core for ocean acidification research. Algae samples were collected for microbial, calcification and isotopic analyses, and a coral core was collected for ocean acidification research. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Ship’s vessels were not launched, due to weather. No towed-diver surveys were conducted, so that the tow vessel could be used by benthic and fish teams. Nearshore conductivity, temperature, and depth (CTD) profiles were collected. Began transit to Swains Island.

18 March — Transit day.

19 March — Transit day.

20 March — Transit day.

21 March — Arrived at Swains Island. Began field operations. Deployed and retrieved the following types of instruments: STR, ARMS, and CAUs. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected.

22 March — Continued field operations at Swains Island. Deployed and retrieved the following types of instruments: STR, ARMS, and CAUs. Coral samples were collected for taxonomic identification and coral rubble was collected for microbial analyses. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations included acoustic Doppler current profiler (ADCP)

transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations.

23 March — Continued field operations at Swains Island. Deployed and retrieved ARMS. Coral cores were collected for ocean acidification research. Nearshore water samples were collected for microbial community analyses. Began transit to Tutuila Island.

24 March — Arrived at Tutuila Island at 1500. Began field operations when *Hi'ialakai* launched the *Rubber Duck* to retrieve SST and STR.

25 March — Continued field operations at Tutuila Island. Deployed and retrieved the following types of instruments: SST, EAR, STR, and CAUs. Nearshore water samples were collected for chlorophyll-*a* (Chl-*a*), nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA) salinity, and microbial community analyses. Nearshore conductivity, temperature, and depth (CTD) profiles were collected, and shipboard operations included acoustic Doppler current profiler (ADCP) transects, deepwater CTD casts, and water sampling for Chl-*a* and nutrient concentrations. No benthic REA surveys were performed, as small boats HI-1 and HI-2 were not launched due to the ship entering port. Arrived at Pago Pago, American Samoa. Disembarked Jacob Asher, Richard Coleman, Kelsie Ernsberger, Marie Ferguson, Noah Pomeroy, Hailey Ramey, Benjamin Ruttenberg, and Jared Underwood. End of HA-12-01, Leg I.

MISSIONS:

A. Conducted ecosystem monitoring of the species composition, abundance, percentage of cover, size distribution, and general health of the populations of fishes, corals, target macroinvertebrates, and algae of the shallow-water (≤ 30 m) coral reef ecosystems of Johnston Atoll, Howland Island, Baker Island, Swains Island, and Tutuila Island.

B. Deployed and retrieved a suite of instruments and installations—including SST buoys, STRs, WTRs, ARMS, CAUs, and EARs—to allow for remote, long-term monitoring of oceanographic, environmental, and ecological conditions of the coral reef ecosystems of Johnston Atoll, Howland Island, Baker Island, Swains Island, and Tutuila Island.

C. Conducted shallow-water CTD casts and collected water samples for Chl-*a*, nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, and microbial community analyses to depths ≤ 30 m to examine physical and biological linkages supporting and maintaining these island ecosystems.

D. Conducted shipboard oceanographic and meteorological observations to examine physical and biological linkages supporting and maintaining these island ecosystems, using CTD casts deployed to a depth of 500 m with concurrent water samples taken at select locations and depths, collecting continuous ADCP, SST, salinity, and partial pressure of carbon dioxide (pCO_2) data around reef ecosystems and fundamental meteorological data, such as air temperature, wind speed and direction, barometric pressure, and relative humidity.

E. Collected shallow-water coral cores to examine calcification (growth) rates in recent decades and assess potential early impacts of ocean acidification.

F. Collected algae samples to examine calcification (growth) rates in recent decades and assess potential early impacts of ocean acidification.

G. Conducted terrestrial surveys of seabirds, invertebrates 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 HA-12-01, Leg I, and a summary of important observations. For more information pertaining to the data collected and methodology employed at the islands visited, see Appendices A–G.

Table 1.--Statistics for the Pacific RAMP 2012 cruise to Johnston Atoll (JOH), Howland Island (HOW), and Baker Island (BAK) of the Pacific Remote Island Areas, and Swains (SWA) and Tutuila Islands (TUT) of American Samoa (cruise HA-12-01, Leg I). The numbers in the first row for towed-diver surveys include calibration surveys, but the numbers in the separate rows for benthic and fish surveys do not. The totals for scuba dives include all dives carried out for all activities at each island.

Research Activity	JOH	HOW	BAK	SWA	TUT	Total
Scuba Dives	179	207	119	180	40	725
Biological Surveys						
Towed-diver Surveys: Benthic and Fish	18	13	10	11	6	58
Combined Length (km) of Towed-diver Surveys	36.1	22	19.8	21.9	13.5	113.3
Towed-diver Surveys: Benthic	18	12	10	11	6	57
Towed-diver Surveys: Fish	17	12	10	10	6	55
REA Sites: Benthic	10	8	6	9	0	33
REA Sites: Fish	35	39	24	38	5	141
Biological Sample Collections						
Algal Voucher Specimens	0	2	3	1	0	6
Halimeda Samples (calcification analysis)	40	20	30	0	0	90
Halimeda Samples (isotope analysis)	0	12	18	0	0	30
Coral Voucher Specimens	0	0	0	5	0	5
Coral Core Samples	0	4	1	3	0	8
Microbial Water Samples	19	15	8	13	0	55
Microbial Benthic Samples	2	6	7	8	0	23
Biological Monitoring Installations						
ARMS Retrieved	9	9	6	7	0	31
CAUs Retrieved	20	24	19	24	15	102
CAUs Deployed	25	25	25	25	15	115
EARs Retrieved	1	0	0	0	1	2
Oceanographic Moored Instruments						
SST Buoys Retrieved	1	0	0	0	3	4
STRs Retrieved	7	5	5	5	4	26
STRs Deployed	9	6	9	7	3	34
WTRs Retrieved	1	0	0	0	0	1
Hydrographic Surveys						
Shallow-water CTD Casts	5	5	5	5	3	23
Deepwater CTD Casts: Total	14	32	16	8	0	70
Total Length (km) of ADCP Transects	30	80	40	20	0	130
Water-quality Sampling						
Shallow-water Nutrient Water Samples	10	10	10	10	6	46
Shallow-water Chl-*a* Water Samples	10	16	10	10	6	52
Shallow-water Salinity Water Samples	10	10	10	10	6	46
Shallow-water DIC Water Samples	10	10	10	10	6	46
Deepwater Nutrient Water Samples	0	20	10	0	0	30
Deepwater Chl-*a* Water Samples	10	80	40	5	0	135

The coral reef ecosystems of the Johnston Atoll, Howland Island, Baker Island, Swains Island, and Tutuila Island are surveyed biennially through CRED's Pacific RAMP. The cruise HA-12-01, Leg I, marked this program's fifth expedition around Johnston Atoll, seventh around Howland Island and Baker Island, and sixth around Swains Island and Tutuila Island. Here, we present highlights, by island or atoll, from our observations during this latest expedition.

Johnston Atoll

- A seemingly unusually high amount of humpback whale (*Megaptera novaeangliae*) activity was noted
- CRED personnel delivered 161 cases of cat food ashore to aid in United States Fish and Wildlife Service ant eradication efforts.

Howland Island

- A school of hundreds of Heller's barracuda (*Sphyraena helleri*) was sighted off of the northern tip of the island, along with a large school of bottlenose dolphins (*Tursiops truncatus*).
- An abundance of crustose coralline algae (CCA) was seen growing on dead coral skeletons, qualitatively seeming like more CCA than normal. It's possible that this is evidence of recovery from the bleaching encountered on HA-10-01 in 2010.
- An abundance of manta rays (*Manta birostris*), gray reef sharks (*Carcharhinus amblyrhynchos*), dogtooth tuna (*Gymnosarda unicolor*), rainbow runners (*Elagatis bipinnus*) and milkfish (*Chanos chanos*) were seen.

Baker Island

- Abundant schools of hammerhead sharks (*Sphyrna lewini* and *S. mokarran*) were sighted on multiple days.
- An abundance of manta rays (*Manta birostris*), gray reef sharks (*Carcharhinus amblyrhynchos*), dogtooth tuna (*Gymnosarda unicolor*) and large schools of barracuda were noted.
- Benthic REA site BAK-005 seemed to have more rubble and turf algae than in previous years. This site is near some large anchor chains stemming from the days of guano mining in the area.

Swains Island

- A very rare sighting of a juvenile (< 3 m total length) whale shark (*Rhincodon typus*) occurred off of the southern tip of the island.
- An abundance of newly-born gray reef sharks (*Carcharhinus amblyrhynchos*) less than 75 cm length were seen by the towed-diver team.
- Several rarely encountered ocean sunfish (*Mola mola*) were sighted.
- Not a single crown-of-thorns starfish (*Acanthaster planci*) was observed by the benthic towed-diver team.

The following data and samples were collected during this expedition:

REA Benthic Surveys:

- Digital still photographs of overall site character and typical benthos
- Digital still photographs of the benthos along transect lines
- Quantitative assessments of benthic composition from line-point-intercept surveys
- Algal voucher specimens necessary for algal species identification
- Samples of the algal genus *Halimeda* to determine degree of calcification for ocean acidification research
- Samples of the algal genus *Halimeda* for isotope analysis
- Field notes of algal species diversity and relative abundance
- Number, species or genus, size, and health condition of all coral colonies observed within belt transects of known area
- Digital still photographs of diseased corals and coralline algae
- Field notes on signs of coral bleaching or disease
- Specimens of invertebrates collected at REA sites
- Collection of coral cores of massive reef building corals for the assessment of calcification rates
- Water samples and benthic grabs at select REA sites for microbial analyses

REA Fish Surveys:

- Number, species, and estimated sizes of all fishes observed within visually estimated 7.5-m-radius stationary-point-count (SPC) surveys
- Number of boring and motile urchins observed within SPC surveys
- Visual estimates of benthic cover, habitat type, and habitat complexity
- Digital still photographs of the benthos along transect lines
- Digital still photographs of rare or interesting fish species

Towed-diver Surveys:

- Digital still photographs and video of benthic habitats
- Benthic habitat characterization, including visual estimates of habitat complexity, habitat type, and cover of corals, stressed corals, macroalgae, and crustose coralline red algae
- Number, species, and estimated sizes of large (≥ 50 cm in total length) reef fishes
- Counts of target macroinvertebrates, including crown-of-thorns seastars, sea cucumbers, sea urchins, and giant clams
- Quantitative and qualitative assessments of key protected species and species of concern, including cetaceans, sea turtles, and rare fishes
- Temperature and depth data

Shipboard Oceanography:

- Deepwater CTD profiles to a depth of 500 m
- Nutrient and Chl-*a* concentrations from water samples collected at variable depths
- Dissolved oxygen, turbidity, fluorescence, and pH measurements recorded by CTD sensor

- Transects of profiles of ocean current velocity and direction collected using a shipboard ADCP unit
- Solar radiation, air temperature, barometric pressure, and wind speed and direction
- Select surface measurements of partial pressure of carbon dioxide (pCO_2)
- Surface temperature and salinity measurements

Nearshore Oceanography from Small Boats:

- Shallow-water CTD profiles to depths ≤ 30 m, including all REA sites where CAUs were installed, with dissolved oxygen measurements
- Concentrations of nutrients, Chl-*a*, salinity, DIC, and TA from water samples collected in concert with shallow-water (≤ 30 m) CTD casts

Biological Monitoring 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
- Installation and retrieval of calcification acidification units (CAUs) to allow for assessment of calcification rates

Oceanographic Moored Instruments:

- Sea-surface and subsurface temperature at variable depths
- Spectral wave and tidal elevation
- ultraviolet radiation

SCIENTIFIC PERSONNEL:

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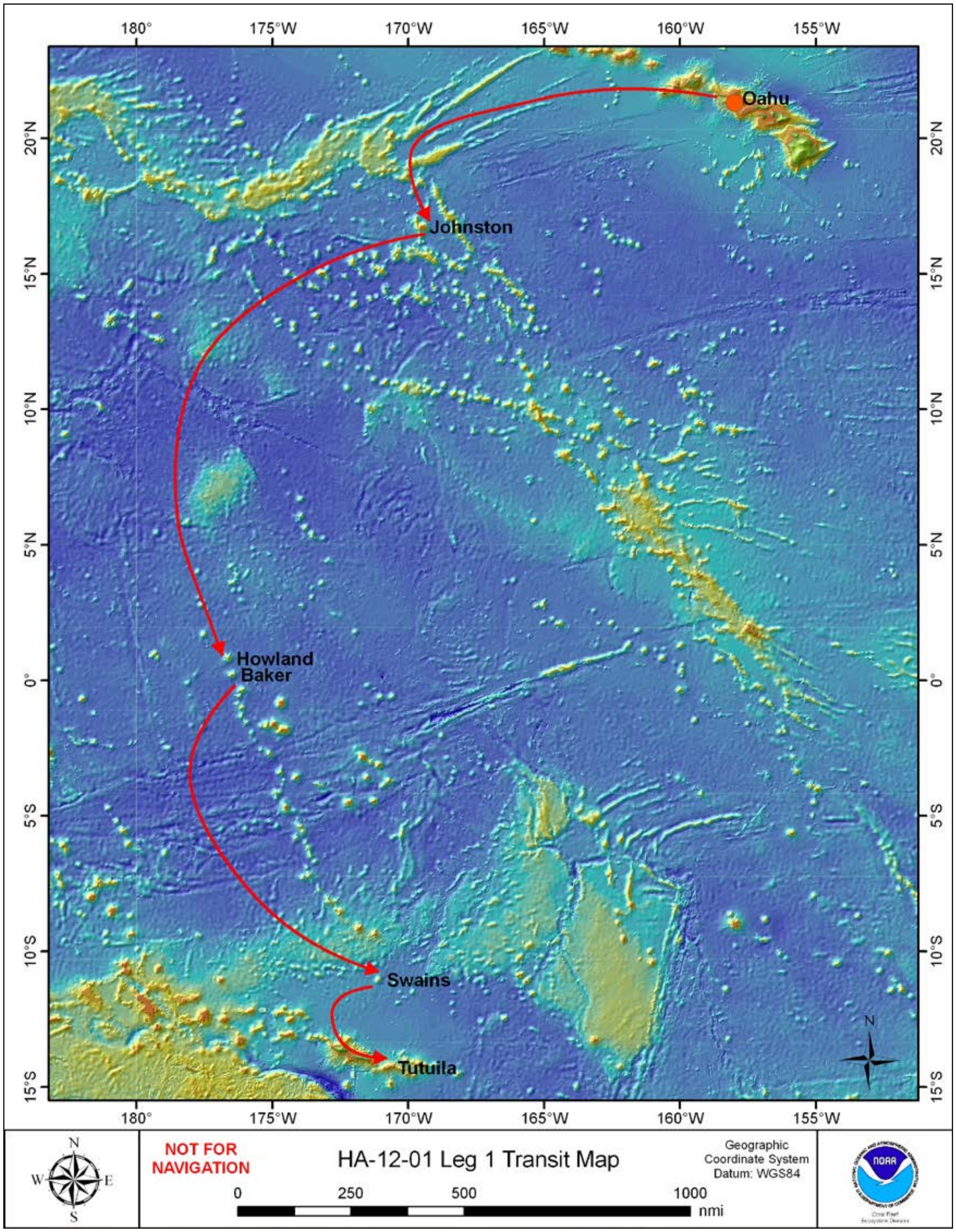

Figure 1.--Track of the NOAA Ship *Hi`ialakai* for the cruise HA-12-01, Leg I, February 27–March 25, 2012, with Johnston Atoll, Howland Island, Baker Island, Swains Island, and Tutuila Island surveyed. Imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

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 during its Pacific Reef Assessment and Monitoring Program (Pacific RAMP) cruise HA-12-01, Leg I on the NOAA Ship *Hi`ialakai* during the period of February 27–March 25, 2012. The last coral reef assessments led by CRED at the islands of Johnston Atoll, Howland Island, Baker Island, Swains Island, and Tutuila Island were conducted in 2010.

A.1. Oceanography and Water Quality

(Daniel Merritt, Noah Pomeroy and Charles Young)

To assess and monitor the oceanographic and water-quality parameters influencing the coral reef ecosystems, the oceanography team performed the following activities: (1) conducted offshore oceanographic surveys characterizing prevailing water properties and ocean currents around these islands, (2) completed nearshore oceanographic and water-quality surveys, and (3) deployed and retrieved an array of subsurface moored instruments designed to provide continuous, high-resolution time-series observations. Shipboard meteorological observations, including wind speed and direction, relative humidity, air temperature, and barometric pressure, were recorded. In addition, the oceanography team retrieved and deployed ecological acoustic recorders (EARs) for monitoring the sounds of marine animals and vessel traffic and participated in installations of calcification acidification units (CAUs) for the assessment of calcification rates of crustose coralline algae and hard corals (see Section A.2.3: "Installations for Monitoring Marine Life," for information about EAR and CAU techniques).

In order to standardize NOAA's long-term monitoring across all U.S.-owned coral reefs, NOAA developed the National Coral Reef Monitoring Plan (NCRMP); a comprehensive multidisciplinary approach for assessing and monitoring coral reef ecosystems. Amongst other disciplines relevant to coral reef research, NCRMP outlines a methodological approach for assessing present and future changes to oceanographic conditions. Specifically, NCRMP focuses on ocean temperature and carbonate chemistry information, as these environmental parameters are among the primary drivers for island- and atoll-scale coral reef ecosystem variability. Details pertaining to the collection of temperature information are outlined below.

NCRMP Temperature: The overarching goals of recording reef-level temperature around coral reef systems are 1) to monitor for long-term changes in the thermal structure within the context of climate change and 2) to quantify ecologically relevant changes in the thermal structure owing to physical forcing mechanisms such as (but not limited to) waves, internal waves, tides, internal tides, and upwelling. Below are the NCRMP guidelines for thermister deployment:

1. Vertical, reef-level transects of temperature sensors will be deployed at 1, 5, 15, and 25 m water depth at each island or atoll. The number of vertical transects will depend upon the size of the island or atoll.
2. Sensors are to be deployed at depths of 1 m only in backreef environments or forereef locations that have a high likelihood of survival and retrieval. Deployment should be in water < 2 m deep and should remain submerged through tidal variations and large wave events.
3. Sensors meant for installation at 5m are to be deployed within a depth range of 4-6 m on forereef environments in a location that has a high probability of being accessible during future field missions.
4. Sensors meant for installation at 15 and 25-m should be deployed within depth ranges of 13−17 m and 23−27 m, respectively.

The guidelines stated above were implemented by CRED during ASRAMP 2012. A large majority of existing subsurface temperature recorder (STR) locations fell within these guidelines, thereby preserving the long-term temperature data set; however, there were a number of STR locations at each of the islands and atolls visited that were either moved or removed altogether in order to meet these guidelines.

A.1.1. Moored Instruments for Time-series Observations

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

Sea-surface Temperature (SST) Buoy: provides high-resolution SST (SBE 39 sensor, Sea-Bird Electronics Inc., Bellevue, Wash., 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 near-real-time, 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 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). 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) also was 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 CAUs were deployed. Data were collected by hand lowering this profiler off a small boat at descent rates of ~ 0.5–0.75 m s^{-1} at depths ≤ 30 m.

Deepwater (Shipboard) CTD Casts: a ship-based CTD profiler provided high-resolution conductivity, temperature, and pressure data (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.

Water Chemistry: water samples for analyses of concentrations of chlorophyll-*a* (Chl-*a*), dissolved inorganic carbon (DIC), Total Alkalinity (TA), and the nutrients phosphate, PO_4^{3-}; silicate, $Si(OH)_4$; nitrate, NO_3^-; and nitrite, NO_2^-, were collected at select locales concurrently with nearshore and shipboard CTD casts.

A.2. Benthic Surveys and Collections, Monitoring Installations, and Microbial Sampling

(Jeff Anderson, Jacob Asher, Richard Coleman, Marie Ferguson, Benjamin Knowles, Kerry Reardon, Russell Reardon, and Cristi Richards)

CRED collected integrated information on the species composition (diversity), condition, abundance, and distribution of communities of corals, algae, and target macroinvertebrates and on benthic habitat complexity and substrates using two primary methodologies: Rapid Ecological Assessment (REA) surveys and towed-diver surveys. Performed at selected hardbottom 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, three types of monitoring installations, autonomous reef monitoring structure

(ARMS), CAUs, and EAR, serve as mechanisms to quantify marine invertebrates that are not easily identifiable during REA surveys, help to determine accretion rates of crustose coralline red algae and hard corals, or monitor the sounds of marine life and vessel traffic. Note that the sites where REA benthic surveys were conducted typically are different locations from the REA sites selected for fish surveys. REA sites for benthic surveys are selected for long-term monitoring of specific benthic communities over time, whereas REA sites for fish surveys are selected using a stratified random sampling design to provide representative coverage of three depth strata.

A.2.1. Benthic Composition

Using a line-point-intercept (LPI) method at REA sites, hard corals, octocorals, macroalgae, crustose coralline red algae, turf algae, cyanobacteria, and macroinvertebrates were identified to the highest possible taxonomic resolution and recorded, along with sand cover, at 20-cm intervals along two 25-m transect lines set in a single file row (separated by 5 m). These surveys generate 125 points per transect (250 points per site) that can be used to generate percentage of cover of benthic organisms and sand at each REA site. Additionally, in concert with LPI surveys, still photographs were taken to record the benthos at intervals of 2 to 5 m along the same two transect lines with a high-resolution digital camera mounted on a pole. This work generates 32 photographs per site that are later analyzed by staff at CRED, using the computer program Coral Point Count with Excel extensions (CPCe), to determine the benthic composition at higher taxonomic levels for each REA site (similar photographs of the benthos taken at REA sites surveyed by the fish team will also be analyzed).

If an algal species encountered during LPI was not identifiable in the field, an example was collected as a voucher specimen and subsequently cataloged and critically analyzed to ensure positive species identification. Provisions were made to ensure appropriate preservation and curation of each algal specimen. These voucher specimens along with the benthic photographs form permanent historical records, the former of algal diversity and the latter of the composition of benthic communities at each REA site.

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 and to quantify the abundance of target macroinvertebrates, including crown-of-thorns seastars (COTS), 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 sensor 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, octocorals, macroalgae, and crustose coralline red algae, and of physical features, including sand and rubble; and counts of target macroinvertebrates and marine debris. Towed divers classified percentage of cover using a system of 10 bins, ranging from 0% to 100% cover of the benthos. Target macroinvertebrates 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 photograph of the substrate every 15 s. These photos, like the SBE 39 data, are linked spatially with GPS track files taken aboard the survey launch. Benthic photos can be analyzed later for community structure information.

A.2.2. Community Structure and Disease

At each REA site, the belt-transect method, with two 25-m transect lines as the focal point, was used to quantitatively assess generic richness, colony density, and size class of coral colonies. On each transect, five 2.5-m^2 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 on either side of each transect line were identified to the highest possible taxonomic resolution and measured using two planar size metrics: maximum diameter and diameter perpendicular to the maximum diameter.

For each coral colony identified during 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), and severity (mild, moderate, marked, severe, or acute). 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.

A.2.3. 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 instruments that were retrieved or deployed during this cruise.

Autonomous Reef Monitoring Structure (ARMS): recovered and deployed at several sites at each island, ARMS provide a mechanism to quantify marine invertebrates that were not easily identifiable or accountable on the transect lines used for REA surveys.

ARMS were previously installed on the benthos by pounding stainless steel rods by hand into bare substrate during the ASRAMP 2010 cruise. They remained on the benthos for 2 years, enabling the recruitment and colonization of lesser known, cryptic marine invertebrates. Each ARMS was composed of 10 grey, Type 1 PVC plates (23 × 23 cm) stacked in an alternating series of open and obstructed layers attached to a base plate (35 × 45 cm) that was affixed to a reef.

ARMS previously deployed during the ASRAMP 2010 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 preserved in ethanol for later genetic and other molecular analyses. At a subsample of these sites, new ARMS units were deployed onto existing stainless steel rods, with the goal of recovering them during the next ASRAMP cruise scheduled for 2013.

Calcification Acidification Unit (CAU): deployed and collected at multiple sites at each island, CAUs provide mechanisms to quantify accretion rates by crustose coralline red algae and scleractinian (hard) corals. Each CAU consists of two grey 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 plate assemblies to those rods. It has been demonstrated that PVC encourages growth of crustose coralline red algae and recruitment of corals, and the net weight gain of calcium carbonate ($CaCO_3$) on the surfaces of the CAUs can be an indicator of net calcification. The CAUs installed during this cruise will remain on the benthos for about 3 years, enabling the recruitment and colonization of crustose coralline red algae and hard corals, upon which time they will be collected and analyzed. The data obtained from CAUs will enable a comparison of net calcification rates among islands and atolls 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.

Ecosystem Acoustic Recorder (EAR): the 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. The 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 or cetaceans passing nearby. This type of subsurface instrument typically was deployed at depths of 5–25 m. Note: information about retrievals and deployments of EARs are provided along with information about STR installations in the island appendices, since those instruments are sometimes moored to the same anchor and EARs are typically installed by members of the oceanography team.

A.2.4. Coral Core Collections

In support of CRED's ocean acidification research, coral cores and tissue will be collected from *Porites* sp. at select sites to develop historical, skeletal extension (annual growth) rates and calcification rates, and gain insight into the energetic status of each sampled coral colony. In conjunction with ancillary water quality data, these cores will provide important information about the past environmental conditions in which these corals lived and how they responded. Quantification and analysis of growth banding, skeletal density and extension rate is conducted by employing a nondestructive, high resolution CT scan technique. The coral tissue collected is measured for thickness and total lipid content to validate the premise that energetics play a key role in the coral calcification response to ocean acidification.

Pneumatic Coral Coring

Up to six coral cores and tissue samples were collected at each island/atoll/reef visited. Coral cores were collected using a SCUBA diver employed, handheld, pneumatic drill. The drill is powered by compressed air from a standard Al 80 SCUBA tank. A 1.5-in diameter masonry drill bit is used to extract up to a 40-cm long coral core. The pneumatic drill can be equipped with extensions, enabling coral cores up to ~ 1 m. Upon extraction of a coral core sample, the remaining hole is filled with an exact fit concrete plug, positioned flush with the existing surface layer of the coral colony, and fixed in place with an underwater epoxy. This technique has been shown to have minimal impact on the long-term health and survivorship of the coral colony. Photographs of the coral colony and GPS positions will enable CRED researchers to return and monitor the coral heads drilled.

Hydraulic Coral Coring

A 3.5-in diameter masonry drill bit was used to cut up to a 0.75 m long coral core segment. The hydraulic drill can be equipped with extension rods, enabling coral cores up to 8 m, extracted in 0.75 m sections. Upon extraction of the final coral core section, the remaining hole is filled with an exact fit concrete plug, positioned flush with the existing surface layer of the coral colony, and fixed in place with an underwater epoxy. Complete regeneration of coral tissue over the core plug is expected. Photographs of the coral colony and GPS positions will enable CRED researchers to return and monitor the coral heads drilled.

The hydraulic drill used during drilling operations was custom made, using seawater to power the drill, instead of oil. The hydraulic drill is handheld by a SCUBA diver and powered by a seawater hydraulic pump located in a boat on the surface. Water hoses from the hydraulic motor unit extend to the drill and operators on the seafloor for coring operations. The coral coring team constitutes a DPIC (designated person in charge), two safety divers located on the small boat and three in water SCUBA divers: a drill operator, an operator assistant and safety diver.

A.2.5. *Halimeda* Collections for Calcification and Isotopic Analyses

Species of the green algal genus *Halimeda* are among the most important producers of calcified sediments in reef systems. As the acidity of our oceans increase, calcification rates and the ability of *Halimeda* algae to produce sediments may fall precipitously. To gain a baseline understanding of calcification levels in species of *Halimeda*, a joint project between CRED and the Scripps Institution of Oceanography, University of California San Diego, is sampling *Halimeda* populations across the Pacific to determine ambient levels of $CaCO_3$ among different species from different geographic areas. To accomplish this research, ten individuals of three species of *Halimeda* (when present) were collected haphazardly by hand from established benthic REA sites. Samples were frozen aboard the ship and sent to the research labs of Jennifer Smith, Center for Marine Biodiversity and Conservation at the Scripps Institution of Oceanography.

Additionally, algal species can be used to monitor and detect the source of nutrients in a coral reef ecosystem. Analysis of the Carbon and Nitrogen isotope ratios can reveal valuable information about the origin (natural or anthropogenic) of nutrients assimilated and incorporated into the tissue of algae. In the Pacific Remote Island Areas, there are various sources of nutrients, however, this project is focused on determining the nutrient influence that seabird populations have on reefs surrounding the island. Six specimens of the two most common species of *Halimeda* were collected at sites of particular interest, with and without sizable seabird populations nearby. These samples were frozen aboard the ship and then transported to the lab of Don Croll at the University of California Santa Cruz (UCSC). They will be analyzed as part of the Ph.D. thesis of Susy Honig. Isotopic analyses will reveal the extent to which nutrients from bird guano are being incorporated into the algal communities and its contribution to the overall growth and sustainability of algal populations.

A.2.6. Microbial Communities and Water Chemistry

Microbes are a fundamental aspect of all marine ecosystems. Trophic-level interactions within the marine microbial food web can have a big effect on global nutrient and carbon cycling. Within a reef system, the amount of energy from primary production that is remineralized by the microbial fraction determines the amount of energy available for the entire food web. Shifts in the abundance and community composition of the microbial community in a reef system have also been linked to declines in coral health.

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 cells in seawater is typically 1×10^6 cells per mL. Microbial and viral loading and the dominance of heterotrophic bacteria in reef water are linked to coral disease. The most direct method for assessing and monitoring changes in abundance of these microbiological components is by fluorescent microscopy using nucleic acid staining.

A direct parallel exists between microbial and viral loading, increasing human disturbance, and reef health. Microbial communities in more degraded coral reef systems support a high abundance of potential coral pathogens and heterotrophic microbes (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).

Spatial assessment of microbial and viral components with respect to levels of dissolved organic carbon (DOC), nutrients (NO_2; $NO_{3;}$ ammonium, NH_4; and PO_4^{3-}), and particulate organic carbon (POC) within coral reef ecosystems may identify important predictors of coral reef ecosystem degradation. For example, in addition to microbial abundance, bacterial growth efficiency (BGE) may also play a role in reef system health. BGE is affected greatly by DOC:Nitrogen (NO_x+NH_4) ratios in the water column. Water column stoichiometry (C:N:P ratios) directly affect microbial growth rates.

In summary, no long-term data on the dynamics of natural bacterial assemblages in reef systems (let alone other ecotypes) are currently available. Building a pan-Pacific microbial data set is an important step towards greater understanding of the overall health of the reef system. The majority of reefs on the planet are affected and analyses are confounded by the inability to attribute differences in reef system dynamics to variation in resource availability caused by oceanography or human activity. The region monitored through Pacific RAMP includes reefs experiencing various combinations of human activity and resource availability. The hope is that new patterns in the microbial data sets will emerge at regional or pan-Pacific scales and that this information can be used to understand the mechanisms underlying reef system decline.

Collection of Microbial Water Samples: As part of the ongoing effort to understand the microbial community, two types of water samples were collected at each REA site using diver-deployable Niskin bottles (two bottles; 2 L per bottle). The Niskin bottles were filled with “reef water” collected from < 1 m above the benthos. These water samples were returned to the ship and processed for DOC, particulate organic matter (POM), nutrients, microbial (Bacteria and Archaea) and viral abundance (fluorescent microscopy), fluorescence-activated cell sorting (FACS, heterotrophs vs autotrophs), and microbial and viral community composition (coarse analysis: 16s rRNA). In addition, at one or two REA sites per island or atoll, ~ 70 L of reef water were collected from reef crevices and surfaces for metagenomic analysis of the microbial and viral community associated with reef benthos. All microbial collections were done at select REA sites (locations with supporting fish and benthic data).

The following data items were collected daily at each REA site (for reef-water samples):

- DOC: 2 replicates
- POM: 2 replicates
- Nutrients: 2 replicates
- Microbial (Bacteria and Archaea) and viral abundance: 2 replicates (0.02-µm filters, stained using SYBR Gold, Molecular Probes Inc., Eugene, Ore.)
- Microbial (Bacteria and Archaea) size structure: 2 replicates (0.2-µm filters, stained using 4 ft, 6-Diamidino-2-phenylindole (DAPI))
- Microbial community composition (FACS, heterotrophs/autotrophs): 5 replicates
- Microbial community composition (16s rRNA): 2 replicates (0.22-µm filters)

The following data items were collected once per island at REA sites:

- Microbial community composition (metagenome): 1 sample, (3–6 filters of 0.45 µm)
- Viral community composition (metagenome): 1 sample, (3–6 vials)

Processing of Water Samples: This section describes the techniques used to process the water samples.

Enumeration of microbes and viruses. Replicate 5-mL and 500-µL reef-water samples were fixed using paraformaldehyde and filtered through 0.02-µm filters. These filters were stained using the general nucleic acid stain SYBR Gold and mounted on a microscope slide. Bacteria and VLPs were counted under UV light using Image Pro software.

Microbial community size structure. Replicate 5-mL samples of reef water were fixed with glutaraldehyde and filtered through 0.2-µm filters. These filters were stained with DAPI, a general nucleic acid stain for staining double-stranded DNA (dsDNA) that allows length and width data to be obtained for individual microbes. These filters were then mounted on a microscope slide for analysis under UV light using Image Pro software. These slides can also be used to quantify the number of actively dividing microbial cells. Slide analysis will be performed at San Diego State University (SDSU). All filters were stored at –20º C for archival purposes.

Enumeration of autotrophic vs. heterotrophic microbes: Flow cytometry will be used to assess the ratio of autotrophic to heterotrophic microbes in the water column. This technique also will provide complementary data for microbial abundance, microbial community structure, and levels of chlorophyll-*a*.

Five 1-mL samples of water from each REA site were pushed through a 20-µm filter. This filtrate was dispensed into cryovials (5 × 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 SDSU for flow cytometry analysis.

Water Chemistry (DOC/POC): 30 mL of seawater were filtered through precombusted glass fiber filters from each of the 4 Niskin bottles, and the filtrate was collected in precombusted glass bottles. Hydrochloric acid was added to each bottle to remove DIC, and the bottles were stored upright at 4ºC. To assess POC, 500 mL of seawater were filtered through each glass fiber filter (4 replicates), and the filters were stored at –20°C. Stable isotopes of carbon and nitrogen also will be analyzed from the filters via standard protocols at SDSU.

Collection of DNA for metagenomics: The community structure of the microbes and viruses associated with the water column was assessed by metagenomic analysis. Metagenomics is a powerful tool for studying environmental populations, as < 1% of all environmental microbial diversity is currently cultivable. The steps for analysis of microbial community diversity and function involve collection of environmental DNA followed by 454 sequencing. To remove large eukaryotic organisms, reef water was filtered through a 20-µm pre-filter. This 20-µm filtrate was subsequently passed through a 0.22-µm Sterivex filter to trap microbes (two filters, ~ 2.5 L each). The filters were stored at – 20ºC. DNA isolation and metagenomic analysis will be completed at SDSU.

At one to two REA sites per island, four 20-L collapsible carboys of water were filled with water from reef crevices or reef benthos using a manual bilge pump. Upon return to the ship, this water sample was pre-filtered through 100-µm mesh and concentrated using tangential flow filtration (TFF). TFF concentrates the bacteria and viruses in the water, bringing the initial 70–80 L of water to a final volume of ~ 500 mL. This concentrate was then filtered through 0.45-µm filters to capture microbes (Bacteria and Archaea). These filters were frozen. The DNA of the entire community will be extracted and sequenced at SDSU, and the diversity and function of the microbial communities associated with the reef benthos will be analyzed. The filtrate from this sample contains concentrated viruses. Chloroform was added to this filtrate to kill any small microbes that made it through the 0.45-µm filter, and the sample was stored at 4°C. Once shipped to SDSU, 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.

Collection of Benthic Samples (if time permits): This section describes samples, or benthic grabs, collected if time permitted.

Collection of benthic microbial DNA: In addition to changes in the microbial community associated with the water column, we are also interested in whether or not community shifts in microbes associated with the benthos are a useful indicator of reef health. When time permits, six “fist fulls” of coral rubble or sediment and six pieces of the most dominant algal-type will be collected in Ziploc bags. Both the algal and rubble/sediment samples were frozen at –20ºC. These samples stayed on the ship until it returned to Honolulu. The bacterial 16s rRNA genes associated with these samples will be sequenced to characterize the microbial communities associated with the benthos (rubble and algae).

The following data items were collected at REA sites when time permitted:

- Coral rubble or sediment: 6 replicate bags
- Algae: 6 replicate bags

A.3. Surveys of Reef Fishes

(Paula Ayotte, Kevin Lino, Kaylyn McCoy, Marc Nadon, Hailey Ramey, Benjamin Ruttenberg, and Jill Zamzow)

Five 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, while one team had a rotating third diver, and conducted 1 SPC survey 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, in forereef, backreef, and lagoon habitat strata, when applicable. Surveys were performed using a 30-m transect line set along a single depth contour. The REA sites selected for fish surveys typically differ in location from the REA sites where benthic surveys were conducted.

Once a transect line was deployed, the 2 divers moved to the 7.5-m and 22.5-m marks on this transect line to start their SPC surveys. Each of these marks or points, with 1 diver at each, served as the center of a visually estimated cylindrical survey area with a radius of 7.5 m. During the first 5 min, divers only recorded the presence of species within their respective cylinders. Afterwards, divers went down their respective species lists, which were created from their work during the initial 5 min of a survey, sizing and counting all individuals within their cylinder, one species at a time. Cryptic species missed during the initial 5 min of a survey could still be counted, sized, and added to the original species list. Fish species observed at a REA site but not recorded during the SPCs were recorded for presence data.

After a survey was completed, divers recorded benthic habitat information within their respective cylindrical survey areas. Divers visually estimated habitat complexity, habitat type, and percentage of cover for hard corals, macroalgae, crustose coralline red algae, turf algae, and sand. Every meter along the transect line, still photographs were taken of the benthos to the right side of the line. Like the photographs taken along transect lines during surveys at REA benthic sites, these images will be analyzed later.

In addition to site-specific REA surveys, broad-scale towed-diver surveys were used to characterize the fish communities of shallow-water habitats around each island. A pair of divers, by means similar to a manta-tow technique, was towed 60 m behind a small boat, a 6-m survey launch from SAFE Boats International, with one diver quantifying fish populations and the other quantifying the benthos. 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 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 and 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 along a 10-m swath during each 5-min segment. Individual fishes were counted and their species (or lowest possible taxon) and length in centimeters recorded. Sightings of species of particular concern observed outside the survey swath were classified as presence/absence data and were recorded separately from the quantitative swath data. At the end of each day, data were transcribed from field data sheets into a centralized Microsoft Access database. Biomass values are calculated using species-specific length-weight parameters and are normalized by area (i.e., kg 100 m^{-2}). The fish towboard was equipped with a forward-looking digital video camera that created a visual archive of the survey track that can be used to evaluate stochastic changes in reef environments, particularly following episodic events, such as coral bleaching and grounding of a vessel.

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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-12-01, Leg I, to conduct surveys of terrestrial flora and fauna, and conduct ant eradication efforts.

B.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-12-01, Leg I at Johnston Atoll entailed numerous retrievals and deployments of oceanographic moored instruments, installation and retrieval of calcification acidification units (CAUs), nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select 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.

Seven subsurface temperature recorders (STRs) were retrieved, and nine STRs were deployed (Table B.1.1). One SST buoy and anchor were recovered (Table B.1.1). One wave and tide recorder (WTR) and anchor, and one ecological acoustic recorder (EAR) and anchor were recovered but not replaced. For information about CAU deployments completed at Hawai`i Island, see Section B.2: "Benthic Environment."

At nearshore locations around Johnston Atoll, 5 shallow-water CTD casts were performed (Fig. B.1.1), including one cast at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 10 DIC and TA, 10 salinity, 10 nutrient, and 10 Chl-*a* water samples were collected, one from the surface and one near the reef at each REA site. (Fig. B.1.1).

From the NOAA Ship *Hi`ialakai*, eight CTD casts were conducted to the west and six CTD casts were conducted to the east to a depth of 500 m away from this island during night operations on alternate nights. On the reciprocal course, 20 km of ADCP transect lines were run. Chl-*a* water samples were collected concurrently with 2 select shipboard CTD casts at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. B.1.2).

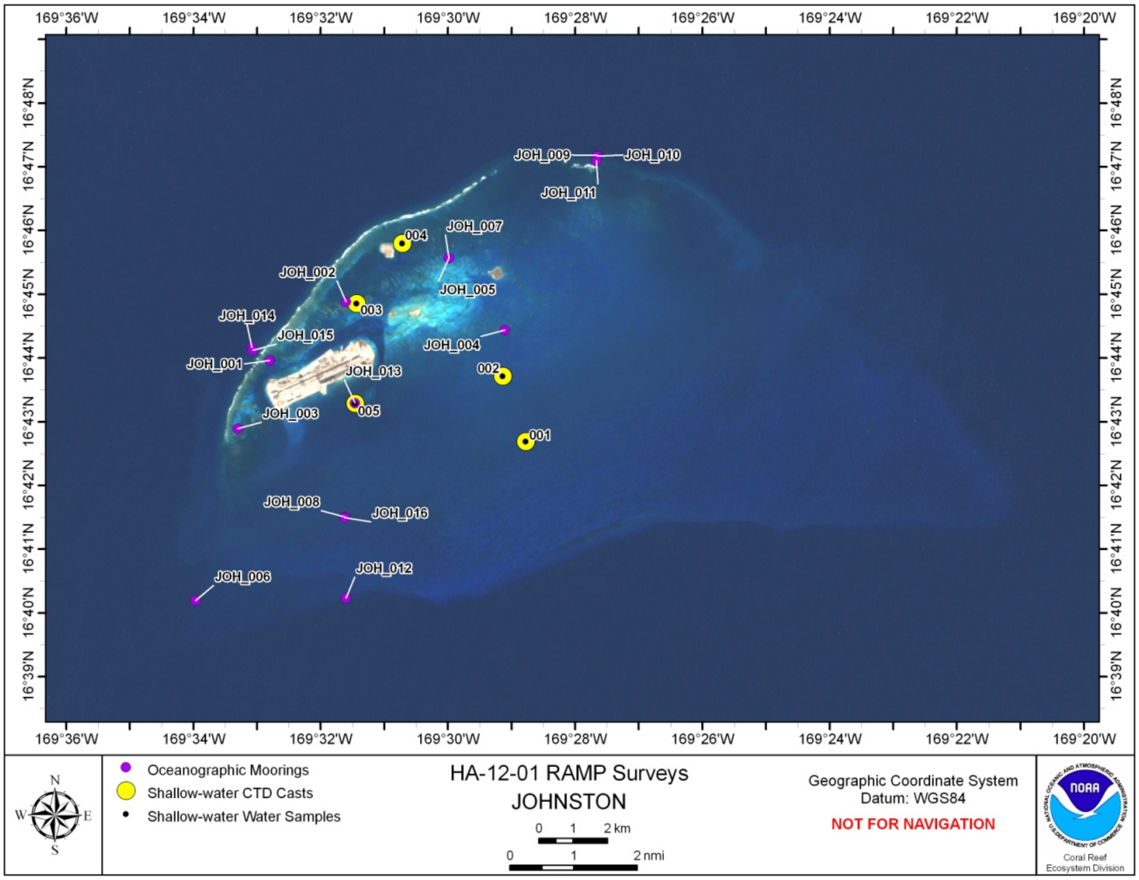

Figure B.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Johnston Atoll during cruise HA-12-01, Leg I. Landsat satellite imagery data used in this map figure are available from the U.S. Geological Survey.

Table B.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments and EAR that were retrieved or deployed at Johnston Atoll during cruise HA-12-01, Leg I.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
JOH_002	3-Mar	STR	16.74805	–169.52674	3.0	1	–
JOH_005	3-Mar	SST	16.75954	–169.49972	0.3	1	–
JOH_007	3-Mar	STR	16.75954	–169.49972	0.3	1	–
JOH_009	3-Mar	STR	16.78640	–169.46085	24.7	–	1
JOH_010	3-Mar	STR	16.78616	–169.46084	15.5	–	1
JOH_011	3-Mar	STR	16.78491	–169.46112	6.1	–	1
JOH_001	4-Mar	STR	16.73273	–169.54668	1.7	2	1
JOH_003	4-Mar	STR	16.71489	–169.55506	3.4	1	–
JOH_004	4-Mar	STR	16.74071	–169.48514	2.1	1	–
JOH_012	4-Mar	STR	16.67061	–169.52675	25.0	–	1
JOH_013	4-Mar	STR	16.72161	–169.52438	5.5	–	1
JOH_014	4-Mar	STR	16.73613	–169.55141	25.0	–	1

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
JOH_015	4-Mar	STR	16.73536	–169.55114	14.9	–	1
JOH_006	5-Mar	WTR	16.66994	–169.56610	24.1	1	–
JOH_008	5-Mar	EAR	16.69182	–169.52703	16.5	1	–
JOH_008	5-Mar	STR	16.69182	–169.52703	16.5	1	–
JOH_016	5-Mar	STR	16.69163	–169.52697	15.5	–	1

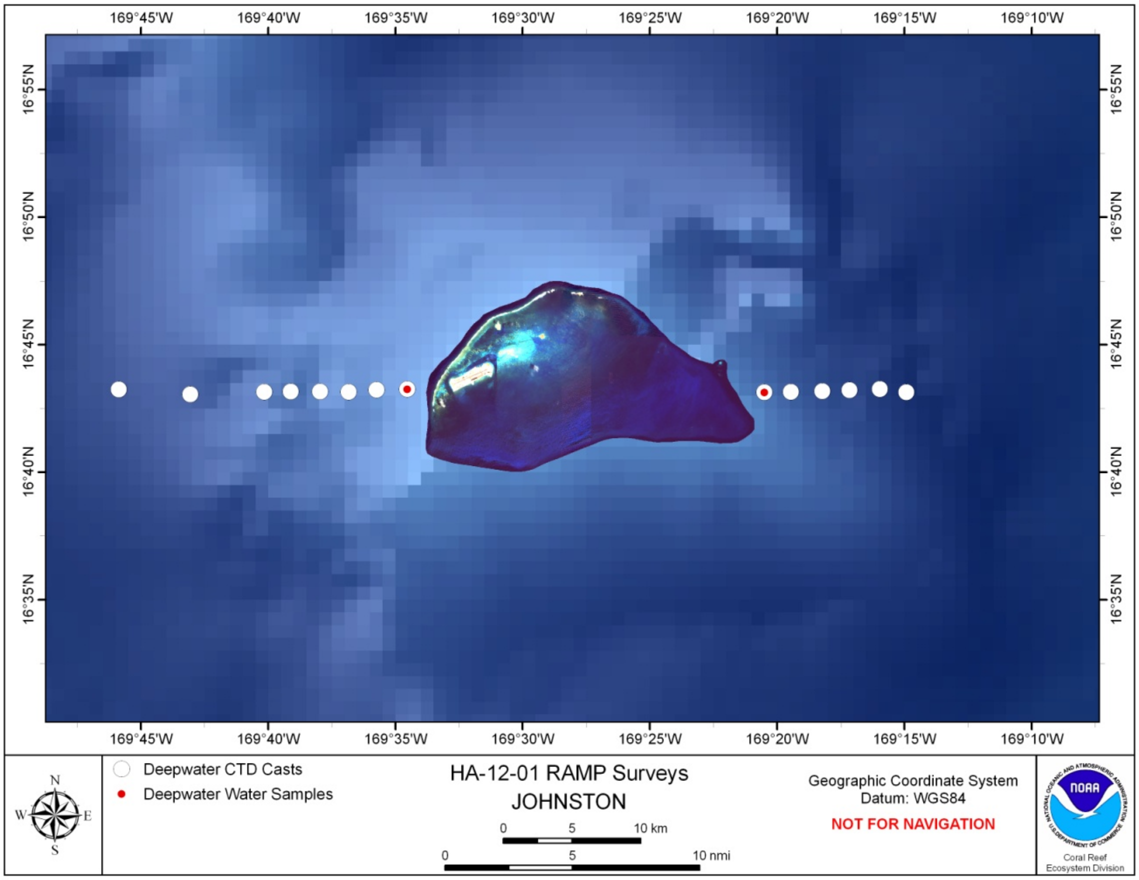

Figure B.1.2.--Locations of deepwater CTD casts and water sampling performed at Johnston Atoll during cruise HA-12-01, Leg I. Satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

B.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver surveys were conducted and photographs were taken along transect lines at nine REA sites around Johnston Atoll to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. B.2.1 and Table B.2.1).

Various samples were collected at eight REA sites (Table B.2.2): 40 individuals of the algal genus *Halimeda* at four REA sites for calcification analysis, and 21 water samples for microbial analyses at four REA sites with four water samples of 2 L each at each site, three water samples of 20 L each at JOH-11, four water samples of 20 L each at JOH-12, and six water samples of 20 L each at JOH-09. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae. For more information about collections made at REA sites, see Table G.1.1 in Appendix G: “Biological Collections.”

Nine autonomous reef-monitoring structures (ARMS) were recovered: three ARMS each from JOH-10, JOH-11 and JOH-12 (Table B.2.2). At each of five select REA sites, an array of five CAUs were deployed for a total of 25 CAUs installed at Johnston Atoll (Table B.2.2). A total of 20 CAUs were recovered from four REA sites. For information about EAR installations, see Section B.1: “Oceanography and Water Quality.”

In total, the benthic team conducted 36 individual dives at REA sites around Johnston Atoll.

During cruise HA-12-01, Leg I, CRED completed 18 towed-diver surveys at Johnston Atoll, covering a total length of 36.1 km (an area of 36.1 ha) on the ocean floor (Fig. B.2.2). The mean survey length was 2.0 km with a range of 1.2–2.8 km. The mean survey depth was 14.0 m with a range of 6.9–21.1 m. The mean temperature from data recorded during these surveys was 25.6°C with a range of 25.5°C–25.8°C.

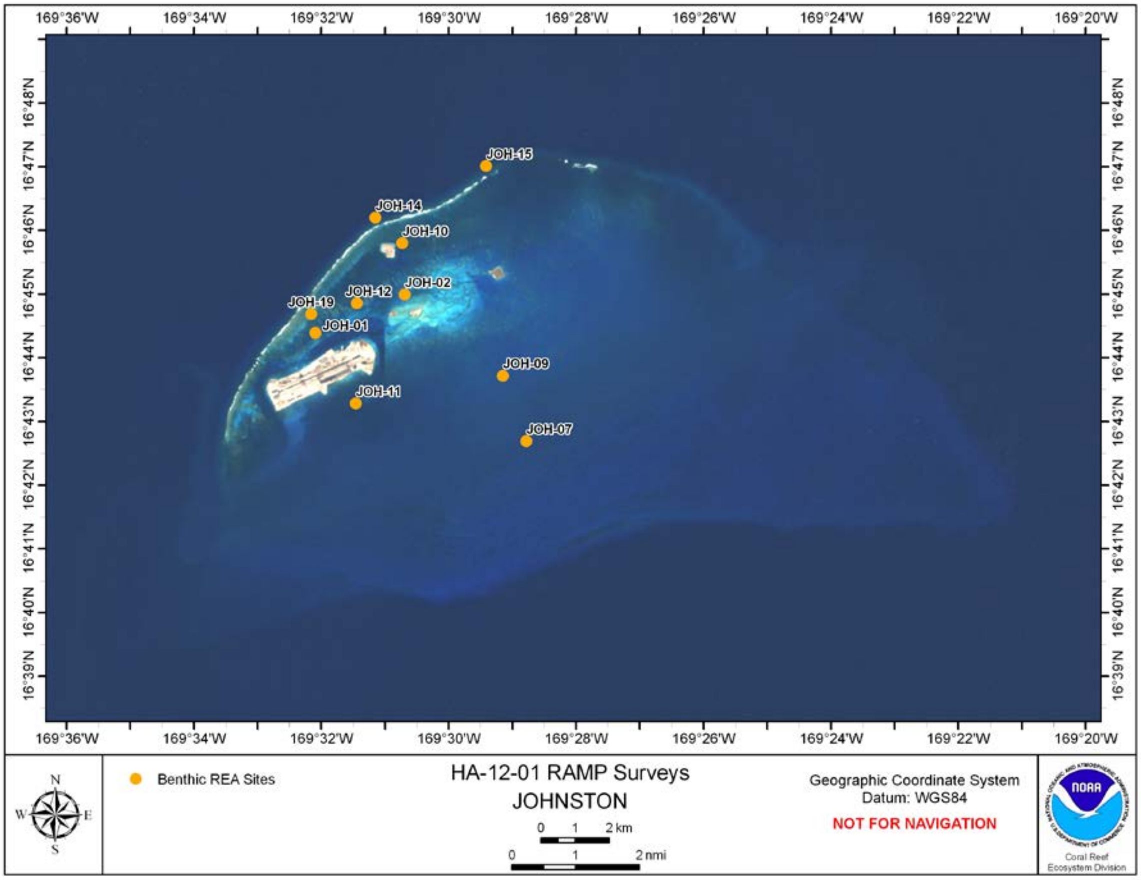

Figure B.2.1.--Locations of REA benthic sites surveyed at Johnston Atoll during cruise HA-12-01, Leg I. Landsat satellite imagery data used in this map figure are available from the U.S. Geological Survey.

Table B.2.1.--Summary of REA benthic surveys performed at Johnston Atoll during cruise HA-12-01, Leg I. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys	
				LPI	**Corals**
JOH-07	2-Mar	16.71156	–169.47969	×	×
JOH-09	2-Mar	16.72867	–169.48577	×	×
JOH-15	2-Mar	16.78352	–169.49016	×	×
JOH-02	3-Mar	16.74993	–169.51149	×	×
JOH-10	3-Mar	16.76338	–169.51209	×	×
JOH-14	3-Mar	16.77005	–169.51915	×	×
JOH-11	4-Mar	16.72140	–169.52421	×	×
JOH-01	5-Mar	16.73984	–169.53480	×	×
JOH-12	5-Mar	16.74761	–169.52397	×	×
JOH-19	5-Mar	16.74478	–169.53593	×	×

Table B.2.2.--Summary of CAU retrievals (Ret.) and installations (Dep.) and ARMS retrievals performed as well as algal specimens, and microbial water and benthic samples collected at Johnston Atoll during cruise HA-12-01, Leg I. Counts of algal samples include both voucher specimens and *Halimeda* samples for calcification analysis.

REA Site	Date	Latitude	Longitude	Installations and Collections				
				CAUs Ret	CAUs Dep	ARMS	Algae	Microbial Samples
JOH-07	2-Mar	16.71156	–169.47969	0	5	0	10	0
JOH-09	2-Mar	16.72867	–169.48577	5	5	0	10	8
JOH-15	2-Mar	16.78352	–169.49016	0	0	0	10	0
JOH-10	3-Mar	16.76338	–169.51209	5	5	3	0	0
JOH-12	3-Mar	16.74766	–169.52396	5	5	0	0	0
JOH-14	3-Mar	16.77005	–169.51915	0	0	0	10	0
JOH-11	4-Mar	16.72140	–169.52421	5	5	3	0	5
JOH-12	5-Mar	16.74761	–169.52397	5	5	3	0	6
JOH-19	5-Mar	16.74478	–169.53593	0	0	0	0	2

During cruise HA-12-01, Leg I, CRED completed 18 towed-diver surveys at Johnston Atoll, covering a total length of 36.1 km (an area of 36.1 ha) on the ocean floor (Fig. B.2.2). The mean survey length was 2.0 km with a range of 1.2–2.8 km. The mean survey depth was 14.0 m with a range of 6.9–21.1 m. The mean temperature from data recorded during these surveys was 25.6°C with a range of 25.5°C–25.8°C.

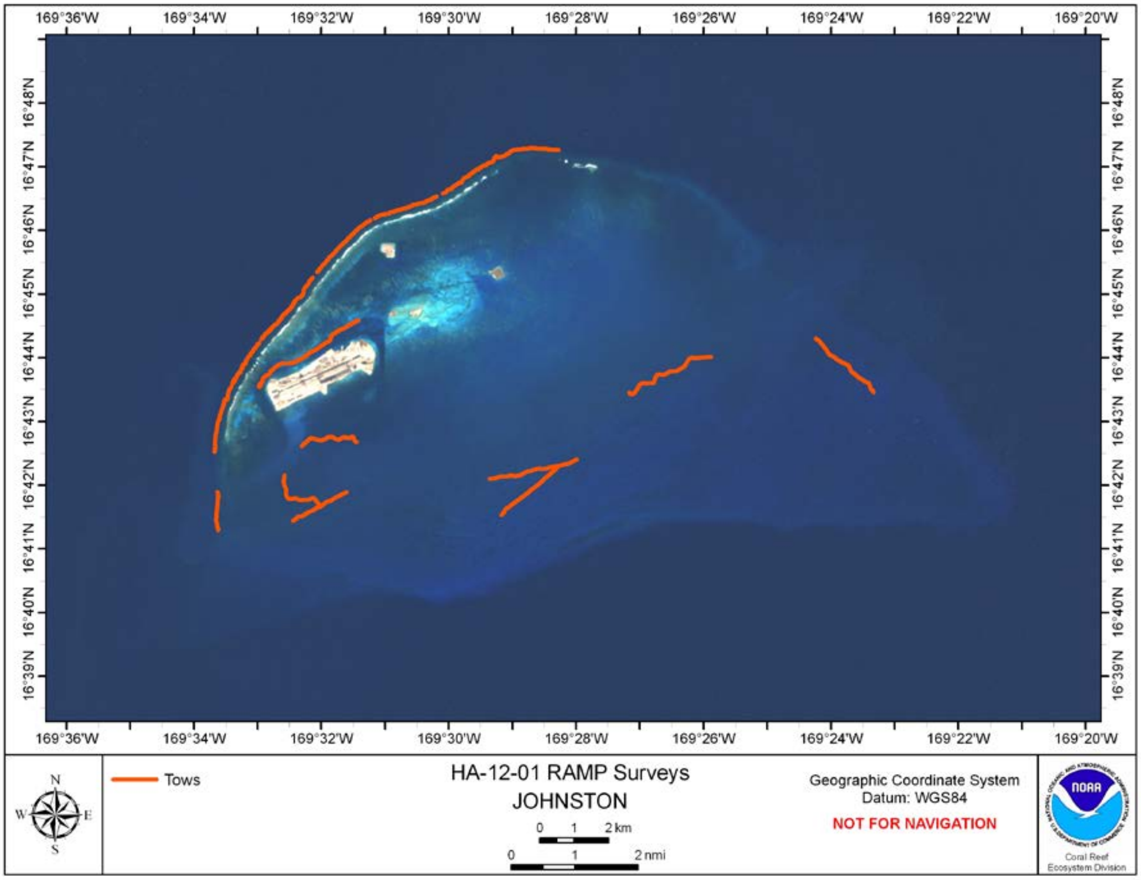

Figure B.2.2.--Track locations of towed-diver surveys conducted at Johnston Atoll during cruise HA-12-01, Leg I. Landsat satellite imagery data used in this map figure are available from the U.S. Geological Survey.

B.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 35 REA sites at Johnston Island over eight different habitat strata: deep forereef, moderate forereef, shallow forereef, deep lagoon, moderate lagoon, shallow lagoon, moderate backreef and shallow backreef (Table B.3.1 and Fig.B.3.1). No fishes were collected during these surveys.

In addition, CRED completed 18 towed-diver surveys at Johnston Atoll, as described previously in Section B.2 of this appendix.

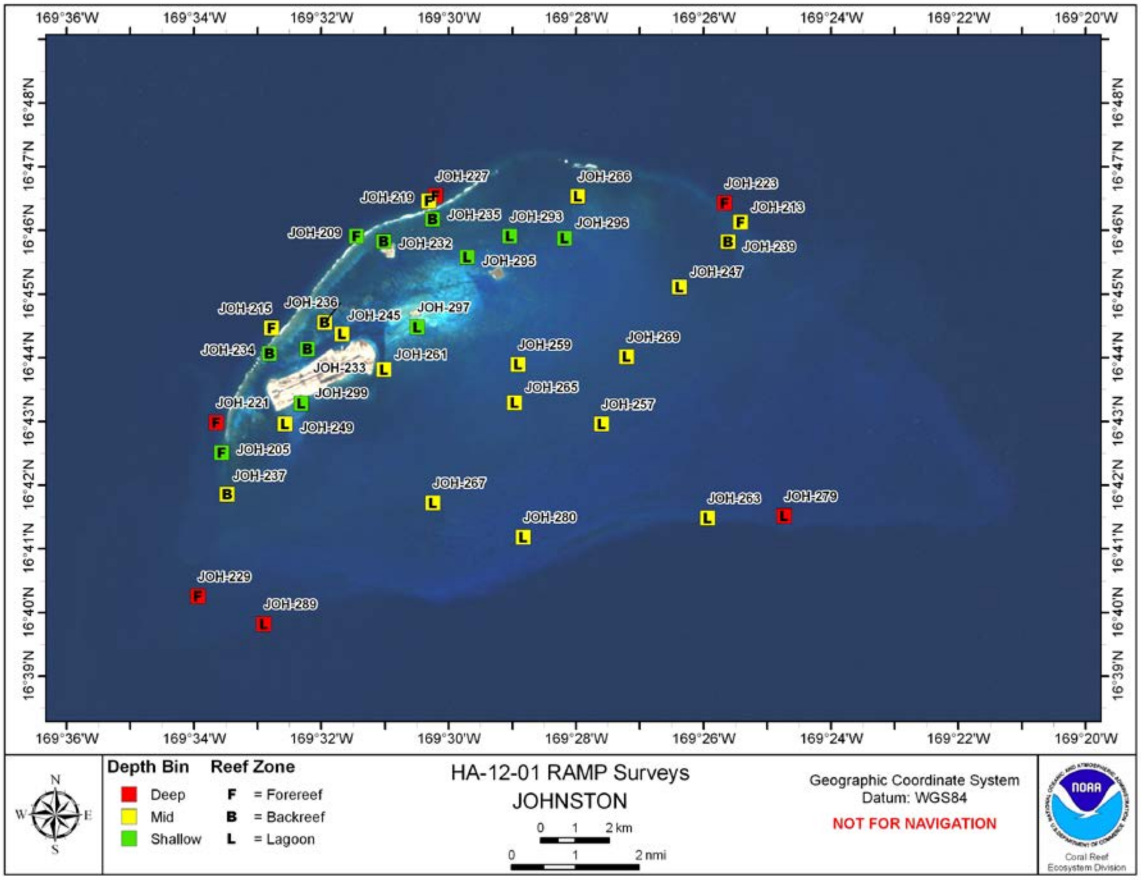

Figure B.3.1.--Locations of REA fish sites surveyed at Johnston Atoll during cruise HA-12-01, Leg I. All of these REA sites were selected using a stratified random design. Landsat satellite imagery data used in this map figure are available from the U.S. Geological Survey.

Table B.3.1.--Summary of sites where REA fish surveys were conducted at Johnston Atoll during cruise HA-12-01, Leg I.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
JOH-205	02-Mar	Shallow	Forereef	5.5	16.70857	–169.55938
JOH-215	02-Mar	Moderate	Forereef	16.0	16.74111	–169.54635
JOH-221	02-Mar	Deep	Forereef	23.6	16.71642	–169.56078
JOH-233	02-Mar	Shallow	Backreef	5.6	16.73568	–169.53694
JOH-245	02-Mar	Moderate	Lagoon	12.0	16.73963	–169.52790
JOH-263	02-Mar	Moderate	Lagoon	16.5	16.69143	–169.43220
JOH-279	02-Mar	Deep	Lagoon	20.0	16.69196	–169.41222
JOH-299	02-Mar	Shallow	Lagoon	7.4	16.72141	–169.53863
JOH-209	03-Mar	Shallow	Forereef	6.0	16.76520	–169.52416
JOH-213	03-Mar	Moderate	Forereef	15.2	16.76880	–169.42361
JOH-219	03-Mar	Moderate	Forereef	14.5	16.77441	–169.50522
JOH-223	03-Mar	Deep	Forereef	22.0	16.77386	–169.42786

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
JOH-227	03-Mar	Deep	Forereef	24.0	16.77578	–169.50344
JOH-235	03-Mar	Shallow	Backreef	5.7	16.76967	–169.50422
JOH-239	03-Mar	Moderate	Backreef	10.9	16.76373	–169.42696
JOH-295	03-Mar	Shallow	Lagoon	5.9	16.75966	–169.49515
JOH-229	04-Mar	Deep	Forereef	25.0	16.67095	–169.56569
JOH-234	04-Mar	Shallow	Backreef	2.4	16.73445	–169.54688
JOH-237	04-Mar	Moderate	Backreef	8.5	16.69761	–169.55796
JOH-249	04-Mar	Moderate	Lagoon	13.0	16.71606	–169.54281
JOH-259	04-Mar	Moderate	Lagoon	8.5	16.73165	–169.48183
JOH-261	04-Mar	Moderate	Lagoon	8.4	16.73024	–169.51694
JOH-267	04-Mar	Moderate	Lagoon	14.8	16.69539	–169.50414
JOH-280	04-Mar	Moderate	Lagoon	16.8	16.68644	–169.48048
JOH-297	04-Mar	Shallow	Lagoon	5.8	16.74135	–169.50821
JOH-232	05-Mar	Shallow	Backreef	4.0	16.76380	–169.51702
JOH-236	05-Mar	Moderate	Backreef	9.2	16.74263	–169.53250
JOH-247	05-Mar	Moderate	Lagoon	12.2	16.75182	–169.43967
JOH-257	05-Mar	Moderate	Lagoon	16.1	16.71598	–169.45999
JOH-265	05-Mar	Moderate	Lagoon	13.4	16.72162	–169.48278
JOH-266	05-Mar	Moderate	Lagoon	11.0	16.77563	–169.46617
JOH-269	05-Mar	Moderate	Lagoon	16.5	16.73362	–169.45345
JOH-289	05-Mar	Deep	Lagoon	25.2	16.66369	–169.54838
JOH-293	05-Mar	Shallow	Lagoon	3.6	16.76514	–169.48400
JOH-296	05-Mar	Shallow	Lagoon	13.3	16.76463	–169.46965

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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-12-01, Leg 1, to conduct surveys of terrestrial flora and fauna.

C.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-12-01, Leg I at Howland Island entailed numerous retrievals and deployments of oceanographic moored instruments, installation and retrieval of calcification acidification units (CAUs), nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites, hydraulic and pneumatic coral coring, shipboard water sampling and CTD casts offshore to a depth of 500 m, and acoustic Doppler current profiler (ADCP) transect lines.

Five subsurface temperature recorders (STRs) were retrieved, and six STRs were deployed (Table C.1.1). For information about CAU deployments completed at Howland Island, see Section C.2: “Benthic Environment.”

Two pneumatic coral cores and 2 hydraulic cores were extracted from mounding porites species on the west side of Howland Island.

At nearshore locations around Howland Island, 5 shallow-water CTD casts were performed (Fig. C.1.1), including one cast at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. Accounting for losses and replicates, a total of 10 DIC and TA, 10 salinity, 10 nutrient, and 16 Chl-*a* water samples were collected, one from the surface and one near the reef at each CAU site.

From the NOAA Ship *Hi`ialakai*, eight CTD casts were conducted to each of the four cardinal directions to a depth of 500 m away from this island during night operations on alternate nights. On the reciprocal course, 80 km of ADCP transect lines were run. Eighty Chl-*a* samples were collected at 16 select sites, and 20 nutrient water samples were collected at 4 select sites concurrently with shipboard CTD casts at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. C.1.2).

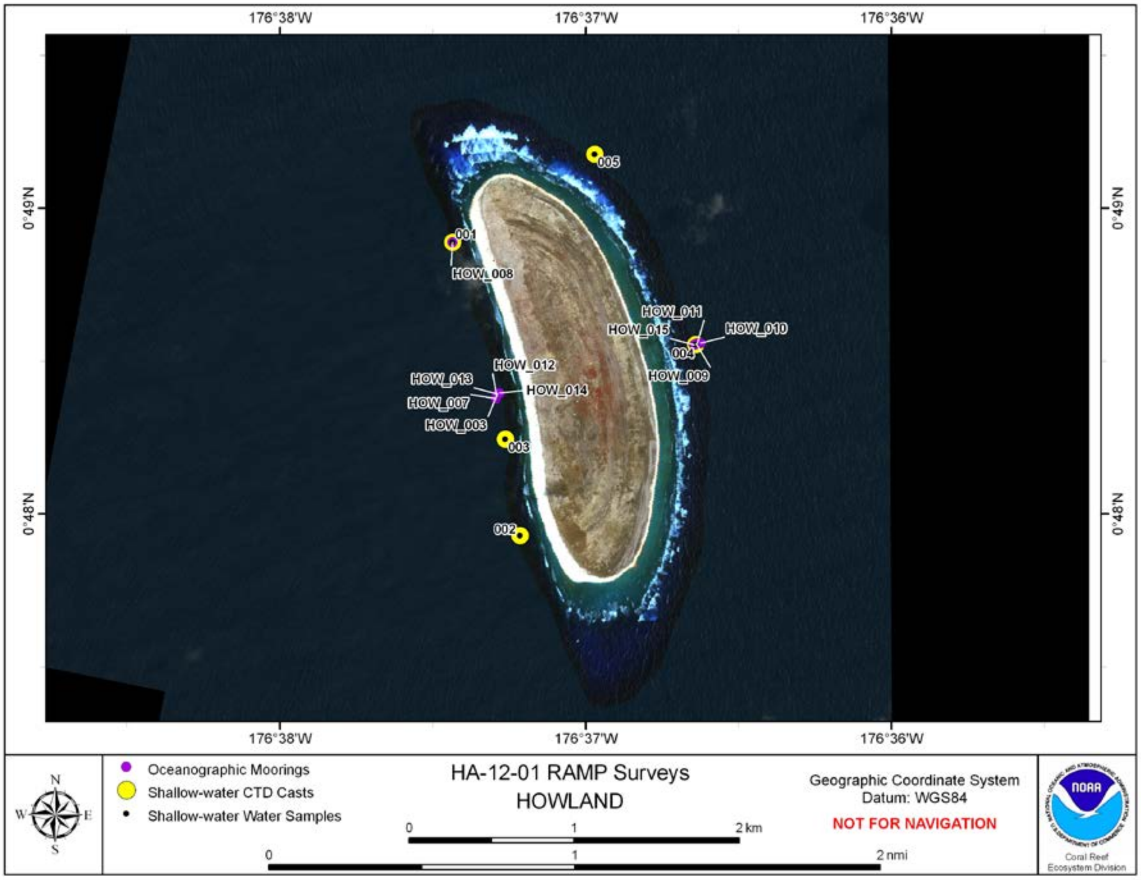

Figure C.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Howland Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

Table C.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments that were retrieved or deployed at Howland Island during cruise HA-12-01, Leg I.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
HOW_008	11-Mar	STR	0.81482	–176.62393	15.2	1	–
HOW_009	11-Mar	STR	0.80927	–176.61065	11.9	1	–
HOW_010	11-Mar	STR	0.80931	–176.61040	25.0	–	1
HOW_011	11-Mar	STR	0.80931	–176.61058	14.9	–	1
HOW_003	12-Mar	STR	0.80648	–176.62151	19.8	1	–
HOW_007	12-Mar	STR	0.80629	–176.62155	38.4	1	–
HOW_012	12-Mar	STR	0.80640	–176.62152	25.0	–	1
HOW_013	12-Mar	STR	0.80653	–176.62148	15.5	–	1
HOW_014	12-Mar	STR	0.80660	–176.62137	4.6	1	1
HOW_015	13-Mar	STR	0.80923	–176.61076	5.2	–	1

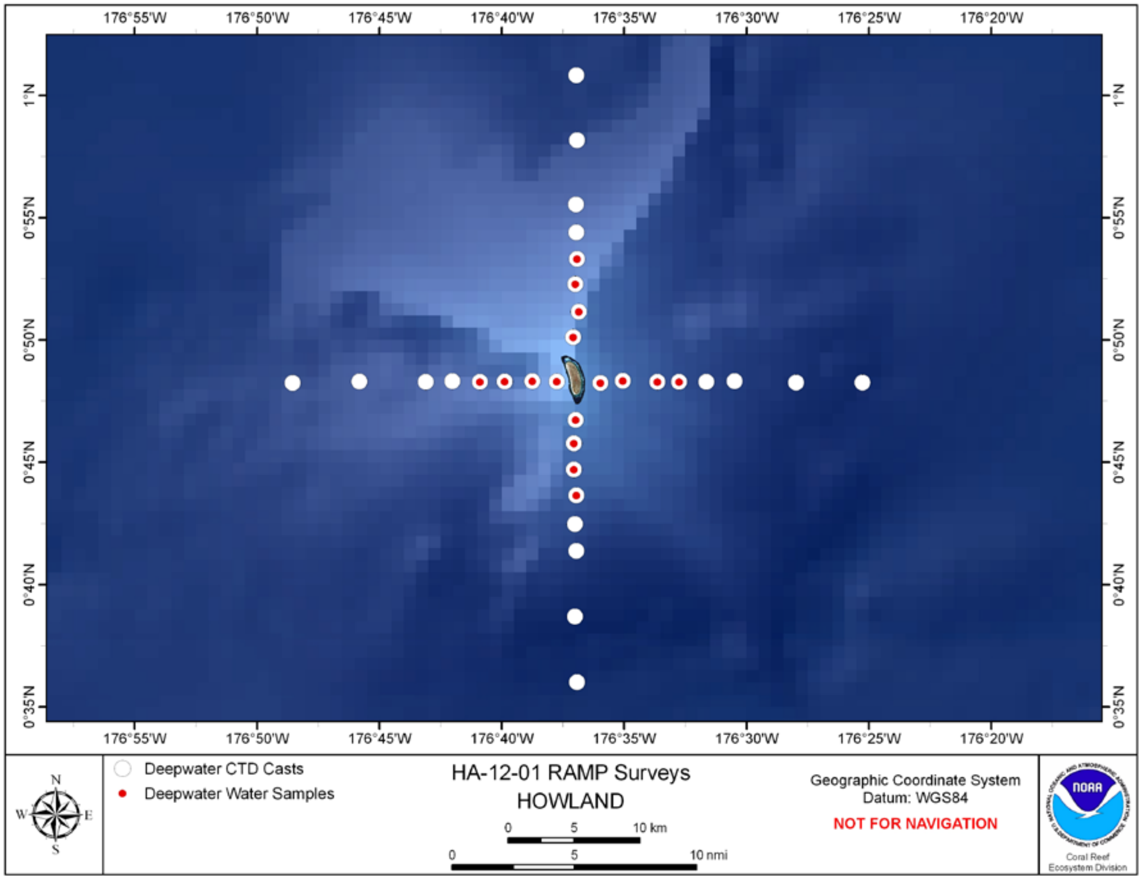

Figure C.1.2.--Locations of deepwater CTD casts and water sampling performed at Howland Island during cruise HA-12-01, Leg I. Island satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

C.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver surveys were conducted and photographs were taken along transect lines at eight REA sites around 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).

Various samples were collected at eight REA sites (Table C.2.2): six algal voucher specimens at three REA sites for taxonomic identification, 120 individuals of the algal genus *Halimeda* at five REA sites for calcification analysis, three fragments of the coral, *Pocillopora meandrina*, for histopathological analysis at REA site KUR-09, 27 samples of two species of macroinvertebrates at six REA sites, four coral cores (10–15 cm in length) from *Porites* coral heads at two REA sites for calcification research, and 19 water samples for microbial analyses at four REA sites with four water samples of 2 L each at each site and three water samples of 20 L each at FFS-34. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at two REA sites and plankton tows conducted at two nearshore and two offshore locations. For more information about collections made at REA sites, see Table G.1.1 in Appendix G: "Biological Collections."

Nine autonomous reef-monitoring structures (ARMS) were recovered: three ARMS each from HOW-05, HOW-11 and HOW-14 (Table B.2.2). At each of five select REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Howland Island (Table B.2.2). A total of 24 CAUs were recovered from 5 REA sites.

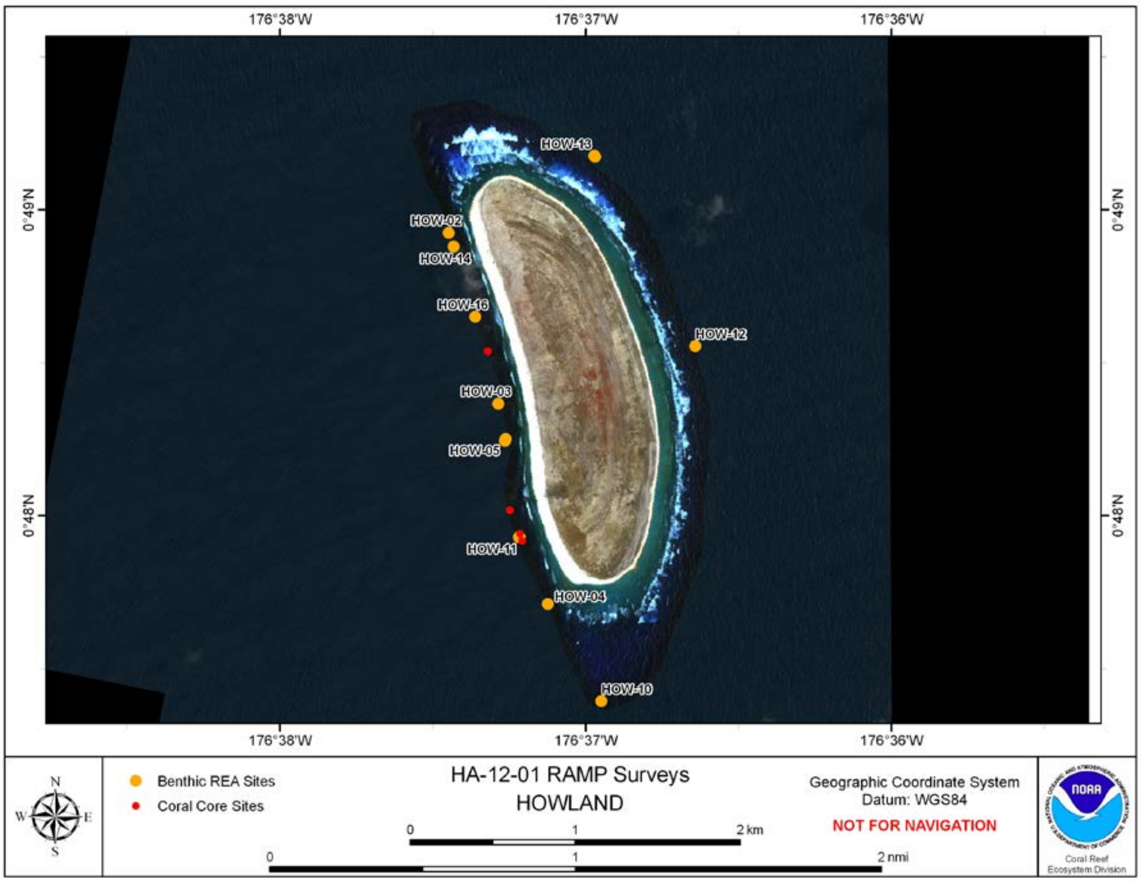

Figure C.2.1.--Locations of REA benthic sites surveyed at Howland Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

Table C.2.1.--Summary of REA benthic surveys performed at Howland Island during cruise HA-12-01, Leg I. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys	
				LPI	Corals
HOW-03	11-Mar	0.80611	–176.62142	×	×
HOW-14	11-Mar	0.81467	–176.62386	×	×
HOW-16	11-Mar	0.81084	–176.62267	×	×
HOW-04	12-Mar	0.79518	–176.61873	×	×
HOW-05	12-Mar	0.80418	–176.62101	×	×
HOW-10	12-Mar	0.78990	–176.61581	×	×
HOW-02	13-Mar	0.81542	–176.62413	×	×
HOW-11	13-Mar	0.79883	–176.62030	×	×

Table C.2.2.--Summary of CAU retrievals (Ret.) and installations (Dep.) and ARMS retrievals performed as well as algal specimens, microbial water and benthic samples, and coral cores collected at Howland Island during cruise HA-12-01, Leg I. Counts of algal samples include algal voucher specimens and *Halimeda* samples for calcification and isotope analyses.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs Ret	CAUs Dep	ARMS	Algae	Microbial Samples	Coral Cores
HOW-05	11-Mar	0.80409	–176.62106	4	5	0	0	0	0
HOW-11	11-Mar	0.79882	–176.62025	5	5	0	0	0	0
HOW-14	11-Mar	0.81467	–176.62386	5	5	3	0	5	0
HOW-04	12-Mar	0.79518	–176.61873	0	0	0	0	2	0
HOW-05	12-Mar	0.80418	–176.62101	0	0	3	0	0	0
HOW-10	12-Mar	0.78990	–176.61581	0	0	0	0	2	0
HOW-12	12-Mar	0.80924	–176.61068	5	5	0	0	0	0
HOW-13	12-Mar	0.81962	–176.61619	5	5	0	0	0	0
HOW-02	13-Mar	0.81542	–176.62413	0	0	0	17	6	0
HOW-11	13-Mar	0.79866	–176.62014	0	0	0	0	0	1
HOW-11	13-Mar	0.79903	–176.62024	0	0	0	0	0	1
HOW-11	13-Mar	0.79883	–176.62030	0	0	3	0	0	0
HOW-05	14-Mar	0.80898	–176.62199	0	0	0	0	0	1
HOW-05	14-Mar	0.80418	–176.62101	0	0	0	17	6	0
HOW-11	14-Mar	0.80031	–176.62080	0	0	0	0	0	1

CRED also completed 13 towed-diver surveys at Howland Island, covering a total length of 22.0 km (an area of 22.0 ha) on the ocean floor (Fig. C.2.2). The mean survey length was 1.7 km with a range of .18–2.6 km. The mean survey depth was 13.4 m with a range of 6.1–15.8 m. The mean temperature from data recorded during these surveys was 27.3°C with a range of 27.0°C –27.5°C.

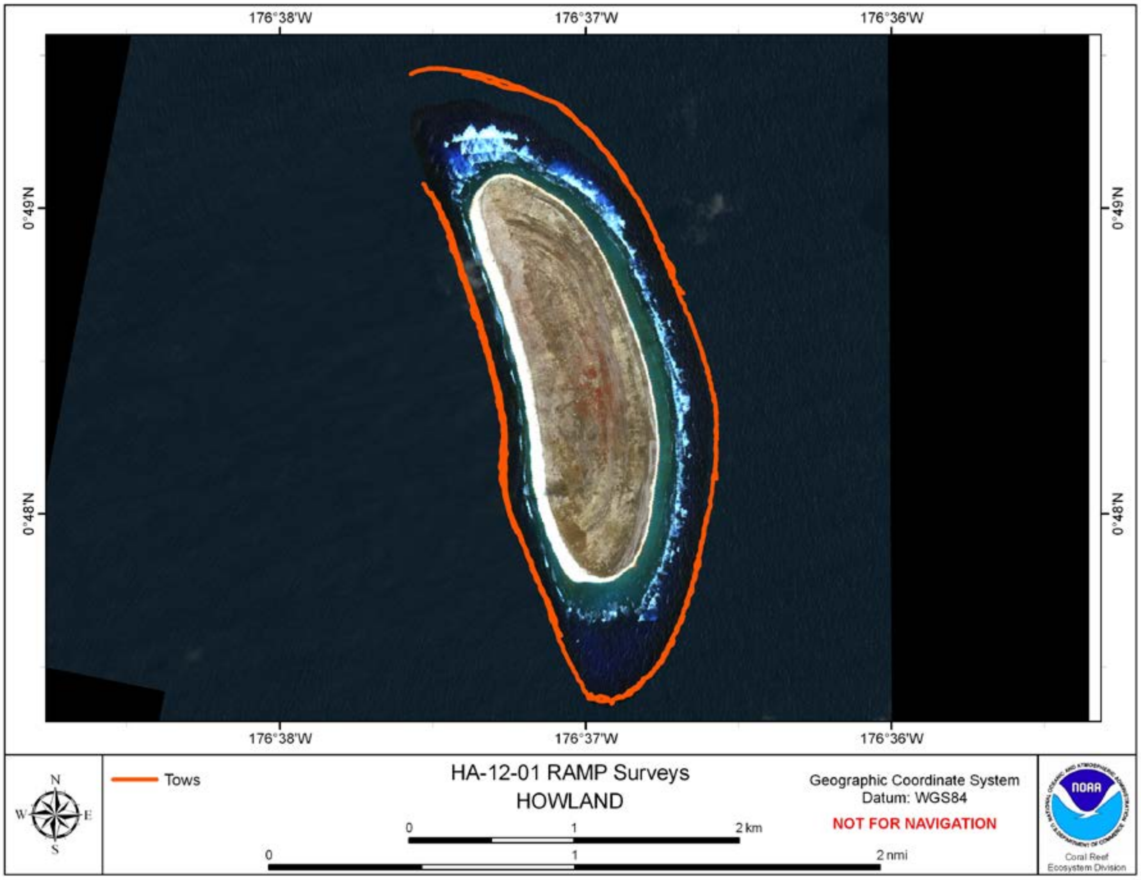

Figure C.2.2.--Track locations of towed-diver surveys conducted at Howland Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

C.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 39 REA sites at Howland Island over 3 different habitat strata: deep, moderate, and shallow forereef (Table C.3.1 and Fig.C.3.1). No fishes were collected during these surveys.

In addition, CRED completed 13 towed-diver surveys at Howland Island, as described previously in Section C.2 of this appendix.

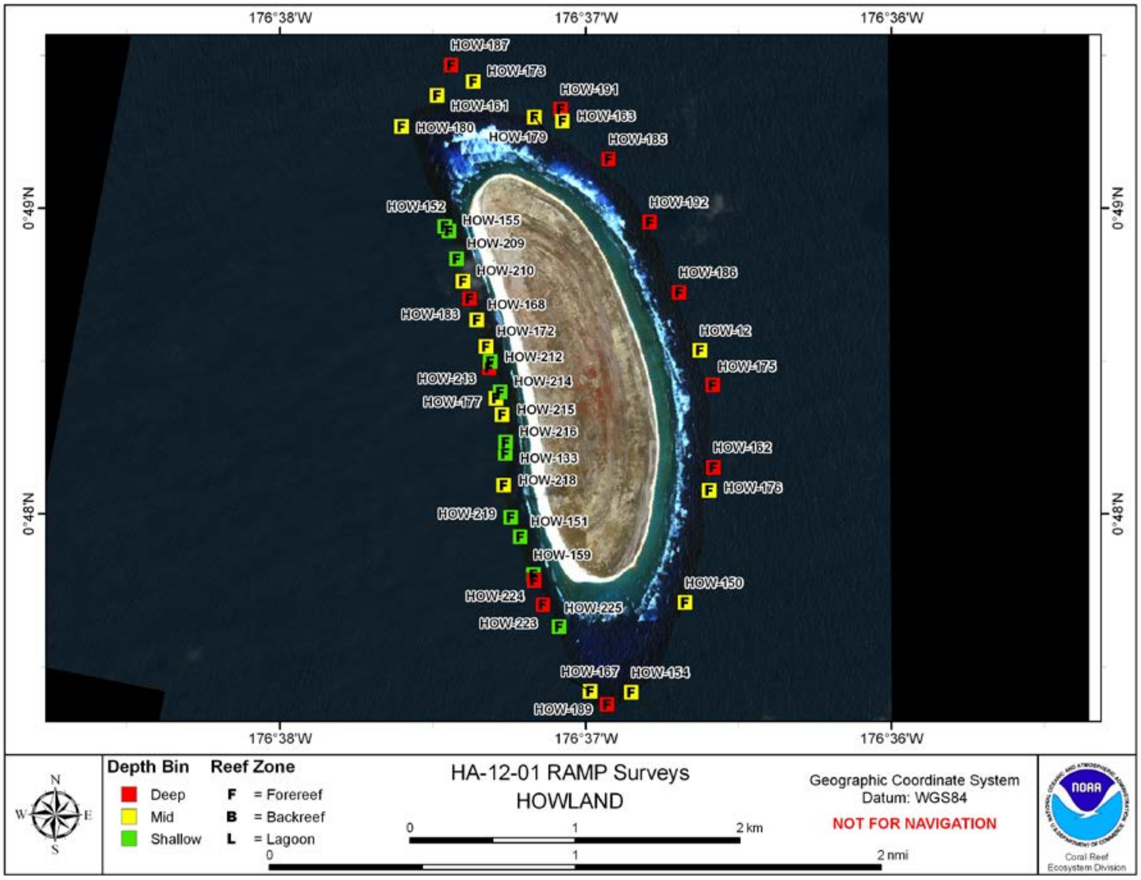

Figure C.3.1.--Locations of REA fish sites surveyed at Howland Island during cruise HA-12-01, Leg I. All of these REA sites were selected using a stratified random design (IKONOS Carterra Geo Data, 2003).

Table C.3.1.--Summary of sites where REA fish surveys were conducted at Howland Island during cruise HA-12-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
HOW-133	11-Mar	Shallow	Forereef	4.7	0.80330	–176.62106
HOW-151	11-Mar	Shallow	Forereef	2.65	0.79875	–176.62024
HOW-155	11-Mar	Shallow	Forereef	5.15	0.81542	–176.62413
HOW-161	11-Mar	Mid	Forereef	13.7	0.82282	–176.62477
HOW-168	11-Mar	Mid	Forereef	12	0.81058	–176.62260
HOW-172	11-Mar	Mid	Forereef	15	0.80913	–176.62210
HOW-177	11-Mar	Mid	Forereef	15	0.80630	–176.62156
HOW-179	11-Mar	Mid	Forereef	12.6	0.82164	–176.61945
HOW-187	11-Mar	Deep	Forereef	25.65	0.82448	–176.62401
HOW-191	11-Mar	Deep	Forereef	17.75	0.82208	–176.61804
HOW-159	12-Mar	Shallow	Forereef	1.7	0.79669	–176.61951
HOW-163	12-Mar	Mid	Forereef	15.9	0.82143	–176.61794
HOW-167	12-Mar	Mid	Forereef	11.45	0.79034	–176.61643

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
HOW-173	12-Mar	Mid	Forereef	17.35	0.82358	–176.62279
HOW-185	12-Mar	Deep	Forereef	23.05	0.81935	–176.61542
HOW-189	12-Mar	Deep	Forereef	22.45	0.78962	–176.61550
HOW-209	12-Mar	Shallow	Forereef	5.75	0.81391	–176.62371
HOW-210	12-Mar	Mid	Forereef	13.2	0.81269	–176.62337
HOW-218	12-Mar	Mid	Forereef	16.65	0.80158	–176.62114
HOW-219	12-Mar	Shallow	Forereef	4.05	0.79982	–176.62076
HOW-162	13-Mar	Deep	Forereef	21.8	0.80255	–176.60972
HOW-176	13-Mar	Mid	Forereef	15.1	0.80128	–176.60994
HOW-213	13-Mar	Deep	Forereef	26	0.80797	–176.62193
HOW-212	13-Mar	Shallow	Forereef	5	0.80830	–176.62189
HOW-214	13-Mar	Shallow	Forereef	2	0.80665	–176.62133
HOW-215	13-Mar	Mid	Forereef	11.1	0.80542	–176.62124
HOW-216	13-Mar	Shallow	Forereef	4.4	0.80392	–176.62104
HOW-224	13-Mar	Deep	Forereef	20.35	0.79637	–176.61948
HOW-225	13-Mar	Shallow	Forereef	6.15	0.79387	–176.61813
HOW-12	14-Mar	Mid	Forereef	13.5	0.80927	–176.61066
HOW-150	14-Mar	Mid	Forereef	14.5	0.79517	–176.61125
HOW-152	14-Mar	Shallow	Forereef	5	0.81568	–176.62435
HOW-154	14-Mar	Mid	Forereef	14.65	0.79027	–176.61419
HOW-175	14-Mar	Deep	Forereef	24.4	0.80704	–176.60976
HOW-180	14-Mar	Mid	Forereef	13.85	0.82111	–176.62671
HOW-183	14-Mar	Deep	Forereef	22.2	0.81174	–176.62300
HOW-186	14-Mar	Deep	Forereef	28.7	0.81208	–176.61158
HOW-192	14-Mar	Deep	Forereef	22.75	0.81591	–176.61317
HOW-223	14-Mar	Deep	Forereef	20.65	0.79506	–176.61900

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-12-01, Leg 1, to conduct surveys of terrestrial flora and fauna.

D.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-12-01, Leg I at Baker Island entailed numerous retrievals and deployments of oceanographic moored instruments, installation of calcification acidification units (CAUs), coral coring, nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites, and shipboard water sampling and CTD casts offshore to a depth of 500 m, and acoustic Doppler current profiler (ADCP) transect lines.

Five subsurface temperature recorders (STRs) were retrieved, and nine STRs were deployed (Table D.1.1). For information about CAU deployments completed at Baker Island, see Section D.2: “Benthic Environment.”

One pneumatic coral core was extracted at Baker Island.

At nearshore locations around Baker Island, 5 shallow-water CTD casts were performed (Fig. D.1.1) at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 10 DIC and TA, 10 salinity, 10 nutrient, and 10 Chl-*a* water samples were collected, one from the surface and one near the reef at each CAU site.

From the NOAA Ship *Hi`ialakai*, eight CTD casts were conducted to the east and west to a depth of 500 m away from this island during night operations on alternate nights. On the reciprocal course, 40 km of ADCP transect lines were run. Forty Chl-*a* samples were collected at 8 select sites, and 10 nutrient water samples were collected at 2 select sites concurrently with shipboard CTD casts at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. D.1.2).

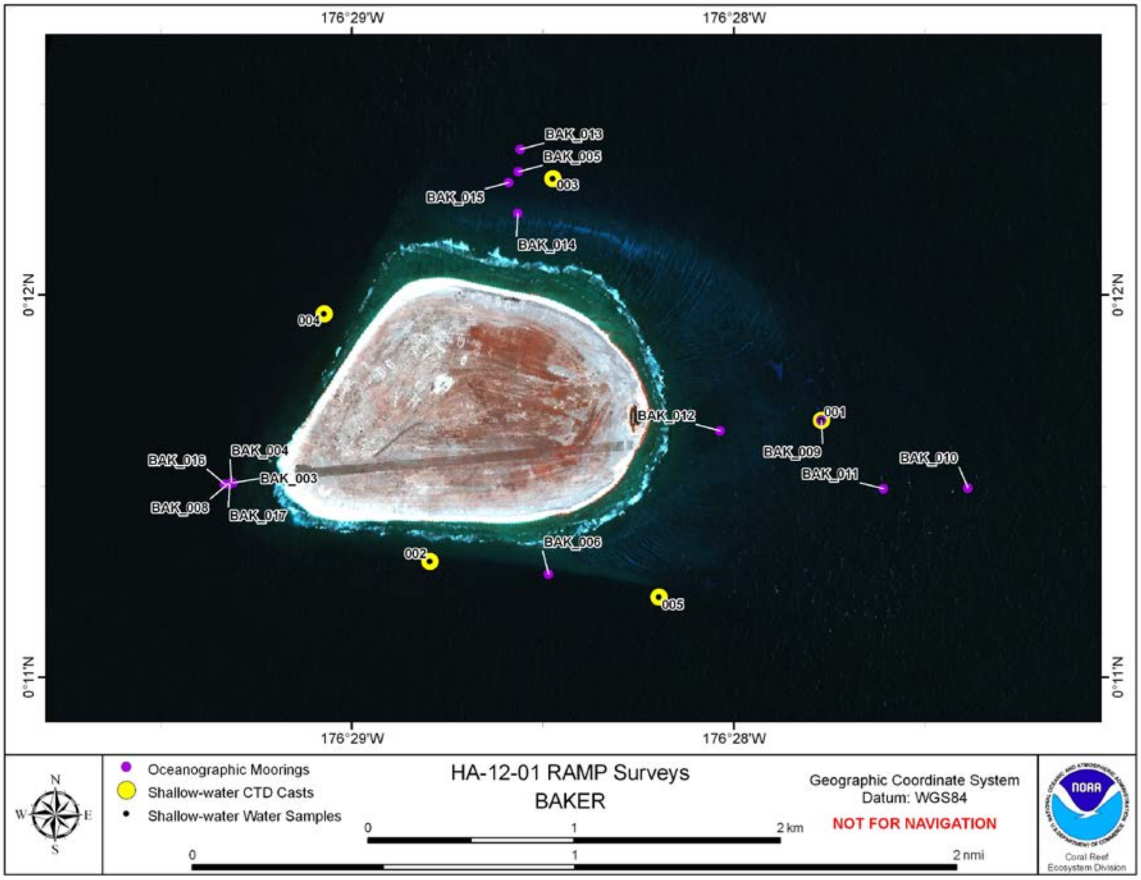

Figure D.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Baker Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

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-12-01, Leg I.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
BAK_006	15-Mar	STR	0.18784	–176.47475	5.2	1	–
BAK_009	15-Mar	STR	0.19454	–176.46287	11.6	1	–
BAK_010	15-Mar	STR	0.19159	–176.45647	24.7	–	1
BAK_011	15-Mar	STR	0.19155	–176.46015	15.5	–	1
BAK_012	15-Mar	STR	0.19409	–176.46728	5.5	–	1
BAK_003	16-Mar	STR	0.19182	–176.48851	5.2	–	1
BAK_004	16-Mar	STR	0.19184	–176.48859	18.6	1	–
BAK_005	16-Mar	STR	0.20539	–176.47606	17.7	1	–
BAK_008	16-Mar	STR	0.19177	–176.48874	9.1	1	–
BAK_013	16-Mar	STR	0.20637	–176.47599	25.0	–	1
BAK_014	16-Mar	STR	0.20357	–176.47609	5.2	–	1
BAK_015	16-Mar	STR	0.20491	–176.47649	14.3	–	1

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
BAK_016	16-Mar	STR	0.19175	–176.48887	25.3	–	1
BAK_017	16-Mar	STR	0.19177	–176.48866	14.9	–	1

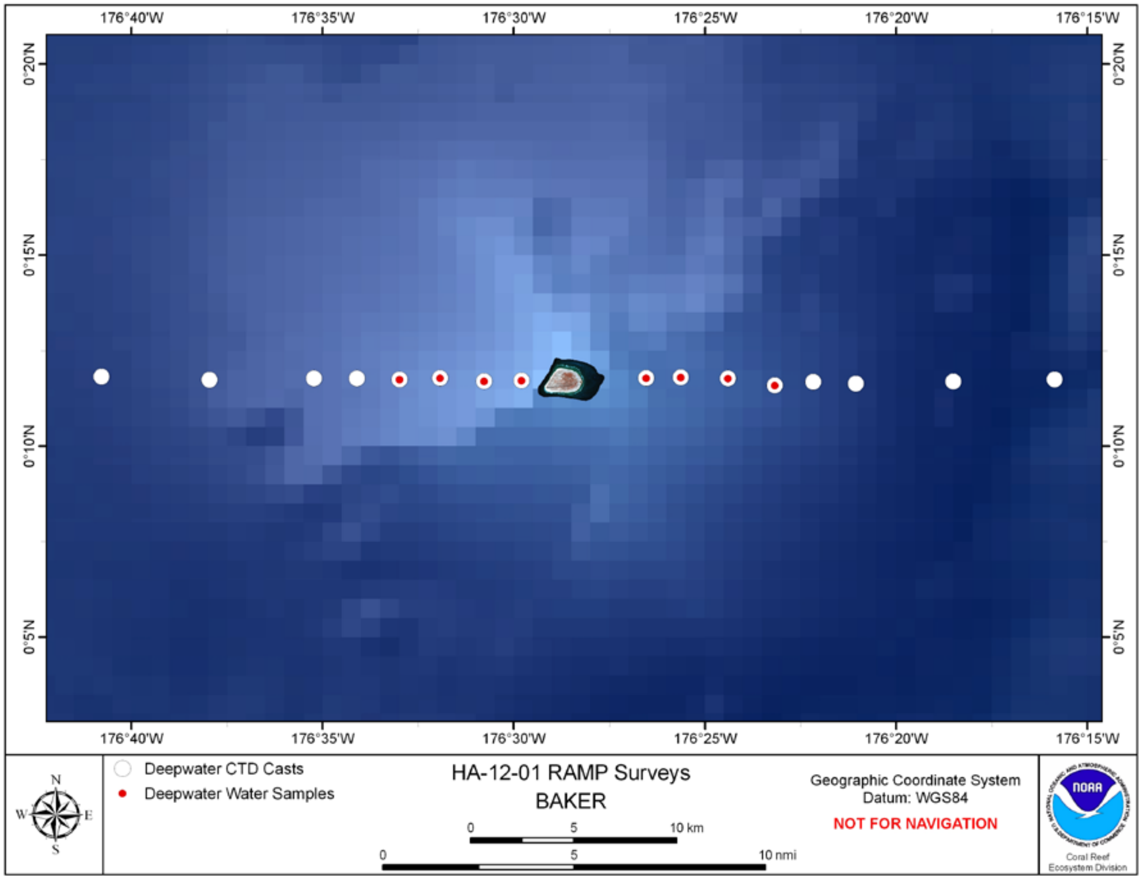

Figure D.1.2.--Locations of deepwater CTD casts and water sampling performed at Baker Island during cruise HA-12-01, Leg I. Island satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

D.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver surveys were conducted and photographs were taken along transect lines at six REA sites around Baker Island to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. D.2.1 and Table D.2.1).

Various samples were collected at six REA sites (Table D.2.2): 51 individuals of the algal genus *Halimeda* at three REA sites for calcification and isotopic analysis, one coral core

(10–15 cm in length) from a *Porites* coral head at one REA site for calcification research, and 15 water samples for microbial analyses at four REA sites with two water samples of 2 L each at each site and seven water samples of 20 L each at BAK-02. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at four REA sites. For more information about collections made at REA sites, see Table G.1.1 in Appendix G: “Biological Collections.”

Six autonomous reef monitoring structures (ARMS) were recovered: three ARMS each from BAK-11 and BAK-16 (Table D.2.2). At each of five select REA sites, an array of five CAUs were deployed for a total of 25 CAUs installed at Baker Island (Table D.2.2). A total of 19 CAUs were recovered from four REA sites.

Figure D.2.1.--Locations of REA benthic sites surveyed at Baker Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

Table D.2.1.--Summary of REA benthic surveys performed at Baker Island during cruise HA-12-01, Leg I. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys	
				LPI	Corals
BAK-09	15-Mar	0.18686	–176.46996	×	×
BAK-11	15-Mar	0.19924	–176.48459	×	×
BAK-14	15-Mar	0.20503	–176.47445	×	×
BAK-16	16-Mar	0.19469	–176.46279	×	×
BAK-02	17-Mar	0.18842	–176.47992	×	×
BAK-05	17-Mar	0.19685	–176.48588	×	×

Table D.2.2.--Summary of CAU retrievals (Ret.) and installations (Dep.) and ARMS retrievals performed as well as algal specimens, microbial water and benthic samples, and coral cores collected at Baker Island during cruise HA-12-01, Leg I. Counts of algal samples include algal voucher specimens and *Halimeda* samples for calcification and isotope analyses.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs Ret	CAUs Dep	ARMS	Algae	Microbial Samples	Coral Cores
BAK-02	15-Mar	0.18839	–176.47994	5	5	0	0	0	0
BAK-09	15-Mar	0.18686	–176.46996	0	5	0	17	2	0
BAK-11	15-Mar	0.19924	–176.48459	0	0	3	0	2	0
BAK-14	15-Mar	0.20503	–176.47445	0	0	0	17	0	0
BAK-16	15-Mar	0.19454	–176.46287	5	5	0	0	0	0
BAK-11	16-Mar	0.19918	–176.48454	4	5	0	0	0	0
BAK-14	16-Mar	0.20509	–176.47457	5	5	0	0	0	0
BAK-16	16-Mar	0.19469	–176.46279	0	0	3	0	2	0
BAK-02	17-Mar	0.18842	–176.47992	0	0	0	17	9	0
BAK-09	17-Mar	0.18684	–176.46994	0	5	0	0	0	0
BAK-11	17-Mar	0.19394	–176.48752	0	0	0	0	0	1

During cruise HA-12-01, Leg I, CRED completed 10 towed-diver surveys at Baker Island, covering a total length of 19.8 km (an area of 19.8 ha) on the ocean floor (Fig. D.2.2).The mean survey length was 2.0 km with a range of 1.6–2.8 km. The mean survey depth was 15.1 m with a range of 10.5–17.7 m. The mean temperature from data recorded during these surveys was 27.2°C with a range of 26.2°C–27.5°C.

Figure D.2.2.--Track locations of towed-diver surveys conducted at Baker Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

D.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 24 REA sites at Baker Island over 3 different habitat strata: deep, moderate, and shallow forereef (Table D.3.1 and Fig.D.3.1). No fishes were collected during these surveys.

In addition, CRED completed 10 towed-diver surveys at Baker Island, as described previously in Section D.2 of this appendix.

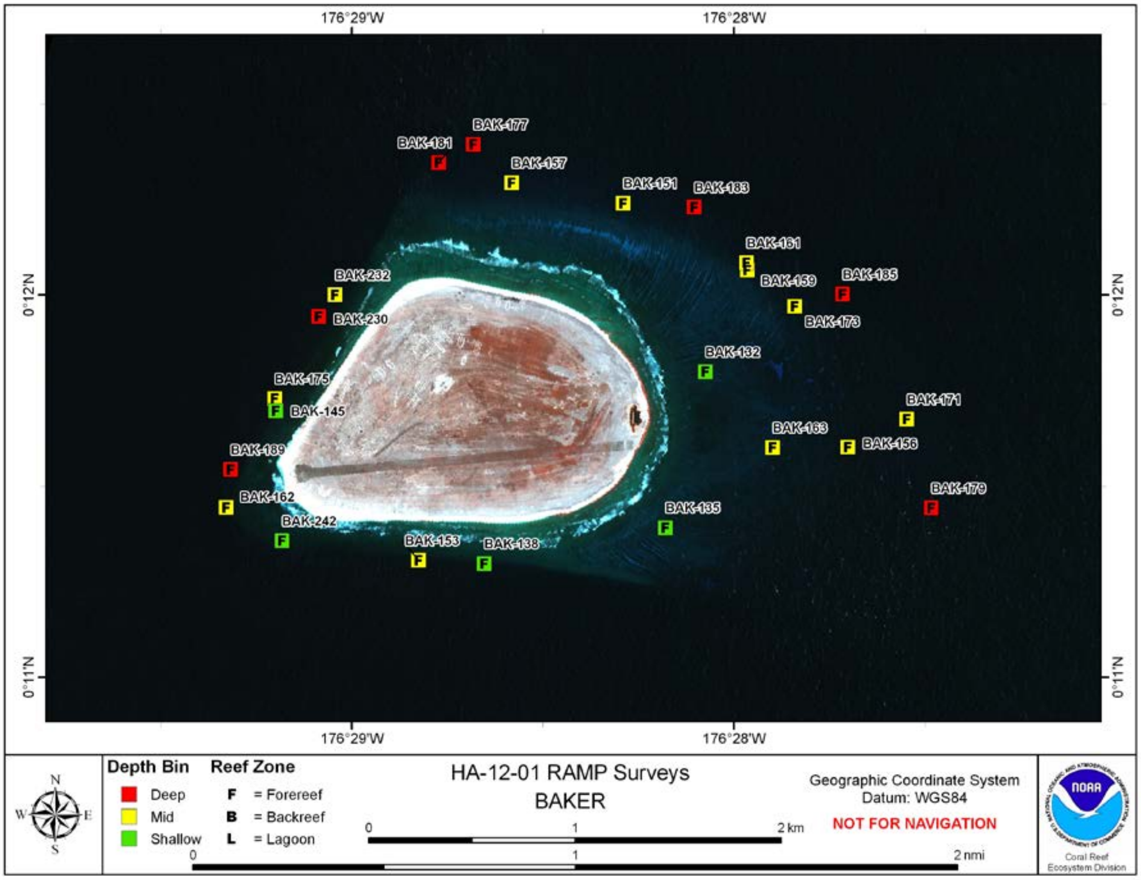

Figure D.3.1.--Locations of REA fish sites surveyed at Baker Island during cruise HA-12-01, Leg I. All of these REA sites were selected using a stratified random design (IKONOS Carterra Geo Data, 2003).

Table D.3.1.--Summary of sites where REA fish surveys were conducted at Baker Island during cruise HA-12-01, Leg I.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
BAK-132	15-Mar	Shallow	Forereef	4.8	0.19666	–176.46791
BAK-135	15-Mar	Shallow	Forereef	6.0	0.18986	–176.46966
BAK-151	15-Mar	Moderate	Forereef	15.0	0.20401	–176.47149
BAK-157	15-Mar	Moderate	Forereef	12.2	0.20489	–176.47636
BAK-159	15-Mar	Moderate	Forereef	11.0	0.20109	–176.46609
BAK-161	15-Mar	Moderate	Forereef	12.0	0.20141	–176.46612
BAK-171	15-Mar	Moderate	Forereef	16.8	0.19459	–176.45913
BAK-173	15-Mar	Moderate	Forereef	12.3	0.19951	–176.46402
BAK-177	15-Mar	Deep	Forereef	25.3	0.20658	–176.47803
BAK-181	15-Mar	Deep	Forereef	21.4	0.20578	–176.47954
BAK-183	15-Mar	Deep	Forereef	21.3	0.20383	–176.46840
BAK-138	16-Mar	Shallow	Forereef	4.6	0.18829	–176.47756
BAK-153	16-Mar	Moderate	Forereef	10.0	0.18843	–176.48042
BAK-156	16-Mar	Moderate	Forereef	11.5	0.19337	–176.46171
BAK-163	16-Mar	Moderate	Forereef	7.5	0.19335	–176.46499
BAK-179	16-Mar	Deep	Forereef	21.0	0.19071	–176.45806
BAK-185	16-Mar	Deep	Forereef	27.5	0.20003	–176.46194
BAK-242	16-Mar	Shallow	Forereef	3.6	0.18928	–176.48637
BAK-145	17-Mar	Shallow	Forereef	5.5	0.19496	–176.48664
BAK-162	17-Mar	Moderate	Forereef	11.0	0.19074	–176.48881
BAK-175	17-Mar	Moderate	Forereef	12.7	0.19548	–176.48669
BAK-189	17-Mar	Deep	Forereef	23.0	0.19239	–176.48861
BAK-230	17-Mar	Deep	Forereef	26.0	0.19907	–176.48478
BAK-232	17-Mar	Moderate	Forereef	13.5	0.20001	–176.48407

APPENDIX E: SWAINS ISLAND

Swains Island, located at 11°3′ S, 171°9′ W, is a part of American Samoa. For more information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

E.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-12-01, Leg I at Swains Island entailed numerous retrievals and deployments of oceanographic moored instruments, installation of calcification acidification units (CAUs), coral coring, nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select 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.

Five subsurface temperature recorders (STRs) were retrieved, and seven STRs were deployed (Table E.1.1). For information about CAU deployments completed at Swains Island, see Section E.2: “Benthic Environment.”

At nearshore locations around Swains Island, 5 shallow-water CTD casts were performed (Fig. E.1.1) at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 10 DIC and TA, 10 salinity, 10 nutrient, and 10 Chl-*a* water samples were collected, one from the surface and one near the reef at each CAU site.

Three pneumatic coral cores were extracted from Swains Island.

From the NOAA Ship *Hi`ialakai* eight CTD casts were conducted to the west to a depth of 500 m away from this island during night operations. On the reciprocal course, a 20 km of ADCP transect lines was run. Five Chl-*a* samples were collected at 1 select site concurrently with shipboard CTD casts at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. E.1.2).

Figure E.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Swains Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

Table E.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments that were retrieved or deployed at Swains Island during cruise HA-12-01, Leg I.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
SWA_001	21-Mar	STR	–11.05859	–171.09096	15.2	1	1
SWA_002	21-Mar	STR	–11.05862	–171.09078	6.1	1	1
SWA_003	21-Mar	STR	–11.05870	–171.09120	29.6	1	–
SWA_004	21-Mar	STR	–11.05257	–171.06472	15.1	1	1
SWA_005	21-Mar	STR	–11.04564	–171.07605	14.9	1	–
SWA_006	21-Mar	STR	–11.05869	–171.09112	24.1	–	1
SWA_007	21-Mar	STR	–11.05252	–171.06472	25.3	–	1
SWA_008	21-Mar	STR	–11.05261	–171.06492	5.2	–	1
SWA_009	22-Mar	STR	–11.05718	–171.09039	0.3	–	1

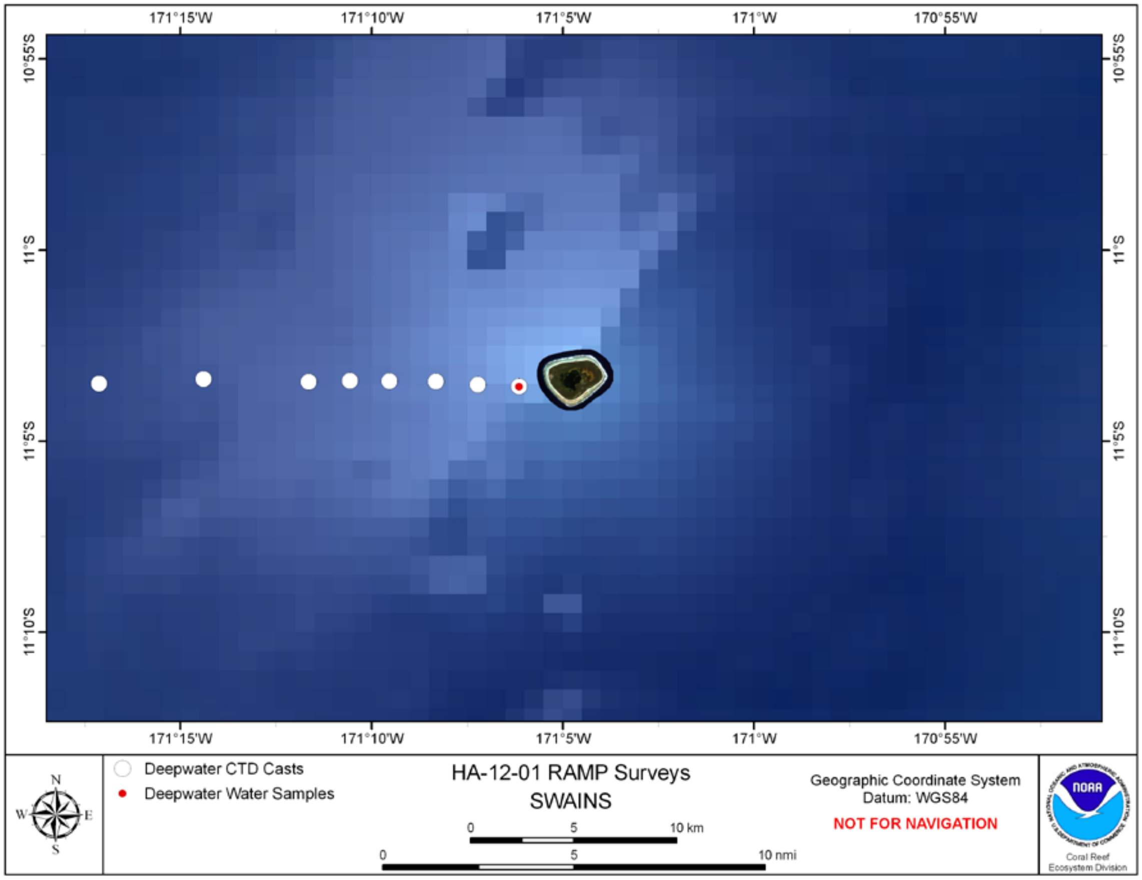

Figure E.1.2.--Locations of deepwater CTD casts and water sampling performed at Swains Island during cruise HA-12-01, Leg I. Island satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

E.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver surveys were conducted and photographs were taken along transect lines at nine REA sites around Swains Island to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. E.2.1 and Table E.2.1).

Various samples were collected at six REA sites (Table E.2.2): one algal voucher specimen at one REA site for taxonomic identification, 120 individuals of the algal genus *Halimeda* at five REA sites for calcification analysis, five fragments of the coral, *Pocillopora meandrina*, for histopathological analysis at REA site SWA-01, three coral cores (10–15 cm in length) from *Porites* coral heads at one REA site for calcification research, and 21 water samples for microbial analyses at five REA sites with two water samples of 2 L each at each site and three water samples of 20 L each at FFS-34. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at two REA sites. For more information about collections made at REA sites, see Table G.1.1 in Appendix G: “Biological Collections.”

Seven autonomous reef monitoring structures (ARMS) were recovered: three ARMS each from SWA-01 and SWA-03 and one from SWA-16 (Table B.2.2). At each of five select REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Swains Island (Table E.2.2). A total of 24 CAUs were recovered from five REA sites.

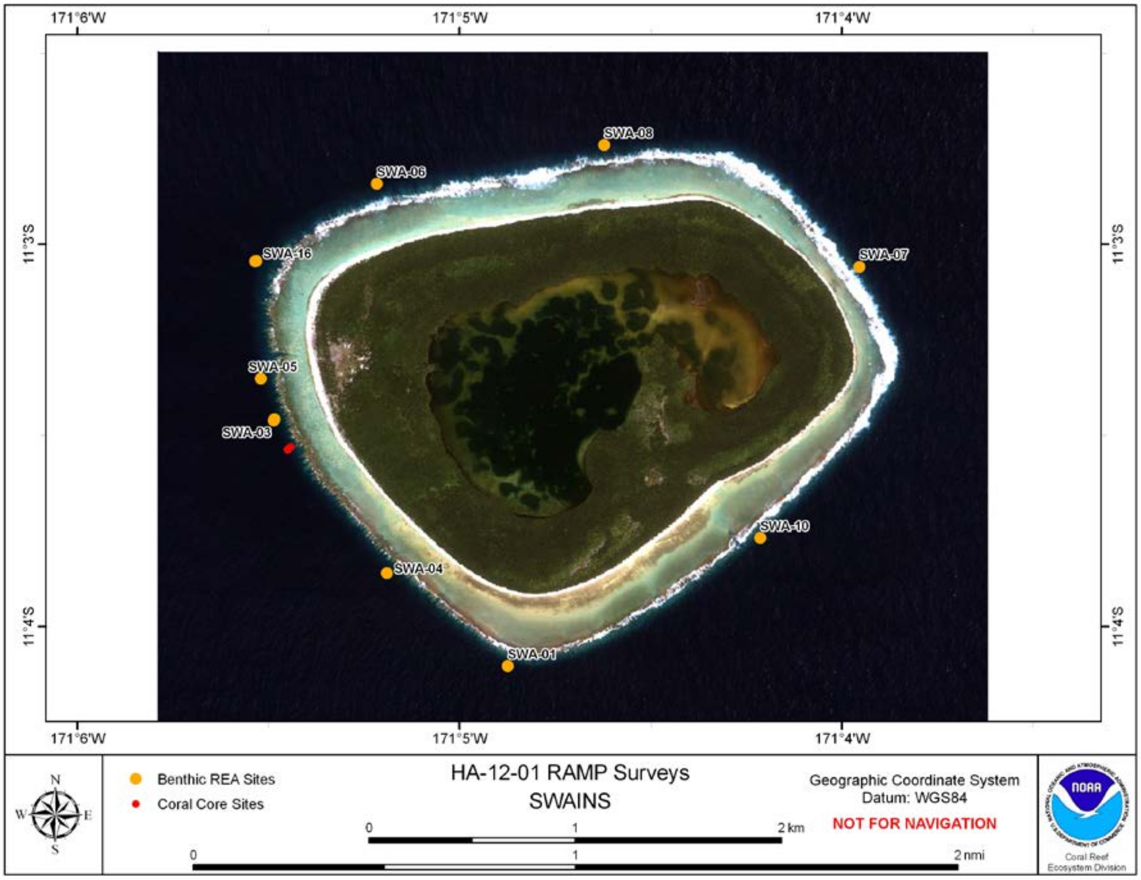

Figure E.2.1.--Locations of REA benthic sites surveyed at Swains Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

Table E.2.1.--Summary of REA benthic surveys performed at Swains Island during cruise HA-12-01, Leg I. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys	
				LPI	Corals
SWA-07	21-Mar	–11.05097	–171.06589	×	×
SWA-08	21-Mar	–11.04567	–171.07702	×	×
SWA-16	21-Mar	–11.05073	–171.09219	×	×
SWA-01	22-Mar	–11.06839	–171.08122	×	×
SWA-05	22-Mar	–11.05585	–171.09199	×	×
SWA-06	22-Mar	–11.04736	–171.08693	×	×
SWA-10	22-Mar	–11.06281	–171.07021	×	×
SWA-03	23-Mar	–11.05763	–171.09139	×	×
SWA-04	23-Mar	–11.06433	–171.08650	×	×

Table E.2.2.--Summary of CAU retrievals (Ret.) and installations (Dep.) performed as well as algal specimens, microbial water and benthic samples, and coral cores collected at Swains Island during cruise HA-12-01, Leg I. Counts of algal samples include algal voucher specimens.

REA Site	Date	Latitude	Longitude	Installations and Collections						
				CAUs Ret	CAUs Dep	ARMS	Algae	Coral	Microbial Samples	Coral Cores
SWA-07	21-Mar	–11.05097	–171.06589	5	5	0	0	0	0	0
SWA-08	21-Mar	–11.04567	–171.07702	4	5	0	1	0	5	0
SWA-16	21-Mar	–11.05073	–171.09219	0	0	1	0	0	2	0
SWA-01	22-Mar	–11.06839	–171.08122	5	5	3	0	5	10	0
SWA-03	22-Mar	–11.05769	–171.09142	5	5	0	0	0	0	0
SWA-10	22-Mar	–11.06281	–171.07021	0	0	0	0	0	2	0
SWA-16	22-Mar	–11.05074	–171.09223	5	5	0	0	0	0	0
SWA-03	23-Mar	–11.05893	–171.09082	0	0	0	0	0	0	1
SWA-03	23-Mar	–11.05882	–171.09070	0	0	0	0	0	0	1
SWA-03	23-Mar	–11.05894	–171.09082	0	0	0	0	0	0	1
SWA-03	23-Mar	–11.05763	–171.09139	0	0	3	0	0	2	0

During cruise HA-12-01, Leg I, CRED completed 11 towed-diver surveys at Swains Island, covering a total length of 21.9 km (an area of 21.9 ha) on the ocean floor (Fig. E.2.2). The mean survey length was 2.0 km with a range of 1.3–2.8 km. The mean survey depth was 13.9 m with a range of 6.4–20.1 m. The mean temperature from data recorded during these surveys was 29.2°C with a range of 29.0°C–29.2°C.

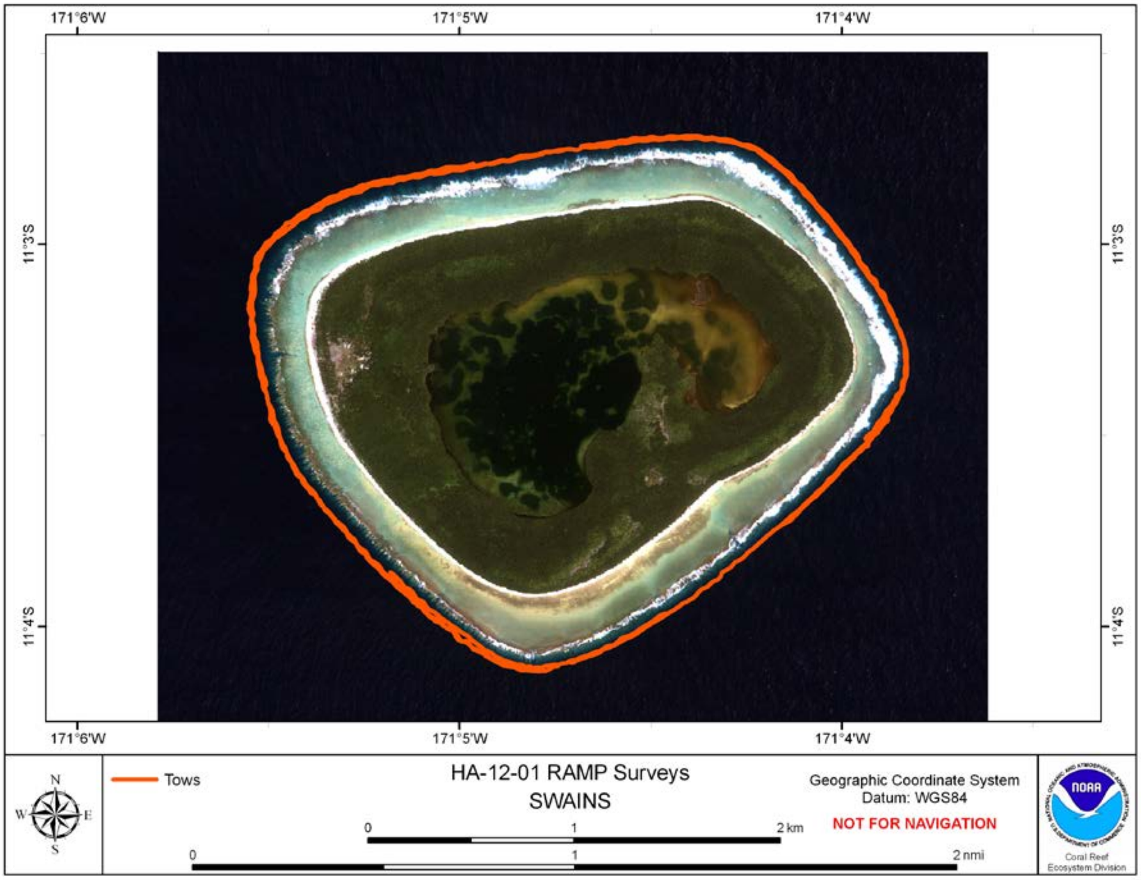

Figure E.2.2.--Track locations of towed-diver surveys conducted at Swains Island during cruise HA-12-01, Leg I (IKONOS Carterra Geo Data, 2003).

E.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 38 REA sites at Swains Island over three different habitat strata: deep, moderate, and shallow forereef (Table E.3.1 and Fig.E.3.1). No fishes were collected during these surveys.

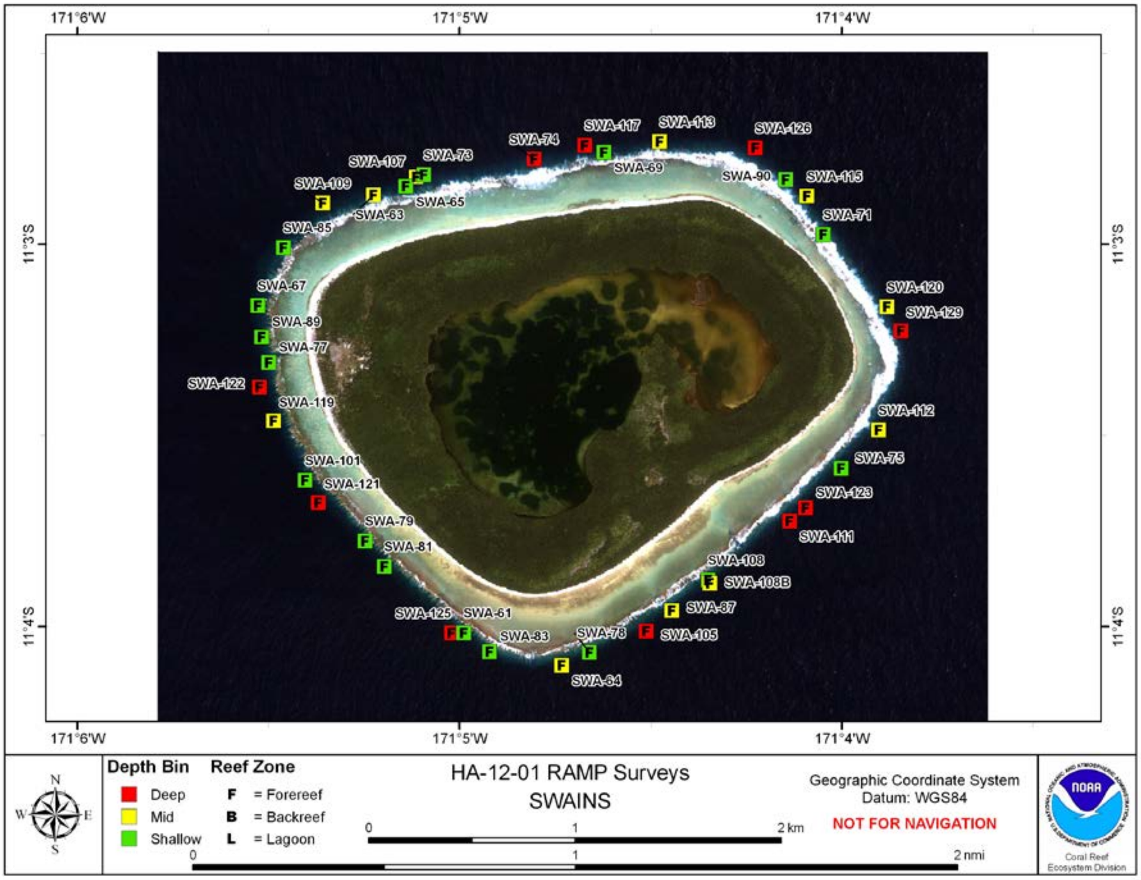

Figure E.3.1.--Locations of REA fish sites surveyed at Swains Island during cruise HA-12-01, Leg I. All of these REA sites were selected using a stratified random design (IKONOS Carterra Geo Data, 2003).

Table E.3.1--Summary of sites where REA fish surveys were conducted at Swains Island during cruise HA-12-01, Leg I.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
SWA-107	21-Mar	Moderate	Forereef	16.8	–11.04705	–171.08523
SWA-109	21-Mar	Moderate	Forereef	19.1	–11.04820	–171.08929
SWA-111	21-Mar	Deep	Forereef	27.5	–11.06206	–171.06895
SWA-117	21-Mar	Deep	Forereef	25.0	–11.04567	–171.07788
SWA-63	21-Mar	Moderate	Forereef	8.5	–11.04785	–171.08708
SWA-65	21-Mar	Shallow	Forereef	5.0	–11.04747	–171.08569
SWA-67	21-Mar	Shallow	Forereef	3.5	–11.05267	–171.09214
SWA-73	21-Mar	Shallow	Forereef	5.0	–11.04696	–171.08489
SWA-74	21-Mar	Deep	Forereef	27.7	–11.04628	–171.08008
SWA-77	21-Mar	Shallow	Forereef	5.0	–11.05515	–171.09166
SWA-85	21-Mar	Shallow	Forereef	5.2	–11.05014	–171.09101
SWA-89	21-Mar	Shallow	Forereef	4.5	–11.05404	–171.09196
SWA-101	22-Mar	Shallow	Forereef	5.2	–11.06029	–171.09008
SWA-105	22-Mar	Deep	Forereef	23.1	–11.06687	–171.07519

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
SWA-108	22-Mar	Shallow	Forereef	4.8	–11.06464	–171.07250
SWA-119	22-Mar	Moderate	Forereef	14.0	–11.05769	–171.09145
SWA-121	22-Mar	Deep	Forereef	26.3	–11.06126	–171.08949
SWA-125	22-Mar	Deep	Forereef	25.5	–11.06694	–171.08370
SWA-61	22-Mar	Shallow	Forereef	4.0	–11.06694	–171.08316
SWA-64	22-Mar	Moderate	Forereef	15.8	–11.06836	–171.07889
SWA-79	22-Mar	Shallow	Forereef	5.0	–11.06293	–171.08746
SWA-81	22-Mar	Shallow	Forereef	5.4	–11.06404	–171.08662
SWA-83	22-Mar	Shallow	Forereef	5.0	–11.06776	–171.08203
SWA-87	22-Mar	Moderate	Forereef	13.0	–11.06596	–171.07408
SWA-108B	23-Mar	Moderate	Forereef	14.0	–11.06478	–171.07241
SWA-112	23-Mar	Moderate	Forereef	15.5	–11.05810	–171.06507
SWA-113	23-Mar	Moderate	Forereef	16.0	–11.04552	–171.07461
SWA-115	23-Mar	Moderate	Forereef	11.6	–11.04789	–171.06818
SWA-120	23-Mar	Moderate	Forereef	14.0	–11.05272	–171.06470
SWA-122	23-Mar	Deep	Forereef	26.0	–11.05623	–171.09207
SWA-123	23-Mar	Deep	Forereef	23.5	–11.06149	–171.06824
SWA-126	23-Mar	Deep	Forereef	25.0	–11.04579	–171.07044
SWA-129	23-Mar	Deep	Forereef	28.0	–11.05377	–171.06409
SWA-69	23-Mar	Shallow	Forereef	6.0	–11.04598	–171.07704
SWA-71	23-Mar	Shallow	Forereef	5.0	–11.04956	–171.06747
SWA-75	23-Mar	Shallow	Forereef	14.6	–11.05977	–171.06669
SWA-78	23-Mar	Shallow	Forereef	6.0	–11.06780	–171.07767
SWA-90	23-Mar	Shallow	Forereef	5.0	–11.04717	–171.06911

APPENDIX F: TUTUILA ISLAND

Tutuila Island, located at 14°17′ S, 170°41′ W, is the largest island of American Samoa. For more information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

F.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-12-01, Leg I at Tutuila Island entailed retrievals and deployments of oceanographic moored instruments, installation of calcification acidification units (CAUs), and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites.

One environmental acoustic recorder (EAR) and five subsurface temperature recorders (STRs) were retrieved, and three STRs were deployed (Fig. F.1.1). Two of these STRs were deployed on SST anchors. Two SST buoys were recovered. For information about CAU deployments completed at Tutuila Island, see Section F.2: “Benthic Environment.”

At nearshore locations around Tutuila Island, 3 shallow-water CTD casts were performed (Fig. F.1.1) at three select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 6 DIC and TA, 6 salinity, 6 nutrient, and 6 Chl-*a* water samples were collected, one from the surface and one near the reef at each CAU site.

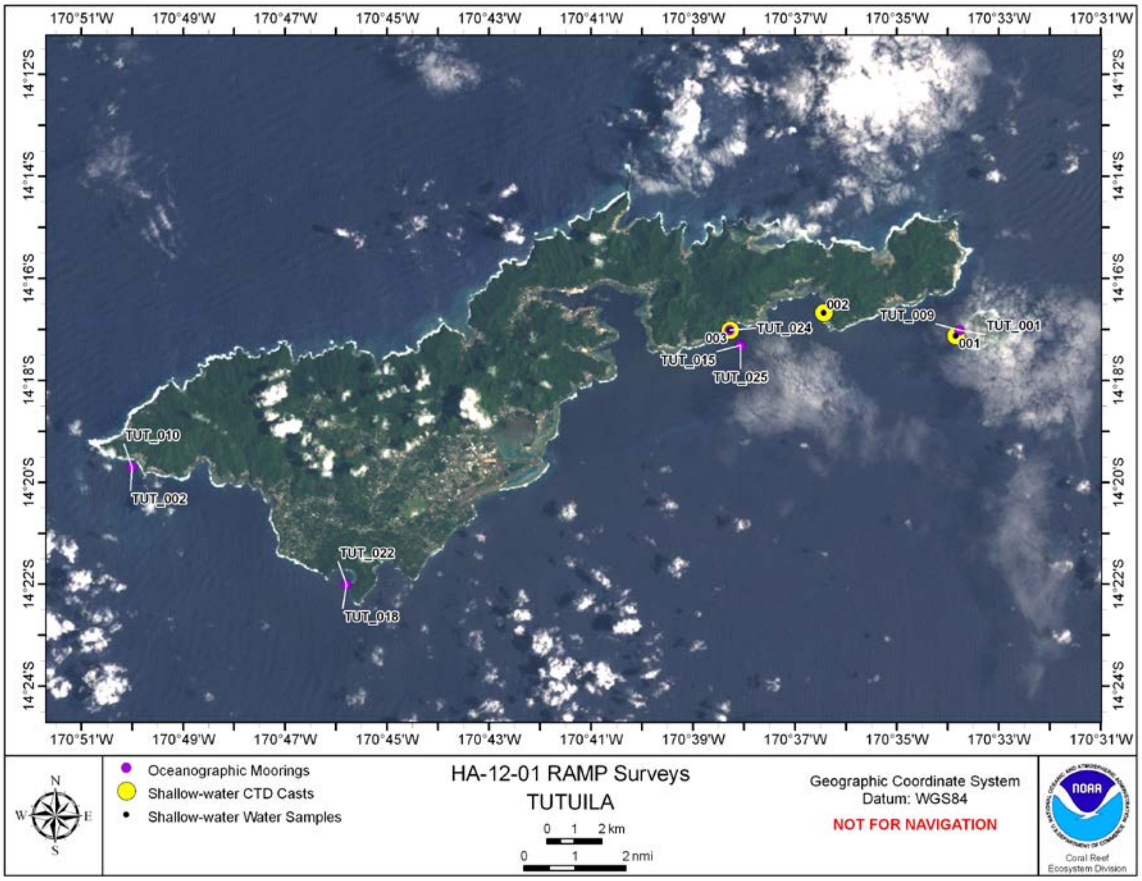

Figure F.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Tutuila during cruise HA-12-01, Leg I. Landsat satellite imagery data used in this map figure are available from the U.S. Geological Survey.

Table F.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments and EAR that were retrieved or deployed at Tutuila Island during cruise HA-12-01, Leg I.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
TUT_002	24-Mar	SST	–14.32830	–170.83342	0.3	1	–
TUT_010	24-Mar	STR	–14.32830	–170.83342	28.0	1	–
TUT_018	24-Mar	SST	–14.36675	–170.76330	0.3	1	–
TUT_022	24-Mar	STR	–14.36675	–170.76330	19.5	1	–
TUT_001	25-Mar	SST	–14.28355	–170.56286	23.8	1	–
TUT_009	25-Mar	STR	–14.28355	–170.56286	22.9	1	–
TUT_015	25-Mar	EAR	–14.28835	–170.63452	14.9	1	–
TUT_015	25-Mar	STR	–14.28838	–170.63451	15.1	1	1
TUT_024	25-Mar	STR	–14.28352	–170.63796	5.5	–	1
TUT_025	25-Mar	STR	–14.28858	–170.63441	24.4	–	1

F.2. Benthic Environment

No benthic REA surveys were performed, as HI-1 and HI-2 were not launched. These two boats were kept aboard because the ship was entering Pago Pago Harbor and they could not be safely recovered while the ship was alongside the pier. The oceanography team deployed CAUs at three sites (Table F.2.1).

Table F.2.1.--Summary of CAU retrievals and installations performed at Tutuila Island during cruise HA-12-01, Leg I.

REA Site	Date	Latitude	Longitude	Installations and Collections	
				CAUs Retrieved	CAUs Deployed
TUT-01	25-Mar	–14.28354	–170.63782	5	5
TUT-02	25-Mar	–14.27780	–170.60723	5	5
TUT-16	25-Mar	–14.28532	–170.56407	5	5

During cruise HA-12-01, Leg I, CRED completed 6 towed-diver surveys at Tutuila Island, covering a total length of 13.5 km on the ocean floor (Fig. F.2.2). The mean survey length was 2.3 km with a range of 2.1-2.4 km. The mean survey depth was 14.3 m with a range of 12.4-15.5 m. The mean temperature from data recorded during these surveys was 28.7°C with a range of 28.6°C–28.8°C.

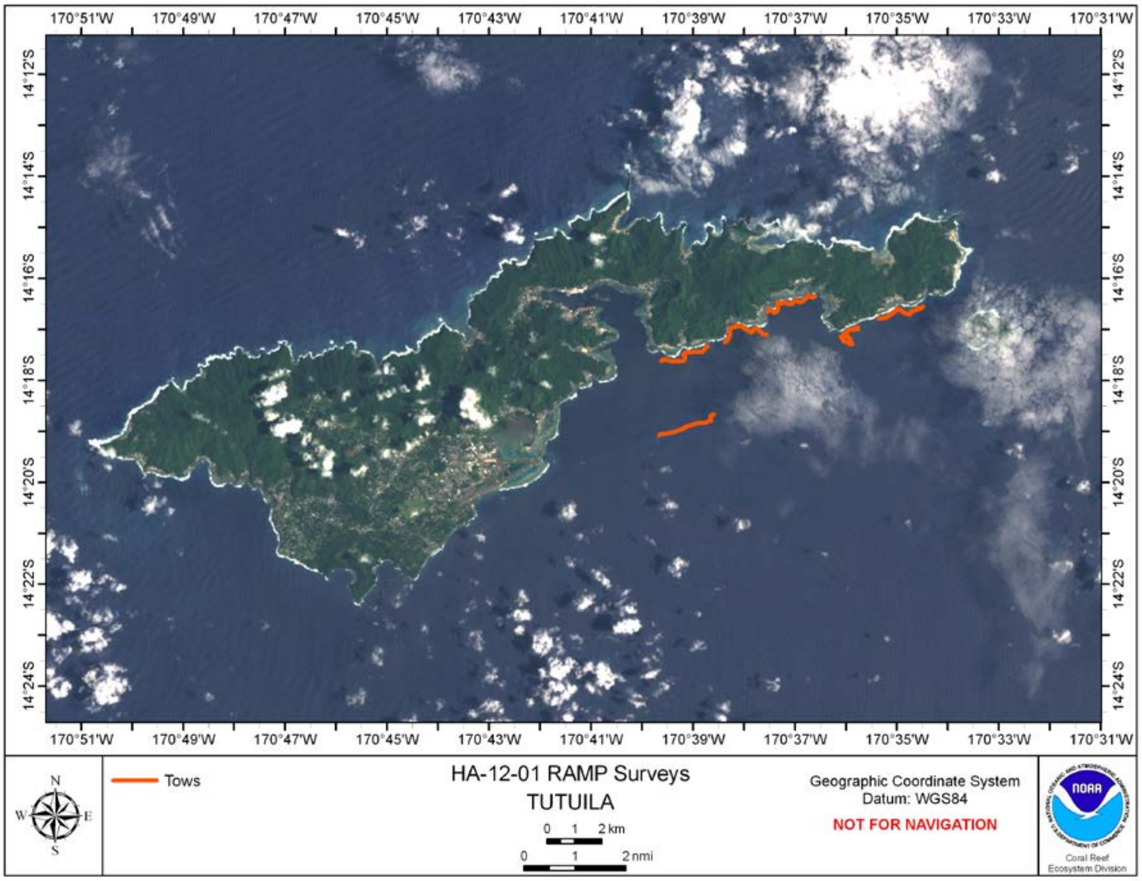

Figure F.2.2.--Track locations of towed-diver surveys conducted at Tutuila Island during cruise HA-12-01, Leg I. Landsat satellite imagery data used in this map figure are available from the U.S. Geological Survey.

F.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 5 REA sites at Tutuila Island over three different habitat strata: deep forereef, moderate forereef, and shallow forereef (Table F.3.1 and Fig. F.3.1). No fishes were collected during these surveys.

In addition, CRED completed 6 towed-diver surveys at Tutuila Island, as described previously in Section B.2 of this appendix.

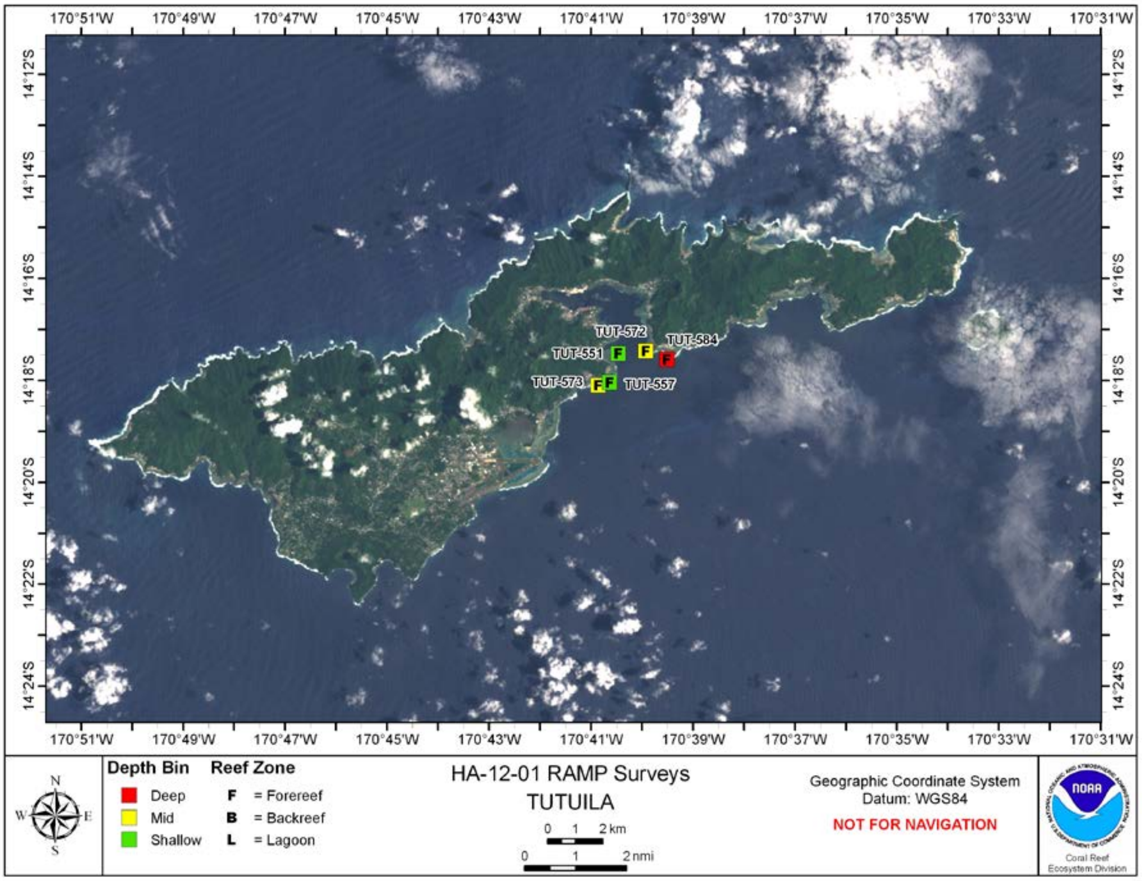

Figure F.3.1.--Locations of REA fish sites surveyed at Tutuila Island during cruise HA-12-01, Leg I. All of these REA sites were selected using a stratified random design. Landsat satellite imagery data used in this map figure are available from the U.S. Geological Survey.

Table F.3.1.--Summary of sites where REA fish surveys were conducted at Tutuila Island during cruise HA-12-01, Leg I.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
TUT-551	25-Mar	Shallow	Forereef	4.2	–14.29117	–170.67448
TUT-557	25-Mar	Shallow	Forereef	6.5	–14.30065	–170.67731
TUT-572	25-Mar	Moderate	Forereef	14.5	–14.29044	–170.66538
TUT-573	25-Mar	Moderate	Forereef	14.2	–14.30155	–170.68104
TUT-584	25-Mar	Deep	Forereef	23.4	–14.29318	–170.65851

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APPENDIX G: BIOLOGICAL COLLECTIONS

Biological samples were collected at Johnston Atoll, Howland Island, Baker Island, Swains Island, Tutuila Island and their surrounding waters for multiple research purposes. These collections are listed here in Table G.1.1.

Table G.1.1.--Samples collected at Johnston Atoll, Howland Island, Baker Island, Swains Island, and Tutuila Island for taxonomic identification, ocean acidification research, or microbial analyses during cruise HA-12-01, Leg I.

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
Algal Collections: Calcification Analysis						
JOH-07	2-Mar	16.71156	–169.47969	*Halimeda taenicola*	10	13.7
JOH-09	2-Mar	16.72867	–169.48577	*Halimeda taenicola*	10	13.7
JOH-15	2-Mar	16.78352	–169.49016	*Halimeda taenicola*	10	13.7
JOH-14	3-Mar	16.77005	–169.51915	*Halimeda taenicola*	10	13.7
HOW-02	13-Mar	0.81542	–176.62413	*Halimeda fragilis*	10	13.7
HOW-05	14-Mar	0.80418	–176.62101	*Halimeda fragilis*	10	13.7
BAK-09	15-Mar	0.18686	–176.46996	*Halimeda fragilis*	10	13.7
BAK-14	15-Mar	0.20503	–176.47445	*Halimeda fragilis*	10	13.7
BAK-02	17-Mar	0.18842	–176.47992	*Halimeda fragilis*	10	13.7
Algal Collections: Isotope Analysis						
HOW-02	13-Mar	0.81542	–176.62413	*Halimeda fragilis*	6	13.7
HOW-05	14-Mar	0.80418	–176.62101	*Halimeda fragilis*	6	13.7
BAK-09	15-Mar	0.18686	–176.46996	*Halimeda fragilis*	6	13.7
BAK-14	15-Mar	0.20503	–176.47445	*Halimeda fragilis*	6	13.7
BAK-02	17-Mar	0.18842	–176.47992	*Halimeda fragilis*	6	13.7
Algal Collections: Voucher Specimens						
HOW-02	13-Mar	0.81542	–176.62413	*Halimeda* sp.	1	13.7
HOW-05	14-Mar	0.80418	–176.62101	*Halimeda* sp.	1	13.7
BAK-09	15-Mar	0.18686	–176.46996	*Halimeda* sp.	1	13.7
BAK-14	15-Mar	0.20503	–176.47445	*Halimeda* sp.	1	13.7
BAK-02	17-Mar	0.18842	–176.47992	*Halimeda* sp.	1	13.7
SWA-08	21-Mar	–11.04567	–171.07702	*Microdictyon* sp.	1	13.7
Coral Collections: Voucher Specimens						
SWA-01	22-Mar	–11.06839	–171.08122	*Montipora aequituberculata*	5	13.7
Coral Collections: Cores						
HOW-11	13-Mar	0.79866	–176.62014	*Porites* sp.	3	10.4
HOW-11	13-Mar	0.79903	–176.62024	*Porites* sp.	3	5.8
HOW-05	14-Mar	0.80898	–176.62199	*Porites* sp.	3	5.5
HOW-11	14-Mar	0.80031	–176.62080	*Porites* sp.	1	10.1
BAK-11	17-Mar	0.19394	–176.48752	*Porites* sp.	4	9.1
SWA-03	23-Mar	–11.05894	–171.09082	*Porites* sp.	4	11.3
SWA-03	23-Mar	–11.05893	–171.09082	*Porites* sp.	3	11.9
SWA-03	23-Mar	–11.05882	–171.09070	*Porites* sp.	3	8.2
Microbial Collections: Water Samples, Coral Rubble, and Macroalgae						
JOH-09	2-Mar	16.72867	–169.48577	2 L	2	12.2
JOH-09	2-Mar	16.72867	–169.48577	20 L	4	12.2
JOH-09	2-Mar	16.72867	–169.48577	Unidentified macroalgae	2	13.7

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
JOH-11	4-Mar	16.72140	–169.52421	2 L	2	12.2
JOH-11	4-Mar	16.72140	–169.52421	20 L	3	12.2
JOH-12	5-Mar	16.74761	–169.52397	2 L	2	12.2
JOH-12	5-Mar	16.74761	–169.52397	20 L	4	12.2
JOH-19	5-Mar	16.74478	–169.53593	2 L	2	12.2
HOW-14	11-Mar	0.81467	–176.62386	2 L	2	13.7
HOW-14	11-Mar	0.81467	–176.62386	20 L	3	13.7
HOW-04	12-Mar	0.79518	–176.61873	2 L	2	13.7
HOW-10	12-Mar	0.78990	–176.61581	2 L	2	13.7
HOW-02	13-Mar	0.81542	–176.62413	Unidentified macroalgae	3	–
HOW-02	13-Mar	0.81542	–176.62413	Coral rubble	3	–
HOW-05	14-Mar	0.80418	–176.62101	2 L	2	13.7
HOW-05	14-Mar	0.80418	–176.62101	20 L	4	13.7
BAK-09	15-Mar	0.18686	–176.46996	2 L	2	13.7
BAK-11	15-Mar	0.19924	–176.48459	2 L	2	13.7
BAK-16	16-Mar	0.19469	–176.46279	2 L	2	11
BAK-02	17-Mar	0.18842	–176.47992	2 L	2	13.7
BAK-02	17-Mar	0.18842	–176.47992	Unidentified macroalgae	3	21.3
BAK-02	17-Mar	0.18842	–176.47992	Coral rubble	4	21.3
SWA-08	21-Mar	–11.04567	–171.07702	2 L	2	13.7
SWA-08	21-Mar	–11.04567	–171.07702	20 L	3	13.7
SWA-16	21-Mar	–11.05073	–171.09219	2 L	2	13.7
SWA-01	22-Mar	–11.06839	–171.08122	2 L	2	13.7
SWA-01	22-Mar	–11.06839	–171.08122	Unidentified macroalgae	4	–
SWA-01	22-Mar	–11.06839	–171.08122	Coral rubble	4	–
SWA-10	22-Mar	–11.06281	–171.07021	2 L	2	13.7
SWA-03	23-Mar	–11.05763	–171.09139	2 L	2	13.7