U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Pacific Islands Fisheries Science Center
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PROJECT REPORT

VESSEL: NOAA Ship *Hi'ialakai*, Project HA-17-01, Leg 1

PROJECT PERIOD: 26 March – 29 April, 2017

AREA OF OPERATION: Pacific Remote Island Areas National Marine Monument: Jarvis, Baker, Howland Islands; Wake Atoll

TYPE OF OPERATION: Personnel from the Ecosystem Sciences Division (ESD) and Scientific Operations Division of the NOAA Pacific Islands Fisheries Science Center (PIFSC), University of Hawai'i at Mānoa (UHM), Scripps Oceanographic Institution (SIO), San Diego State University (SDSU) and Woods Hole Oceanographic Institution (WHOI) conducted interdisciplinary surveys of benthos, fishes, and oceanographic parameters related to climate change in coastal waters Pacific Remote Islands Marine National Monument (PRIMNM). All activities described in this report were covered by the following permits and authorizations: Environmental Assessment (PIFSC-20100901); Endangered Species Act, Section 7 consultation (PIR-2015-9580).

MISSION:

The Marianna Archipelago Reef Assessment and Monitoring Program (MARAMP) is a component of an integrated coral reef ecosystem assessment led by the ESD of the PIFSC at some 40 U.S.-affiliated Pacific islands. This comprehensive, multi-agency research and education effort is sponsored by NOAA's Coral Reef Conservation Program (CRCP), a partnership between the National Marine Fisheries Service, National Ocean Service, and other NOAA agencies with the objective of improving understanding and management of coral reef ecosystems.

The CRCP has made the strategic decision to invest a portion of its annual operating budget in perpetuity to support a National Coral Reef Monitoring Plan (NCRMP). This plan is designed to assess and report the status and trends of environmental conditions, living reef resources, and the people and processes that interact with coral reef ecosystems. The NCRMP builds upon a decade of CRCP-supported, nationwide coral reef monitoring and reporting efforts, such as the Pacific Reef Assessment and Monitoring Program (Pacific RAMP), and *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States*, a NOAA Technical Memorandum compiled by the NOAA Center for Coastal Monitoring and Assessment. Although the scope of NCRMP is broad, it is intended to assess the status of coral reef ecosystems and their conditions throughout U.S. states and territories and provide a steady and comprehensive analytical context to gauge changes in conditions at the sub-jurisdictional scale of an island or atoll.

The NCRMP focuses on four priority themes: climate change and ocean acidification; coral populations and benthic communities; reef-associated fish populations and communities; and socioeconomics. Biological monitoring for benthic and fish communities are conducted throughout shallow-water (0–30 m), hard-bottom coral reef habitats using a stratified random sampling design. Monitoring of climate change and ocean acidification is achieved by means of sustained, remotely sensed and *in situ* observations of ocean temperature; autonomous and discrete water sampling for analyses of near reef and surface seawater carbonate chemistry; and distinct biological installations designed to provide integrated, ecosystem-wide response data (e.g., biodiversity, calcification, and bioerosion) in the context of climate change. In the Pacific, biological (benthic and fish) and climate monitoring are conducted on a triennial basis. Socioeconomic monitoring is led by the CRCP at headquarters in Silver Spring, MD, and stands outside the scope of the NCRMP monitoring and assessment expeditions; therefore, it is not addressed in this project report.

In addition to the standardized, triennial MARAMP surveys that began at Wake Atoll, HA-17-01 included research at three islands that are normally surveyed as part of the American Samoa RAMP: Jarvis, Howland, and Baker. These islands were surveyed to assess the effects on coral reefs of an extended period of abnormally high water temperatures that occurred in 2015-2016.

The goals of the HA-17-01 Pacific Reef Assessment and Monitoring Project were as follows:

1. Conduct ecosystem monitoring of the species composition, abundance, percent cover, size distribution, recruitment and general health of the fishes, corals, other invertebrates, and algae of the shallow water (< 35 m) coral reef ecosystems of PRIMNM.
2. Deploy, retrieve and/or service an array of moored Acoustic Doppler Current Profilers (ADCPs), Autonomous Reef Monitoring Structures (ARMS), Bioerosion Monitoring Units (BMUs), Calcification Accretion Units (CAUs), Subsurface Temperature Recorders (STRs); as well as anchored arrays consisting of a Conductivity Temperature Pressure (CTP) recorder, a portable underwater collector (PUC), and a thermistor string to allow remote long-term monitoring of oceanographic and environmental conditions affecting the coral reef ecosystems of PRIMNM.
3. Monitor nearshore physical and ecological factors associated with ocean acidification and general water quality, including analysis of seawater for nutrients, chlorophyll concentration, salinity, temperature, dissolved oxygen, transmissivity, total alkalinity, and dissolved inorganic carbon.
4. Collect shallow water coral cores to examine calcification/growth rates in recent decades and assess potential early impacts of ocean acidification. Coring operations will be conducted opportunistically (as scientific dives).
5. Conduct plankton tows to expand upon the documentation of the marine biota on coral reefs.
6. Conduct shipboard ADCP surveys around reef ecosystems to examine physical and biological linkages supporting island ecosystems.
7. Collect oceanographic data utilizing ship-based measurement systems (ADCP, ThermoSalinoGraph—TSG, and the Scientific Computer System - SCS) during all transits for the duration of the project.
8. Conduct investigations of marine microbial communities, including the collection of specimens via water sampling, plankton tows, coral/algal biopsies and benthic grab samples.
9. Determine the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.
10. Investigate coral bleaching event impacts and recovery at Jarvis, Howland and Baker Islands via Benthic and Oceanographic surveys.
11. Conduct a variety of shallow water oceanographic experiments to investigate the impacts of climate change on coral reefs in partnership with scientists from the WHOI:
    - Benthic Surveys at 3 depths on the west and east side of Jarvis
    - Discrete water sampling for TA/DIC, salinity and nutrients on the west and east side of Jarvis at different parts of the diel/tidal cycles.
    - Deploy SAMI-pH sensors, dissolve oxygen sensors, tilt current meters, and temperature loggers at two sites at Jarvis
    - Coring of *Porites* sp. at Jarvis Island.
12. Deploy and recover of High Frequency Acoustic Recording Packages (HARPs) used for long-term monitoring of cetaceans in the Pacific Island Region.
13. Conduct 4 shipboard CTD casts at each island 15 km offshore in each cardinal direction along with a concurrent water sample using a CREP-provided shallow water CTD unit and a remotely-triggered niskin bottle.
14. Use photomosaics to collect coral community composition data at climate stations and contextualize any physical and/or biological changes recorded at the climate stations over time.

ITINERARY:

March 26	Left Pearl Harbor and sailed for Jarvis Island.
March 27 – April 1	Transited to Jarvis Island.
April 2– April 5	Conducted operations at Jarvis Island.
April 6 – April 9	Transited to Baker Island.
April 10	Conducted operations at Baker Island. Transited to Howland Island.
April 11	Conducted operations at Howland Island.
April 12– April 18	Transited to Wake Atoll, crossed International Date Line en route.
April 19– April 23	Conducted operations at Wake Atoll.
April 24– April 28	Transited to Guam.
April 29	Arrived at Apra Harbor, Guam; Project HA-17-01, Leg 1 complete.

RESULTS:

Note that this report only highlights work conducted in the PRIMNM during HA-17-01, Leg 1. All activities conducted around Guam and the Commonwealth of the Northern Mariana Islands (HA-17-01, Legs 2 & 3) will be described in a separate report. It should be noted that the ship crossed the International Dateline during the transit between Howland Island and Wake Atoll. Dates of activities are reported as local (i.e. the date on the ship), as that is how they are recorded in ESD databases.

ISLAND HIGHLIGHTS:

The coral reef ecosystems of US-affiliated Pacific islands have been surveyed biennially since 2000 and triennially starting in 2010 through Pacific RAMP. Herein, we present highlights from our observations during this latest expedition by island.

Jarvis Island (JAR)

- Benthic
  - Adult coral density and cover are extremely low
    - *Montipora* spp. almost entirely absent, skeletal structures no longer visible
    - *Acropora* spp. very rare
  - Almost no juvenile scleractinian corals were recorded
  - Patchy spatial pattern of high macroalgae cover alternating with high crustose coralline algae cover
  - Large *Porites* colonies observed that had almost completely succumbed to the effects of bleaching. However, there is also evidence of tissue recovery on some colonies
- Fish
  - Available summaries of fish surveys available at https://www.pifsc.noaa.gov/cred/monitoring_briefs.php
- Tow
  - Fish
    - A few scalloped hammerhead shark sightings (*Sphyrna lewini* SPLE)
    - Giant grouper on survey (*Epinephelus lanceolatus* EPLA) 175 cm
    - A few giant humphead wrasse (*Cheilinus undulates,* CHUD) sightings
    - Large schools of anthias – more than seen in previous years
  - Benthic
    - Percent coral cover is negligible
    - Dense carpets of red macro and turf algae are dominant benthic organism covering up to hundreds of square meters of the bottom
    - Some large mounding colonies of *Porites* spp. remain

Baker Island (BAK)

- Benthic
  - No substantial impacts to coral assemblage from 2015–2016 sea surface temperature anomaly
  - Some patches of partial mortality and total mortality on the west side of the island between 0 and 45 ft.
  - *Montipora* spp. – Foliose colonies still common
  - *Acropora* spp.
    - Multiple species and growth forms present
    - Extensive fields of *Acropora intermedia* that were previously recorded around the island are still present
  - Corallimorphs are severely impacting corals on west side of island
- Fish
  - No fish surveys done at this island
- Tow
  - Benthic
    - Diverse assemblage of *Acropora* with respect to growth form (e.g. tables, branching, digitate and small corymbose clumps)
    - Extensive fields of branching *Acropora intermedia*
    - Vibrant and healthy coral reef in many areas of the island
    - Dense patches of the corallimorph (*Rhodactis* sp.) cover patches of substrate > 100 m^2

Howland Island (HOW)

- Benthic
  - No substantial impacts to coral assemblage from 2015-2016 sea surface temperature anomaly
  - Some patches of partial mortality and total mortality on the west side of the island between 0 and 45 ft.
  - *Montipora* spp. – Foliose colonies still common
  - *Acropora* spp.
    - Multiple species and growth forms present
    - Extensive fields of *Acropora intermedia* that were previously recorded around the north, east and south parts of the island are still present
  - Corallimorphs are severely impacting corals on west side of island
- Fish
  - No fish surveys done at this island
- Tow
  - Benthic
    - Diverse assemblage of *Acropora* with respect to growth form (e.g. tables, branching, digitate and small corymbose clumps)
    - Extensive fields of branching *Acropora intermedia*
    - Vibrant and healthy coral reef in many areas of the island
    - Dense patches of the corallimorph (*Rhodactis* sp.) cover patches of substrate > 100 m^2

Wake Atoll (WAK)

Benthic

- Diverse, abundant coral assemblage
- Qualitatively more partial mortality than previous survey in 2014
- Many colonies exhibited initial signs of bleaching

- Fish
  - Available summaries of fish surveys available at https://www.pifsc.noaa.gov/cred/monitoring_briefs.php
- Tow
  - Fish
    - High densities of reefcrest parrotfishes (*Chlorurus frontalis*), lots of schools (< 50 cm)
    - High densities of black durgons (*Melichthys niger*), lots of schools (< 50 cm)
    - Few sightings of humphead parrotfishes (*Bolbometopon muricatum*), few schools (10+) seen off transect
    - Not many giant humphead wrasses (*Cheilinus undulatus*) sightings
  - Benthic
    - Vibrant and healthy coral reef in many areas of the island
    - Dark cyanobacteria on some areas of the southwest side of the island, near harbor entrance
    - Common corals include mounding corals such as *Favia matthai, Goniastrea* spp., and *Porites lobata*, and small branching *Pocillopora* spp.

DAILY SUMMARIES:

This section provides operational totals regarding research activities (Table 1), specifics regarding data collected during cruise HA-17-01, Leg 1 and a summary of important observations made while at sea. For more information pertaining to the data collected and methodology employed at the islands visited, see Appendices A–F.

Unless otherwise specified in the following daily summaries, these surveys occurred during each operational day: Benthic Rapid Ecological Assessment (REA) surveys, Fish REA surveys, towed-diver surveys; nearshore conductivity-temperature-depth (CTD) casts; water sample collections for dissolved inorganic carbon (DIC), total alkalinity (TA), and/or microbial analyses; and the deployments and recoveries of oceanographic instrumentation. Furthermore, shipboard multi-beam bathymetry data was collected opportunistically. For oceanographic instrumentation activities, several types of equipment may be used: Acoustic Doppler Current Profiler (ADCP); Conductivity, Temperature and Depth meter (CTD), Ecological Acoustic Recorder (EAR), High-frequency Acoustic Recording Package (HARP), Soundtrap acoustic recorder, and Subsurface Temperature Recorder (STR). More detail on data collection is available in Appendix A – Methods.

March 26 Leave Pearl Harbor and sail for Jarvis Island.

March 27– April 1 Transit to Jarvis Island. Conduct ship orientation and training activities for scientists and crew as needed.

April 2 Arrive Jarvis Island and begin operations

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ADCP	0	1
CTD	0	1
pH meter	0	1
STR	1	1

Biological Collections

Collection	Number of Samples
Microbial water (2 L)	4
Photomosaic (100 m-sq)	1

April 3 Continued operations at Jarvis Island.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ADCP	1	0
CTD	1	0
pH meter	1	0
EAR	0	1
Soundtrap	0	1

Biological Collections

Collection	Number of Samples
Microbial water (2 L)	4
Photomosaic (100 m-sq)	3

April 4 Continued operations at Jarvis Island.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ADCP	0	1
CTD	0	1
pH meter	0	1
STR	2	2

Biological Collections

Collection	Number of samples
Microbial water (2 L)	5.5
Coral growth core	11
Plankton	2

April 5 Continued operations at Jarvis Island. Begin transit to Baker Island.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ADCP	1	0
CTD	1	0
pH meter	1	0
EAR	0	1
Soundtrap	0	1

Biological Collections

Collection	Number of samples
Coral growth core	1
Microbial coral biopsy	11
Photomosaic (100 m-sq)	2
Plankton	2

April 6– April 9 Transit to Baker Island.

April 10 Commence operations at Baker Island. Transit to Howland Island.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
EAR	0	1
Soundtrap	0	1
STR	1	1

Biological Collections

Collection	Number of samples
Microbial water (2 L)	5.5
Photomosaic (100 m-sq)	1

April 11 Commence operations at Howland Island. Transit to Wake Atoll.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
HARP	0	1
STR	2	2

Biological Collections

Collection	Number of samples
Microbial water (2 L)	6
Microbial coral biopsy	11
Photomosaic (100 m-sq)	3

April 12– April 18 Transit to Wake Atoll, crossing International Date Line.

April 19 Commence operations at Wake Atoll.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ARMS	2	3
BMU	3	5
CAU	1	5
STR	3	3

April 19 Commence operations at Wake Atoll – continued.

Biological Collections

Collection	Number of samples
Microbial water (2 L)	6
BMU UNIT	1
CAU UNIT	1
Photomosaic (100 m-sq)	3

April 20 Continue operations at Wake Atoll.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ARMS	3	3
BMU	5	5
CAU	5	5
STR	3	3

Biological Collections

Collection	Number of samples
Microbial water (2 L)	6
BMU UNIT	5
CAU UNIT	5
Photomosaic (100 m-sq)	1
Plankton	3

April 21 Continue operations at Wake Atoll.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
CAU	5	3
HARP	1	0
STR	3	5

Biological Collections

Collection	Number of samples
Microbial water (2 L)	8
CAU UNIT	5
Microbial coral biopsy	11
Photomosaic (100 m-sq)	1
Plankton	2

April 22 Continue operations at Wake Atoll.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ARMS	3	3
BMU	5	5
CAU	5	5
STR	1	1

Biological Collections

Collection	Number of samples
Microbial water (2 L)	6
BMU UNIT	5
CAU UNIT	5
Microbial coral biopsy	11
Photomosaic (100 m-sq)	1
Plankton	2

April 23 Complete operations at Wake Atoll. Transit to Guam.

Oceanographic Instrumentation

Instrument Type	Recovered	Deployed
ARMS	3	3
BMU	5	5
CAU	5	5
HARP	0	1
STR	2	2

Biological Collections

Collection	Number of samples
BMU UNIT	5
CAU UNIT	5
Microbial coral biopsy	11
Photomosaic (100 m-sq)	2
Plankton	4

April 24 – April 28 Transit to Guam.

April 29 Arrive Apra Harbor, Guam.

Table 1. Statistics for the Pacific RAMP 2017 project to the Pacific Remote Island Marine National Monument (Project HA-17-01, Leg 1), including Jarvis Island (JAR), Baker Island (BAK), Howland Island (HOW), and Wake Atoll (WAK). Totals for scuba dives include all dives carried out for all activities at each island.

Research Activity	BAK	HOW	JAR	WAK	Total
			22	28	**66**
Scuba Dives	79	72	6	4	**1**
Biological Surveys					
REA sites: Benthic	7	6	32	28	**73**
					11
REA sites: Fish	16	14	28	53	**1**
Towed-diver Surveys (TDS) Fish & Benthic	5	5	7	9	**26**
	11.		17.	20.	**60.**
Combined Length (km) of TDS	1	11	8	3	**2**
Benthic photomosaic surveys	1	3	6	8	**18**
Biological Sample Collections					
Coral-Algal Microbial Biopsies	0	11	11	33	**55**
Coral Calcification Cores	0	0	12	0	**12**
			13.		
Microbial Water Samples (2-L)	5.5	6	5	26	**51**
Plankton Tows	0	0	4	11	**15**
Biological Monitoring Installations					
ARMS Recovered	0	0	0	11	**11**
ARMS Deployed	0	0	0	12	**12**
CAUs Recovered	0	0	0	21	**21**
CAUs Deployed	0	0	0	25	**25**
BMUs Deployed	0	0	0	20	**20**
BMUs Recovered	0	0	0	16	**16**
EARs Deployed	1	0	2	0	**3**
HARPs Recovered	0	0	0	1	**1**
HARPs Deployed	0	1	0	1	**2**
Soundtrap Deployed	1	0	2	0	**3**
Oceanographic Moored Instruments					
STRs Recovered	1	2	3	11	**17**
STRs Deployed	1	2	3	11	**17**
ADPs Recovered	0	0	2	0	**2**
ADPs Deployed	0	0	2	0	**2**
CTD Sensors Recovered	0	0	2	0	**2**
CTD Sensors Deployed	0	0	2	0	**2**
Hydrographic Surveys					
Shallow-water CTD Casts	4	4	7	11	**26**
Water-quality Sampling					
Shallow-water Salinity Water Samples	7	6	2	14	**29**
Shallow-water DIC Water Samples	7	7	35	16	**65**

The following data and samples were collected during this expedition:

Climate and Ocean Acidification Monitoring

Oceanographic Instrumentation and Biological Installations:

- Seawater temperature at 1, 5, 15, 25 m depths
- Assessment of taxonomic diversity of coral reef species by collection of invertebrate specimens from retrieved ARMS
- Installation of CAUs to allow for future assessment of $CaCO_3$ deposition rates once they are retrieved in about three years
- Installation of BMUs to allow for future assessment of bioerosion rates once they are retrieved in about three years
- Water samples and coral samples at select sites for microbial studies

Nearshore Oceanography from Small Boats:

- Shallow-water CTD profiles to depths ≤ 30 m, including all sites where CAUs were installed and selected benthic REA sites
- Water samples for salinity, DIC, and TA collected in concert with shallow-water (≤ 30 m) CTD casts

Shipboard Oceanography:

- 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
- Surface seawater temperature and salinity measurements from real-time flow through shipboard instrumentation

Biological Monitoring

Benthic REA surveys:

- Digital still photographs of overall site character and typical benthos
- Digital still photographs of the benthos along transect lines
- Number, species or genus, size, and condition of all coral colonies observed within belt transects of known area
- Digital still photographs of diseased corals and coralline algae

Fish REA surveys:

- Number, species, and estimated sizes of all fishes observed within visually estimated 7.5-m radius, stationary-point-count 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
- Species presence checklists for estimates of fish community diversity

SCIENTIFIC PERSONNEL:

Name (Last, First)	Team(s)	Role	Affiliation
Lino, Kevin	Fish	Fish Team Lead, Fish Diver	JIMAR/ESD
Heenan, Adel	Fish	Fish Diver	JIMAR/ESD
Giuseffi, Louise	Fish	Fish Diver	SOD
Wester, Tate	Fish	Fish Diver	JIMAR/ESD
Weible, Rebecca	Fish	Fish Diver	JIMAR/ESD
Swanson, Dione	Benthic	Benthic Team Lead, Benthic Diver	JIMAR/ESD
Ferguson, Marie	Benthic	Benthic Diver	UHM, JIMAR/ESD
McCoy, Kaylyn	Tow, Fish	Tow Team Lead, Tow Diver	JIMAR/ESD
Gray, Andrew	Tow, Fish	Tow Diver	JIMAR/ESD
Garriques, Joao	Tow, Benthic	Operations Lead, Benthic Diver, Tow Diver	JIMAR/ESD
Schumacher, Brett	Tow, Benthic	Chief Scientist, Benthic Diver, Tow Diver	JIMAR/ESD
Pomeroy, Noah	Oceanography/Instrumentation	Oceanography/Instrumentation Team Lead, Diver	JIMAR/ESD
Barkley, Hanna	Oceanography/Instrumentation	Ocean Acidification	WHOI
Counsell, Chelsie	Oceanography/Instrumentation	Instrumentation Diver	HIMB
Mathews, Lauren	Oceanography/Instrumentation	Microbiologist	SDSU
Morioka, James	Oceanography/Instrumentation	Instrumentation Diver	JIMAR/ESD
Sullivan, Chris	Oceanography/Instrumentation	Photomosaic	SIO
Timmers, Molly	Oceanography/Instrumentation	Instrumentation Diver	JIMAR/ESD
Mahaffey, Kathleen	Dive Safety	Chamber Operator	NOAA Dive Program
Trick, Kevin	Data management	Data Manager	JIMAR/ESD

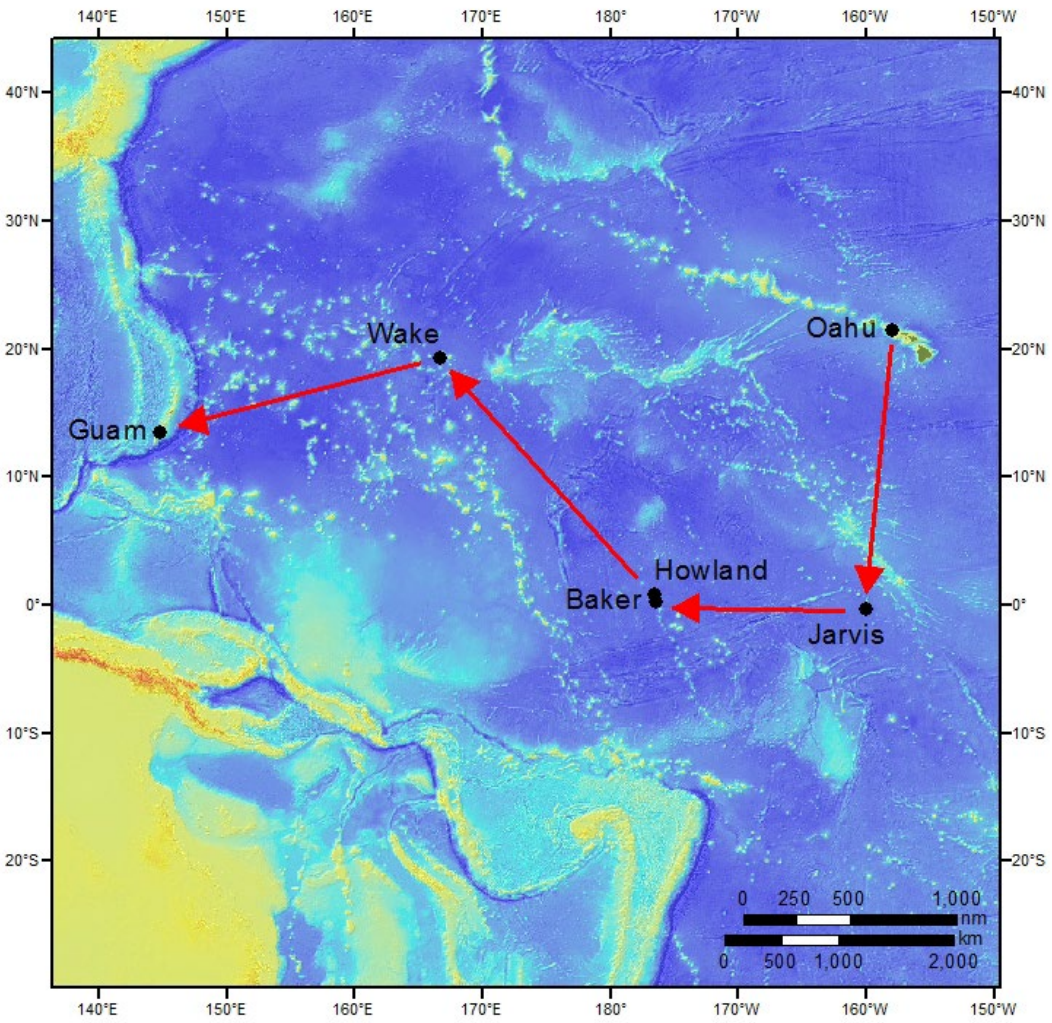

Figure 1. Operating area of the NOAA Ship *Hi'ialakai* for the cruise project HA-17-01 Leg 1, March 26 – April 29, 2017.

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Michael P. Seki, Ph.D.
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APPENDIX A: METHODS

This appendix describes the methods and procedures used by the Ecosystem Sciences Division (ESD) of the NOAA Pacific Islands Fisheries Science Center during its Pacific Reef Assessment and Monitoring Program (Pacific RAMP) project HA-17-01 on the NOAA Ship *Hi'ialakai* during the period of March 26 – April 29, 2017. An asterisk (*) in the list of team members indicates the individual was a team lead.

A.1. Climate and Ocean Acidification Monitoring: Instrumentation, Biological Installations, and Water Quality and Microbial Sampling

(Noah Pomeroy, Hanna Barkley, Chelsie Counsell, Lauren Mathews, James Morioka, Chris Sullivan, and Molly Timmers)*

Four main activities were conducted for the monitoring of climate and ocean change: (1) near-shore oceanographic and water quality surveys; (2) deployment and retrieval of an array of subsurface moored instrumentation and installations to provide continuous, high-resolution time-series of physical observations or integrated, ecosystem-wide biological process data; (3) offshore oceanographic surveys characterizing physical, biological, and chemical water properties, and ocean currents around these islands; and (4) shipboard meteorological observations, including wind speed and direction, relative humidity, air temperature, and barometric pressure. In addition, previously deployed instrumentation such as Ecological Acoustic Recorders (EARs), which monitor the sounds of marine animals and vessel traffic around the islands, were deployed.

Climate and ocean acidification monitoring efforts at each survey site fall into four complementary levels of increasing resolution. These are intended to document the island-scale, water chemistry, spatial and temporal variability of reef water thermal structure across a depth gradient, and the integrated biological responses of the reef community to the prevailing chemical and physical conditions.

- Class 0 sites: Only discrete water samples are collected and analyzed for dissolved inorganic carbon (DIC) and total alkalinity (TA).
- Class 1 sites: Only subsurface temperature recorders (STRs), SBE 56 temperature loggers (Sea-Bird Electronics, Inc., Bellevue, Wash.), are deployed.
- Class 2 sites: Include collection of discrete water for DIC and TA; STR deployments; benthic community surveys and benthic still photograph records. Biological installations, including Calcification Accretion Units (CAUs), Bioerosion Monitoring Units (BMUs), Autonomous Reef Monitoring Structures (ARMS), and coral coring are added.
- Class 3 sites: A MAPpCO2 buoy system is added to the Class 2 site setup.

Most of the CRED's efforts focus on establishing Class 0 and Class 2 sites at select locations distributed along the four cardinal directions around each island surveyed. For "Class 2 sites" and above, thermal structure measurements are obtained based on the deployment of subsurface temperature recorders (STRs; SBE 56) along a perpendicular forereef transect at 1-, 5-, 15-, and 25-m depth; each SBE 56 records the near-reef water temperature at the same time, on a 5-min interval, for the duration of the instrument's deployment. Within this context, a permanent water quality, temperature, and biological survey/sampling site, designated as *NCRMP Monitoring Station*, is established at the 15-m depth STR location, at select islands. In addition to the SBE 56 the NCRMP Monitoring Station includes: deployment of 3 ARMS units, 5 CAUs, and 5 BMUs; collection of 3 carbonate chemistry water samples (with associated CTD casts); acquisition of still photographic benthic imagery to document benthic cover and composition; and rugosity measurements of benthic topographic complexity.

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 platforms, which either electronically record *in-situ* measurements (temperature, currents, and waves) or by facilitating biological recruitment/growth on fabricated structures. The following types of oceanographic instruments and biological installations were retrieved or deployed during this project.

Subsurface Temperature Recorder (STR): provides high-resolution temperature data (SBE 39 or SBE 56). Data are internally recorded at 5-min intervals. This type of subsurface instrument is deployed at depths of 0.5–40 m. All loggers retrieved were of the type SBE 39; all loggers deployed were of the type SBE 56.

Wave-and-tide Recorder (WTR): Provides high-resolution wave and tide records (SBE 26plus 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.

Calcification Accretion Unit (CAU): are used to detect changes in calcification rates and net accretion of crustose coralline algae and other benthic sessile calcifiers.

Bioerosion Monitoring Unit (BMU): provides proxy for an integrated signal of net reef bioerosion.

Autonomous Reef Monitoring Structure (ARMS): provides an assessment of cryptic taxonomic diversity of coral reef associated species.

A.1.2. Hydrographic Surveys

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

Shallow-water (Near-shore) Conductivity, Temperature, and Depth Casts: a CTD profiler deployed from a small boat provided water column 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 location where a water sample was collected. The CTD is lowered by hand, off a small boat at descent rates of ~ 0.5–0.75 m/s to depths up to 30 m.

Water Chemistry: water samples for analyses of dissolved inorganic carbon (DIC), nutrients (N and P), salinity (S‰), and Total Alkalinity (TA) were collected at select locales concurrently with CTD casts.

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.

Shipboard CTD casts: Conduct 4 shipboard CTD casts at each island 15 km offshore in each cardinal direction along with a concurrent water sample using a CREP-provided shallow water CTD unit and a remotely-triggered niskin bottle. The cast and water collection will be conducted by ESD Ocean and Climate Change Team personnel and/or the trained survey technician along with a deckhand utilizing the ships CTD winch. If a hand lowered cast may be conducted safely, the CTD winch may not be used. These will ideally occur at 1745 after each day of operating around an island. Multiple CTDs may need to be conducted in a given evening if the ship will not be at an island for 4 nights. These offshore CTDs may not be conducted in circumstances where the time taken to conduct them would cause a delay to the start of the next operational day.

A.1.3. Microbial Communities

The data collected by the microbial partner will provide added value to the assessment and monitoring of coral reefs by combining the microbial taxonomic and functional composition and the fluxes of matter and energy they facilitate with the data on benthic and pelagic macro-biota. This will allow for characterization of coral reef ecosystems from a molecular to an ecosystem scale across the entire US pacific.

Collection of water chemistry using Minidon Niskin bottles

Primary goal: Collect water from reef benthos (light reef), reef matrix (dark reef), reef water column (5 m) and offshore water column (5 m) for DOC and inorganic nutrient concentrations, microbial abundances, and microbial DNA.

This provides (A) Most of the long term monitoring samples (water chemistry: organic carbon, inorganic nutrients; microbial activity: abundances and biomass, autotroph:heterotroph) and (B) On this round of projects we have paired our sampling (reef, surface, offshore) with the OCC team's water samples for inorganic measurements (DIC/TA).

Procedural overview: The minidons will replace the standard 2-L Niskin water chemistry set. The minidons allow for filtration of seawater through filter apparatus into the analytical vials during the dive. At every reef site, samples will be collected from 1) the reef benthos, 2) the reef matrix, and 3) the reef water column. Offshore samples will be collected opportunistically whenever the OCC team samples there. Each pair of minidons will produce the following analytes:

- DOC in a 60 ml plastic vial (via a 25-mm GF/F) (1)
- fDOM in a 20 ml plastic vial (via a 0.2-um polycarbonate filter) (1)
- inorganic nutrients in a 20 ml plastic vial (via a 0.2-um polycarbonate filter) (1)
- microbial sizes and abundances (epi-tubes with 1-ml fixed seawater) (2)
- flow cytometry (cryovials with seawater fixed in PFA or glutaraldehyde) (3)
- 0.2-um Sterivex filter for extraction of microbial DNA (1)

Two minidons will be deployed at each collection site (as listed above). When the paired minidons are taken apart for labeling and storage, each analyte will be pooled into one vial (detailed below).

Collection of water samples using Mega-Niskin (10-L water) for SPE-DOM (Solid Phase Eluted Dissolved Organic Matter) and benthic community sample (2-L water collected via bilge pump)

Primary goal: Isolation of DOM from seawater with low salt contamination for downstream analysis by HPLC, LCMS, NMR, or FTICRMS. These analyses will yield information concerning both the quality and quantity of DOM in benthic-associated seawater. Benthic associated samples will also be collected and processed to yield viromes via serial filtration and PEG precipitation. These should be collected along with the minidons as much as possible.

This provides (A) deeper characterization of the organic matter pool on reefs and (B) other long term monitoring samples (benthic microbiomes and viromes for metagenomic sequencing).

Procedural overview SPE-DOM: Large volumes of water (10 l) are collected in inert polycarbonate Niskin-type bottles and pressure-filtered through 0.2-um filter to remove particles. The water is acidified to pH 2 with concentrated HCl to increase extraction efficiency. The acidified water is passed over the PPL sorbent (pre-cleaned with methanol) using a peristaltic pump at a flow rate < 40 mL/min to bind SPE-DOM, requiring roughly 4h. The cartridges are rinsed twice with 1 volume 0.01 M HCl made in low-DOC water to remove salts. The cartridges are dried with 5 min of airflow and immediately eluted with 1-volume methanol at a flow rate < 2 mL/min into borosilicate vials with crimp-seal teflon-lined silicone lids and stored –20°C.

Benthic metagenomes: This protocol is to replace the 80 liter water collections in cubies and TFF concentration methods. Instead, 1 cubie will be filled about ¼ full with the bilge pump (vacuum the reef as usual benthic metagenome collection process). On surface, pour water from the cubie into a 2-L Niskin. Microbial metagenomes will be collected onto 0.45-um Sterivex filters. The 0.45-um filtrate will be collected into Nalgene bottles (600 mls, PEG precipitates) and onto 0.03 um PES filters (the remaining 1400 ml). PEG precipitates will be combined by island to generate “pooled viromes” via CsCl. Site level comparisons will be made using “total viral DNA” collected onto 0.03um filters.

Collection of coral:algal interaction tissue biopsies

Primary goal: Microbiologist will collect 1 coral:algal biopsy transects across coral-algal interaction interfaces per site (goal: 2-4 punch transects per island depending on island size. Biopsies will be processed to yield coral and algal metagenomes, metatranscriptomes, viromes, and metabolomes. These samples are to be collected at reef sites, but do not need to be at NCRMP sites.

These collections (A) replace the collections of rubble and algae (i.e., smashed reef) that we have collected on previous projects and (B) provide a spatial data set for investigating mechanisms of coral resistance to algal competition at coral:algal interaction interfaces.

Procedural overview : Find a coral-algal interaction with enough surface area to take 11 punches. For coral species, we are aiming for *Porites lobata* or *Pocillopora meandrina*. Use underwater drill to collect 1-cm diameter “biopsies” from coral algal interactions. Once back on ship, remove samples from drill bit into their respective vials: (a) virome samples (n = 3) into cryovial, then into dewer; (b) metatranscriptome (n = 5) into cryovial with 1 ml RNA later (c) metabolome samples (n = 3) into 20-ml amber vials with 5-ml 70% methanol.

Measurement of coral geometry

Primary goal: Microbiologists will take high resolution images of single coral colonies to create 3D coral models, which will allow for the calculation of precise surface area, perimeter, and rugosity measurements.

Procedural overview: Once the coral to image has been chosen, lay a chain link on the coral interface and try to get the link as close to the perimeter as possible without blocking the camera's view of the interface. Start imaging the perimeter from about 25-cm working distance. Try to achieve a 90% overlap with each picture and keep the same camera orientation as you move around the coral. Make sure the chain link is in at least one of the images. Also, if there are other interactions within the colony, repeat the process for those interactions and include at least one chain link for calibration. The chain is carefully removed when the imaging is completed.

A.1.4. Benthic photomosiaic

Photomosaics are used to collect coral community composition data at climate stations and contextualize any physical and/or biological changes recorded at the climate stations over time. The collection of photomosaics is straightforward and requires little special equipment or dive operations. The mosaic camera system consists of two SLR Nikon D7000 cameras and a single GoPro video camera mounted to a custom frame. To obtain continuous coverage of the reef floor within a plot, the diver operating the camera system swims a gridded pattern approximately 1.5 m above the average depth of the plot at speeds sufficient to maintain maximum overlap between adjacent images. Depending on local conditions a single mosaic will take 45–60 min. To calibrate mosaic images, a second diver collects a series of detailed measurements between a number of temporary and/or permanent reference markers deployed during surveys.

A.2. Biological Monitoring: Rapid Ecological Assessment (REA) Surveys

A two-stage stratified random sampling design was employed to survey REA sites. The survey domain encompassed reef and hard bottom habitat, and was divided into strata based upon depth. Depth categories of shallow (0–6 m), mid (> 6–18 m) and deep (> 18–30 m) were also incorporated into the stratification scheme. Allocation of sampling effort was proportional to strata area. Sites were randomly selected within each stratum.

A.2.1. Benthic Surveys —Benthic composition and coral demographics

(Dione Swanson, Marie Ferguson, Joao Garriques, and Brett Schumacher)*

Adult corals: Surveys at each site were conducted within two, 18-m belt transects. Adult coral colonies (≥ 5 cm) were surveyed within four segments that were 1.0 wide by 2.5 m long. Along the transect tape, the segments were located at 0–2.5 m, 5.0–7.5m, 10–12.5 m, and 15–17.5 m. All colonies whose center fell within 0.5 m on either side of each transect line were identified to lowest taxonomic level possible (species or genus), measured for size (maximum diameter to nearest cm), and morphology was noted. In addition, partial mortality and condition of each colony was assessed. Partial mortality was estimated as percent of the colony in terms of 'old dead' and 'recent dead' and attributed to cause of mortality when possible. The condition of each colony, including disease and bleaching, was noted along with the extent (percent of colony affected) and severity (range from mild to acute).

Juvenile coral colonies: Juvenile coral colonies (< 5 cm) were surveyed within three segments along the same two transects. Juvenile segments were 1.0 m wide by 1.0 m long, and were located within the segments used for adults at 0–1.0 m, 5.0–6.0 m, and 10.0–11.0 m (covering 3 m^2 per transect). Juvenile colonies were distinguished in the field by a distinct tissue

and skeletal boundary (not a fragment of larger colony). Each juvenile colony was identified to lowest taxonomic level (genus or species) and measured for size by recording both the maximum and perpendicular diameter to the nearest 2 mm.

Benthic composition: Still photographs were collected to record the benthic community composition at predetermined points along the same 2 transect lines with a high-resolution digital camera mounted on a pole. Photographs were taken every 1 m from the 1 m to the 15-m mark. This work generated 30 photographs per site, which are later analyzed by CREP staff and partners using the computer program CoralNet. This analysis is the basis for estimating benthic cover and composition at each site (benthic habitat photographs at sites surveyed by the fish team are also analyzed using CoralNet).

Modifications at specific islands: At Jarvis Island and Wake Atoll, the full Benthic REA protocol was used. Due to limited time available at Baker and Howland Islands, adult coral colony counts were not conducted; the survey protocol was reduced to include only the juvenile colony and photographic components.

A.2.2 Reef fish surveys

(Kevin Lino, Louise Giuseffi, Andrew Gray, Adel Heenan, Kaylyn McCoy, Rebecca Weible, and Tate Wester)*

Divers conducted Fish REA surveys using the stationary-point-count (SPC) method at preselected REA sites. All fish REA sites visited were selected using a stratified random sampling design in shallow (0–6 m), mid (6–18 m), or deep (18–30 m) depth strata, in the forereef habitat strata. 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.

Fish survey: Each fish REA site consists of a team of two divers conducting two adjacent and simultaneous SPC surveys. 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 created a list of all fish species found within their cylinder. 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.

Benthic assessment: 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. Urchin densities were also estimated. Every meter along the transect line, still photographs were taken of the benthos to the right side of the line. This work generates 30 photographs per site, which analyzed later using CoralNet to estimate the benthic cover and composition at each site.

Modifications at specific islands: At Jarvis Island and Wake Atoll, the full Fish REA protocol was used. Due to limited time available at Baker and Howland Islands and the interest in studying potential impacts to coral from the period of abnormally high water temperatures from 2015-16, the survey protocol was reduced to include only the habitat survey and photographic components.

A.3. Biological Monitoring: Towed-Diver Surveys

(Kaylyn McCoy, Joao Garriques, Andrew Gray, and Brett Schumacher)*

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, 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.

Benthic survey: 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.

Fish survey: 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.

A.4. Biological Monitoring: Plankton Tows

A plankton net 50-cm diameter with a 80-µm mesh size having a 1-L cod end attached to net with flow meter will be trailing a few yards behind the stern of a small boat. Each tow will be assigned a unique station number with corresponding GPS coordinates, date & time recorded for start and finish of each tow. The tows will be just below the surface, for 5 min and the small boat will be going just fast enough for net to be tight and flow meter to run (1–2 kn). The net will be brought back onto the small boat and processed in the field. The outside of the plankton net will be washed down with seawater applied to outside collecting flora and fauna in the cod end. Plankton tows are conducted opportunistically, and depending on the number of days spent at each island, we expect to conduct 5–10 plankton tows per island. After using a hand net to separate taxa, all samples will be put into 50-mL Falcon tube(s) using 95% ethanol in squirt bottles to be fixed.

APPENDIX B: JARVIS ISLAND

Jarvis Island, located at 0.036667° S, 160.016778° W, is the southernmost US-affiliated island in the Line Islands. Administratively, it is one of seven islands included in 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."

B.1. Climate and Ocean Acidification Monitoring: Instrumentation, Biological Installations, and Water Quality

Oceanographic operations during the project HA-17-01 entailed numerous retrievals and deployments of oceanographic moored instruments, installation of subsurface temperature recorders (STRs), calcification acidification units (CAUs), Autonomous Reef Monitoring Structures (ARMS), bioerosion monitoring units (BMUs), Ecological Acoustic Recorders (EARs), Soundtrap acoustic recorders, near-shore water sampling, and conductivity, temperature and depth (CTD) casts at select NCRMP sites.

Shallow-water CTD casts were performed at each location where water samples were collected, and these included sample locations taken in concert with the installation of NCRMP monitoring stations as well as at stratified random locations around the island. Thirty-five shallow-water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity. In addition, 3 STRs were retrieved and deployed. (Fig. B.1.1and Table B.1.1). For more information about microbial collections, see Table F.1.1 in Appendix F: "Biological Collections."

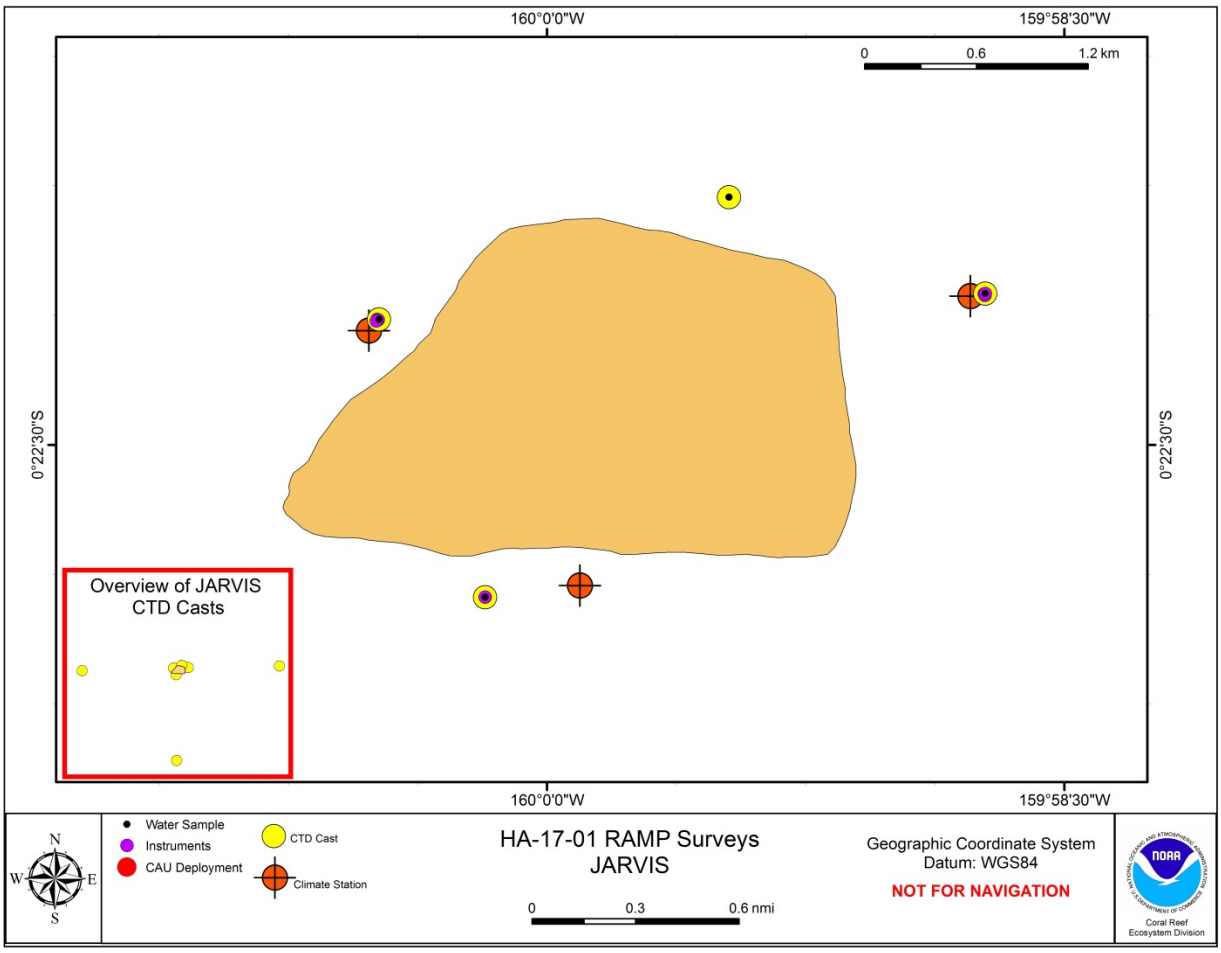

Figure B.1. 1. Sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Jarvis Island during project HA-17-07.

Table B.1. 1. Geographic coordinates and depths of microbial sampling and oceanographic instruments that were retrieved or deployed at Jarvis Island during project HA-17-01: Acoustic Doppler Current Profiler (ADCP); Conductivity, Temperature and Depth meter (CTD); Ecological Acoustic Recorder (EAR); and Subsurface Temperature Recorder (STR).

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
JAR_OCEAN_029	02-Apr-17	ADCP	-0.36776	-159.97889	16.15	–	1
JAR_OCEAN_029	02-Apr-17	CTD	-0.36776	-159.97889	16.15	–	1
JAR_OCEAN_029	02-Apr-17	pH meter	-0.36776	-159.97889	16.15	–	1
JAR_OCEAN_029	02-Apr-17	STR	-0.36771	-159.97881	14.94	1	1
JAR-01	02-Apr-17	Microbial	-0.36771	-159.97882	15.45	1	NA
JAR_OCEAN_029	03-Apr-17	ADCP	-0.36772	-159.97886	16.15	1	–
JAR_OCEAN_029	03-Apr-17	CTD	-0.36772	-159.97886	16.15	1	–
JAR_OCEAN_029	03-Apr-17	pH meter	-0.36772	-159.97886	16.15	1	–
JAR_OCEAN_019	03-Apr-17	EAR	-0.36897	-160.00816	16.76	–	1
JAR_OCEAN_019	03-Apr-17	Soundtrap	-0.36897	-160.00816	16.76	–	1
JAR-11	03-Apr-17	Microbial	-0.36897	-160.00816	15.76	1	NA
JAR_OCEAN_026	04-Apr-17	STR	-0.38235	-160.00299	14.33	1	1
JAR-625	04-Apr-17	Microbial	-0.38235	-160.00299	16.97	1	NA
JAR_OCEAN_014	04-Apr-17	STR	-0.36903	-160.00824	14.94	1	–
JAR_OCEAN_015	04-Apr-17	STR	-0.36903	-160.00824	14.94	–	1
JAR_OCEAN_019	04-Apr-17	ADCP	-0.36903	-160.00824	16.76	–	1
JAR_OCEAN_019	04-Apr-17	CTD	-0.36903	-160.00824	16.76	–	1
JAR_OCEAN_019	04-Apr-17	pH meter	-0.36903	-160.00824	16.76	–	1
JAR_OCEAN_029	05-Apr-17	EAR	-0.36780	-159.97883	16.15	–	1
JAR_OCEAN_029	05-Apr-17	Soundtrap	-0.36780	-159.97883	16.15	–	1
JAR_OCEAN_019	05-Apr-17	ADCP	-0.36896	-160.00821	16.76	1	–
JAR_OCEAN_019	05-Apr-17	CTD	-0.36896	-160.00821	16.76	1	–
JAR_OCEAN_019	05-Apr-17	pH meter	-0.36896	-160.00821	16.76	1	–
JAR-07	05-Apr-17	Microbial	-0.37605	-160.01393	16.67	1	NA

B.2. Biological Monitoring: Benthic Surveys

Belt-transect surveys were conducted and photographs were taken along transect lines at 32 REA sites around Jarvis Island to assess benthic composition, coral community structure, and coral and algal disease.

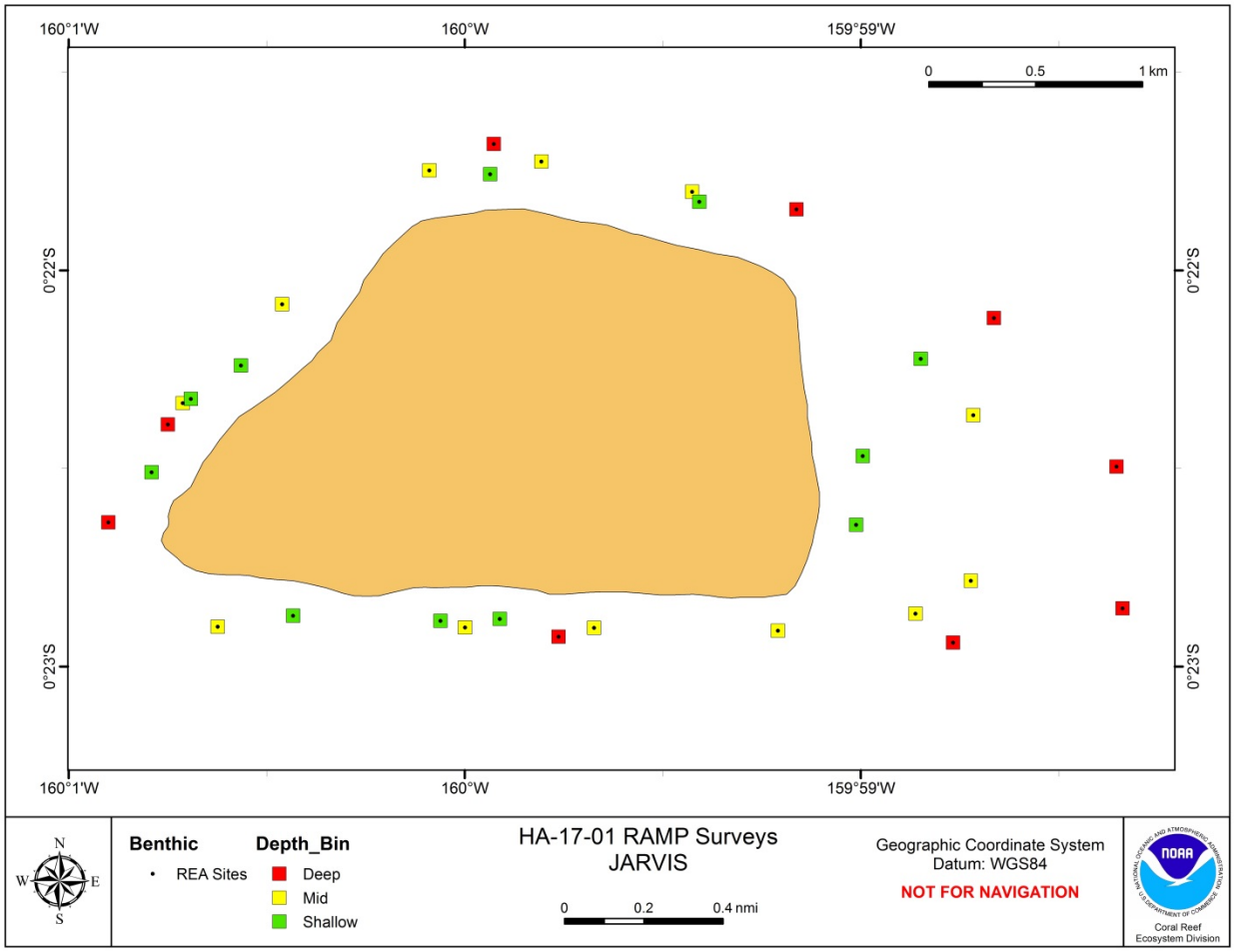

Figure B.2. 1. Locations of benthic REA sites surveyed at Jarvis Island during project HA-17-01. REA sites were selected using a stratified random design.

Table B.2. 1. Summary of the Benthic REA surveys performed at Jarvis Island during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude
JAR-1113	02-Apr-17	Deep	Forereef	82	-0.38233
JAR-1715	02-Apr-17	Mid	Forereef	29	-0.37973
JAR-1688	02-Apr-17	Mid	Forereef	40	-0.38182
JAR-1767	02-Apr-17	Shallow	Forereef	19	-0.38133
JAR-1745	02-Apr-17	Shallow	Forereef	19	-0.38141
JAR-1131	03-Apr-17	Deep	Forereef	80	-0.38088
JAR-1126	03-Apr-17	Deep	Forereef	74	-0.36867
JAR-1133	03-Apr-17	Deep	Forereef	70	-0.37492
JAR-1752	03-Apr-17	Shallow	Forereef	21	-0.37039
JAR-1681	03-Apr-17	Mid	Forereef	32	-0.38111
JAR-1680	03-Apr-17	Mid	Forereef	39	-0.38169
JAR-1685	03-Apr-17	Mid	Forereef	37	-0.38170
JAR-1751	03-Apr-17	Shallow	Forereef	19	-0.38120
JAR-1718	03-Apr-17	Mid	Forereef	54	-0.38165
JAR-1111	04-Apr-17	Deep	Forereef	80	-0.37727
JAR-1122	04-Apr-17	Deep	Forereef	75	-0.36410
JAR-1142	04-Apr-17	Deep	Forereef	80	-0.37314
JAR-1158	04-Apr-17	Deep	Forereef	74	-0.36135
JAR-1699	04-Apr-17	Mid	Forereef	56	-0.36336
JAR-1760	04-Apr-17	Mid	Forereef	40	-0.37225
JAR-1687	04-Apr-17	Mid	Forereef	41	-0.36809
JAR-1720	04-Apr-17	Mid	Forereef	38	-0.36208
JAR-1723	04-Apr-17	Mid	Forereef	34	-0.36246
JAR-1137	05-Apr-17	Deep	Forereef	83	-0.38208
JAR-1763	05-Apr-17	Shallow	Forereef	18	-0.36378
JAR-1761	05-Apr-17	Shallow	Forereef	18	-0.37516
JAR-1753	05-Apr-17	Shallow	Forereef	17	-0.37737
JAR-1776	05-Apr-17	Shallow	Forereef	19	-0.37207
JAR-1779	05-Apr-17	Shallow	Forereef	15	-0.37447
JAR-1757	05-Apr-17	Shallow	Forereef	19	-0.37066
JAR-1686	05-Apr-17	Mid	Forereef	30	-0.37276
JAR-1789	05-Apr-17	Shallow	Forereef	22	-0.36262

Additionally, during the HA-17-01 project, 7 towed-diver surveys were completed around Jarvis Island, covering a total length of 17.8 km (an area of 17.8 ha) of the ocean floor (Figure B.2. 2).

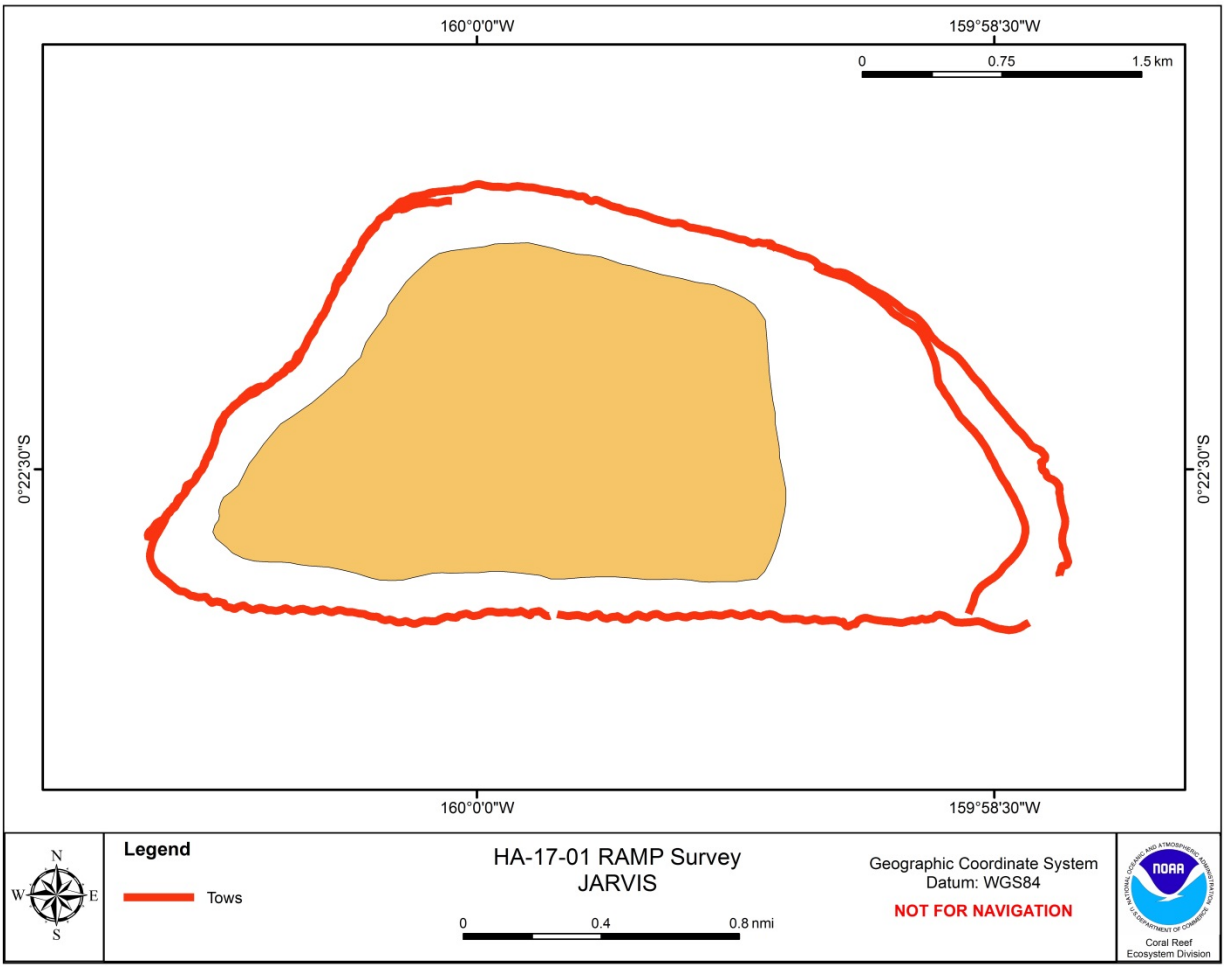

Figure B.2. 2. Track locations of towed-diver surveys conducted at Jarvis Island during the cruise HA-17-01.

B.3. Biological Monitoring: Reef Fish Community

Fish REA survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 28 REA sites at Jarvis Island over three different habitat depths: deep, mid, and shallow; and two different reef habitat zones: forereef and protected reef slope (Fig.B.3.1 and Table B.3.1). No fishes were collected during these surveys.

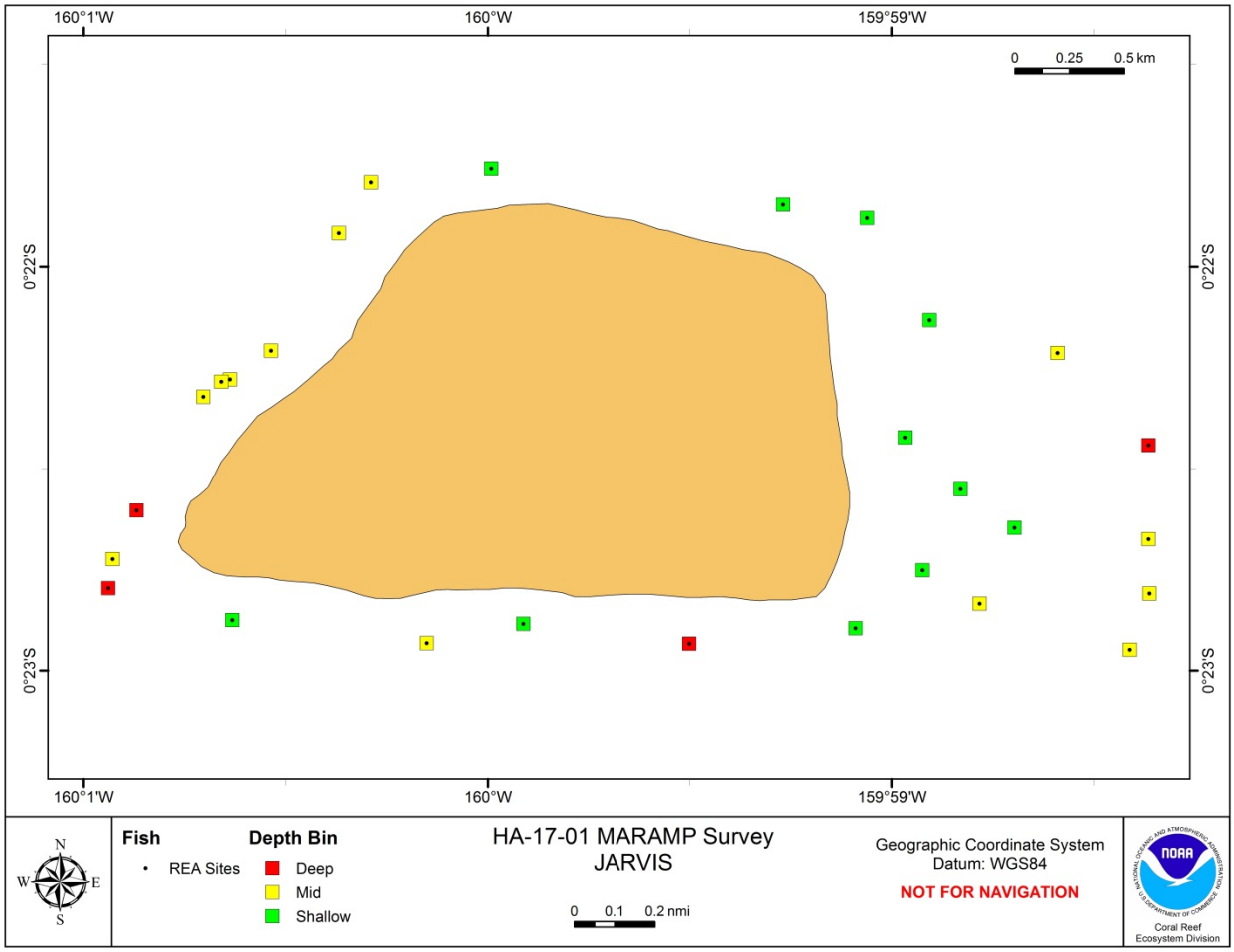

Figure B.3. 1. Locations of Fish REA sites surveyed at Jarvis Island during project HA-17-01. REA sites were selected using a stratified random design.

Table B.3. 1. Summary of sites where Fish REA surveys were conducted at Jarvis Island during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
JAR-1017	02-Apr-17	Mid	Forereef	9.8	-0.37013	-160.00894
JAR-1047	02-Apr-17	Mid	Forereef	11.7	-0.36319	-160.00482
JAR-1052	02-Apr-17	Mid	Forereef	14.0	-0.37203	-160.01173
JAR-1054	02-Apr-17	Mid	Forereef	12.7	-0.37874	-160.01547
JAR-1055	02-Apr-17	Mid	Forereef	14.0	-0.36528	-160.00614
JAR-979	02-Apr-17	Mid	Forereef	15.0	-0.37141	-160.01099
JAR-986	02-Apr-17	Mid	Forereef	12.2	-0.37131	-160.01063
JAR-1010	03-Apr-17	Mid	Forereef	12.0	-0.37022	-159.97650
JAR-1018	03-Apr-17	Shallow	Forereef	4.8	-0.38141	-159.99854
JAR-1031	03-Apr-17	Shallow	Forereef	6.5	-0.37920	-159.98208
JAR-1035	03-Apr-17	Shallow	Forereef	5.5	-0.36887	-159.98179
JAR-1051	03-Apr-17	Shallow	Forereef	5.2	-0.38125	-160.01053
JAR-1053	03-Apr-17	Shallow	Forereef	5.9	-0.38159	-159.98482
JAR-1064	03-Apr-17	Deep	Forereef	20.5	-0.37994	-160.01565
JAR-967	03-Apr-17	Deep	Forereef	22.3	-0.37673	-160.01448
JAR-984	03-Apr-17	Mid	Forereef	12.5	-0.38221	-160.00253
JAR-1015	04-Apr-17	Shallow	Forereef	7.0	-0.37585	-159.98050
JAR-1036	04-Apr-17	Shallow	Forereef	5.8	-0.37371	-159.98278
JAR-1050	04-Apr-17	Shallow	Forereef	6.7	-0.37744	-159.97828
JAR-1063	04-Apr-17	Mid	Forereef	19.5	-0.38248	-159.97353
JAR-994	04-Apr-17	Mid	Forereef	8.5	-0.38058	-159.97972
JAR-996	04-Apr-17	Deep	Forereef	23.6	-0.38223	-159.99168
JAR-1005	05-Apr-17	Mid	Forereef	8.4	-0.37791	-159.97277
JAR-1016	05-Apr-17	Shallow	Forereef	6.6	-0.36264	-159.99986
JAR-1025	05-Apr-17	Shallow	Forereef	6.0	-0.36411	-159.98781
JAR-1058	05-Apr-17	Shallow	Forereef	13.7	-0.36466	-159.98434
JAR-1059	05-Apr-17	Mid	Forereef	9.8	-0.38016	-159.97272
JAR-1067	05-Apr-17	Deep	Forereef	22.0	-0.37403	-159.97276

APPENDIX C: BAKER ISLAND

Baker Island, located at 0.216667° N, 176.466667° W, is the southern of two US-affiliated islands in the Phoenix Islands. Administratively, it is one of seven islands included in 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."

C.1. Climate and Ocean Acidification Monitoring: Instrumentation, Biological Installations, and Water Quality

Oceanographic operations during the project HA-17-01 entailed numerous retrievals and deployments of oceanographic moored instruments, installation of subsurface temperature recorders (STRs), calcification acidification units (CAUs), Autonomous Reef Monitoring Structures (ARMS), bioerosion monitoring units (BMUs), Ecological Acoustic Recorders (EARs), Soundtrap acoustic recorders, near-shore water sampling, and conductivity, temperature and depth (CTD) casts at select NCRMP sites.

Shallow-water CTD casts were performed at each location where water samples were collected, and these included sample locations taken in concert with the installation of NCRMP monitoring stations as well as at stratified random locations around the island. Seven shallow-water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity. In addition, 1 STR was retrieved and deployed. (Fig. C.1.1 and Table C.1.1).). For more information about microbial collections, see Table F.1.1 in Appendix F: "Biological Collections."

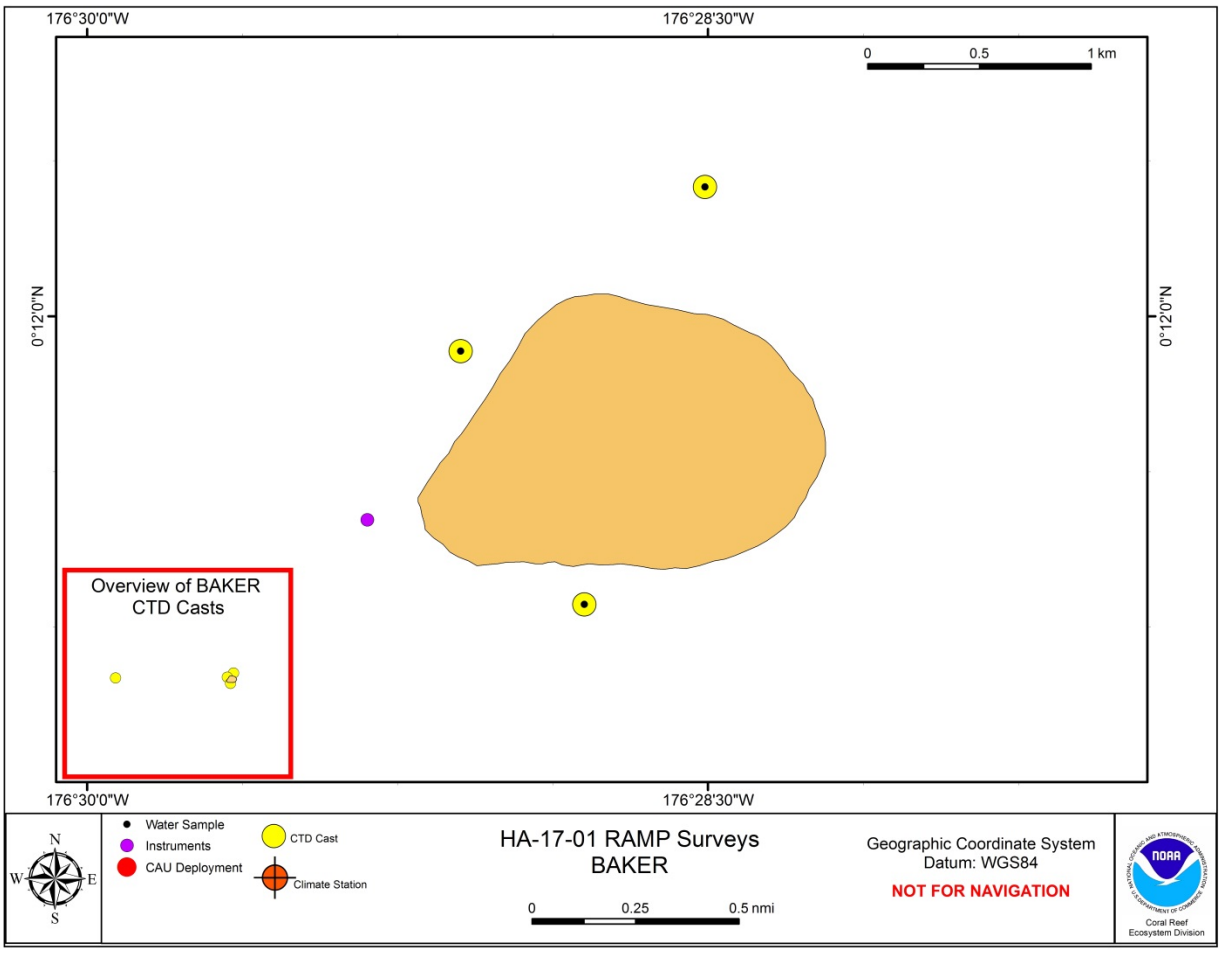

Figure C.1. 1. Sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Baker Island during project HA-17-07.

Table C.1. 1. Geographic coordinates and depths of microbial sampling and oceanographic instruments that were retrieved or deployed at Baker Island during project HA-17-01: Ecological Acoustic Recorder (EAR); and Subsurface Temperature Recorder (STR).

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
BAK_OCEAN_017	10-Apr-17	STR	0.19181	-176.48871	13.72	1	–
BAK_OCEAN_017	10-Apr-17	EAR	0.19181	-176.48871	14.94	–	1
BAK_OCEAN_017	10-Apr-17	Soundtrap	0.19181	-176.48871	14.94	–	1
BAK_OCEAN_017	10-Apr-17	STR	0.19181	-176.48871	14.02	–	1
BAK-02	10-Apr-17	Microbial	0.18842	-176.47997	18.48	1	NA

C.2. Biological Monitoring: Benthic Surveys

Belt-transect surveys were conducted and photographs were taken along transect lines at 7 REA sites around Baker Island to assess benthic composition and coral community structure and recruitment.

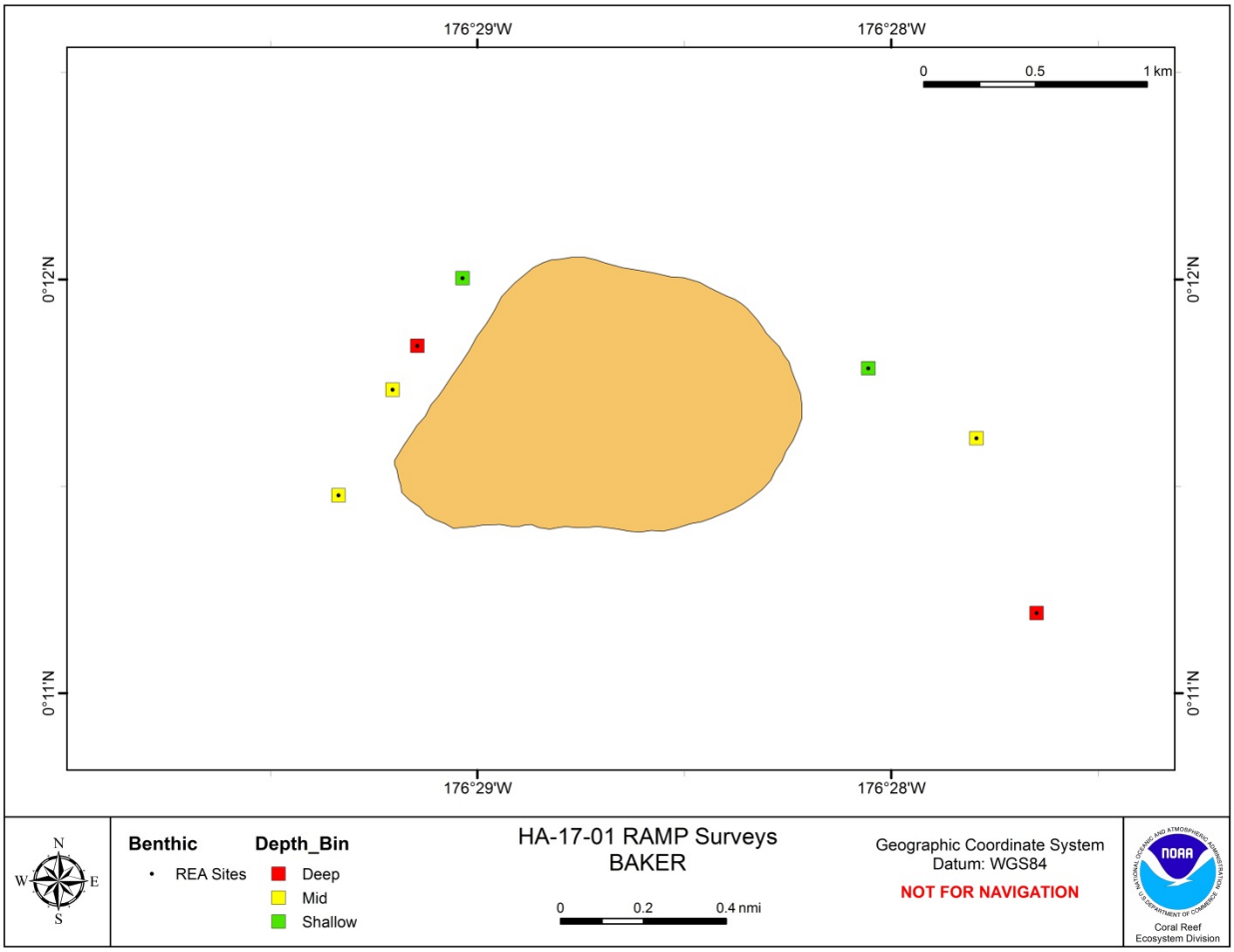

Figure C.2. 1. Locations of benthic REA sites surveyed at Baker Island during project HA-17-01. REA sites were selected using a stratified random design.

Table C.2. 1. Summary of the Benthic REA surveys performed at Baker Island during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude
BAK-511	10-Apr-17	Deep	Forereef	80	0.19732	-176.48575
BAK-509	10-Apr-17	Deep	Forereef	76	0.18656	-176.46081
BAK-581	10-Apr-17	Mid	Forereef	29	0.19360	-176.46324
BAK-644	10-Apr-17	Shallow	Forereef	18	0.19642	-176.46759
BAK-678	10-Apr-17	Mid	Forereef	44	0.19556	-176.48675
BAK-649	10-Apr-17	Shallow	Forereef	17	0.20006	-176.48393
BAK-573	10-Apr-17	Mid	Forereef	37	0.19130	-176.48893

Additionally, during the HA-17-01 project, 5 towed-diver surveys were completed around Baker Island, covering a total length of 11.1 km (an area of 11.1 ha) of the ocean floor (Fig. C.2.2).

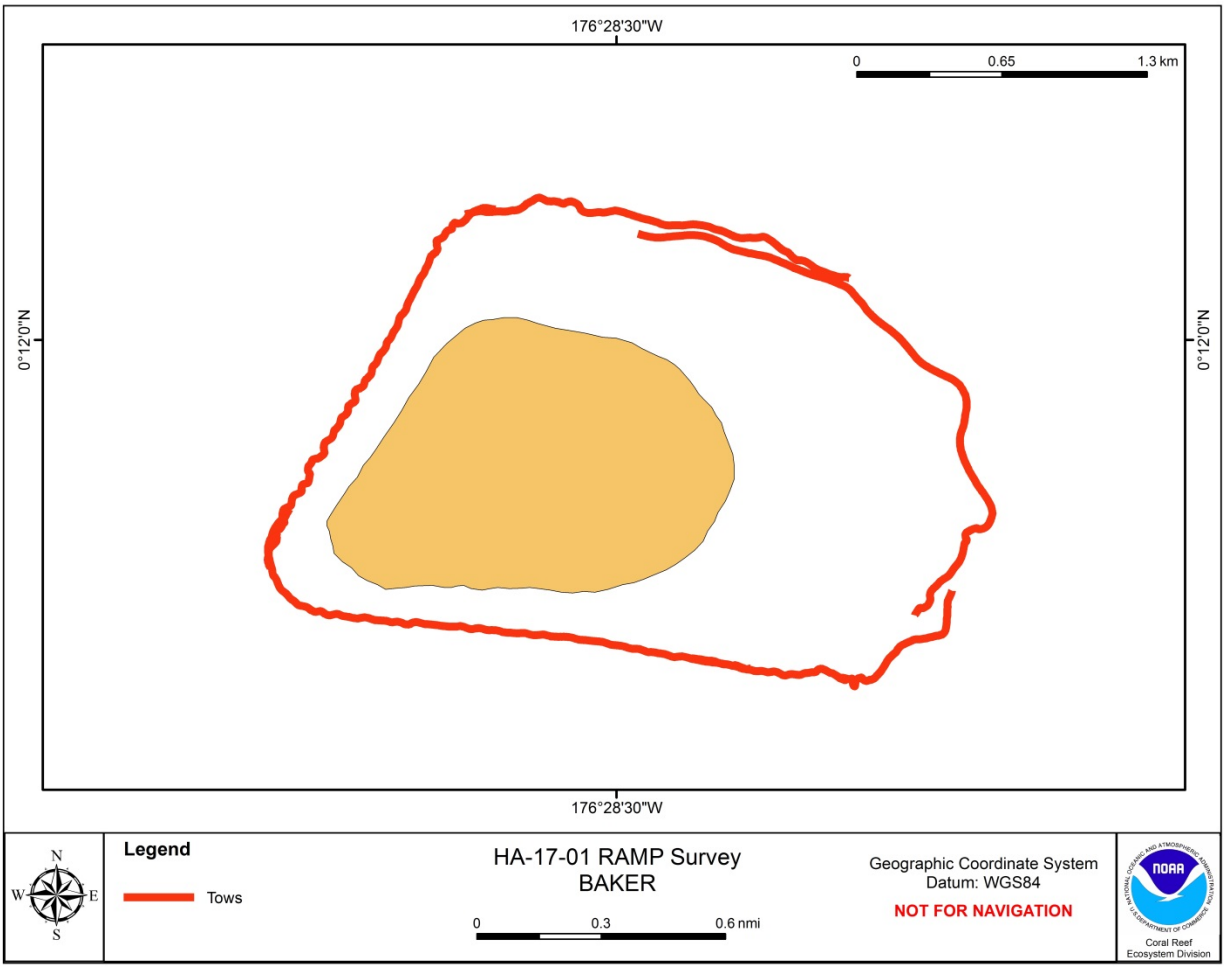

Figure C.2. 2. Track locations of towed-diver surveys conducted at Baker Island during the project HA-17-01.

C.3. Biological Monitoring: Modified Reef Fish Community Surveys

Sites for modified stationary-point-count surveys (including only photoquadrat and benthic habitat characterization) were chosen using a stratified random design. These surveys were conducted at 16 REA sites at Baker Island over three different habitat strata: deep, mid, and shallow forereef (Fig.C.3.1 and Table C.3.1). No fishes were collected during these surveys.

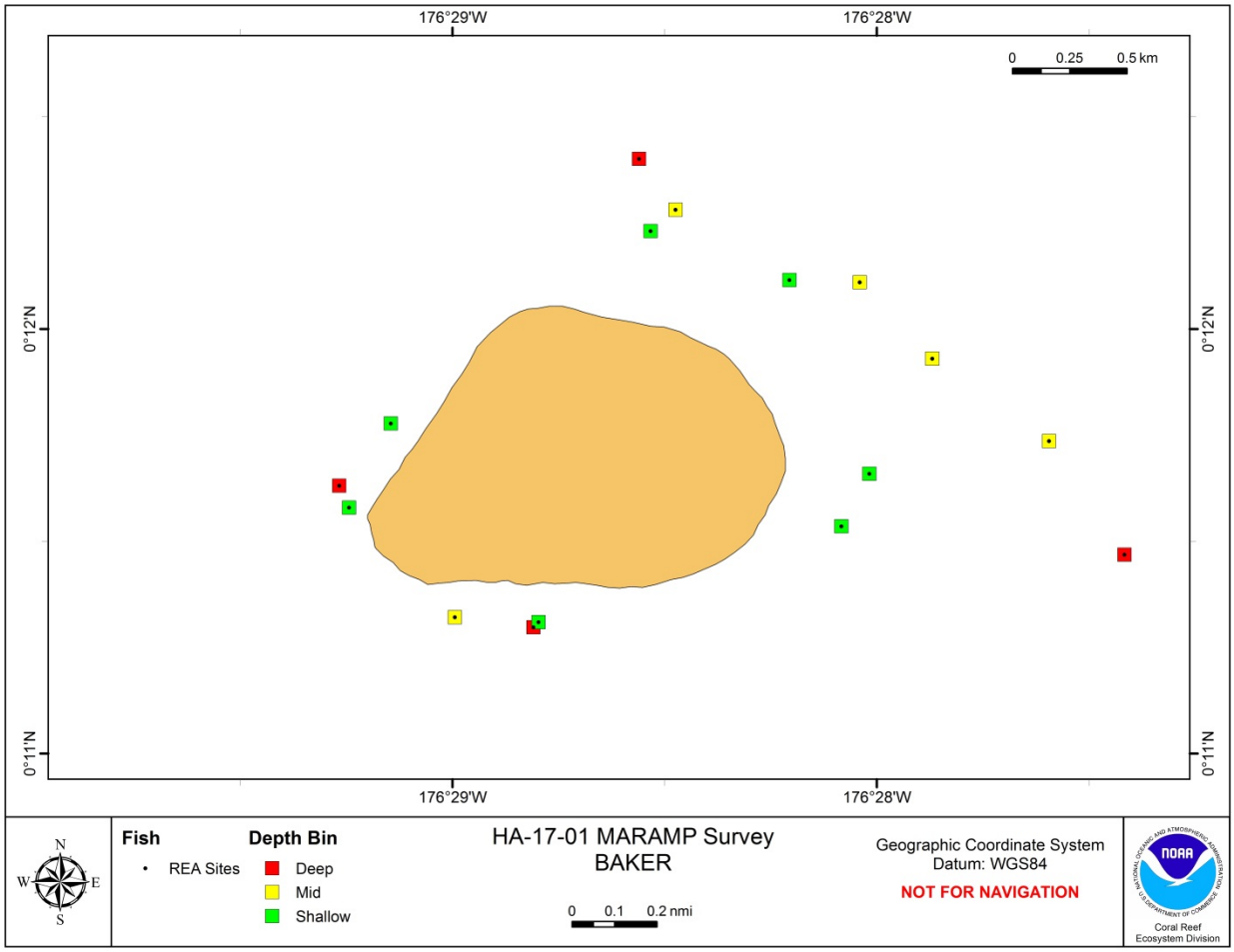

Figure C.3. 1. Locations of modified Fish REA sites surveyed at Baker Island during project HA-17-01. REA sites were selected using a stratified random design.

Table C.3. 1. Summary of sites where modified Fish REA surveys were conducted at Baker Island during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
BAK-530	10-Apr-17	Deep	Forereef	26.2	0.20668	-176.47601
BAK-536	10-Apr-17	Deep	Forereef	18.1	0.19114	-176.45695
BAK-557	10-Apr-17	Deep	Forereef	24.9	0.18829	-176.48015
BAK-564	10-Apr-17	Deep	Forereef	23.0	0.19385	-176.48778
BAK-576	10-Apr-17	Moderate	Forereef	14.0	0.19560	-176.45990
BAK-599	10-Apr-17	Moderate	Forereef	7.5	0.19884	-176.46449
BAK-601	10-Apr-17	Moderate	Forereef	15.2	0.20468	-176.47457
BAK-604	10-Apr-17	Moderate	Forereef	9.6	0.20183	-176.46734
BAK-625	10-Apr-17	Moderate	Forereef	12.0	0.18869	-176.48324
BAK-634	10-Apr-17	Shallow	Forereef	4.5	0.19431	-176.46696
BAK-635	10-Apr-17	Shallow	Forereef	6.0	0.19298	-176.48740
BAK-655	10-Apr-17	Shallow	Forereef	3.5	0.19225	-176.46806
BAK-656	10-Apr-17	Shallow	Forereef	5.4	0.20384	-176.47555
BAK-674	10-Apr-17	Shallow	Forereef	5.0	0.18849	-176.47995
BAK-679	10-Apr-17	Shallow	Forereef	4.0	0.20192	-176.47010
BAK-694	10-Apr-17	Shallow	Forereef	9.6	0.19629	-176.48576

APPENDIX D: HOWLAND ISLAND

Howland Island, located at 0.8° N, 178.633333 ° W, is the northern of two US-affiliated islands in the Phoenix Islands. Administratively, it is one of seven islands included in 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.”

D.1. Climate and Ocean Acidification Monitoring: Instrumentation, Biological Installations, and Water Quality

Oceanographic operations during the project HA-17-01 entailed numerous retrievals and deployments of oceanographic moored instruments, installation of subsurface temperature recorders (STRs), calcification acidification units (CAUs), Autonomous Reef Monitoring Structures (ARMS), bioerosion monitoring units (BMUs), Ecological Acoustic Recorders (EARs), Soundtrap acoustic recorders, near-shore water sampling, and conductivity, temperature and depth (CTD) casts at select NCRMP sites.

Shallow-water CTD casts were performed at each location where water samples were collected, and these included sample locations taken in concert with the installation of NCRMP monitoring stations as well as at stratified random locations around the island. Seven shallow-water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity. In addition, 2 STRs were retrieved and deployed. (Fig. D.1.1 and Table D.1.1).). For more information about microbial collections, see Table F.1.1 in Appendix F: “Biological Collections.”

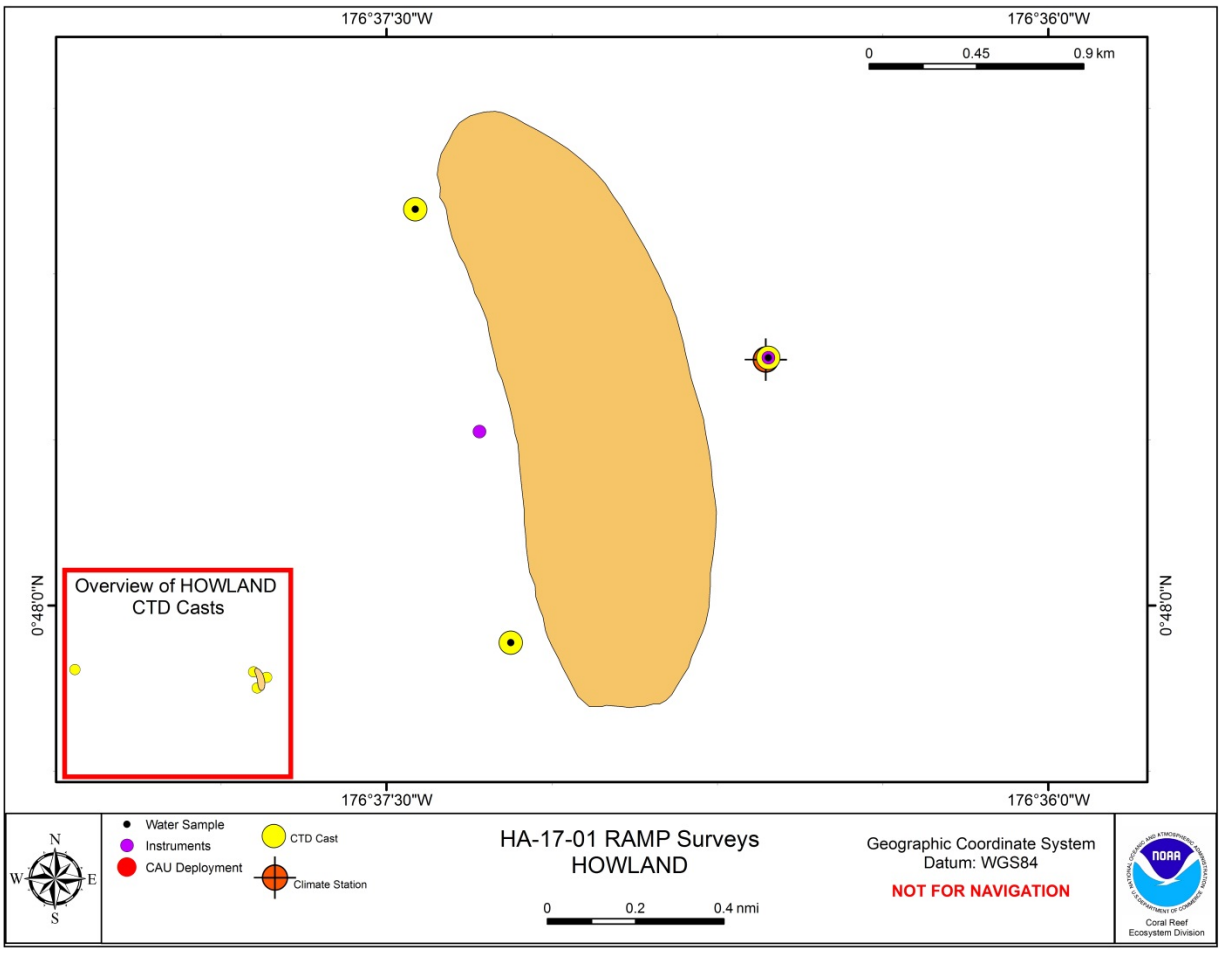

Figure D.1. 1. Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Howland Island during project HA-17-01.

Table D.1. 1. Geographic coordinates and depths of microbial sampling and oceanographic instruments that were retrieved or deployed at Howland Island during project HA-17-01: Acoustic Doppler Current Profiler (ADCP); Conductivity, Temperature and Depth meter (CTD); Ecological Acoustic Recorder (EAR); High-frequency Acoustic Recording Package (HARP); and Subsurface Temperature Recorder (STR).

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
HOWLAND HARP	11-Apr-17	HARP	0.82568	-176.64488	779.07	–	1
HOW_OCEAN_013	11-Apr-17	STR	0.80655	-176.62148	14.33	1	–
HOW_OCEAN_013	11-Apr-17	STR	0.80655	-176.62148	14.33	–	1
HOW_OCEAN_011	11-Apr-17	STR	0.80934	-176.61057	14.33	1	1
HOW-12	11-Apr-17	Microbial	0.80934	-176.61057	13.94	1	NA
HOW-11	11-Apr-17	Microbial	0.79860	-176.62300	16.06	1	NA

D.2. Biological Monitoring: Benthic Surveys

Belt-transect surveys were conducted and photographs were taken along transect lines at 6 REA sites around Howland Island to assess benthic composition and coral community structure and recruitment.

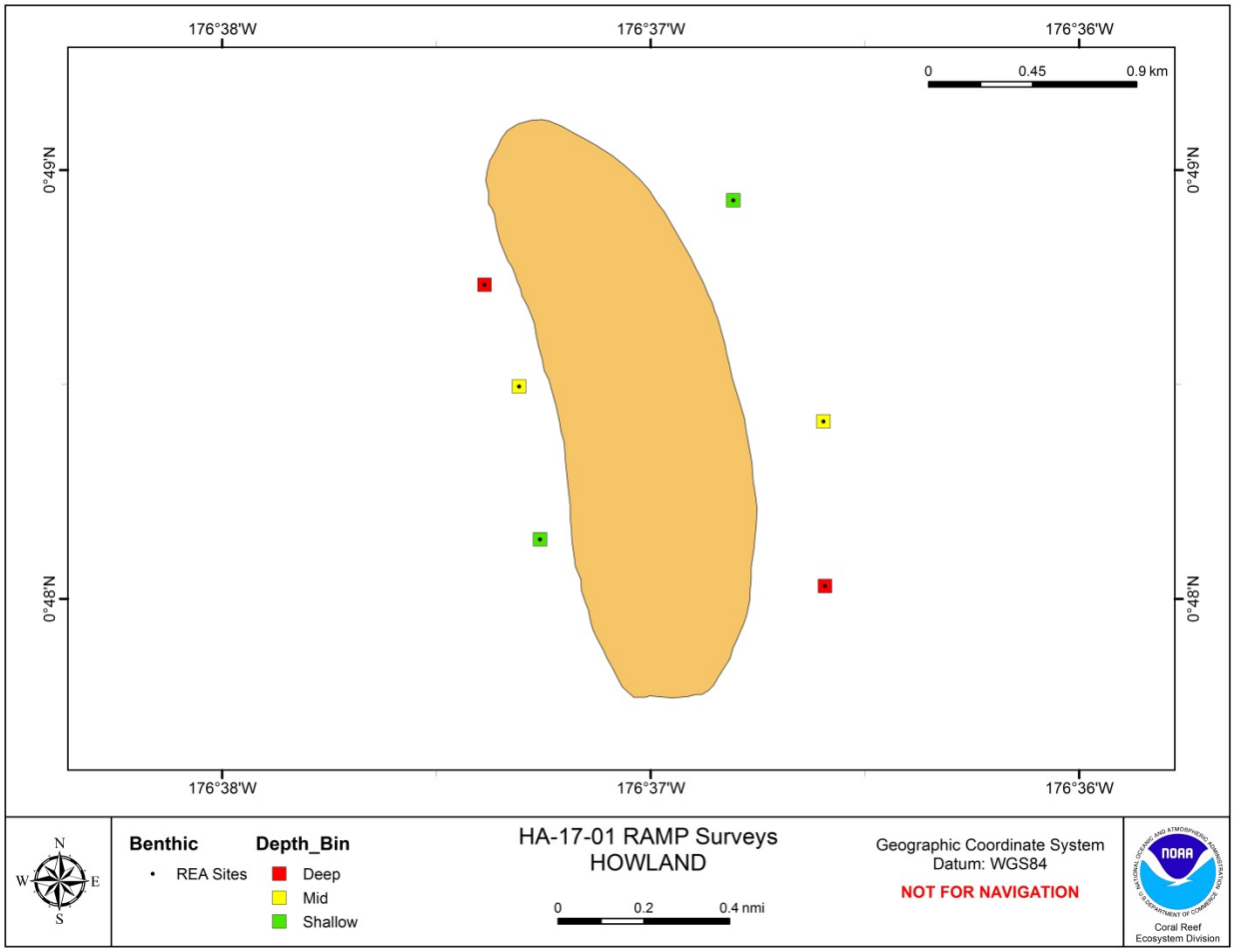

Figure D.2. 1. Locations of benthic REA sites surveyed at Howland Island during project HA-17-01. REA sites were selected using a stratified random design.

Table D.2. 1. Summary of the Benthic REA surveys performed at Howland Island during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude
HOW-746	11-Apr-17	Deep	Forereef	75	0.81221	-176.62312
HOW-719	11-Apr-17	Deep	Forereef	78	0.80050	-176.60988
HOW-778	11-Apr-17	Mid	Forereef	48	0.80690	-176.60994
HOW-805	11-Apr-17	Shallow	Forereef	19	0.81550	-176.61344
HOW-822	11-Apr-17	Mid	Forereef	38	0.80826	-176.62178
HOW-818	11-Apr-17	Shallow	Forereef	15	0.80231	-176.62096

Additionally, during the HA-17-01 project, 5 towed-diver surveys were completed around Howland Island, covering a total length of 11.0 km (an area of 11.0 ha) of the ocean floor (Fig. D.2.2).

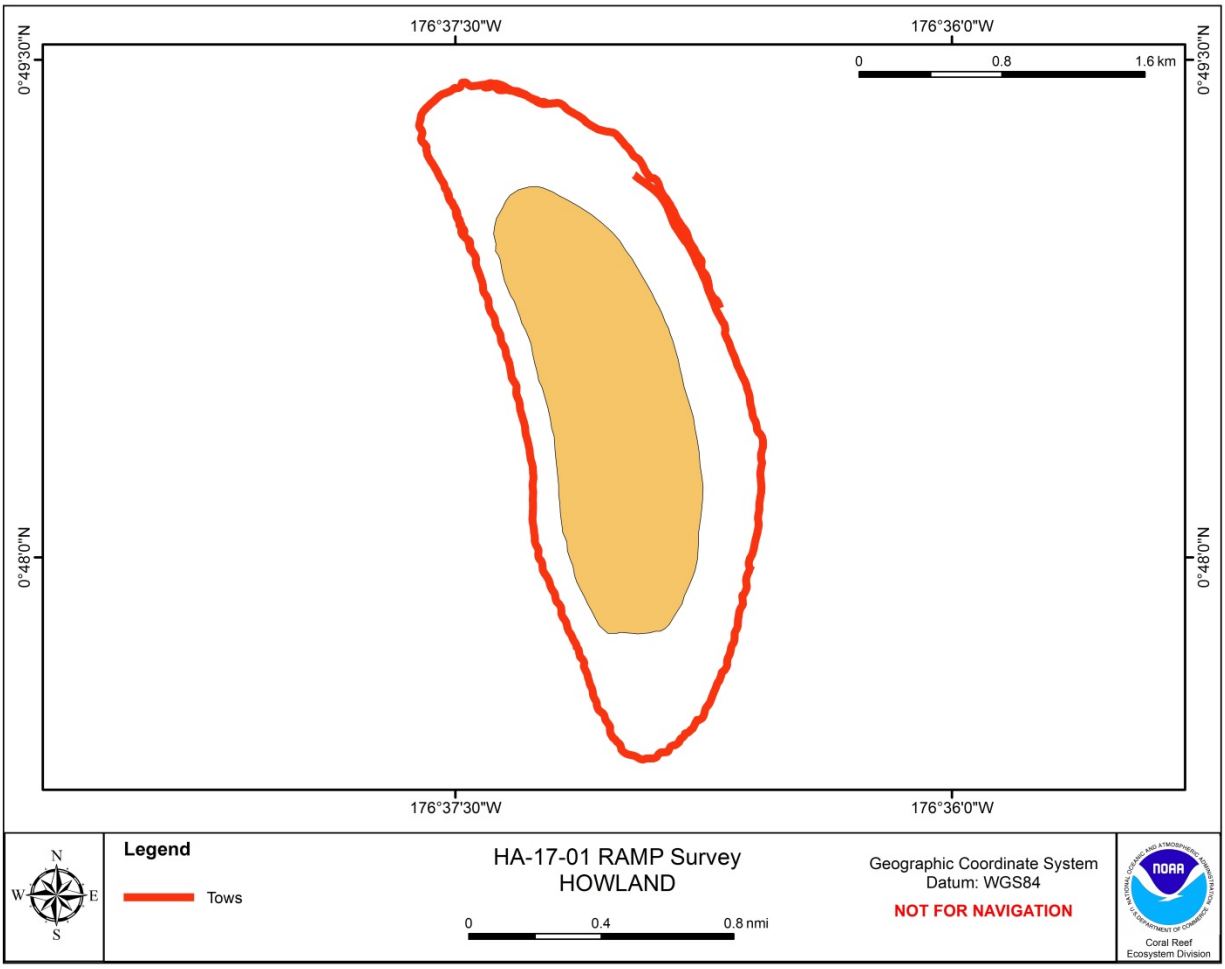

Figure D.2. 2. Track locations of towed-diver surveys conducted at Howland Island during the project HA-17-01.

D.3. Biological Monitoring: Modified Reef Fish Community Surveys

Sites for modified stationary-point-count surveys (including only photoquadrat and benthic habitat characterization) were chosen using a stratified random design. These surveys were conducted at 14 REA sites at Howland Island over three different habitat strata: deep, mid, and shallow forereef (Fig. D.3.1 and Table D.3.1). No fishes were collected during these surveys.

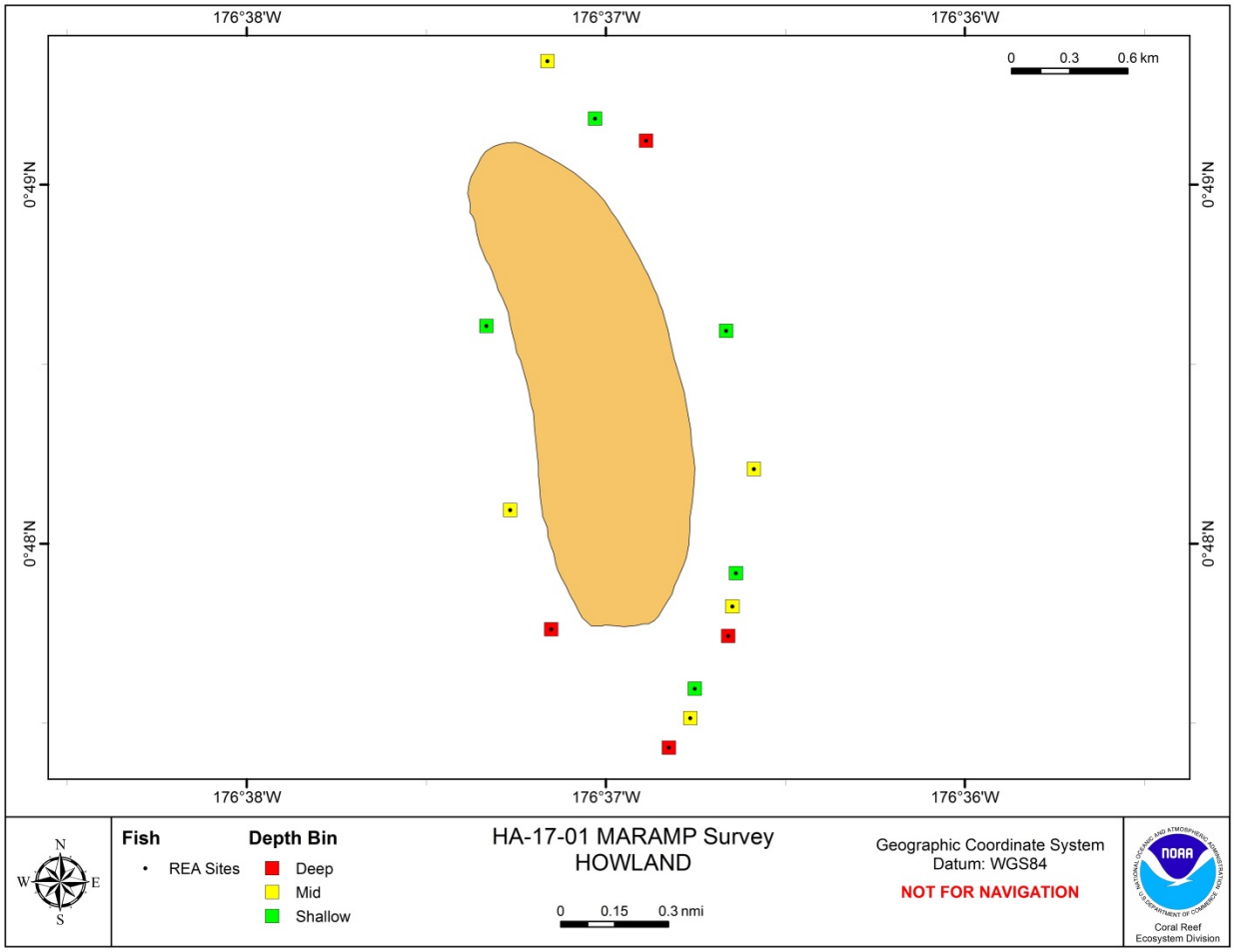

Figure D.3.1. Locations of modified Fish REA sites surveyed at Howland Island during project HA-17-01. REA sites were selected using a stratified random design.

Table D.3. 1. Summary of sites where modified Fish REA surveys were conducted at Howland Island during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
HOW-714	11-Apr-17	Deep	Forereef	24.5	0.79054	-176.61374
HOW-717	11-Apr-17	Deep	Forereef	21.0	0.79572	-176.61098
HOW-725	11-Apr-17	Deep	Forereef	24.0	0.79603	-176.61920
HOW-728	11-Apr-17	Deep	Forereef	18.5	0.81870	-176.61479
HOW-757	11-Apr-17	Mid	Forereef	16.0	0.82239	-176.61937
HOW-762	11-Apr-17	Mid	Forereef	15.6	0.80157	-176.62110
HOW-767	11-Apr-17	Mid	Forereef	12.0	0.79709	-176.61079
HOW-793	11-Apr-17	Mid	Forereef	8.0	0.80347	-176.60979
HOW-801	11-Apr-17	Shallow	Forereef	4.0	0.79327	-176.61253
HOW-802	11-Apr-17	Shallow	Forereef	4.0	0.80987	-176.61107
HOW-808	11-Apr-17	Shallow	Forereef	2.2	0.81010	-176.62221
HOW-809	11-Apr-17	Mid	Forereef	13.0	0.79190	-176.61274
HOW-810	11-Apr-17	Shallow	Forereef	5.0	0.81973	-176.61716
HOW-847	11-Apr-17	Shallow	Forereef	5.0	0.79863	-176.61062

APPENDIX E: WAKE ATOLL

Wake Atoll, located at 19.280000° N, 167.65000° E, is easternmost US-island and is one of the most isolated island in the world. Administratively, it is one of seven islands included in 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."

E.1. Climate and Ocean Acidification Monitoring: Instrumentation, Biological Installations, and Water Quality

Oceanographic operations during the project HA-17-01 entailed numerous retrievals and deployments of oceanographic moored instruments, installation of subsurface temperature recorders (STRs), calcification acidification units (CAUs), Autonomous Reef Monitoring Structures (ARMS), bioerosion monitoring units (BMUs), Ecological Acoustic Recorders (EARs), Soundtrap acoustic recorders, near-shore water sampling, and conductivity, temperature and depth (CTD) casts at select NCRMP sites.

Shallow-water CTD casts were performed at each location where water samples were collected, and these included sample locations taken in concert with the installation of NCRMP monitoring stations as well as at stratified random locations around the island. Sixteen shallow-water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity. In addition, 11 STRs were retrieved and deployed. Eleven ARMS were recovered and processed for taxonomic analysis and 12 ARMS were deployed. Twenty one CAUs were retrieved and 25 deployed at 5 locations around the island as a part of the NCRMP monitoring stations. Sixteen collocated BMUs were retrieved and 20 were deployed (Fig. E.1.1 and Table E.1.1).). For more information about microbial collections, see Table F.1.1 in Appendix F: "Biological Collections."

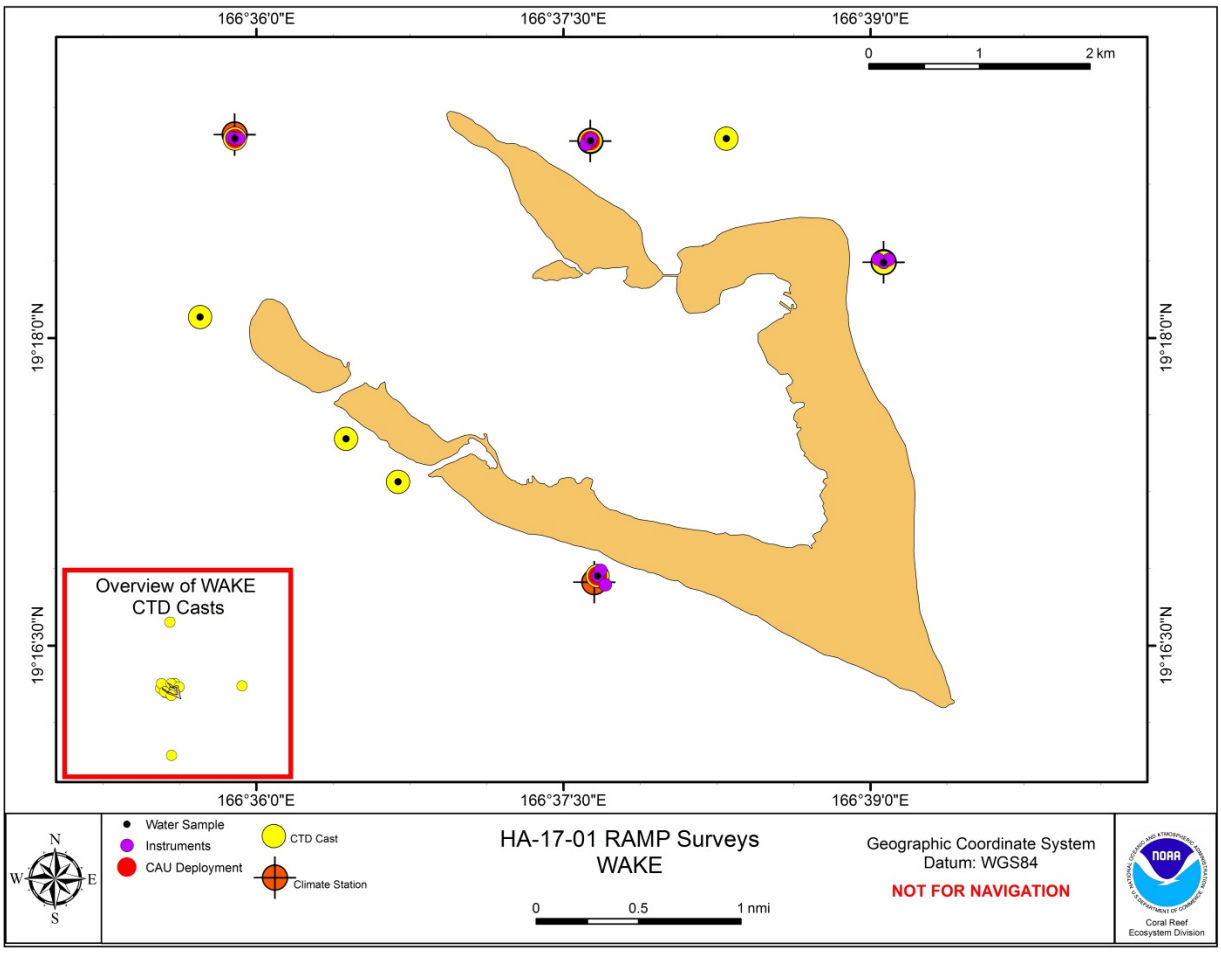

Figure E.1. 1. Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Wake Atoll during project HA-17-01.

Table E.1. 1. . Geographic coordinates and depths of microbial sampling and biological and oceanographic instruments that were retrieved or deployed at Wake Atoll during project HA-17-01: Autonomous Reef Monitoring Structure (ARMS), Bioerosion Monitoring Unit (BMU), Calcification-Accretion Unit (CAU) and Subsurface Temperature Recorder (STR).

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
WAK_OCEAN_006	19-Apr-17	STR	19.31621	166.59826	13.41	–	1
WAK_OCEAN_020	19-Apr-17	STR	19.31621	166.59826	12.80	1	–
WAK-08	19-Apr-17	BMU	19.31621	166.59827	42.00	3	5
WAK-08	19-Apr-17	CAU	19.31621	166.59827	42.00	1	5
WAK_OCEAN_021	19-Apr-17	STR	19.31622	166.59858	5.18	1	1
WAK-08	19-Apr-17	ARMS	19.31625	166.59824	53.00	2	3
WAK-08	19-Apr-17	Microbial	19.31625	166.59824	16.06	1	NA
WAK_OCEAN_007	19-Apr-17	STR	19.31629	166.59800	23.47	1	1
WAK_OCEAN_031	20-Apr-17	STR	19.31575	166.62685	6.10	1	1
WAK-23	20-Apr-17	ARMS	19.31605	166.62721	56.00	3	3
WAK-23	20-Apr-17	BMU	19.31605	166.62721	44.00	5	5
WAK-23	20-Apr-17	CAU	19.31605	166.62721	44.00	5	5
WAK-23	20-Apr-17	Microbial	19.31605	166.62721	16.97	1	NA
WAK_OCEAN_023	20-Apr-17	STR	19.31605	166.62722	13.41	1	1
WAK_OCEAN_032	20-Apr-17	STR	19.31622	166.62725	24.99	1	1
WAK_OCEAN_030	21-Apr-17	STR	19.27993	166.62840	25.60	1	1
WAK_OCEAN_020	21-Apr-17	STR	19.28066	166.62779	15.24	1	1
WAK-01	21-Apr-17	Microbial	19.28066	166.62779	16.36	1	NA
WAK_OCEAN_033	21-Apr-17	STR	19.28110	166.62803	4.57	1	1
WAK-06	21-Apr-17	CAU	19.29180	166.60730	42.00	5	5
WAK-06	21-Apr-17	Microbial	19.29180	166.60730	18.79	1	NA
WAKE HARP	21-Apr-17	HARP	19.22324	166.69378	–	1	–
WAK-01	22-Apr-17	ARMS	19.28066	166.62779	48.00	3	3
WAK-01	22-Apr-17	BMU	19.28066	166.62779	48.00	5	5
WAK-01	22-Apr-17	CAU	19.28066	166.62779	48.00	5	5
WAK_OCEAN_004	22-Apr-17	STR	19.30614	166.65109	14.02	1	1
WAK-24	22-Apr-17	Microbial	19.30614	166.65109	16.67	1	NA
WAK-24	23-Apr-17	BMU	19.30614	166.51090	45.00	5	5
WAK-24	23-Apr-17	CAU	19.30614	166.51090	45.00	5	5
WAK-24	23-Apr-17	Microbial	19.30614	166.51090	13.64	1	NA
WAK_OCEAN_005	23-Apr-17	STR	19.30637	166.65149	25.30	1	1
WAK-24	23-Apr-17	ARMS	19.30637	166.65149	51.00	3	3
WAK_OCEAN_024	23-Apr-17	STR	19.30640	166.65062	5.18	1	1
WAKE HARP	23-Apr-17	HARP	19.22324	166.69378	–	–	1

E.2. Biological Monitoring: Benthic Surveys

Belt-transect surveys were conducted and photographs were taken along transect lines at 28 REA sites around Wake Atoll to assess benthic composition, coral community structure, and coral and algal disease.

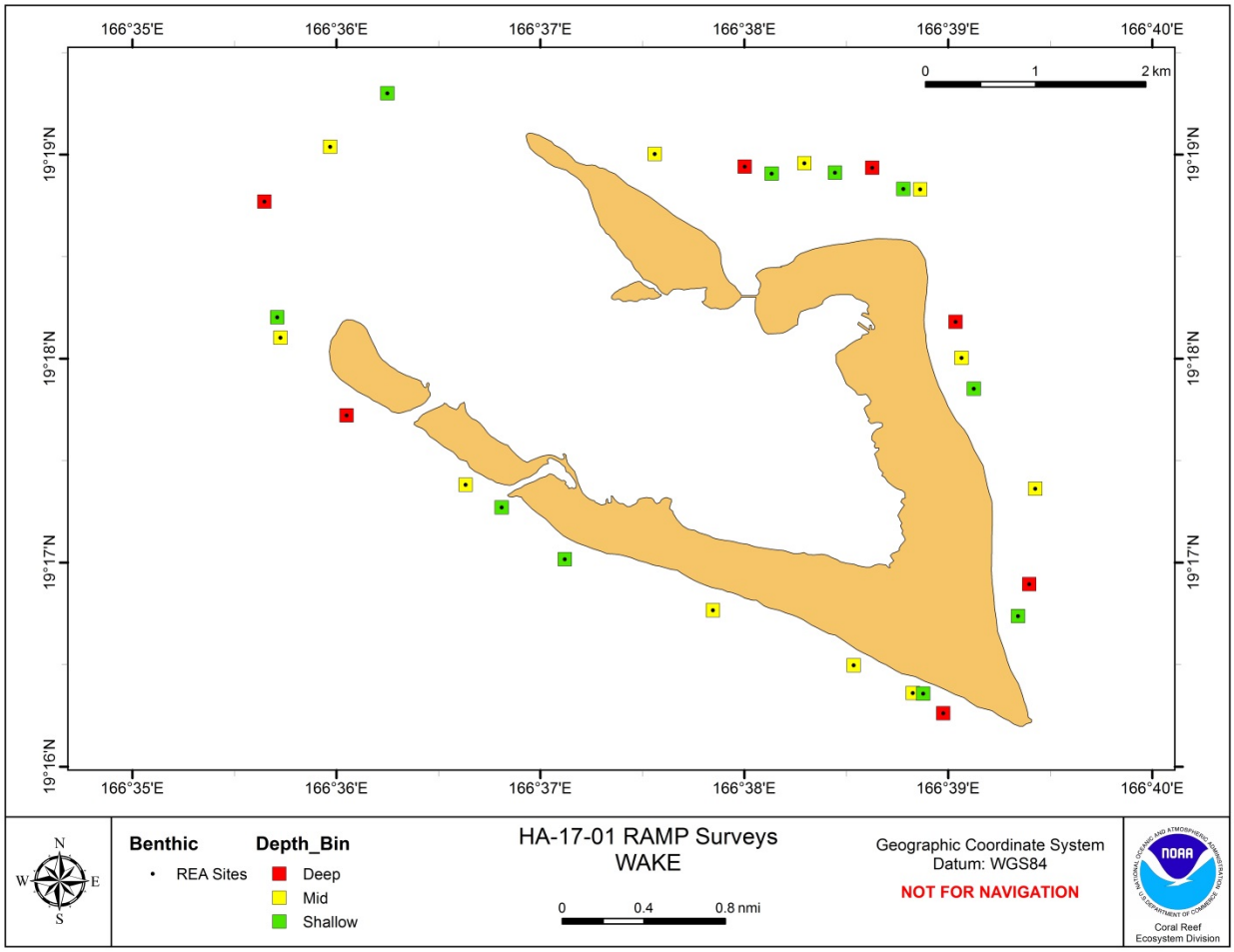

Figure E.2. 1. Locations of benthic REA sites surveyed at Wake Atoll during project HA-17-01. REA sites were selected using a stratified random design.

Table E.2. 1. Summary of the Benthic REA surveys performed at Wake Atoll during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude
WAK-08	19-Apr-17	Mid	Forereef	53	19.31625	166.59824
WAK-605	20-Apr-17	Deep	Forereef	82	19.31283	166.59413
WAK-788	20-Apr-17	Shallow	Forereef	12	19.30338	166.59517
WAK-679	20-Apr-17	Mid	Forereef	51	19.30171	166.59543
WAK-764	20-Apr-17	Shallow	Forereef	13	19.32168	166.60416
WAK-626	21-Apr-17	Deep	Forereef	77	19.31568	166.63337
WAK-675	21-Apr-17	Mid	Forereef	51	19.27945	166.63078
WAK-668	21-Apr-17	Shallow	Forereef	14	19.28362	166.61867
WAK-688	21-Apr-17	Mid	Forereef	49	19.31672	166.62602
WAK-768	21-Apr-17	Shallow	Forereef	20	19.31512	166.63557
WAK-656	21-Apr-17	Mid	Forereef	47	19.28970	166.61057
WAK-718	21-Apr-17	Shallow	Forereef	14	19.28784	166.61352
WAK-618	22-Apr-17	Deep	Forereef	78	19.27103	166.64959
WAK-606	22-Apr-17	Deep	Forereef	80	19.31559	166.64379
WAK-700	22-Apr-17	Mid	Forereef	55	19.27269	166.64712
WAK-707	22-Apr-17	Mid	Forereef	40	19.31384	166.64772
WAK-706	22-Apr-17	Mid	Forereef	41	19.27495	166.64228
WAK-714	22-Apr-17	Mid	Forereef	36	19.31597	166.63825
WAK-770	22-Apr-17	Shallow	Forereef	19	19.31520	166.64076
WAK-752	22-Apr-17	Shallow	Forereef	20	19.27263	166.64796
WAK-735	22-Apr-17	Shallow	Forereef	19	19.31387	166.64633
WAK-596	23-Apr-17	Deep	Forereef	69	19.29536	166.60083
WAK-635	23-Apr-17	Deep	Forereef	76	19.28158	166.65662
WAK-713	23-Apr-17	Mid	Forereef	45	19.30006	166.65109
WAK-711	23-Apr-17	Mid	Forereef	36	19.31732	166.59950
WAK-661	23-Apr-17	Mid	Forereef	55	19.28937	166.65712
WAK-594	23-Apr-17	Deep	Forereef	73	19.30301	166.65060
WAK-763	23-Apr-17	Shallow	Forereef	18	19.29754	166.65210
WAK-766	23-Apr-17	Shallow	Forereef	20	19.27897	166.65572

Additionally, during the HA-17-01 project, 9 towed-diver surveys were completed around Wake Atoll, covering a total length of 20.3 km (an area of 20.3 ha) of the ocean floor (Fig. E.2.2).

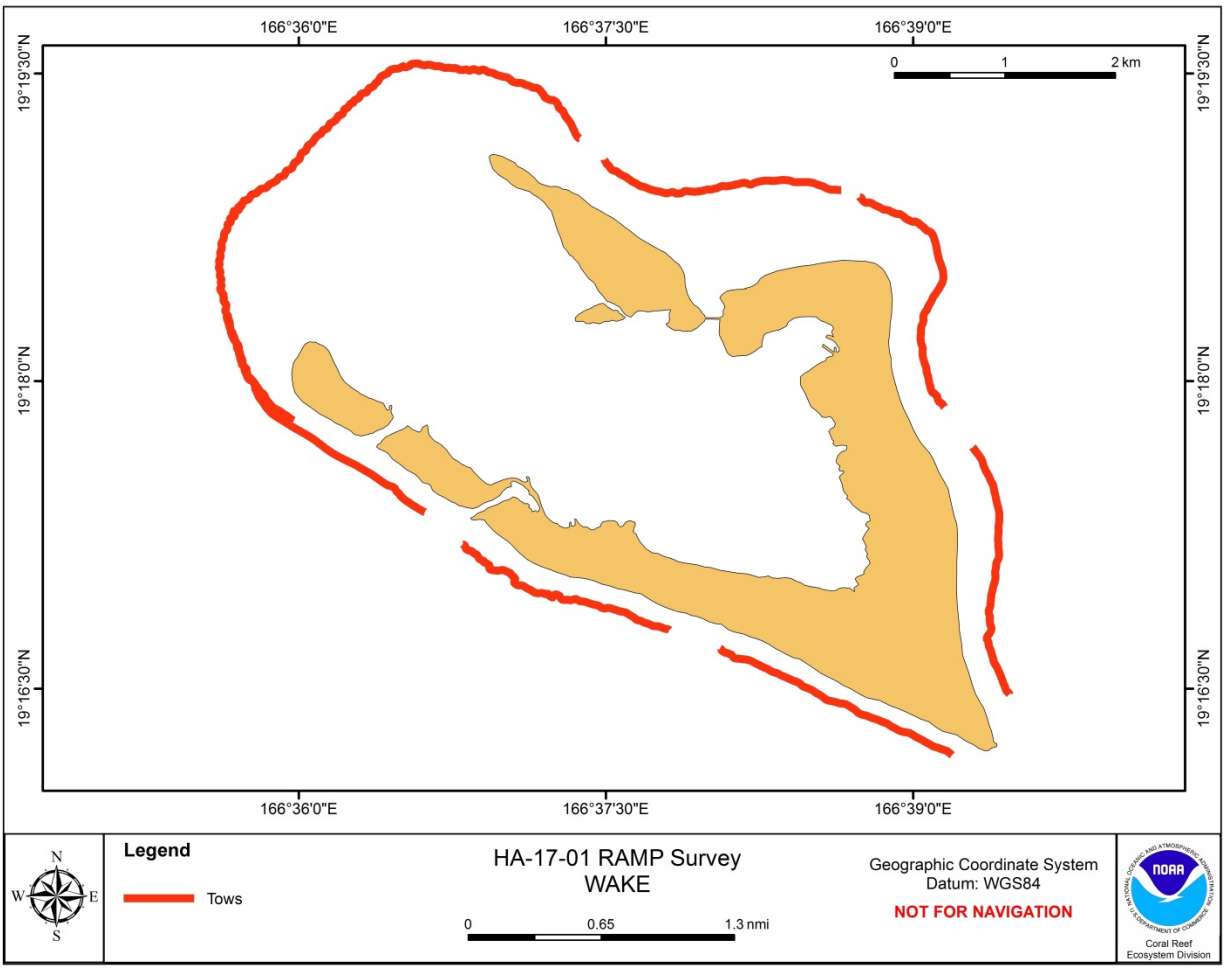

Figure E.2. 2. Track locations of towed-diver surveys conducted at Wake Atoll during the project HA-17-01.

E.3. Biological Monitoring: Reef Fish Community

Fish REA survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 53 REA sites at Wake Atoll over three different depth strata: deep, mid, and shallow; and two different habitat zones: lagoon and forereef (Fig. E.3.1 and Table E.3.1). No fishes were collected during these surveys.

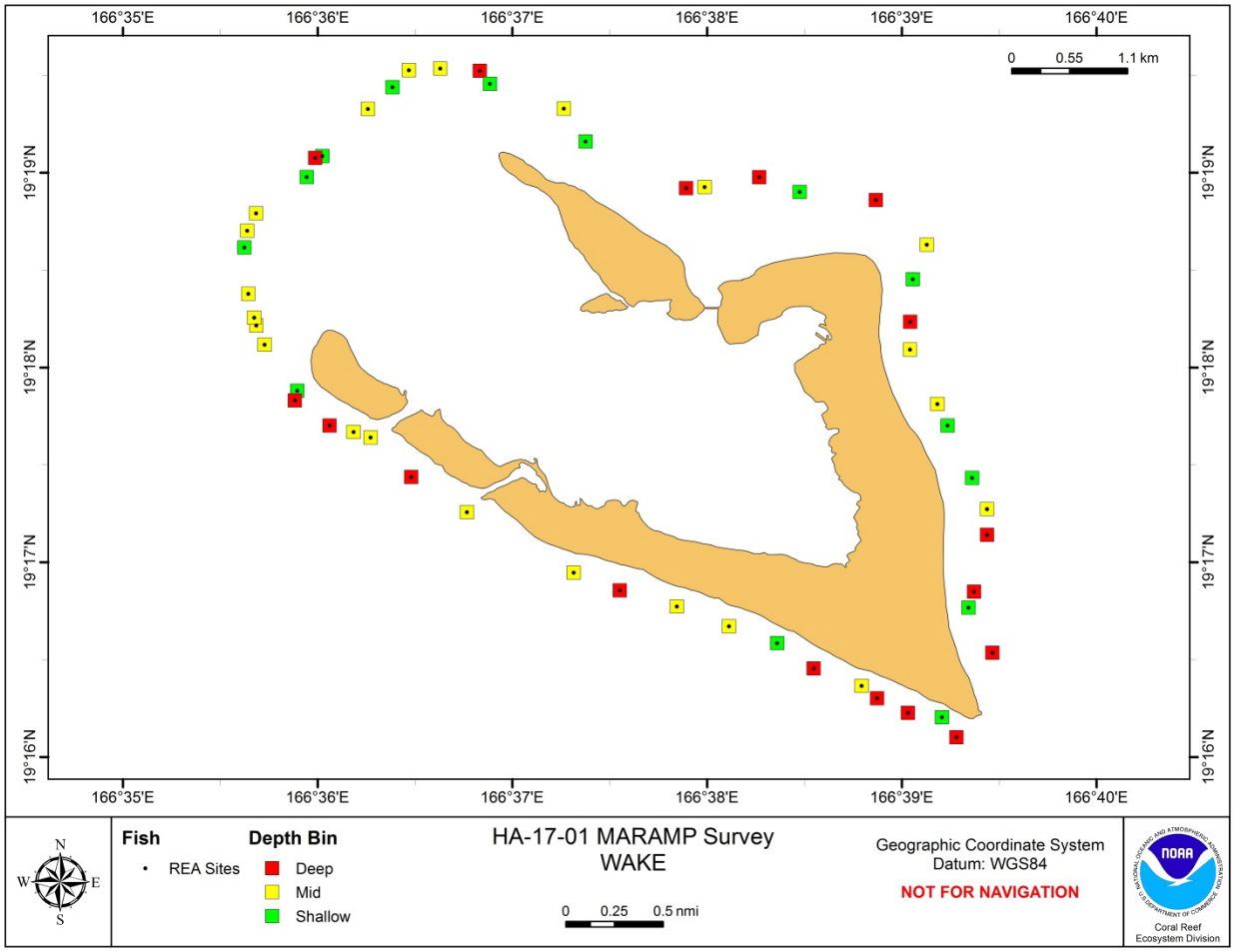

Figure E.3. 1. Locations of Fish REA sites surveyed at Wake Atoll during project HA-17-01. REA sites were selected using a stratified random design.

Table E.3. 1. Summary of sites where Fish REA surveys were conducted at Wake Atoll during project HA-17-01.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
WAK-443	19-Apr-17	Shallow	Forereef	3.6	19.31810	166.60041
WAK-456	19-Apr-17	Shallow	Forereef	5.0	19.31027	166.59373
WAK-461	19-Apr-17	Mid	Forereef	17.0	19.29448	166.60308
WAK-467	19-Apr-17	Mid	Forereef	9.0	19.31319	166.59474
WAK-471	19-Apr-17	Mid	Forereef	14.0	19.30360	166.59475
WAK-473	19-Apr-17	Mid	Forereef	11.7	19.30630	166.59407
WAK-480	19-Apr-17	Mid	Forereef	13.2	19.29401	166.60452
WAK-492	19-Apr-17	Shallow	Forereef	6.0	19.29801	166.59826
WAK-495	19-Apr-17	Mid	Forereef	16.0	19.30195	166.59546
WAK-501	19-Apr-17	Deep	Forereef	27.0	19.29064	166.60800
WAK-522	19-Apr-17	Deep	Forereef	24.3	19.29503	166.60102
WAK-438	20-Apr-17	Shallow	Forereef	4.0	19.32398	166.60640
WAK-439	20-Apr-17	Shallow	Forereef	2.3	19.31630	166.59907
WAK-440	20-Apr-17	Mid	Forereef	11.1	19.32215	166.62107
WAK-442	20-Apr-17	Shallow	Forereef	6.0	19.31934	166.62293
WAK-447	20-Apr-17	Shallow	Forereef	3.6	19.32428	166.61475
WAK-474	20-Apr-17	Mid	Forereef	11.0	19.32212	166.60431
WAK-475	20-Apr-17	Mid	Forereef	13.8	19.32543	166.60781
WAK-478	20-Apr-17	Mid	Forereef	15.1	19.32559	166.61049
WAK-482	20-Apr-17	Mid	Forereef	12.0	19.30426	166.59456
WAK-498	20-Apr-17	Deep	Forereef	22.0	19.31535	166.63154
WAK-504	20-Apr-17	Deep	Forereef	25.0	19.32539	166.61388
WAK-513	20-Apr-17	Deep	Forereef	22.0	19.31792	166.59979
WAK-455	21-Apr-17	Shallow	Forereef	5.5	19.27008	166.65343
WAK-463	21-Apr-17	Mid	Forereef	14.5	19.27277	166.64656
WAK-465	21-Apr-17	Shallow	Forereef	3.0	19.27641	166.63933
WAK-476	21-Apr-17	Mid	Forereef	20.0	19.28763	166.61277
WAK-487	21-Apr-17	Mid	Forereef	12.8	19.28245	166.62192
WAK-488	21-Apr-17	Mid	Forereef	17.0	19.27955	166.63074
WAK-493	21-Apr-17	Mid	Forereef	13.0	19.27786	166.63520
WAK-497	21-Apr-17	Deep	Forereef	26.0	19.27170	166.64788
WAK-502	21-Apr-17	Deep	Forereef	23.0	19.28093	166.62586
WAK-505	21-Apr-17	Deep	Forereef	21.0	19.27424	166.64245
WAK-506	21-Apr-17	Deep	Forereef	22.0	19.26836	166.65468
WAK-518	21-Apr-17	Deep	Forereef	22.7	19.27044	166.65052
WAK-445	22-Apr-17	Shallow	Forereef	4.5	19.30756	166.65095
WAK-446	22-Apr-17	Shallow	Forereef	5.0	19.29055	166.65602
WAK-449	22-Apr-17	Shallow	Forereef	5.5	19.27946	166.65571

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
WAK-452	22-Apr-17	Shallow	Forereef	4.5	19.29504	166.65392
WAK-468	22-Apr-17	Mid	Forereef	15.0	19.29687	166.65304
WAK-469	22-Apr-17	Mid	Forereef	14.0	19.31051	166.65215
WAK-484	22-Apr-17	Mid	Forereef	10.5	19.30154	166.65070
WAK-489	22-Apr-17	Mid	Forereef	17.0	19.28788	166.65730
WAK-496	22-Apr-17	Deep	Forereef	25.0	19.30391	166.65071
WAK-512	22-Apr-17	Deep	Forereef	22.4	19.28568	166.65729
WAK-517	22-Apr-17	Deep	Forereef	24.0	19.27559	166.65776
WAK-524	22-Apr-17	Deep	Forereef	25.6	19.28082	166.65619
WAK-441	23-Apr-17	Shallow	Forereef	4.2	19.31502	166.64125
WAK-458	23-Apr-17	Mid	Forereef	10.3	19.31543	166.63312
WAK-466	23-Apr-17	Mid	Forereef	11.0	19.31171	166.59397
WAK-499	23-Apr-17	Deep	Forereef	25.5	19.31432	166.64777
WAK-500	23-Apr-17	Deep	Forereef	24.0	19.29718	166.59804
WAK-520	23-Apr-17	Deep	Forereef	23.3	19.31628	166.63779

APPENDIX F: BIOLOGICAL COLLECTIONS

Biological samples were collected at Jarvis Island, Baker Island, Howland Island, Wake Atoll, and their surrounding waters for multiple research purposes. A complete listing of these collections is presented here in Table F.1.1.

Table F.1. 1. Biological samples collected at Jarvis Island (JAR), Baker Island (BAK), Howland Island (HOW) and Wake Atoll (WAK) during project HA-17-01.

REA Site	Island	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
Microbial Collections: Water Samples							
JAR-01	JAR	02-Apr-17	-0.36771	-159.97882	2 L	4	15.5
JAR-11	JAR	03-Apr-17	-0.36897	-160.00816	2 L	4	15.8
JAR-625	JAR	04-Apr-17	-0.38235	-160.00299	2 L	5.5	17.1
JAR-07	JAR	05-Apr-17	-0.37605	-160.01393	2 L	-	16.8
BAK-02	BAK	10-Apr-17	0.18842	-176.47997	2 L	5.5	18.6
HOW-12	HOW	11-Apr-17	0.80934	-176.61057	2 L	6	14
WAK-08	WAK	19-Apr-17	19.31625	166.59824	2 L	6	16.2
WAK-23	WAK	20-Apr-17	19.31605	166.62721	2 L	6	17.1
WAK-01	WAK	21-Apr-17	19.28066	166.62779	2 L	6	16.5
WAK-06	WAK	21-Apr-17	19.29180	166.60730	2 L	2	18.9
WAK-24	WAK	22-Apr-17	19.30614	166.65109	2 L	6	16.8
Coral Collections: Woods Hole Calcification Analysis							
JAR-01	JAR	04-Apr-17	-0.37372	-159.98332	Core	1	6.1
JAR-01	JAR	04-Apr-17	-0.37372	-159.98332	Core	1	7
JAR-01	JAR	04-Apr-17	-0.37140	-159.98259	Core	1	6.1
JAR-01	JAR	04-Apr-17	-0.37140	-159.98259	Core	1	6.1
JAR-01	JAR	04-Apr-17	-0.37140	-159.98259	Core	1	6.1
JAR-01	JAR	04-Apr-17	-0.37120	-159.98277	Core	1	6.1
JAR-01	JAR	04-Apr-17	-0.37112	-159.98367	Core	1	6.1
JAR-11	JAR	04-Apr-17	-0.36915	-160.00833	Core	1	11.9
JAR-11	JAR	04-Apr-17	-0.36915	-160.00833	Core	1	13.4
JAR-11	JAR	04-Apr-17	-0.36915	-160.00833	Core	1	14
JAR-11	JAR	04-Apr-17	-0.36901	-160.00818	Core	1	15.2
JAR- 01	JAR	05-Apr-17	-0.37112	-159.98367	Core	1	6.1

REA Site	Island	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
Coral Collections: Microbial Core Samples							
JAR-07	JAR	05-Apr-17	-0.37605	-160.01393	Microbial Core	11	16.8
HOW-11	HOW	11-Apr-17	0.79860	-176.62300	Microbial Core	11	14.3
WAK-06	WAK	21-Apr-17	19.29180	166.60730	Microbial Core	11	18.9
WAK-24	WAK	22-Apr-17	19.30614	166.65109	Microbial Core	11	16.8
WAK-24	WAK	23-Apr-17	19.30614	166.51090	Microbial Core	11	15.5
CAU Collections: Ocean Acidification							
WAK-08	WAK	19-Apr-17	19.31621	166.59827	CAU UNIT	1	12.80
WAK-23	WAK	20-Apr-17	19.31605	166.62721	CAU UNIT	5	13.41
WAK-06	WAK	21-Apr-17	19.29180	166.60730	CAU UNIT	5	12.80
WAK-01	WAK	22-Apr-17	19.28066	166.62779	CAU UNIT	5	14.63
WAK-24	WAK	23-Apr-17	19.30614	166.51090	CAU UNIT	5	13.72
BMU Collections: Ocean Acidification							
WAK-08	WAK	19-Apr-17	19.31621	166.59827	BMU UNIT	1	12.80
WAK-23	WAK	20-Apr-17	19.31605	166.62721	BMU UNIT	5	13.41
WAK-01	WAK	22-Apr-17	19.28066	166.62779	BMU UNIT	5	14.63
WAK-24	WAK	23-Apr-17	19.30614	166.51090	BMU UNIT	5	13.72
Plankton Tow Collections							
AT-HA1701-JAR-001	JAR	4-Apr-17	-0.37157	-160.01089	Plankton	1	42
AT-HA1701-JAR-003	JAR	4-Apr-17	-0.37112	-160.01010	Plankton	1	48
AT-HA1701-JAR-002	JAR	5-Apr-17	-0.37087	-160.01010	Plankton	1	60
AT-HA1701-JAR-004	JAR	5-Apr-17	-0.37101	-160.00990	Plankton	1	35
AT-HA1701-WAK-006	WAK	20-Apr-17	19.31819	166.62413	Plankton	1	38
AT-HA1701-WAK-008	WAK	20-Apr-17	19.32403	166.61841	Plankton	1	40
AT-HA1701-WAK-010	WAK	20-Apr-17	19.31988	166.60158	Plankton	1	45
AT-HA1701-WAK-012	WAK	21-Apr-17	19.28148	166.62530	Plankton	1	50
AT-HA1701-WAK-014	WAK	21-Apr-17	19.28841	166.61263	Plankton	1	48
AT-HA1701-WAK-016	WAK	22-Apr-17	19.27035	166.65198	Plankton	1	47
AT-HA1701-WAK-018	WAK	22-Apr-17	19.27370	166.64481	Plankton	1	48
AT-HA1701-WAK-020	WAK	23-Apr-17	19.31685	166.62564	Plankton	1	36
AT-HA1701-WAK-022	WAK	23-Apr-17	19.31512	166.63083	Plankton	1	46
AT-HA1701-WAK-024	WAK	23-Apr-17	19.31571	166.64246	Plankton	1	47
AT-HA1701-WAK-026	WAK	23-Apr-17	19.31111	166.65187	Plankton	1	36