U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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PROJECT REPORT[1]

VESSEL: NOAA Ship *Hi'ialakai*, Cruise HA-16-06, Legs I and II

CRUISE PERIOD: 12 July – 24 August 2016

AREA OF OPERATION: Main Hawaiian Islands: Hawai'i Island, Kaho'olawe Island, Kaua'i Island, Lāna'i Island, Maui Island, Moloka'i Island, Ni'ihau Island, and O'ahu Island.

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Program (CREP) of the NOAA Pacific Islands Fisheries Science Center, the NOAA Pacific Islands Regional Office, San Diego State University, The Nature Conservancy, Moss Landing Marine Laboratory, and the University of Hawai'i conducted interdisciplinary surveys of benthos, fishes, and climate in waters surrounding the main Hawaiian Islands as part of the National Coral Reef Monitoring Program (NCRMP). All activities described in this report were covered by the following permits: Environmental Assessment (PIFSC-20100901); Endangered Species Act, Section 7 consultation (PIR-2015-9580); U. S. Army Corps of Engineers Permit: USACE POH-2009-00083 (effective date: 18 March 2014; expiration date 18 March 2017); and State of Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources, Special Activity Permit 2017-18 (effective 7 July 2016 – 6 July 2017).

[1] PIFSC Project Report CR-17-001
Issued 7 February 2017

ITINERARY:

Daily field operations included Rapid Ecological Assessment (REA) benthic surveys, REA fish surveys, towed-diver surveys, plankton tows, photo-mosaics, nearshore conductivity-temperature-depth (CTD) casts; water-sample collection for dissolved inorganic carbon (DIC), total alkalinity (TA), and microbial analyses, and the deployment and recovery of oceanographic instrumentation. Unless otherwise specified in the following daily summaries, these surveys occurred during each operational day.

12 July	Start of cruise; embarked all scientific personnel. Routine departure-day activities, including dive safety and operational briefings, diver gear checks, safety drills, etc. Departed Pearl Harbor at 1300 en route to W Maui Island for first day of operations.
13 July	Commenced operations along the SW Maui Island and completed routine biological surveys; no instrument retrieval or deployment.
14 July	Conducted operations along E Maui Island; deployed the following types of instruments: 2 subsurface temperature recorders (STRs) and 5 Calcification Accretion Units (CAUs).
15 July	Conducted operations along N Kaho'olawe and completed routine biological surveys.
16 July	Conducted operations along W Maui; deployed 3 STRs.
17 July	Conducted operations along W Moloka'i Island; retrieved and deployed the following types of instruments: 2 STRs and 5 CAUs.
18 July	Conducted operations along N Lāna'i Island; retrieved and deployed 10 CAUs.
19 July	Conducted operations along N Moloka'i Island; retrieved and deployed 10 CAUs.
20 July	Conducted operations along south Moloka'i Island; retrieved and deployed 10 CAUs.
21 July	Conducted operations along S Lāna'i Island; retrieved and deployed 10 CAUs.
22 July	No small operations; dive rest day.
23 July	Conducted operations along S Kaua'i Island; deployed the following types of instruments: 5 CAUs and 3 STRs.

24 July	No dive operations due to foul weather conditions, owing to Tropical Storm Darby.
25 July	No dive operations due to foul weather conditions, owing to Tropical Storm Darby.
26 July	Conducted operations along W Kaua'i Island; retrieved and deployed the following types of instruments: 2 STRs and 5 CAUs.
27 July	Conducted operations along E Kaua'i Island; retrieved and deployed 2 STRs.
28 July	Conducted operations along W Ni'ihau Island; retrieved and deployed the following types of instruments: 1 STR and 5 CAUs.
29 July	Conducted operations along E Ni'ihau Island; high winds and rough sea conditions precluded launching 3 of the small boats. Retrieved and deployed 5 CAUs.
30 July	In-port at Pearl Harbor. Refueled; disembarked all scientific personnel; end of HA-16-06 Leg I.
5 August	Start of HA-16-06 Leg II. Embarked all scientific personnel. Routine departure-day activities, including dive safety and operational briefings, diver gear checks, safety drills, etc. Departed Pearl Harbor at 1100 en route to Hawai'i Island for first day of operations.
6 August	Commenced operations along E Hawai'i Island. Inclement weather limited field work activities; teams completed 4 tows (10.5 km).
7 August	Conducted operations along S Hawai'i Island; retrieved and deployed the following instruments: 3 Autonomous Reef Monitoring Structures (ARMS), 6 ARMS anchors, 3 CAUs, 5 Bioerosion Monitoring Units (BMUs) and 2 STRs.
8 August	Conducted operations along SE Hawai'i Island; retrieved and deployed 10 CAUs.
9 August	Conducted operations along SE Hawai'i Island; retrieved and deployed the following instruments: 3 ARMS, 5 CAUs, 5 BMUs, and 2 STRs.
10 August	Conducted operations along W Hawai'i Island; teams conducted routine biological surveys and processed 3 ARMS.
11 August	Conducted operations along SW Hawai'i; retrieved and deployed the following instruments: 3 ARMS, 5 CAUs, 5 BMUs and 3 STR.

12 August	Conducted operations along S Lāna'i Island; teams conducted routine biological surveys and processed 3 ARMS retrieved the day before.
13 August	Conducted operations along W Maui Island; no instrument deployment or retrievals, conducted routine biological surveys.
14 August	Conducted operations along W Hawai'i; retrieved and deployed 10 CAUs.
15 August	Conducted operations along N Hawai'i Island; retrieved and deployed the following instruments: 3 ARMS, 10 CAUs, 10 BMUs and 2 STRs.
16 August	No small boat operations; dive rest day.
17 August	Conducted operations along S O'ahu Island; retrieved and deployed the following instruments: 3 ARMS, 5 CAUs, and 5 BMUs.
18 August	Conducted operations along W O'ahu Island; retrieved the following instruments: 3 ARMS, 10 CAUs, 5 BMUs, and 3 STRs.
19 August	Conducted operations along W O'ahu Island; deployed the following instruments: 3 ARMS, 5 CAUs, 5 BMUs, and 1 STR.
20 August	Conducted operations along N O'ahu Island; deployed the following instruments: 3 ARMS, 5 CAUs, 5 BMUs, and 2 STRs;
21 August	Conducted operations along S Kaho'olawe Island; no instrument deployment or retrievals, conducted routine biological surveys.
22 August	Conducted operations along E O'ahu Island; retrieved and deployed the following instruments: 3 ARMS, 5 CAUs, and 5 BMUs, and 3 STRs.
23 August	Conducted operations along ENE O'ahu Island; retrieved 5 CAUs and removed 5 Maui anchors.

MISSION:

NOAA's Coral Reef Conservation Program (CRCP) has made the strategic decision to invest a portion of its annual operating budget in perpetuity to support the National Coral Reef Monitoring Program (NCRMP), designed to provide a consistent flow of information 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), a CREP-led research program, 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; benthic communities (mainly corals); reef-associated fish communities; and socioeconomics. Biological monitoring for benthic and fish communities are conducted using a two-stage stratified random sampling design throughout shallow-water (0–30 m), hard-bottom coral reef habitats. Monitoring of climate change and ocean acidification is achieved by means of remotely sensed and *in situ* observations of ocean temperature; autonomous and discrete grab 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 Pacific RAMP expeditions, and therefore it is not addressed in this cruise report.

The goals of the HA-16-06 Pacific Reef Assessment and Monitoring Cruise are as follows:

A. Conduct ecosystem monitoring for benthic cover (community structure), coral populations (species composition, abundance, size distribution, and condition), and fish populations (species composition, abundance and size) of the shallow-water (≤ 30 m) coral reef ecosystems of the main Hawaiian Islands (Hawai‘i, Kaho‘olawe, Kaua‘i, Lāna‘i, Maui, Moloka‘i, Ni‘ihau, and O‘ahu).

B. Deploy and retrieve a suite of instruments and installations, including: subsurface temperature recorders (STRs), conductivity, temperature, depth profiler (CTD), autonomous reef monitoring structures (ARMS), calcification accretion units (CAUs), and bioerosion monitoring units (BMUs), to enable remote, long-term monitoring of oceanographic, environmental, and ecological conditions of the coral reef ecosystems of the main Hawaiian Islands.

C. Conduct shallow water CTD hydrocasts and collect discrete water samples for dissolved inorganic carbon (DIC), total alkalinity (TA), and microbial community analyses to depths ≤ 30 m to examine the chemical, physical, and biological linkages supporting the coral reef ecosystems of the main Hawaiian Islands.

D. Collect a small number of coral and algal biopsies to support microbial and crypto-fauna analyses for abundance, diversity, and function.

E. Determine the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.

RESULTS:

This section provides the cruise research activities operational totals (Table 1), a list of the data and samples collected during cruise HA-16-06, Legs II and III, and a summary of relevant observations. For more information pertaining to the data collected and the methodology employed at the sites visited, see Appendices A–I.

The coral reef ecosystems of the main Hawaiian Islands have been surveyed annually since 2005, biennially since 2006, and triennially starting in 2013 through CREP's Pacific RAMP. The cruise HA-16-06 marked this program's seventh expedition around the islands of Hawai'i, Kaua'i, Lāna'i, Maui, Moloka'i, Ni'ihau, and O'ahu; and the program's first expedition around of Kaho'olawe. Herein, we present highlights from our observations during this latest expedition by island.

Hawai'i Island

- Not many large fish were observed around the island, although a 75-cm milkfish (*Chanos chanos*) was seen at a shallow site. Divers observed a large school of ta'ape (*Lutjanus kasmira*) at a deep site, counting up to 1000 individuals. Also seen at several deep sites were the rare Hawaiian butterflyfish (*Chaetodon tinkeri*).
- Based on the towed-diver surveys, it appeared that there was heavy bleaching related mortality in the Kawaihae area but that has to be confirmed with the data.
- We checked on the colonies of *Acropora gemmifera* south of Kailua-Kona discovered by DAR personnel in 2014. While most of the colonies are alive and exhibit low levels of partial mortality; tissues still show signs of widespread bleaching (Fig. 1).

Figure 1.--Bleached colony of *Acropora* cf *gemmifera* south of Kailua-Kona. *NOAA photo by Bernardo Vargas-Ángel.*

Kaho'olawe Island

- Our divers noted relatively high fish abundance, compared to the rest of the main Hawaiian Islands; it was also noted that fish did not avoid the presence of divers. Some of the most notable sightings included the white Ulua (*Caranx ignobilis*), white tip reef shark, barracudas, the sleek unicorn fish (*Naso hexacanthus),* as well as abundant herbivores particularly the damselfishes.
- Fish populations seemed healthy, with sightings of several whitetip reef sharks (*Triaenodon obesus*), gray reef sharks (*Carcharinus amblyrhynchos*), several ulua (*Caranx ignobilis*), numerous green jobfish (*Aprion virescens*), and large schools of yellow tang (*Zebrasoma flavecens*).
- Our observations also suggest that the cauliflower corals (*Pocillopora meandrina*) appear to have been the most severely affected by the recent bleaching event, resulting in partial and total mortality of numerous colonies, with many partially dead colonies still remaining pale.

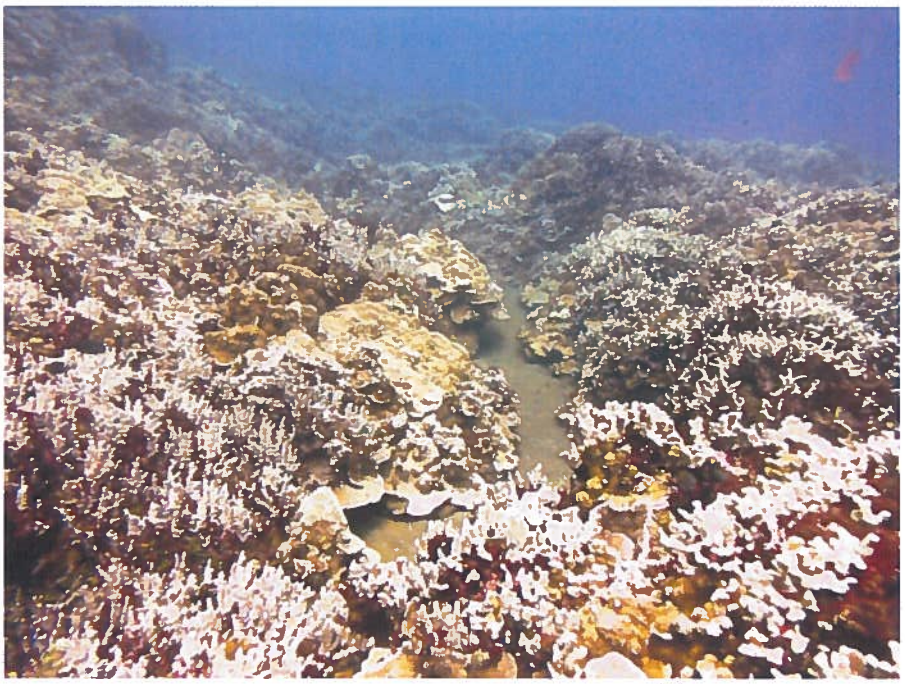

Figure 2.--Underwater view of the Kaho'olawe reef. *NOAA photo by Bernardo Vargas-Ángel.*

Kaua'i Island

- Two notable sightings of large fish here was a 130-cm ulua (*Caranx ignobilis*) as well as a 70-cm greater amberjack (*Seriola dumerili*).
- Gray reef shark sighted off NW side of the island.
- Kaua'i generally has simple coral reefs with encrusting or fast-growing corals such as *Pocillopora meandrina.*

Lāna'i Island

- Acanthurids were relatively abundant here, with large schools of Thompson's surgeonfish (*Acanthurus thompsoni*), the bluelined surgeonfish (*A. nigroris*), the brown surgeonfish (*A. nigrofuscus*), and kole (*Ctenochaetus strigosus*) seen.
- High turbidity at sites on the north shore, in part due to fine sediments that were re-suspended by overhead wave action. Sites on the south shore had high density of coral colonies relative to other areas in the main Hawaiian Islands.

Maui Island

- Fish here tended to be smaller (< 55 cm), with the largest fish recorded the bluespot coronetfish (*Fistularia commersonii*) at 90 cm, and a single greater amberjack (*Seriola dumerili*) at 75 cm.
- Reefs vary in the 3 areas surveyed around the island, with reefs off leeward East Maui having the most complex reefs. Reefs off Leeward West Maui had lower coral density and windward coasts had the least coral.

- The ocean and climate change team recovered a STR deployed at a depth of 4.6 m on west Maui, which documented the unprecedented level of thermal stress the area was subjected to in 2015, with a peak of *in situ* water temperature of 29.8 degrees Celsius on September 10, 2016. For corals with a bleaching threshold at 28°C, it's no surprise that during the November 2015 coral bleaching cruise, HA-16-02, a tow survey in this region observed that 63% of live coral were bleached.

Moloka'i Island

- Moloka'i was characterized by large schools the brown surgeonfish (*Acanthurus nigrofuscus*), the sleek unicornfish (*Naso hexacanthus*), and ta'ape (*Lutjanus kasmira*). There were also sightings of a single whitetip reef shark (*Triaenodon obesus*), several greater amberjacks (*Seriola dumerili*), and numerous green jobfish (*Aprion virescens*).
- Reefs vary in the 3 areas surveyed around the island, with reefs off south Moloka'i having the most complex reefs. Reefs off northeast Moloka'i had primarily boulder habitat and west Moloka'i was primarily pavement; both had low coral density.

Ni'ihau Island

- A large manta ray (*Manta birostris*) was seen in the vicinity of Lehua Rock, as were several gray reef sharks (*Carcharinus amblyrhynchos*). Also seen around Ni'ihau were large schools of the whitebar surgeonfish (*Acanthurus leucopareius*), the brown surgeonfish (*A. nigrofuscus*), and manini (*A. triostegus*).
- Surveys were done along the northwest coast of the island. The habitat at survey sites was predominantly basalt benches and boulders with low densities of coral colonies.

O'ahu Island

- The largest fish recorded were several bluespot coronetfish (*Fistularia commersonii*) ranging upwards of 130 cm, and a single greater amberjack (*Seriola dumerili*) at 80 cm. Also notable were large schools of ta'ape (*Lutjanus kasmira*), the whitebar surgeonfish (*Acanthurus leucopareius*), the brown surgeonfish (*A. nigrofuscus*), and the shoulderbar soldierfish (*Myripristis kuntee*).

Figure 3.--*Manta birostris* off Lehua rock, Ni'ihau Island. *NOAA photo by Paula Ayotte.*

Table 1.--Statistics for the Pacific RAMP 2016 cruise in the main Hawaiian Island (cruise HA-16-06), including the islands of Hawai'i (HAW), Kaho'olawe (KAH), Kaua'i (KAU), Lāna'i (LAN), Maui (MAI), Moloka'i (MOL), Ni'ihau (NII), and O'ahu (OAH). The numbers for REA sites include locations where benthic or fish REA surveys were conducted. The totals for scuba dives include all dives carried out for all activities at each island.

Research Activity	HAW	KAH	KAU	LAN	MAI	MOL	NII	OAH	Totals
Scuba Dives	355	108	156	146	195	150	69	308	**1498**
Biological Surveys									
Towed-diver Surveys: Benthic and Fish	21	0	10	6	17	14	5	0	**73**
Combined Length (km) of Towed-diver Surveys	53.6	0	24.5	15	40	30.8	11.7	0	**175.6**
REA Sites: Benthic	31	11	17	15	15	11	5	32	**137**
REA Sites: Fish	59	24	30	26	29	23	12	54	**257**
Photo-mosaic surveys	7	2	1	1	5	2	1	2	**21**
Biological Sample Collections									
Coral-Algal Microbial Biopsies	44	0	11	22	23	22	0	22	**144**
Microbial Samples (2L water sample)	6	1	2	3	1	2	2	4	**21**
Microbial Metagenome Samples (20L water)	6	2	2	3	1	2	2	4	**22**
Plankton Tow Samples	13	0	3	4	4	4	1	1	**30**
Biological monitoring Installations									
ARMS Retrieved	11	0	0	0	0	0	0	9	**20**
ARMS Deployed	12	0	0	0	0	0	0	12	**24**
CAUs Retrieved	39	0	10	14	4	23	8	34	**132**
CAUs Deployed	45	0	10	15	5	25	10	25	**135**
BMUs Deployed	25	0	0	0	0	0	0	20	**45**
BMUs Retrieved	23	0	0	0	0	0	0	20	**43**
Oceanographic Moored Instruments									
STRs Retrieved	7	0	7	2	5	5	1	8	**35**
STRs Deployed	8	0	7	2	5	5	1	9	**37**
Hydrographic surveys									
Shallow-water CTD Casts	24	6	10	6	5	10	5	20	**86**
Water-quality Sampling									
Shallow-water Nutrient Water Samples	20	6	5	4	4	6	3	8	**56**
Shallow-water DIC Water Samples	28	6	12	8	6	12	6	25	**103**
Microbial Water Chemistry Samples	6	2	2	3	3	2	2	4	**24**

The following data and samples were collected during this expedition:

Ocean and Climate Change Monitoring
Oceanographic Instrumentation and Biological Installations:

- STR deployments 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 3 years
- Installation of BMUs to allow for future assessment of bioerosion rates once they are retrieved in about 3 years
- Collection of photo-mosaic imagery at climate stations

Nearshore Oceanography from Small Boats:

- Shallow-water CTD profiles to depths $\leq$ 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 ($\leq$ 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
REA Benthic 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
- Water samples and coral/algae biopsies at select REA sites for microbial studies

REA Fish 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:

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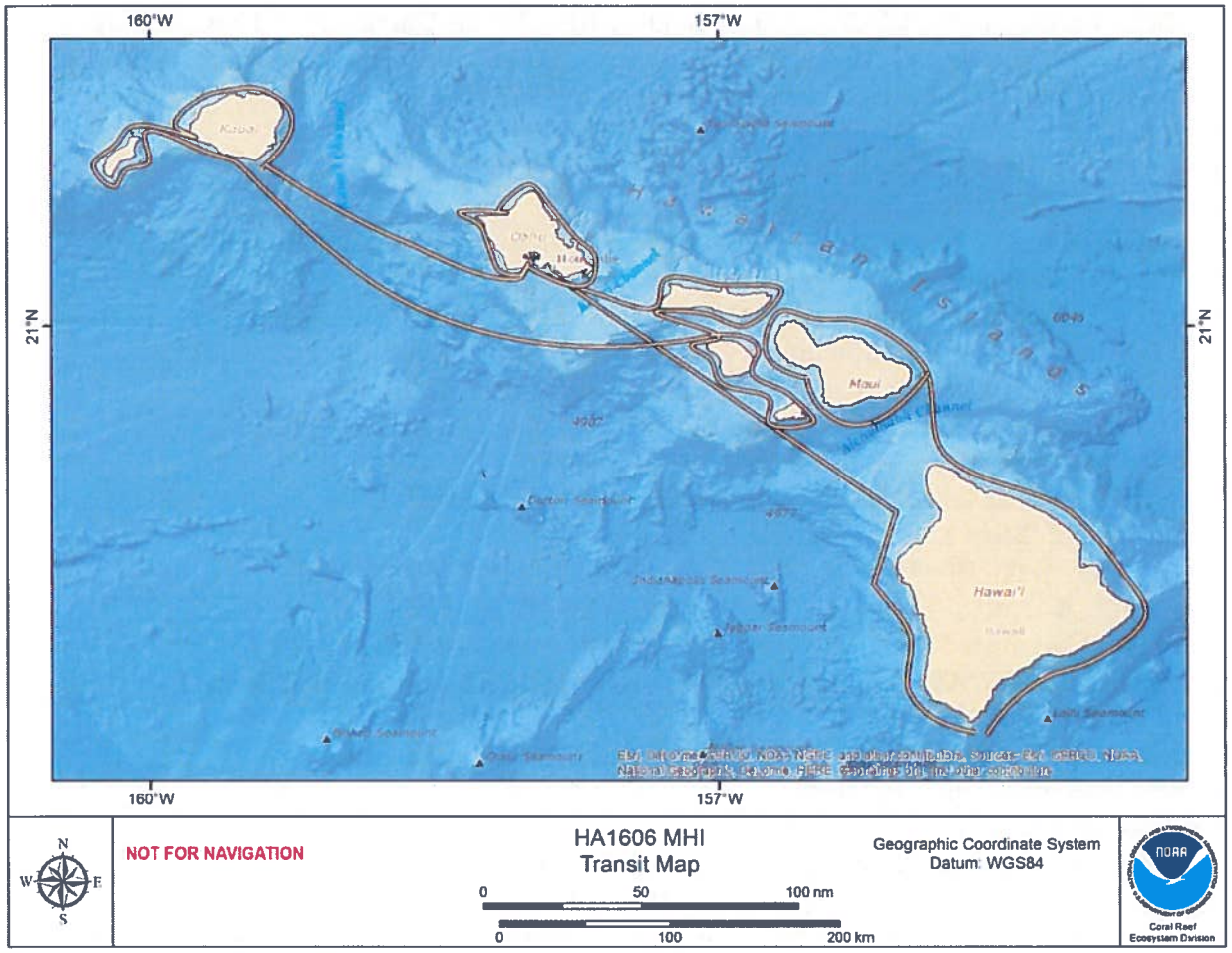

Figure 4.--Track of the NOAA Ship *Hi'ialakai* for the cruise HA-16-06 Legs I–II, 12 July –24 August 2016, around the main Hawaiian Islands. Image source: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors.

APPENDIX A: METHODS

This appendix describes the methods and procedures used by the Coral Reef Ecosystem Program (CREP) of the NOAA Pacific Islands Fisheries Science Center during its Pacific Reef Assessment and Monitoring Program (Pacific RAMP) cruise HA-16-06 on the NOAA Ship *Hi'ialakai* during the period of 12 July –24 August 2016.

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

(Noah Pomeroy, Russell Reardon, Clint Edwards, Kerry Reardon, Jeanette Clark, Lindsey Bonito, Scott Godwin, Mark Little, and Ty Roach)

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.

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.

1- Class 0 sites: Only discrete water samples are collected and analyzed for dissolved inorganic carbon (DIC) and total alkalinity (TA).

2- Class 1 sites: Only subsurface temperature recorders (STRs), SBE 56 temperature loggers (Sea-Bird Electronics, Inc., Bellevue, Wash.), are deployed.

3- 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.

4- 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 cruise.

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.

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 dissolved inorganic carbon (DIC), nutrients (N and P), salinity (S‰), and Total Alkalinity (TA) were collected at select locales concurrently with CTD casts.

A.1.3. Microbial Communities

Collection of water chemistry using Minidon Niskin bottles: 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: 1) Most of the long term monitoring samples (water chemistry: organic carbon, inorganic nutrients; microbial activity: abundances and biomass, autotroph:heterotroph), and 2) On this round of cruises we have paired our sampling (reef, surface, offshore) with the OCC team's water samples for inorganic measurements (DIC/TA).

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-μm polycarbonate filter) (1)
- inorganic nutrients in a 20-ml plastic vial (via a 0.2-μm 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-μm 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-liter water) for SPE-DOM (Solid Phase Eluted Dissolved Organic Matter) and benthic community sample (2-liter water collected via bilge pump): 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: 1) deeper characterization of the organic matter pool on reefs and 2) other long term monitoring samples (benthic microbiomes and viromes for metagenomic sequencing).

Large volumes of water (10 liters) are collected in inert polycarbonate Niskin-type bottles and pressure-filtered through 0.2 µm 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 4 h. The cartridges are rinsed twice with 1 v 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: One gallon 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-liter Niskin. Microbial metagenomes will be collected onto 0.45-um Sterivex filters. The 0.45-µm filtrate will be collected into Nalgene bottles (600 mls, PEG precipitates) and onto 0.03-µm PES filters (the remaining 1400ml). 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 0.03-µm filters.

Collection of coral:algal interaction tissue biopsies: 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. 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: 1) virome samples (n = 3) into cryovial, then into dewer; 2) metatranscriptome (n = 5) into cryovial with 1 ml RNA later; and 3) metabolome samples (n = 3) into 20-ml amber vials with 5-ml 70% methanol.

Measurement of coral geometry: 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. 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. Remove the chain after you're done.

A.2. Biological Monitoring: Benthic Surveys

(Brett Schumacher, Darla White, Marie Ferguson, Kaylie Pascoe, and Bernardo Vargas-Ángel)

A two-stage stratified random sampling design was employed to survey the Rapid Ecological Assessment (REA) sites. The survey domain encompassed reef and hard bottom habitat, and was divided into strata based on depth. Depth categories of shallow (0–6 m), moderate (> 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 composition and coral demographics

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 the cause of recent mortality was identified if possible. The condition of each colony including disease and bleaching was noted along with the extent (percent of colony affected) and level of severity (range from moderate to acute).

Juvenile coral colonies (< 5 cm) were surveyed within three segments that along the same two transects that were 1.0 m wide by 1.0 m long. the segments were located within the segments used for adults, and were located at 0–1.0 m, 5.0–6.0 m, and 10.0–11.0 m. 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.

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).

A.3. Biological Monitoring: Surveys of Reef Fishes

(Paula Ayotte, Jill Zamzow, Kristin Raja, Andrew Purves, Ryan Carr, Rebecca Weible, and Kendal Tejchma)

Divers conducted REA fish surveys using the stationary-point-count (SPC) method at preselected REA sites. Two separate teams performed these surveys. Each team consisted of 2 divers, and conducted 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 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.

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, 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 together with the habitat photographs at sites surveyed by the benthic team, are later analyzed, implementing Coral Point Count with Excel extensions (CPCe), to estimate the benthic cover and composition at each site.

A.4. Biological Monitoring: Towed-Diver Surveys

(Joao Garriques, Hatsue Bailey, Frances Lichowski, Andrew Gray, James Morioka, and Kaylyn McCoy)

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.

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.

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.5. 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 and time recorded for start and finish of each tow. The tows will be just below the surface, for 5 minutes and the small boat will be going just fast enough for net to be tight and flow meter to run (1–2 knots). 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. All samples will be put into 50-mL Falcon tube(s) using 95% ethanol in squirt bottles to be fixed.

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APPENDIX B: HAWAI'I ISLAND

The island of Hawai'i, located at 19°34′ N, 155°31′ W in the north Pacific and is the largest of the main Hawaiian Islands. 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 cruise HA-16-06 at Hawai'i Island 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), near-shore water sampling, and conductivity, temperature and depth (CTD) casts at select NCRMP sites.

At nearshore locations around Hawai'i, 24 shallow-water CTD casts were performed, these included samples collected in concert with the installation of NCRMP monitoring stations as well as at stratified random locations around the island. Twenty-eight samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 20 samples for the analysis of nutrients. In addition, 7 STRs were retrieved and 8 STRs were deployed; 11ARMS were recovered and processed for taxonomic analysis and 12 ARMS were deployed. Thirty-nine CAUs were retrieved and 45 deployed at 10 locations around the island, and 23 BMUs were retrieved and 25 deployed collocated with CAUs at the NCRMP monitoring stations (Fig. B.1.1and Table B.1.1).

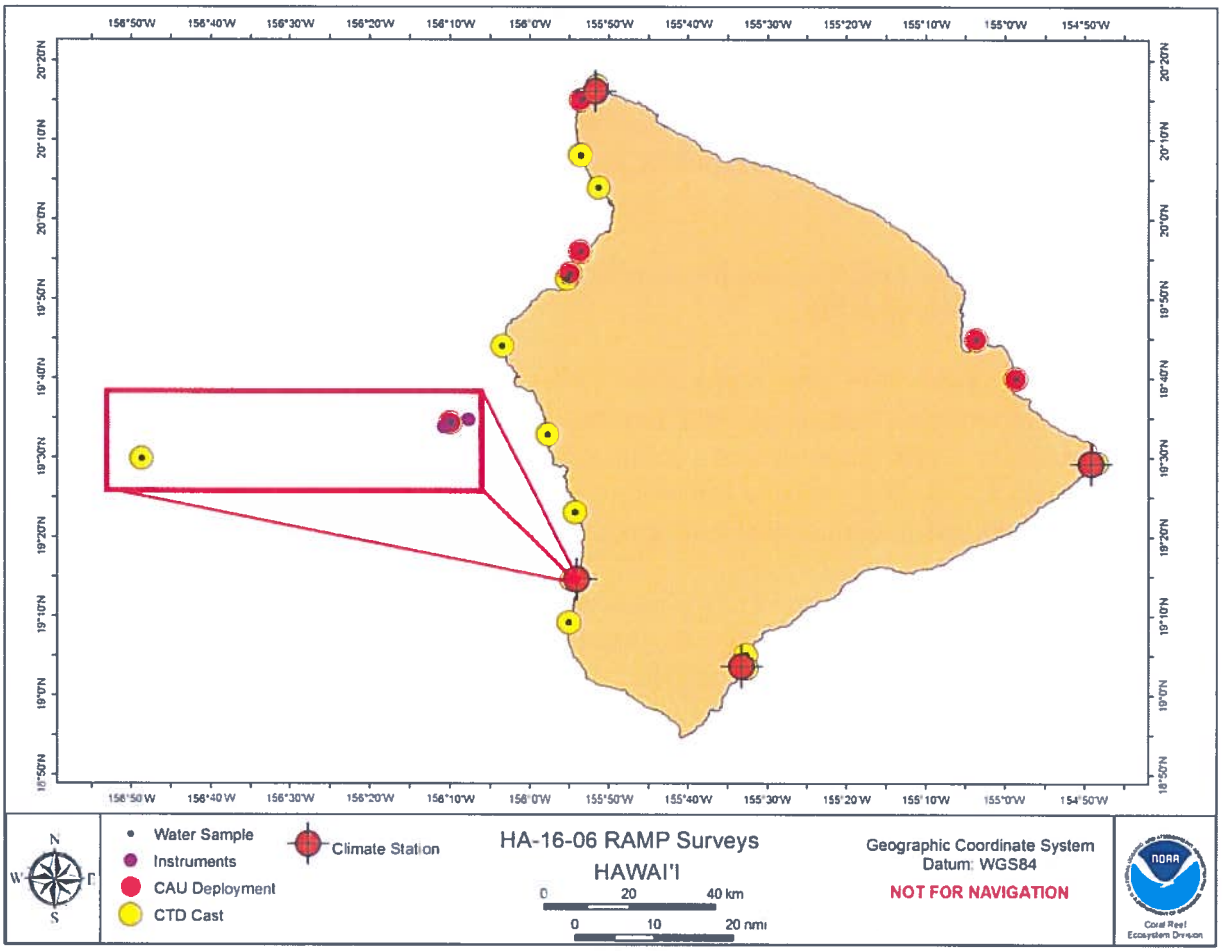

Figure B.1.1.--Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Hawai'i Island during cruise
HA-16-06.

Table B.1.1.--Geographic coordinates and depths of the moored oceanographic instruments (STR) and biological installations (CAUs, ARMS, BMUs) that were retrieved or deployed at Hawai'i Island during cruise HA-16-06.

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
HAW-48	07-Aug-16	ARMS	19.06071	-155.55237	14.9	3	3
HAW-48	07-Aug-16	BMU	19.06071	-155.55237	14.9	5	5
HAW-48	07-Aug-16	CAU	19.06071	-155.55237	14.9	3	5
HAW-48	07-Aug-16	STR	19.06071	-155.55237	14.9	–	1
HAW-48	07-Aug-16	STR	19.06071	-155.55237	14.9	1	–
HAW-48	07-Aug-16	STR	19.05797	-155.55019	25.6	1	1
HAW-44	08-Aug-16	CAU	19.74694	-155.05806	13.1	5	5
HAW-45	08-Aug-16	CAU	19.66466	-154.97470	12.8	4	5
HAW-46	09-Aug-16	ARMS	19.48638	-154.81766	11.9	3	3
HAW-46	09-Aug-16	BMU	19.48638	-154.81766	11.9	4	5
HAW-46	09-Aug-16	CAU	19.48638	-154.81766	11.9	4	5
HAW-46	09-Aug-16	STR	19.48638	-154.81766	13.1	–	1
HAW-46	09-Aug-16	STR	19.48632	-154.81673	24.4	–	1
HAW-46	09-Aug-16	STR	19.48638	-154.81766	12.2	1	–
HAW-43	11-Aug-16	ARMS	19.24436	-155.90028	13.7	3	3
HAW-43	11-Aug-16	BMU	19.24436	-155.90028	13.7	5	5
HAW-43	11-Aug-16	CAU	19.24436	-155.90028	13.7	5	5
HAW-43	11-Aug-16	STR	19.24436	-155.90028	14.6	–	1
HAW-43	11-Aug-16	STR	19.24423	-155.90050	24.4	–	1
HAW-43	11-Aug-16	STR	19.24446	-155.89972	4.9	–	1
HAW-43	11-Aug-16	STR	19.24436	-155.90028	14.6	1	–
HAW-43	11-Aug-16	STR	19.24423	-155.90050	24.4	1	–
HAW-43	11-Aug-16	STR	19.24446	-155.89972	4.9	1	–
HAW-49	14-Aug-16	CAU	19.93087	-155.89211	14.6	5	5
HAW-73	14-Aug-16	CAU	19.88451	-155.91393	14.6	5	5
HAW-41	15-Aug-16	ARMS	20.68240	-155.86038	14.0	2	3
HAW-41	15-Aug-16	BMU	20.68240	-155.86038	14.0	4	5
HAW-41	15-Aug-16	CAU	20.68240	-155.86038	14.0	3	5
HAW-41	15-Aug-16	STR	20.26824	-155.86038	14.0	–	1
HAW-41	15-Aug-16	STR	20.27025	-155.86092	25.3	–	1
HAW-41	15-Aug-16	STR	20.26824	-155.86038	14.0	1	–
HAW-41	15-Aug-16	STR	20.27025	-155.86092	25.3	1	–
HAW-42	15-Aug-16	BMU	20.24916	-155.89093	13.7	5	5
HAW-42	15-Aug-16	CAU	20.24916	-155.89093	13.7	5	5

B.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 31 REA sites around Hawai'i Island to assess benthic composition, coral community structure, and coral and algal disease; 12 water samples and 44 coral/algal biopsies were collected for microbial

studies (Fig. B.2.1 and Table B.2.1). For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

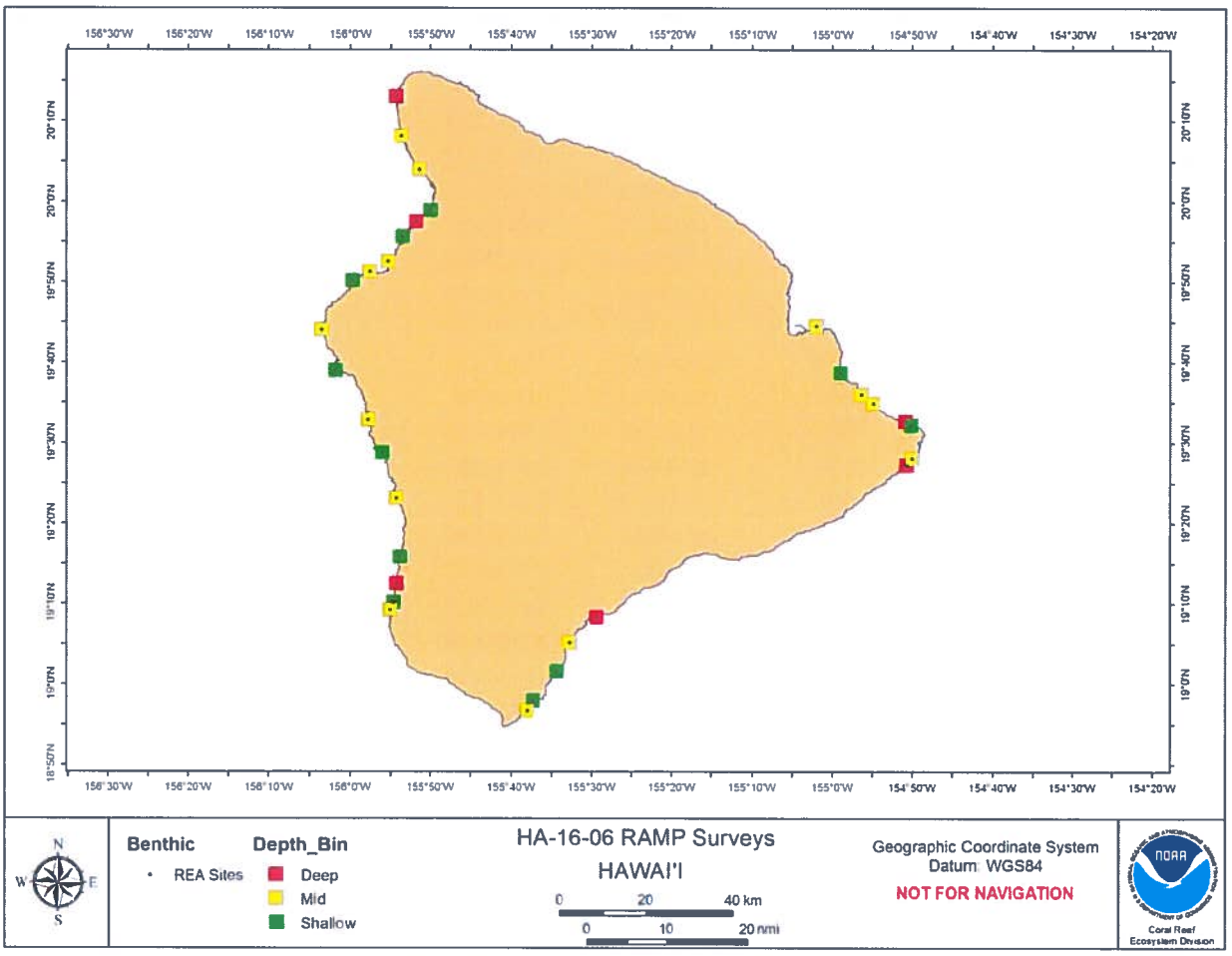

Figure B.2.1.--Locations of benthic REA sites surveyed at Hawai'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table B.2.1.--Summary of the benthic REA surveys and microbial water collections performed at Hawai'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
HAW-3236	07-Aug-16	Deep	Forereef	74	19.13677	-155.4877	x	
HAW-3261	07-Aug-16	Mid	Forereef	46	19.08456	-155.5428	x	
HAW-3281	07-Aug-16	Shallow	Forereef	18	19.02523	-155.5704	x	
HAW-3288	07-Aug-16	Shallow	Forereef	17	18.96514	-155.62	x	
HAW-3291	07-Aug-16	Mid	Forereef	41	18.944	-155.6307	x	
HAW-48	07-Aug-16	Mid	Forereef	49	19.06071	-155.5524		x
HAW-3132	08-Aug-16	Deep	Forereef	70	19.54405	-154.8445	x	

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
HAW-3151	08-Aug-16	Mid	Forereef	40	19.5992	-154.9366	x	
HAW-3157	08-Aug-16	Mid	Forereef	40	19.741	-155.0308	x	
HAW-3204	08-Aug-16	Shallow	Forereef	16	19.64395	-154.981	x	
HAW-45	08-Aug-16	Mid	Forereef	42	19.66466	-154.9747		x
HAW-3148	09-Aug-16	Deep	Forereef	76	19.45348	-154.8422	x	
HAW-3172	09-Aug-16	Mid	Forereef	47	19.46677	-154.8315	x	
HAW-3186	09-Aug-16	Mid	Forereef	45	19.5805	-154.9122	x	
HAW-3192	09-Aug-16	Shallow	Forereef	21	19.53519	-154.8339	x	
HAW-3042	10-Aug-16	Mid	Forereef	39	19.54732	-155.9619	x	x
HAW-3095	10-Aug-16	Shallow	Forereef	22	19.47918	-155.9329	x	
HAW-3106	10-Aug-16	Shallow	Forereef	23	19.64897	-156.0288	x	
HAW-3326	10-Aug-16	Mid	Forereef	45	19.73307	-156.0568	x	
HAW-3008	11-Aug-16	Deep	Forereef	75	19.20787	-155.9032	x	
HAW-3057	11-Aug-16	Mid	Forereef	42	19.38398	-155.9034	x	
HAW-3084	11-Aug-16	Shallow	Forereef	16	19.16825	-155.909	x	
HAW-3087	11-Aug-16	Shallow	Forereef	21	19.26251	-155.896	x	
HAW-3321	11-Aug-16	Mid	Forereef	36	19.15241	-155.9162	x	
HAW-43	11-Aug-16	Mid	Forereef	45	19.24436	-155.9003		x
HAW-43	11-Aug-16	Mid	Forereef	48	19.24436	-155.9003		x
HAW-3010	14-Aug-16	Deep	Forereef	70	19.95788	-155.8615	x	
HAW-3079	14-Aug-16	Mid	Forereef	37	19.87484	-155.9204	x	
HAW-3115	14-Aug-16	Shallow	Forereef	13	19.92627	-155.8901	x	
HAW-3317	14-Aug-16	Mid	Forereef	40	19.85387	-155.958	x	
HAW-3336	14-Aug-16	Shallow	Forereef	20	19.8344	-155.9933	x	
HAW-49	14-Aug-16	Mid	Forereef	48	19.93087	-155.8921		x
HAW-3009	15-Aug-16	Deep	Forereef	73	20.21626	-155.9036	x	
HAW-3075	15-Aug-16	Mid	Forereef	38	20.06528	-155.8544	x	
HAW-3077	15-Aug-16	Mid	Forereef	37	20.13448	-155.8935	x	
HAW-3085	15-Aug-16	Shallow	Forereef	19	19.97992	-155.8311	x	
HAW-41	15-Aug-16	Mid	Forereef	46	20.6824	-155.8604		x
HAW-41	15-Aug-16	Deep	Forereef	83	20.025	-155.8609		x

Additionally, during the HA-16-06 cruise, 21 towed-diver surveys were completed Hawai'i Island, covering a total length of 53.6 km (an area of 53.6 ha) of the ocean floor (Fig. B.2.2).

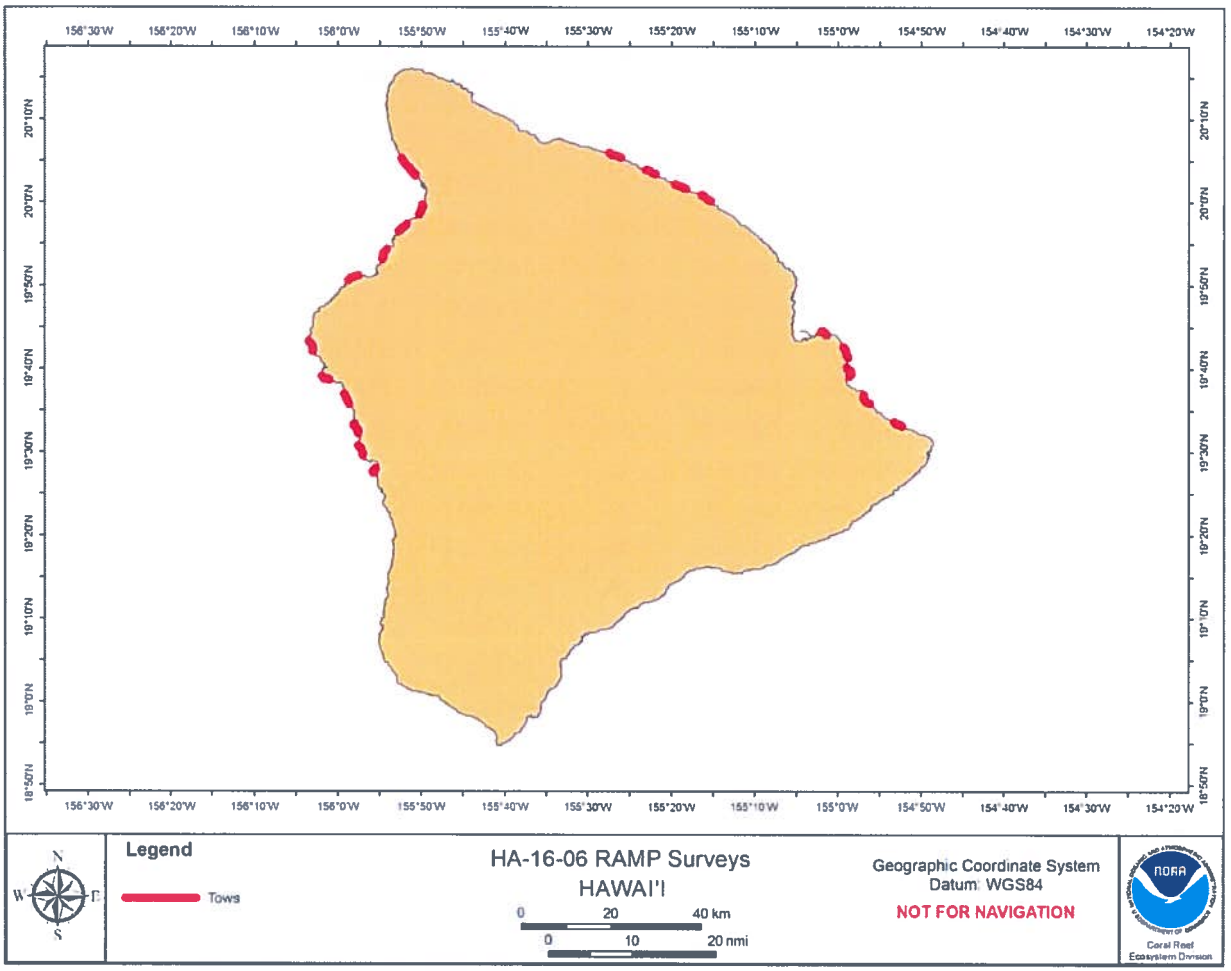

Figure B.2.2.--Track locations of towed-diver surveys conducted at Hawai'i Island during the cruise HA-16-06.

B.3. Biological Monitoring: Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 59 REA sites at Hawai'i Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig.B.3.1 and Table B.3.1). No fishes were collected during these surveys.

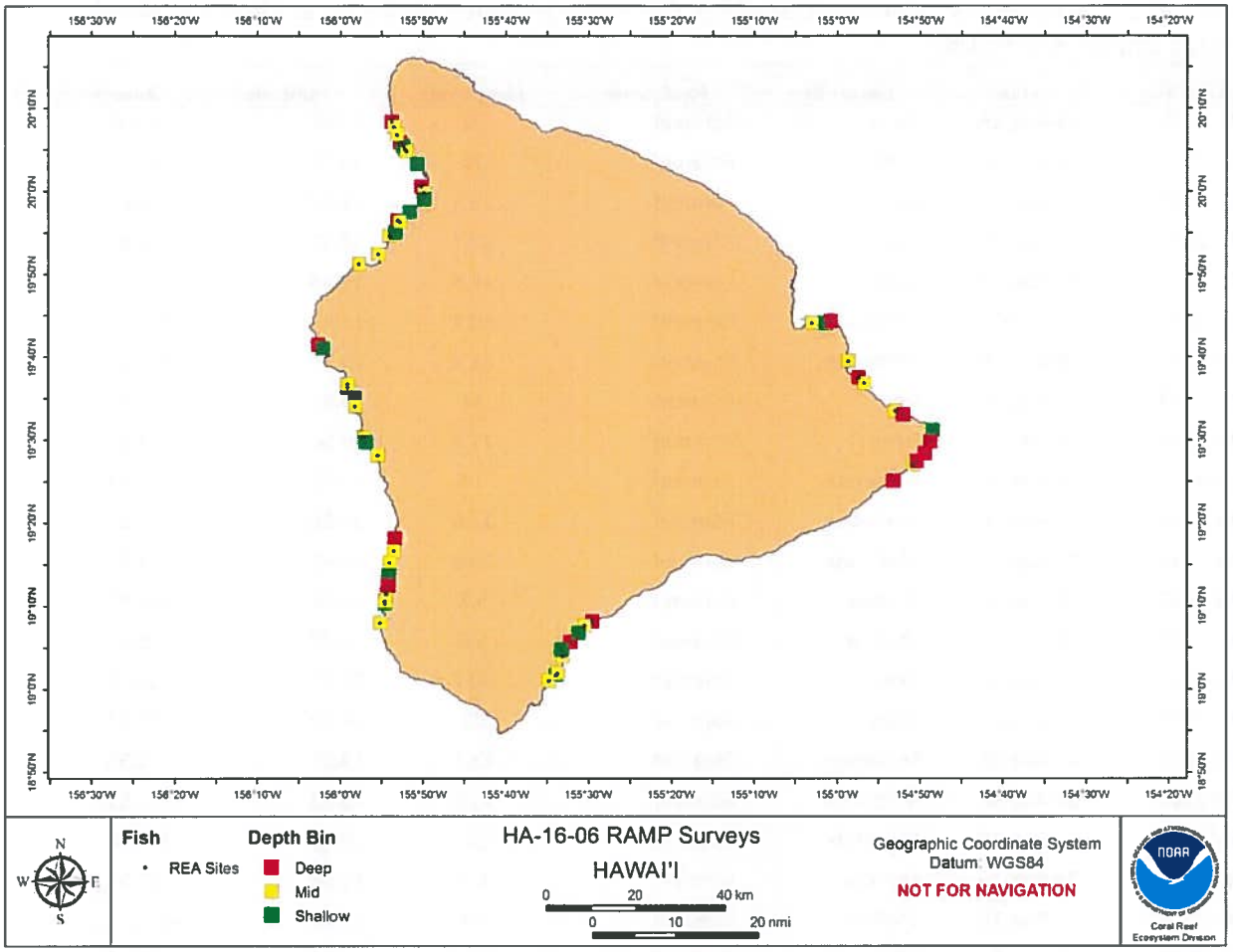

Figure B.3.1.--Locations of REA fish sites surveyed at Hawai'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table B.3.1.--Summary of sites where REA fish surveys were conducted at Hawai'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
HAW-2515	08-Aug-16	Deep	Forereef	22	19.62	-154.96
HAW-2516	08-Aug-16	Deep	Forereef	21	19.74	-155.01
HAW-2519	09-Aug-16	Deep	Forereef	19.5	19.42	-154.89
HAW-2524	08-Aug-16	Deep	Forereef	22.3	19.55	-154.87
HAW-2527	09-Aug-16	Deep	Forereef	19.8	19.46	-154.84
HAW-2533	08-Aug-16	Moderate	Forereef	10.1	19.61	-154.95
HAW-2536	08-Aug-16	Moderate	Forereef	11.4	19.74	-155.05
HAW-2539	09-Aug-16	Deep	Forereef	14	19.47	-154.82
HAW-2540	09-Aug-16	Deep	Forereef	11.8	19.50	-154.81
HAW-2548	08-Aug-16	Moderate	Forereef	13	19.56	-154.88
HAW-2549	08-Aug-16	Moderate	Forereef	12.6	19.66	-154.98
HAW-2555	09-Aug-16	Moderate	Forereef	15.6	19.45	-154.85
HAW-2562	09-Aug-16	Shallow	Forereef	5.8	19.52	-154.81
HAW-2565	08-Aug-16	Shallow	Forereef	5.9	19.73	-155.02
HAW-2577	07-Aug-16	Deep	Forereef	20.7	19.14	-155.49
HAW-2583	07-Aug-16	Deep	Forereef	23	19.09	-155.54
HAW-2597	07-Aug-16	Moderate	Forereef	13.1	19.07	-155.55
HAW-2602	07-Aug-16	Moderate	Forereef	15.6	19.13	-155.51
HAW-2615	07-Aug-16	Moderate	Forereef	15.5	19.02	-155.58
HAW-2618	07-Aug-16	Shallow	Forereef	6.4	19.08	-155.55
HAW-2626	07-Aug-16	Shallow	Forereef	6.4	19.11	-155.52
HAW-2694	07-Aug-16	Moderate	Forereef	14.4	19.03	-155.56
HAW-2711	15-Aug-16	Moderate	Forereef	16.7	20.08	-155.87
HAW-2733	07-Aug-16	Shallow	Forereef	6	19.03	-155.56
HAW-2747	14-Aug-16	Deep	Forereef	21	20.01	-155.84
HAW-2761	11-Aug-16	Deep	Forereef	25.9	19.30	-155.89
HAW-2762	15-Aug-16	Shallow	Forereef	6	20.05	-155.85
HAW-2763	14-Aug-16	Deep	Forereef	26.4	19.94	-155.88
HAW-2766	10-Aug-16	Deep	Forereef	26.7	19.61	-155.98
HAW-2767	15-Aug-16	Deep	Forereef	22.3	20.10	-155.88
HAW-2770	11-Aug-16	Deep	Forereef	27.2	19.21	-155.90
HAW-2771	15-Aug-16	Moderate	Forereef	16.4	20.11	-155.89
HAW-2773	15-Aug-16	Deep	Forereef	21.5	20.14	-155.90
HAW-2777	14-Aug-16	Moderate	Forereef	11	20.00	-155.83
HAW-2778	10-Aug-16	Moderate	Forereef	16	19.61	-155.99
HAW-2786	11-Aug-16	Moderate	Forereef	16	19.13	-155.92
HAW-2787	11-Aug-16	Moderate	Forereef	10.9	19.18	-155.91
HAW-2792	15-Aug-16	Moderate	Forereef	16.2	20.08	-155.87

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
HAW-2793	10-Aug-16	Shallow	Forereef	5.2	19.50	-155.95
HAW-2794	10-Aug-16	Deep	Forereef	24	19.69	-156.04
HAW-2795	10-Aug-16	Moderate	Forereef	11.6	19.51	-155.95
HAW-2797	14-Aug-16	Moderate	Forereef	13.4	19.87	-155.92
HAW-2802	15-Aug-16	Moderate	Forereef	9.9	20.13	-155.89
HAW-2804	10-Aug-16	Moderate	Forereef	11.6	19.47	-155.92
HAW-2805	11-Aug-16	Moderate	Forereef	10.7	19.28	-155.89
HAW-2806	11-Aug-16	Moderate	Forereef	8.5	19.19	-155.91
HAW-2808	11-Aug-16	Moderate	Forereef	17.7	19.25	-155.90
HAW-2810	14-Aug-16	Moderate	Forereef	12.6	19.85	-155.96
HAW-2818	14-Aug-16	Moderate	Forereef	15.6	19.91	-155.90
HAW-2821	14-Aug-16	Moderate	Forereef	9.9	19.94	-155.88
HAW-2824	10-Aug-16	Moderate	Forereef	7.6	19.57	-155.97
HAW-2826	14-Aug-16	Shallow	Forereef	3.7	19.98	-155.83
HAW-2827	10-Aug-16	Shallow	Forereef	5.1	19.58	-155.97
HAW-2830	14-Aug-16	Shallow	Forereef	3	19.96	-155.86
HAW-2832	11-Aug-16	Shallow	Forereef	4.6	19.17	-155.91
HAW-2834	10-Aug-16	Shallow	Forereef	5.8	19.68	-156.03
HAW-2838	11-Aug-16	Shallow	Forereef	4.6	19.23	-155.90
HAW-2844	14-Aug-16	Shallow	Forereef	2.3	19.92	-155.89
HAW-2846	15-Aug-16	Shallow	Forereef	4.9	20.09	-155.87

APPENDIX C: KAHO'OLAWE ISLAND

The island of Kaho'olawe, located at 30°30′ N, 156°37′ W in the north Pacific and is one of the main Hawaiian Islands. 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 cruise HA-16-06 at Kaho'olawe entailed a number of near-shore water sampling, and conductivity-temperature-depth (CTD) casts at select sites.

Six shallow-water CTD casts were performed and 6 shallow-water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 6 additional water samples were collected for nutrient analysis. (Fig. C.1.1)

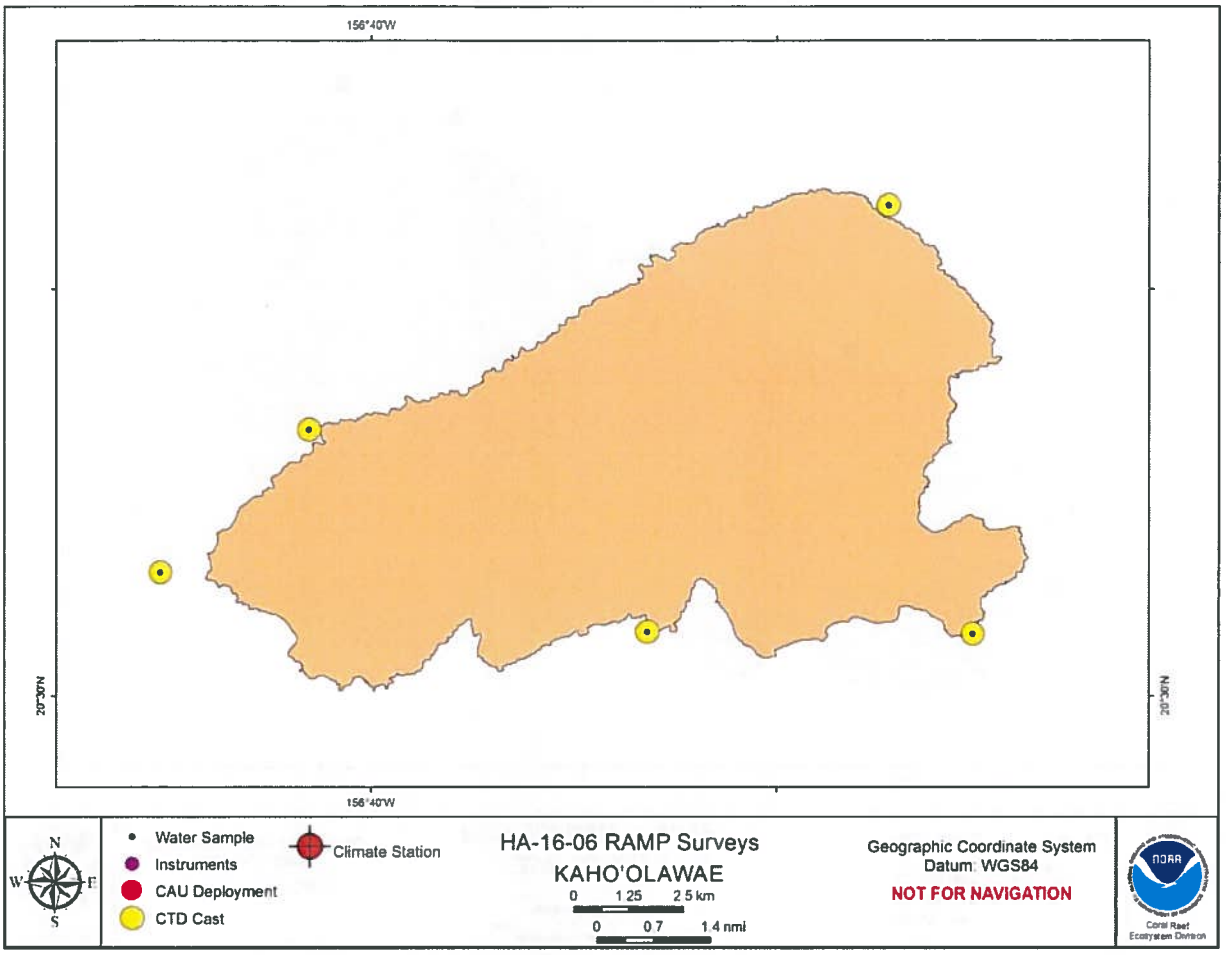

Figure C.1.1.--Locations of near-shore CTD casts and water sampling performed at Kaho'olawe Island during cruise HA-16-06.

C.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 11 REA sites around Kaho'olawe Island to assess benthic composition, coral community structure, and coral and algal disease; 4 water samples were collected for microbial analyses (Fig. C.2.1 and Table C.2.1). No towed-diver surveys were conducted around Kaho'olawe. For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

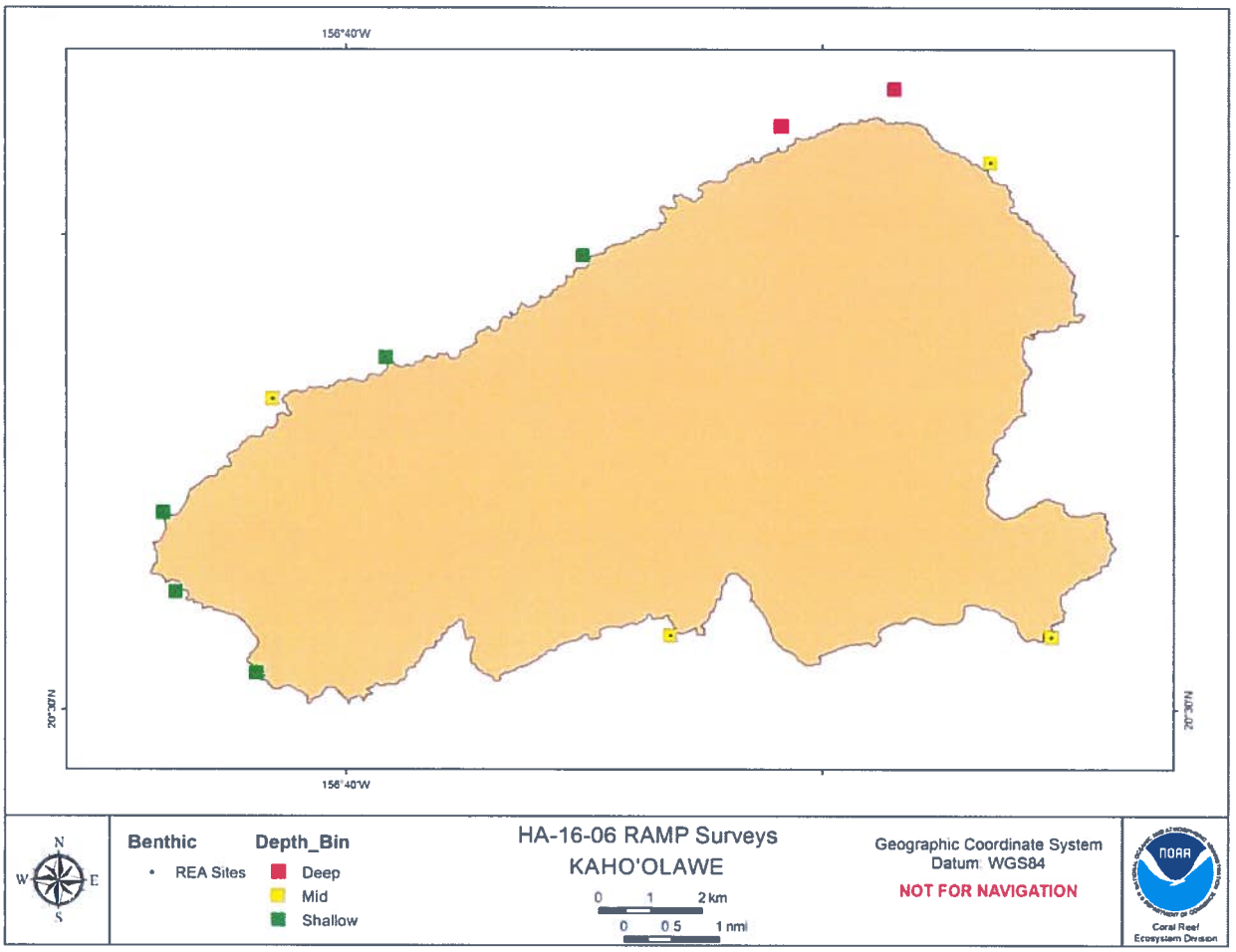

Figure C.2.1.--Locations of benthic REA sites surveyed at Kaho'olawe Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table C.2.1.--Summary of the benthic REA surveys and microbial water collections performed at Kaho'olawe Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
KAH-327	15-Jul-16	Shallow	Forereef	21	20.52063	-156.6963	x	
KAH-336	15-Jul-16	Shallow	Forereef	18	20.53455	-156.6985	x	
KAH-358	15-Jul-16	Shallow	Forereef	19	20.56181	-156.6596	x	
KAH-363	15-Jul-16	Mid	Forereef	50	20.5545	-156.6793	x	
KAH-369	15-Jul-16	Shallow	Forereef	20	20.5797	-156.6251	x	
KAH-370	15-Jul-16	Deep	Forereef	69	20.60883	-156.5705	x	
KAH-385	15-Jul-16	Deep	Forereef	80	20.60233	-156.5905	x	
KAH-90	15-Jul-16	Mid	Forereef	30	20.55276	-156.6794		x
KAH-321	21-Aug-16	Mid	Forereef	40	20.59595	-156.5536	x	
KAH-334	21-Aug-16	Shallow	Forereef	19	20.50641	-156.6822	x	
KAH-362	21-Aug-16	Mid	Forereef	46	20.51305	-156.6098	x	
KAH-419	21-Aug-16	Mid	Forereef	48	20.51269	-156.543	x	
KAH-03	21-Aug-16	Mid	Forereef	36	20.60048	-156.5604		x

C.3. Biological Monitoring: 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 Kaho'olawe Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig.C.3.1 and Table C.3.1). No fishes were collected during these surveys.

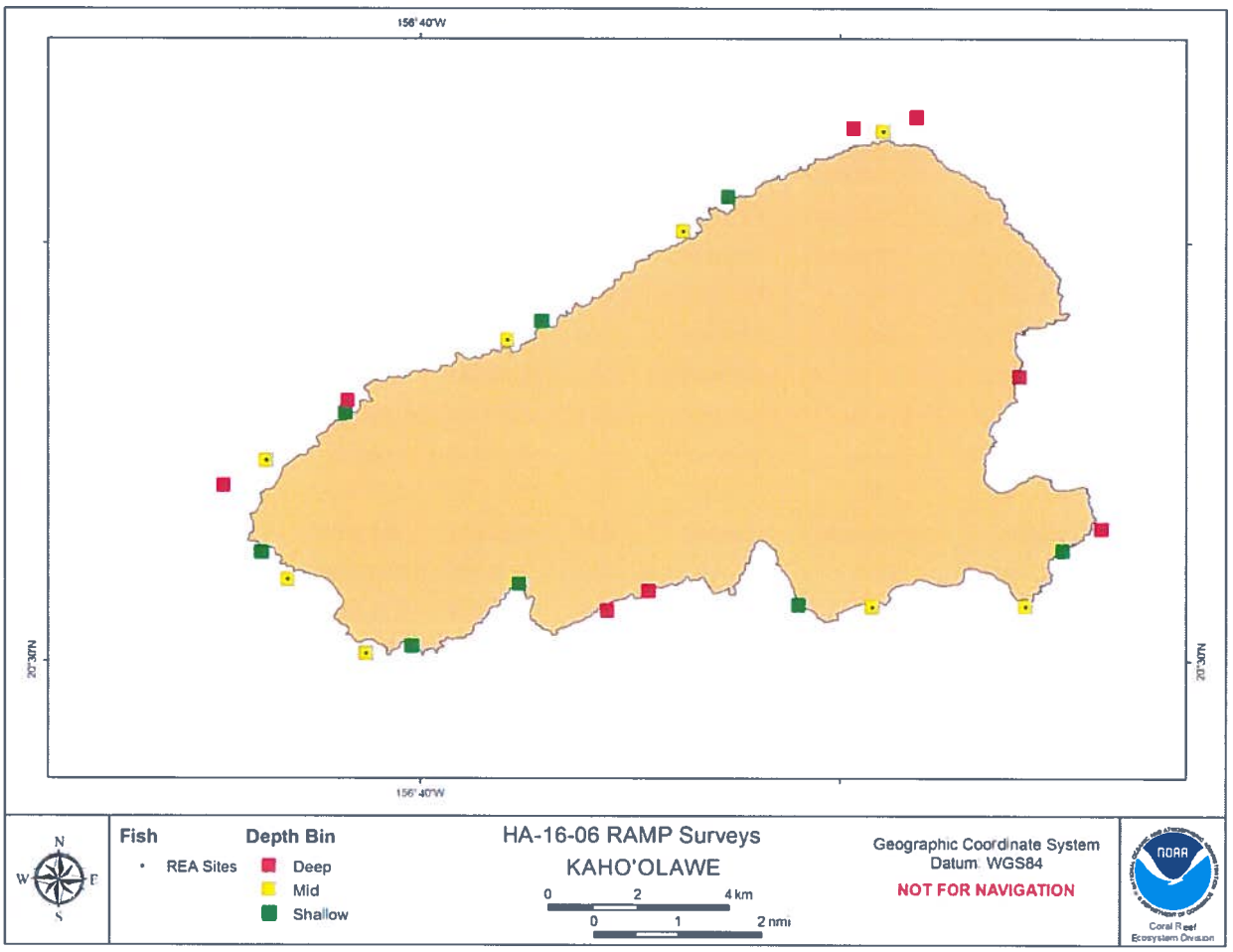

Figure C.3.1.--Locations of REA fish sites surveyed at Kaho'olawe Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table B.3.1.--Summary of sites where REA fish surveys were conducted at Kaho'olawe Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
KAH-101	15-Jul-16	Moderate	Forereef	8.8	20.50284	-156.66819
KAH-105	15-Jul-16	Shallow	Forereef	5	20.52189	-156.53855
KAH-106	21-Aug-16	Moderate	Forereef	11.5	20.51067	-156.5765
KAH-119	21-Aug-16	Shallow	Forereef	4.7	20.5161	-156.69272
KAH-123	21-Aug-16	Shallow	Forereef	5	20.55664	-156.54712
KAH-127	21-Aug-16	Shallow	Forereef	5.5	20.60562	-156.57433
KAH-128	21-Aug-16	Moderate	Forereef	13.9	20.52624	-156.53069
KAH-145	21-Aug-16	Moderate	Forereef	9.5	20.55184	-156.68094
KAH-146	21-Aug-16	Deep	Forereef	22.1	20.52151	-156.69807
KAH-157	15-Jul-16	Moderate	Forereef	7.6	20.51099	-156.59133
KAH-163	21-Aug-16	Deep	Forereef	23.5	20.60855	-156.56797
KAH-164	15-Jul-16	Deep	Forereef	19	20.53488	-156.70547
KAH-167	15-Jul-16	Shallow	Forereef	6.7	20.56404	-156.64927
KAH-172	21-Aug-16	Shallow	Forereef	7	20.51379	-156.62109
KAH-173	15-Jul-16	Deep	Forereef	23.8	20.50989	-156.62939
KAH-174	15-Jul-16	Deep	Forereef	21.2	20.60645	-156.58027
KAH-176	15-Jul-16	Moderate	Forereef	8.5	20.56768	-156.64248
KAH-178	21-Aug-16	Deep	Forereef	20.2	20.53986	-156.69706
KAH-181	21-Aug-16	Deep	Forereef	22.7	20.59248	-156.60552
KAH-185	15-Jul-16	Deep	Forereef	19.7	20.51073	-156.54588
KAH-187	15-Jul-16	Shallow	Forereef	5.8	20.50284	-156.66819
KAH-188	15-Jul-16	Moderate	Forereef	12.3	20.52189	-156.53855
KAH-195	15-Jul-16	Shallow	Forereef	5.7	20.51067	-156.5765
KAH-198	21-Aug-16	Moderate	Forereef	15.3	20.5161	-156.69272

APPENDIX D: KAUA'I ISLAND

The island of Kaua'i, located at 22°01′ N, 159°33′ W in the north Pacific and it is part of the Main Hawaiian Islands chain. 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 cruise HA-16-06 at Kaua'i Island entailed a number of retrievals and deployments of subsurface temperature recorders (STRs), calcification acidification units (CAUs), near-shore water sampling, and conductivity-temperature-depth (CTD) casts at select sites.

At nearshore locations around Kaua'i Island, 10 shallow-water CTD casts were performed; 12 samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 5 water samples were collected for analysis of nutrients. In addition, 7 STRs were retrieved and 7 STRs were deployed; and 10 CAUs were retrieved and 10 deployed at 8 locations around the island (Fig. D.1.1and Table D.1.1).

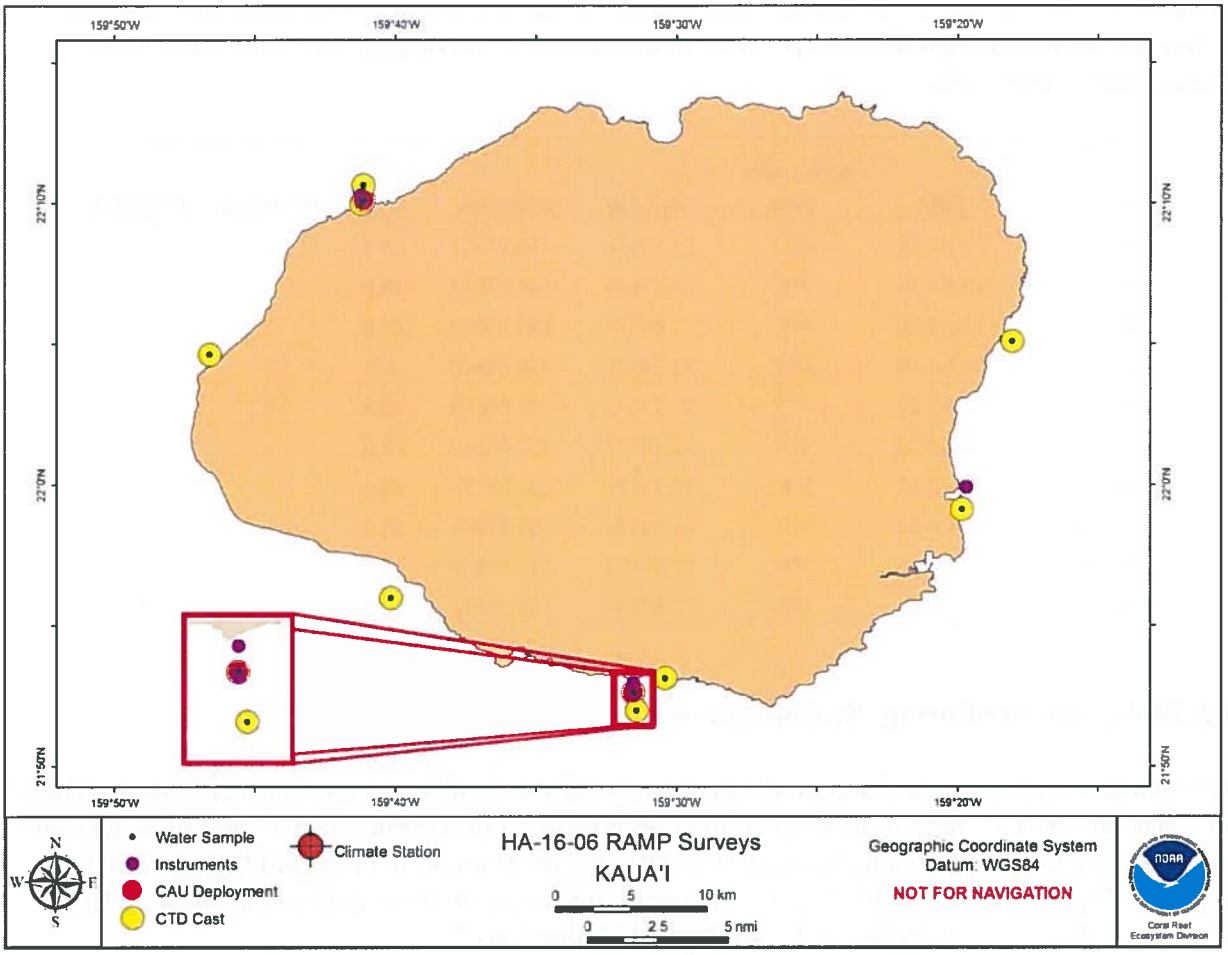

Figure D.1.1.--Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Kaua'i Island during cruise HA-16-06.

Table D.1.1.--Geographic coordinates and depths of the moored oceanographic instruments (STR) and biological installations (CAUs) that were retrieved or deployed on Kaua'i Island during cruise HA-16-06.

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
KAU-22	23-Jul-16	CAU	21.87666	-159.52551	13.7	5	5
KAU-22	23-Jul-16	STR	21.87666	-159.52552	14.6	1	1
KAU-22	23-Jul-16	STR	21.87578	-159.52544	25.6	1	1
KAU-22	23-Jul-16	STR	21.88223	-159.52549	5.5	1	1
KAU-21	26-Jul-16	CAU	22.16847	-159.68564	14.6	5	5
KAU-21	26-Jul-16	STR	22.16847	-159.68563	14.6	1	1
KAU-21	26-Jul-16	STR	22.17149	-159.68716	26.4	1	1
KAU-20	27-Jul-16	STR	21.99831	-159.32808	24.1	1	1
KAU-20	27-Jul-16	STR	21.99845	-159.32853	14.9	1	–
KAU-20	27-Jul-16	STR	21.99845	-159.32853	14.9	–	1

D.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 17 REA sites around Kaua'i Island to assess benthic composition, coral community structure, and coral and algal disease; 4 water samples and 11 coral/algal biopsies were collected for microbial analyses (Fig. D.2.1. and Table D.2.1.). For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

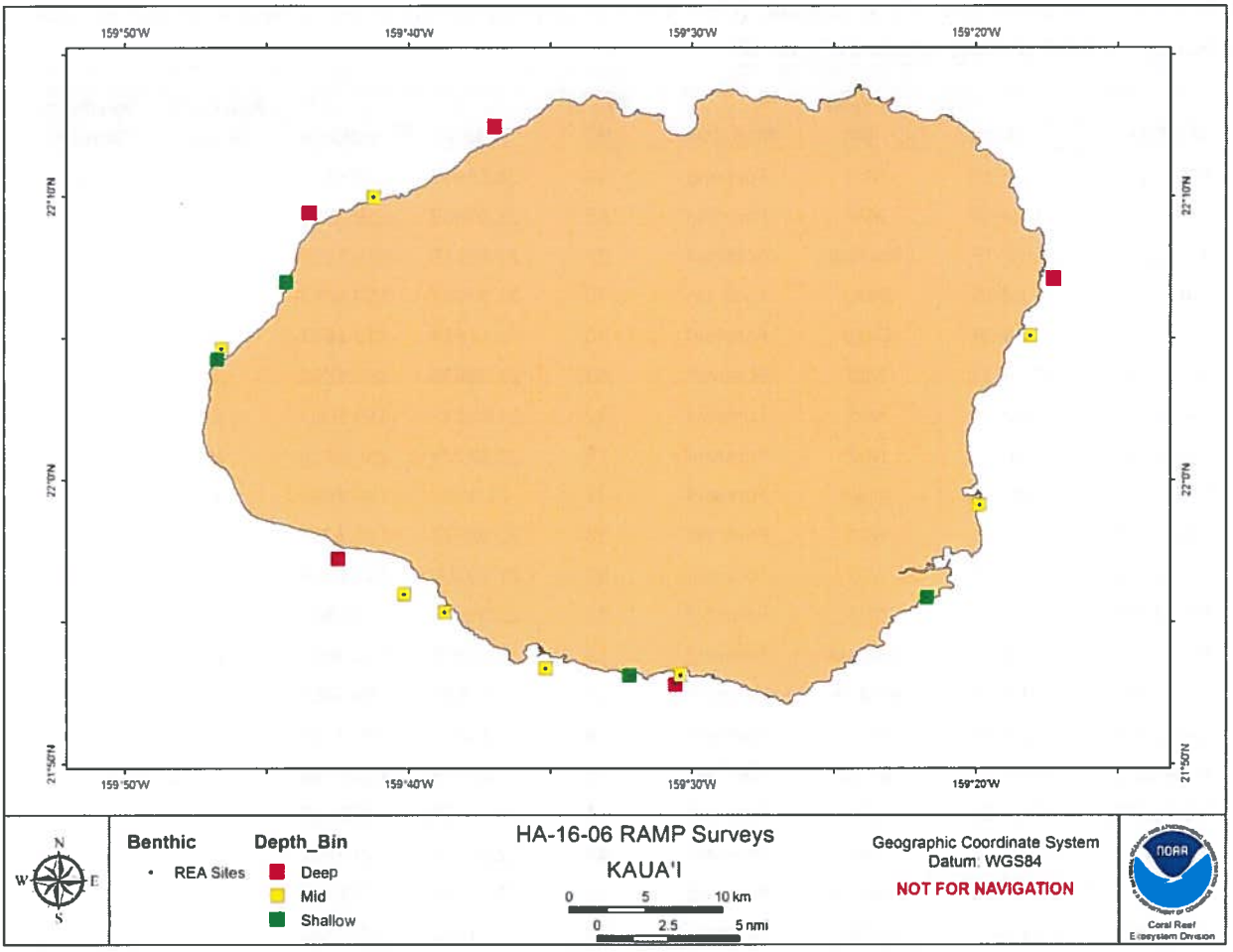

Figure D.2.1.--Locations of benthic REA sites surveyed at Kaua'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table D.2.1.--Summary of the benthic REA surveys and microbial water collections performed at Kaua'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
KAU-21	26-Jul-16	Mid	Forereef	48	22.16847	-159.6856		x
KAU-22	23-Jul-16	Mid	Forereef	45	21.87666	-159.5255		x
KAU-22	24-Jul-16	Shallow	Forereef	18	21.88223	-159.5255		x
KAU-1704	23-Jul-16	Deep	Forereef	70	21.87967	-159.5099	x	
KAU-1709	27-Jul-16	Deep	Forereef	70	22.11824	-159.2871	x	
KAU-1729	23-Jul-16	Mid	Forereef	62	21.88926	-159.5861	x	
KAU-1732	23-Jul-16	Mid	Forereef	32	21.88535	-159.5067	x	
KAU-1739	23-Jul-16	Mid	Forereef	24	21.92225	-159.6456	x	
KAU-1748	23-Jul-16	Deep	Forereef	32	21.9537	-159.7081	x	
KAU-1763	27-Jul-16	Mid	Forereef	38	21.98523	-159.3309	x	
KAU-1764	23-Jul-16	Mid	Forereef	32	21.93289	-159.6694	x	
KAU-1766	27-Jul-16	Mid	Forereef	43	22.08463	-159.301	x	
KAU-1771	27-Jul-16	Shallow	Forereef	18	21.9309	-159.3619	x	
KAU-1785	23-Jul-16	Shallow	Forereef	17	21.885	-159.5367	x	
KAU-1799	26-Jul-16	Deep	Forereef	79	22.15704	-159.7249	x	
KAU-1815	26-Jul-16	Deep	Forereef	75	22.20766	-159.6162	x	
KAU-1848	26-Jul-16	Mid	Forereef	34	22.16623	-159.687	x	
KAU-1851	26-Jul-16	Mid	Forereef	48	22.07709	-159.7767	x	
KAU-1874	26-Jul-16	Shallow	Forereef	15	22.07064	-159.7795	x	
KAU-1875	26-Jul-16	Shallow	Forereef	16	22.11611	-159.7388	x	

Additionally, during the HA-16-06 cruise, 10 towed-diver surveys were completed around Kaua'i Island, covering a total length of 24.5 km (an area of 24.5 ha) of the ocean floor (Fig. D.2.2.).

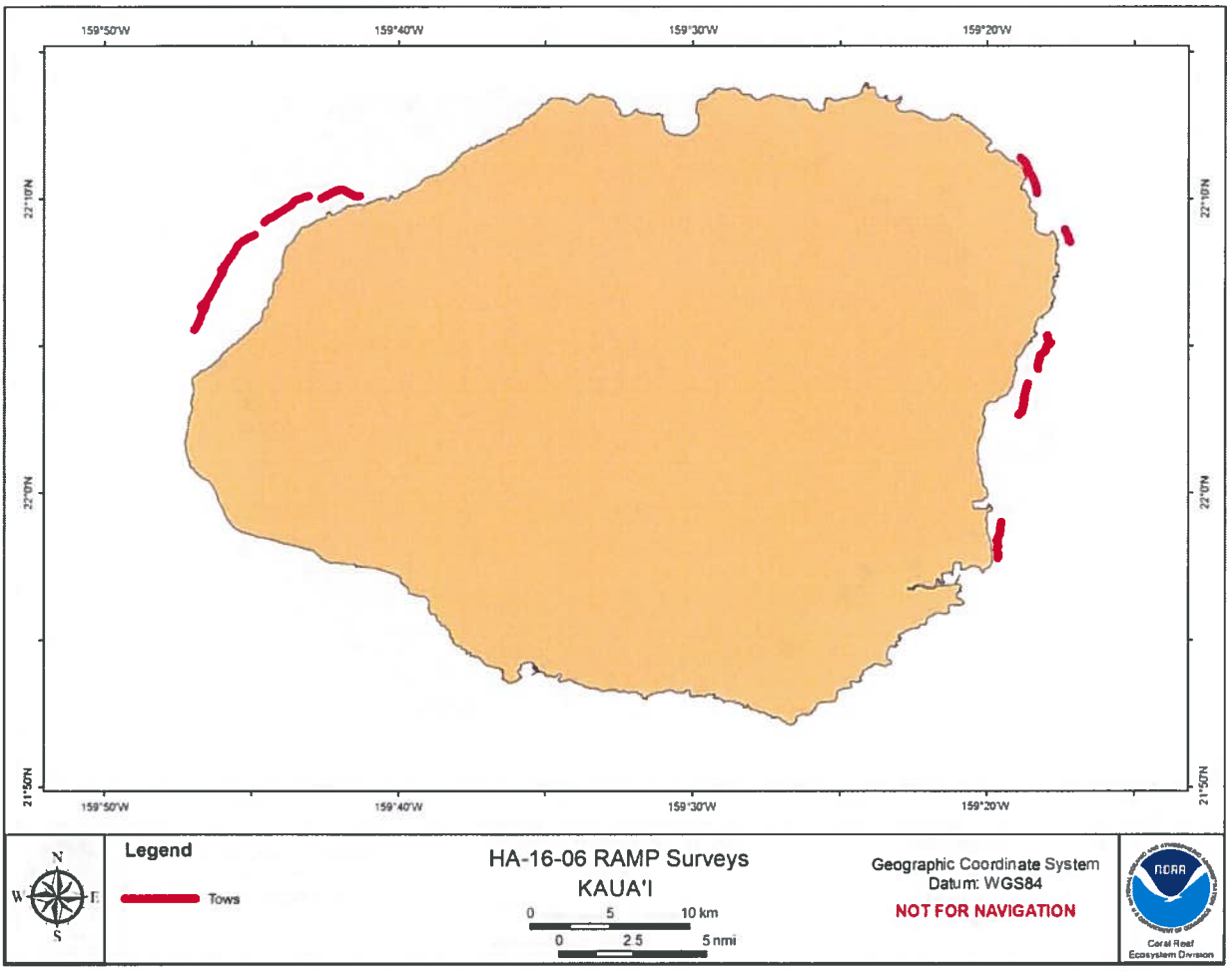

Figure D.2.2.--Track locations of towed-diver surveys conducted at Kaua'i Island during the cruise HA-16-06.

D.3. Biological Monitoring: Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 30 REA sites at Kaua'i Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig.D.3.1. and Table D.3.1.). No fishes were collected during these surveys.

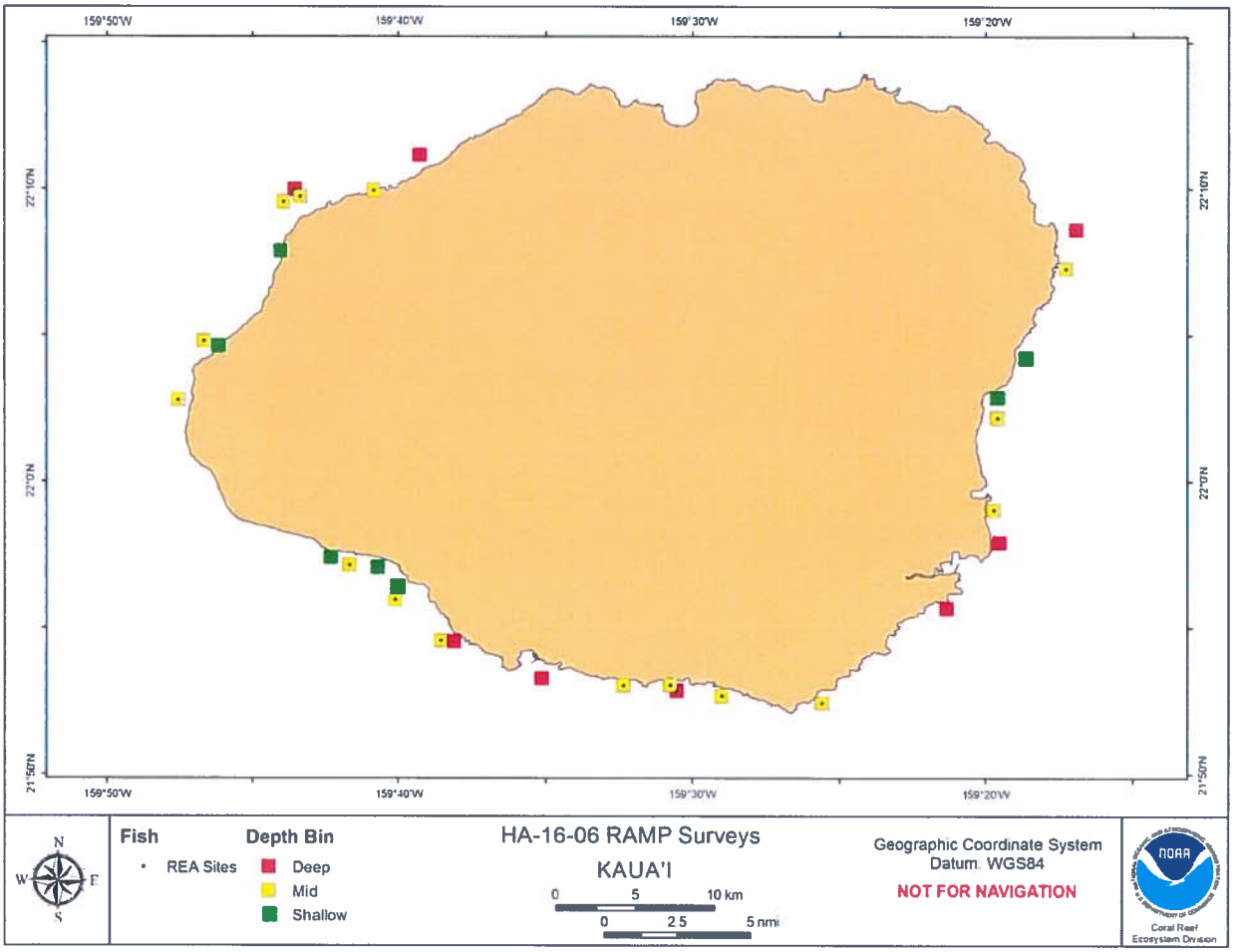

Figure D.3.1.--Locations of REA fish sites surveyed at Kaua'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table D.3.1.--Summary of sites where REA fish surveys were conducted at Kaua'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
KAU-1525	27-Jul-16	Deep	Forereef	20.5	21.88391	-159.51244
KAU-1533	23-Jul-16	Deep	Forereef	22.8	22.12133	-159.28796
KAU-1534	23-Jul-16	Deep	Forereef	22.6	21.87787	-159.48304
KAU-1536	23-Jul-16	Deep	Forereef	20	21.90953	-159.64222
KAU-1538	27-Jul-16	Deep	Forereef	18.5	21.95236	-159.69407
KAU-1544	27-Jul-16	Deep	Forereef	26	22.03629	-159.32636
KAU-1549	27-Jul-16	Moderate	Forereef	15	22.04786	-159.3264
KAU-1552	27-Jul-16	Moderate	Forereef	15.7	21.94014	-159.66687
KAU-1554	23-Jul-16	Moderate	Forereef	8.3	22.07065	-159.31026
KAU-1556	23-Jul-16	Moderate	Forereef	10	21.95673	-159.70532
KAU-1561	23-Jul-16	Moderate	Forereef	10.3	21.95122	-159.67822
KAU-1562	27-Jul-16	Moderate	Forereef	15.6	22.16628	-159.7254
KAU-1575	23-Jul-16	Moderate	Forereef	11.4	22.18598	-159.65448
KAU-1580	23-Jul-16	Moderate	Forereef	16.3	22.16573	-159.68082
KAU-1582	23-Jul-16	Moderate	Forereef	13.1	22.16232	-159.72253
KAU-1592	27-Jul-16	Moderate	Forereef	14.5	22.1593	-159.73186
KAU-1599	27-Jul-16	Shallow	Forereef	5.5	22.08005	-159.77765
KAU-1607	23-Jul-16	Shallow	Forereef	4.7	22.04653	-159.79196
KAU-1610	27-Jul-16	Shallow	Forereef	6	22.07714	-159.76927
KAU-1615	23-Jul-16	Shallow	Forereef	5.7	22.13112	-159.73393
KAU-1616	23-Jul-16	Shallow	Forereef	5.3	21.88391	-159.51244
KAU-1620	26-Jul-16	Deep	Forereef	22	22.12133	-159.28796
KAU-1632	26-Jul-16	Deep	Forereef	24.1	21.87787	-159.48304
KAU-1637	26-Jul-16	Moderate	Forereef	12	21.90953	-159.64222
KAU-1638	26-Jul-16	Moderate	Forereef	13.8	21.95236	-159.69407
KAU-1639	26-Jul-16	Moderate	Forereef	16.1	22.03629	-159.32636
KAU-1642	26-Jul-16	Moderate	Forereef	17	22.04786	-159.3264
KAU-1646	26-Jul-16	Moderate	Forereef	14.3	21.94014	-159.66687
KAU-1647	26-Jul-16	Shallow	Forereef	2.9	22.07065	-159.31026
KAU-1648	26-Jul-16	Shallow	Forereef	5.5	21.95673	-159.70532

APPENDIX E: LĀNA'I ISLAND

The island of Lāna'i located at 28°48′ N, 156°55′ W in the north Pacific, is one of the main Hawaiian Islands. 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 cruise HA-16-06 at Lāna'i Island entailed the retrieval and deployment of subsurface temperature recorders (STRs), calcification acidification units (CAUs), near-shore water sampling, and conductivity-temperature-depth (CTD) casts at select NCRMP sites.

At nearshore locations around Lāna'i thirteen 6 shallow-water CTD casts were performed. Eight water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 4 water samples were collected for nutrient analyses. In addition, 2 STRs were retrieved and 2 STRs were deployed, and 14 CAUs were retrieved and 15 deployed at 3 locations around the island (Fig. E.1.1 and Table E.1.1).

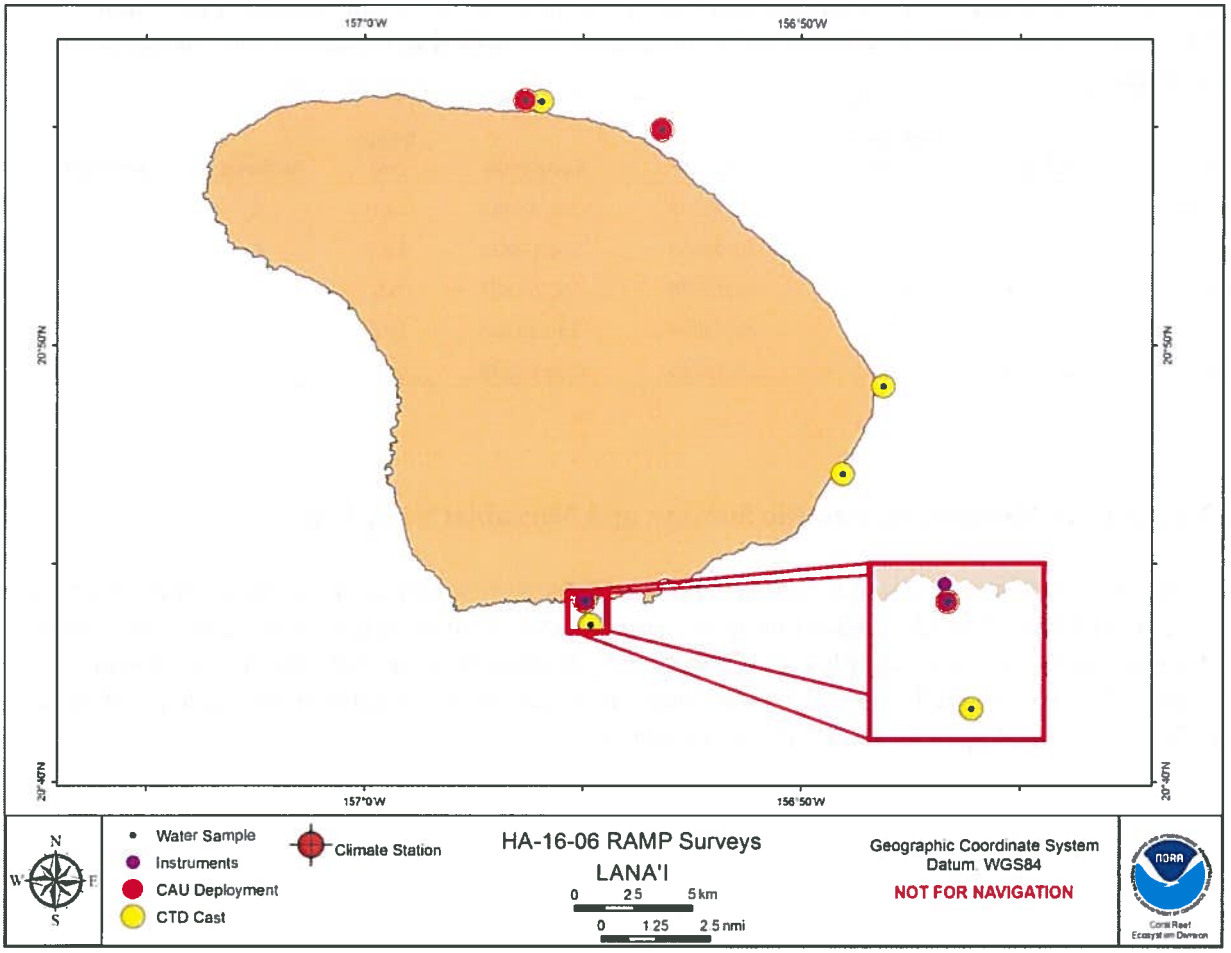

Figure E.1.1.--Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Lāna‘i Island during cruise HA-16-06.

Table E.1.1.--Geographic coordinates and depths of the moored oceanographic instruments (STR) and biological installations (CAU) retrieved or deployed at Lāna'i Island during cruise HA-16-06.

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
LAN-10	18-Jul-16	CAU	20.91534	-156.88640	14.0	5	5
LAN-11	18-Jul-16	CAU	20.92650	-156.93851	13.7	4	5
LAN-12	21-Jul-16	CAU	20.73574	-156.91551	5.5	5	5
LAN-12	21-Jul-16	STR	20.73574	-156.91551	14.9	1	1
LAN-12	21-Jul-16	STR	20.73726	-156.91578	5.5	1	1

E.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 15 REA sites around Lāna'i Island to assess benthic composition, coral community structure, and coral and algal disease; 6 water samples and 22 coral/algal biopsies were collected for microbial analyses (Fig. E.2.1 and Table E.2.1). For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

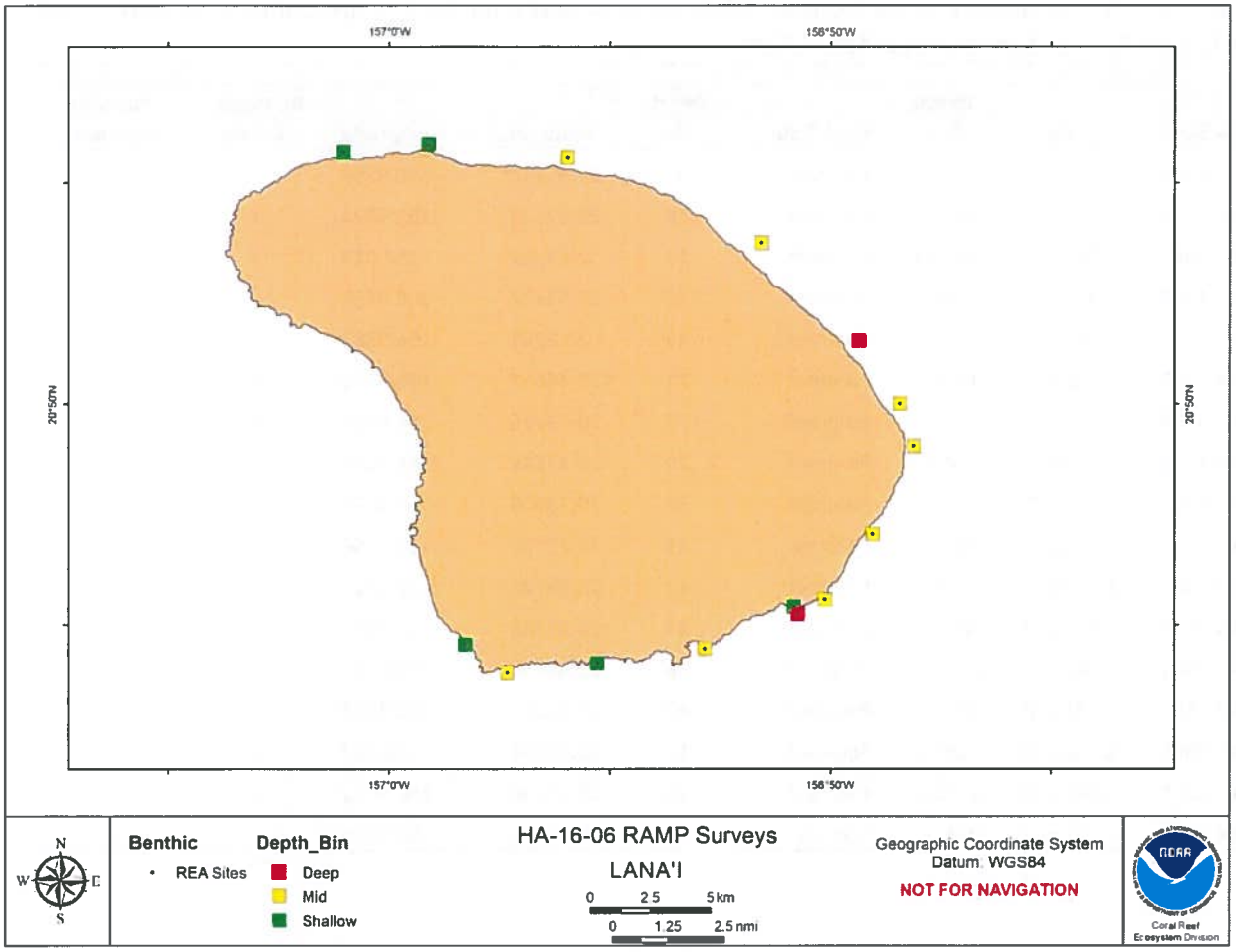

Figure E.2.1.--Locations of benthic REA sites surveyed at Lāna'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table D.2.1.--Summary of the benthic REA surveys and microbial water collections performed at Lāna'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
LAN-1600	18-Jul-16	Mid	Forereef	61	20.89418	-156.8594	x	
LAN-1618	18-Jul-16	Mid	Forereef	48	20.92628	-156.9324	x	
LAN-1643	18-Jul-16	Shallow	Forereef	17	20.9284	-157.017	x	
LAN-1648	18-Jul-16	Shallow	Forereef	19	20.93127	-156.9851	x	
LAN-11	18-Jul-16	Mid	Forereef	45	20.9265	-156.9385		x
LAN-1662	21-Jul-16	Deep	Forereef	71	20.75417	-156.8456	x	
LAN-1679	21-Jul-16	Mid	Forereef	51	20.73176	-156.9553	x	
LAN-1693	21-Jul-16	Shallow	Forereef	20	20.73545	-156.9213	x	
LAN-1701	21-Jul-16	Mid	Forereef	38	20.78408	-156.8174	x	
LAN-12	21-Jul-16	Mid	Forereef	49	20.73726	-156.9158		x
LAN-1661	12-Aug-16	Deep	Forereef	72	20.85728	-156.8223	x	
LAN-1671	12-Aug-16	Mid	Forereef	41	20.83338	-156.8071	x	
LAN-1681	12-Aug-16	Mid	Forereef	38	20.81752	-156.802	x	x
LAN-1684	12-Aug-16	Mid	Forereef	42	20.74099	-156.8808	x	
LAN-1695	12-Aug-16	Shallow	Forereef	19	20.75684	-156.847	x	
LAN-1721	12-Aug-16	Shallow	Forereef	16	20.74256	-156.9712	x	
LAN-1724	12-Aug-16	Mid	Forereef	42	20.75949	-156.8354	x	

Additionally, during the HA-16-06 cruise, 6 towed-diver surveys were completed Lāna'i Island, covering a total length of 15 km (an area of 15 ha) of the ocean floor (Fig. E.2.2).

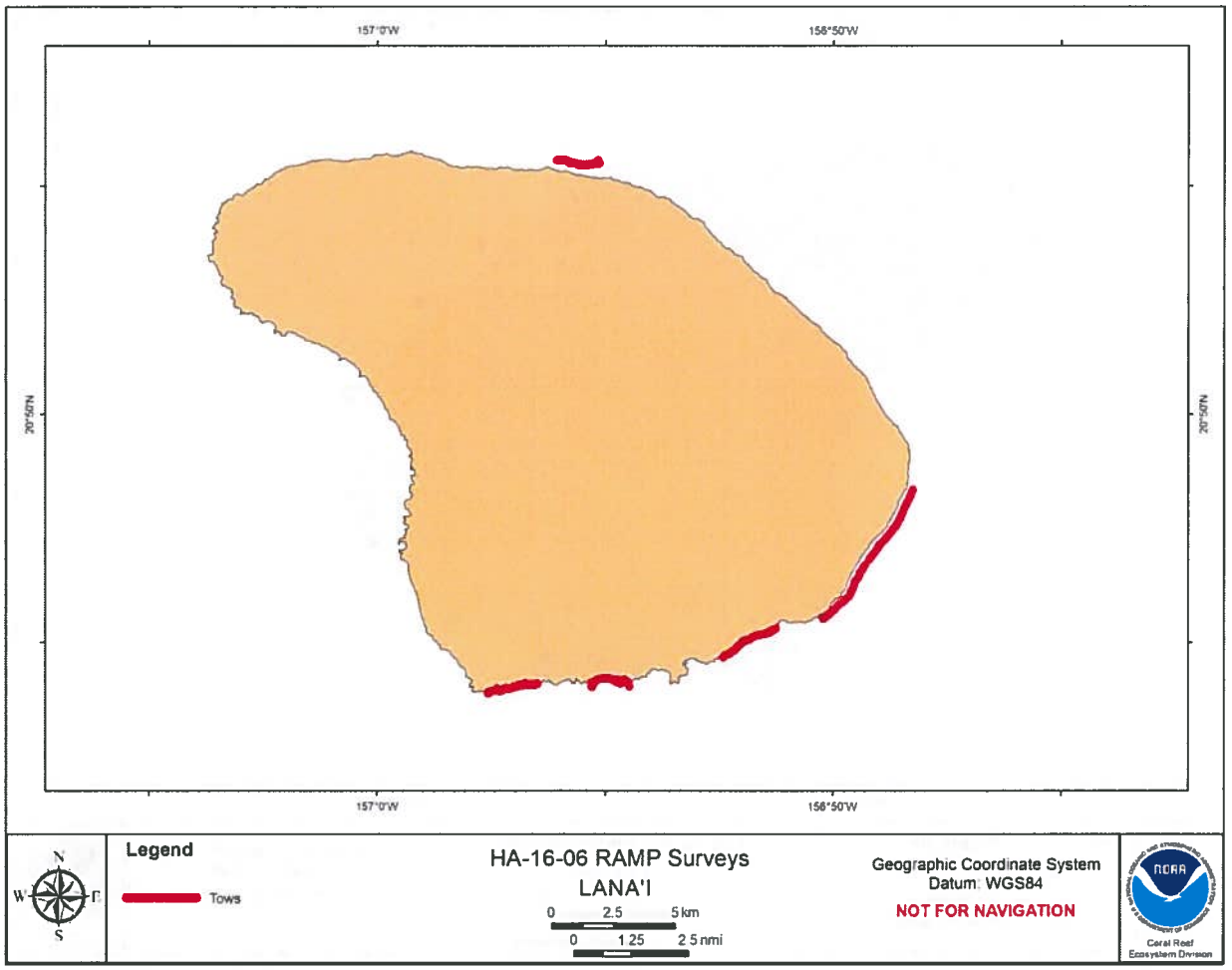

Figure E.2.2.--Track locations of towed-diver surveys conducted at Lāna'i Island during the cruise HA-16-06.

E.3. Biological Monitoring: Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 26 REA sites at Lāna'i Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig.E.3.1 and Table E.3.1). No fishes were collected during these surveys.

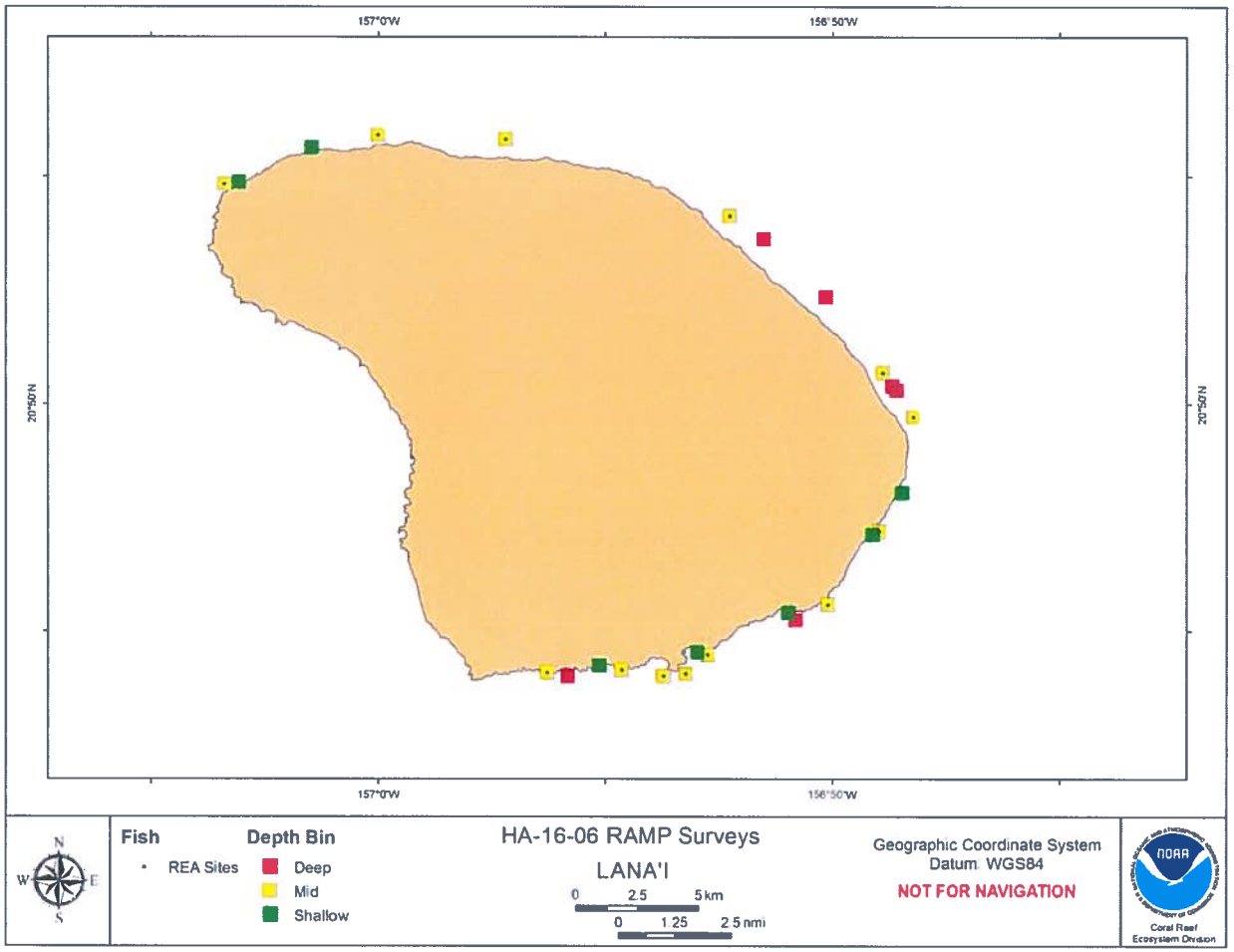

Figure E.3.1.--Locations of REA fish sites surveyed at Lāna'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table E.3.1.--Summary of sites where REA fish surveys were conducted at Lāna'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
LAN-1430	12-Aug-16	Deep	Forereef	20	20.83809	-156.80943
LAN-1437	21-Jul-16	Deep	Forereef	19.3	20.75394	-156.84626
LAN-1440	21-Jul-16	Moderate	Forereef	10.9	20.73553	-156.91044
LAN-1446	12-Aug-16	Deep	Forereef	19.8	20.8397	-156.81083
LAN-1452	12-Aug-16	Moderate	Forereef	16.8	20.82828	-156.80329
LAN-1454	21-Jul-16	Deep	Forereef	19.6	20.73313	-156.92982
LAN-1458	12-Aug-16	Moderate	Forereef	21.5	20.73418	-156.8867
LAN-1461	18-Jul-16	Moderate	Forereef	14.4	20.93017	-156.95245
LAN-1472	18-Jul-16	Moderate	Forereef	12.5	20.902	-156.87051
LAN-1486	12-Aug-16	Moderate	Forereef	8.5	20.84457	-156.81438
LAN-1488	18-Jul-16	Moderate	Forereef	8.5	20.9316	-156.9997
LAN-1494	21-Jul-16	Moderate	Forereef	10.4	20.73458	-156.93724
LAN-1499	21-Jul-16	Moderate	Forereef	8.1	20.74122	-156.8784
LAN-1500	12-Aug-16	Moderate	Forereef	10.1	20.78642	-156.81574
LAN-1503	12-Aug-16	Moderate	Forereef	16.8	20.73333	-156.89483
LAN-1504	21-Jul-16	Moderate	Forereef	15.5	20.75955	-156.83451
LAN-1521	21-Jul-16	Shallow	Forereef	4.8	20.75659	-156.84894
LAN-1527	21-Jul-16	Shallow	Forereef	5.3	20.7372	-156.91836
LAN-1529	12-Aug-16	Shallow	Forereef	4.6	20.78523	-156.81819
LAN-1535	21-Jul-16	Shallow	Forereef	6	20.74198	-156.88235
LAN-1538	12-Aug-16	Shallow	Forereef	4.6	20.80049	-156.8074
LAN-1542	18-Jul-16	Deep	Forereef	20.4	20.87246	-156.83544
LAN-1554	18-Jul-16	Deep	Forereef	20	20.89347	-156.85785
LAN-1557	18-Jul-16	Moderate	Forereef	18.3	20.91364	-157.05613
LAN-1571	18-Jul-16	Shallow	Forereef	4	20.92709	-157.02392
LAN-1572	18-Jul-16	Shallow	Forereef	4.3	20.91439	-157.05077

APPENDIX F: MAUI ISLAND

The island of Maui located at 20°45′ N, 156°16′ W in the north Pacific, is one of the main Hawaiian Islands. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: "Methods."

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

Oceanographic operations during the cruise HA-16-06 at Maui Island entailed the retrieval and deployment of subsurface temperature recorders (STRs), calcification acidification units (CAUs), near-shore water sampling, and conductivity-temperature-depth (CTD) casts at select NCRMP sites.

At nearshore locations around Maui Island, 5 shallow-water CTD casts were performed; 6 water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 4 water samples for nutrient analyses. In addition, 5 STRs were retrieved and 5 STRs were deployed; 4 CAUs were retrieved and 5 deployed around the island. (Fig. F.1.1and Table F.1.1).

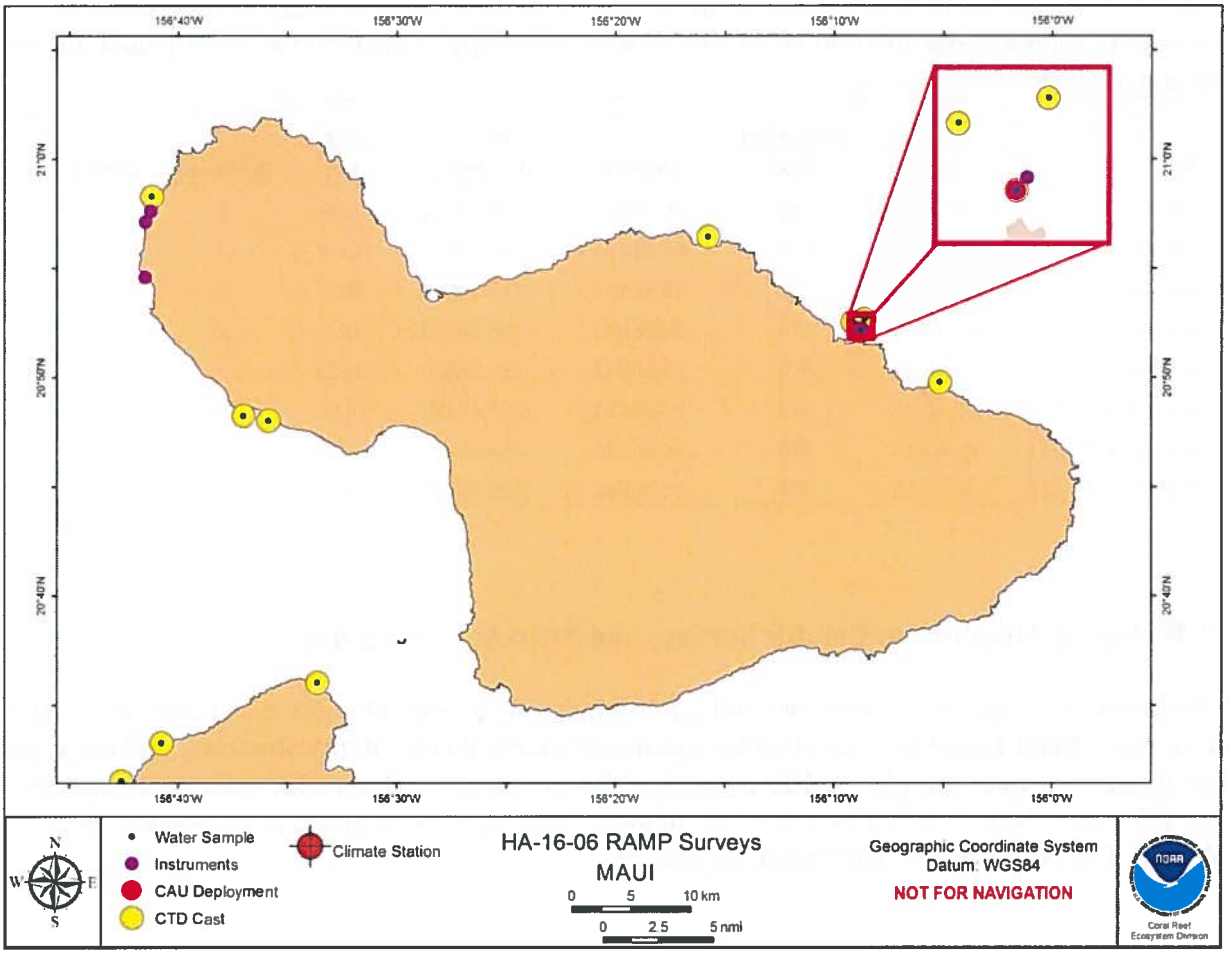

Figure F.1.1.--Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Maui Island during cruise HA-16-06.

Table DS.1.1.--Geographic coordinates and depths of the moored oceanographic instruments (STR) and biological installations (CAUs) that were retrieved or deployed at Maui Island during cruise HA-16-06.

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
MAI-30	14-Jul-16	CAU	20.86862	-156.14632	15.3	4	5
MAI-30	14-Jul-16	STR	20.86862	-156.14632	14.6	–	1
MAI-30	14-Jul-16	STR	20.86992	-156.14526	25.3	–	1
MAI-30	14-Jul-16	STR	20.86862	-156.14632	14.6	1	–
MAI-30	14-Jul-16	STR	20.86992	-156.14526	25.3	1	–
MAI_OCEAN_010	16-Jul-16	STR	20.95183	-156.69184	5.9	1	1
MAI_OCEAN_011	16-Jul-16	STR	20.96018	-156.68773	6.1	1	1
MAI_OCEAN_012	16-Jul-16	STR	20.90962	-156.69195	6.4	1	1

F.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 15 REA sites around Maui Island to assess benthic composition, coral community structure, and coral and algal disease; 4 water samples and 23 coral/algal biopsies were collected for microbial analyses (Fig. F.2.1 and Table F.2.1). For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

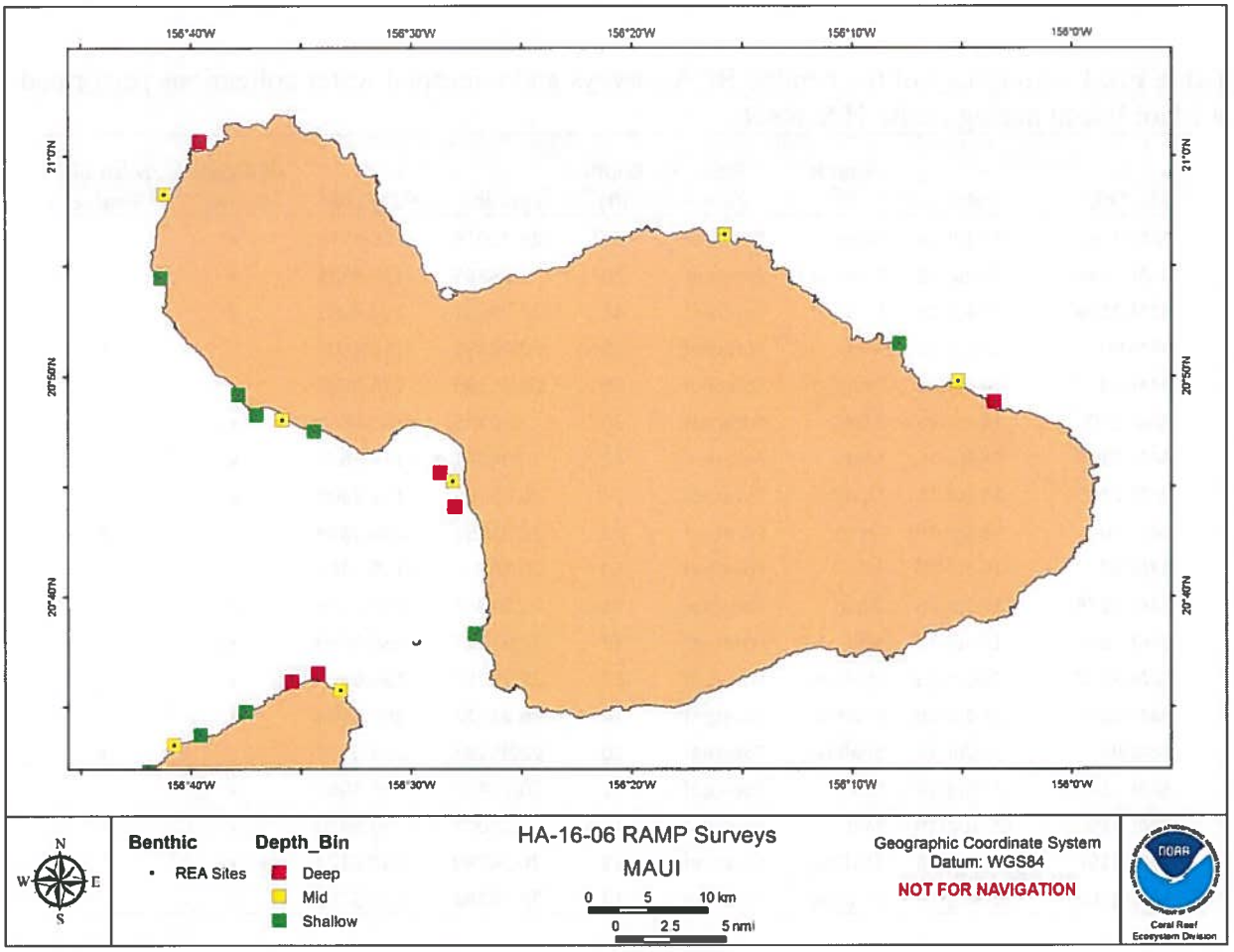

Figure F.2.1.--Locations of benthic REA sites surveyed at Maui Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table F.2.1.--Summary of the benthic REA surveys and microbial water collections performed at Maui Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
MAI-2165	13-Jul-16	Deep	Forereef	64	20.76016	-156.4775	x	
MAI-2184	13-Jul-16	Shallow	Forereef	20	20.6385	-156.4519	x	
MAI-2188	13-Jul-16	Mid	Forereef	48	20.75391	-156.4683	x	
MAI-90	13-Jul-16	Mid	Forereef	28	20.70485	-156.4505		x
MAI-2077	14-Jul-16	Deep	Forereef	78	20.81386	-156.0583	x	
MAI-2104	14-Jul-16	Mid	Forereef	38	20.8295	-156.0858	x	
MAI-2109	14-Jul-16	Mid	Forereef	42	20.94041	-156.2627	x	
MAI-2115	14-Jul-16	Shallow	Forereef	22	20.85766	-156.1301	x	
MAI-30	14-Jul-16	Deep	Forereef	83	20.86992	-156.1453		x
MAI-30	14-Jul-16	Mid	Forereef	50	20.86862	-156.1463		x
MAI-2278	16-Jul-16	Deep	Forereef	71	21.01083	-156.6598	x	
MAI-2297	16-Jul-16	Mid	Forereef	52	20.97113	-156.6869	x	
MAI-2307	16-Jul-16	Shallow	Forereef	23	20.90757	-156.6893	x	
MAI-2309	16-Jul-16	Shallow	Forereef	14	20.81922	-156.6306	x	
MAI-91	16-Jul-16	Shallow	Forereef	20	20.95183	-156.6918		x
MAI-2178	13-Aug-16	Deep	Forereef	72	20.73486	-156.4669	x	
MAI-2192	13-Aug-16	Mid	Forereef	40	20.8001	-156.5978	x	
MAI-2196	13-Aug-16	Shallow	Forereef	18	20.80389	-156.6171	x	
MAI-2206	13-Aug-16	Shallow	Forereef	12	20.79162	-156.5736	x	

Additionally, during the HA-16-06 cruise, 17 towed-diver surveys were completed around Maui Island, covering a total length of 40 km (an area of 40 ha) of the ocean floor (Fig. F.2.2).

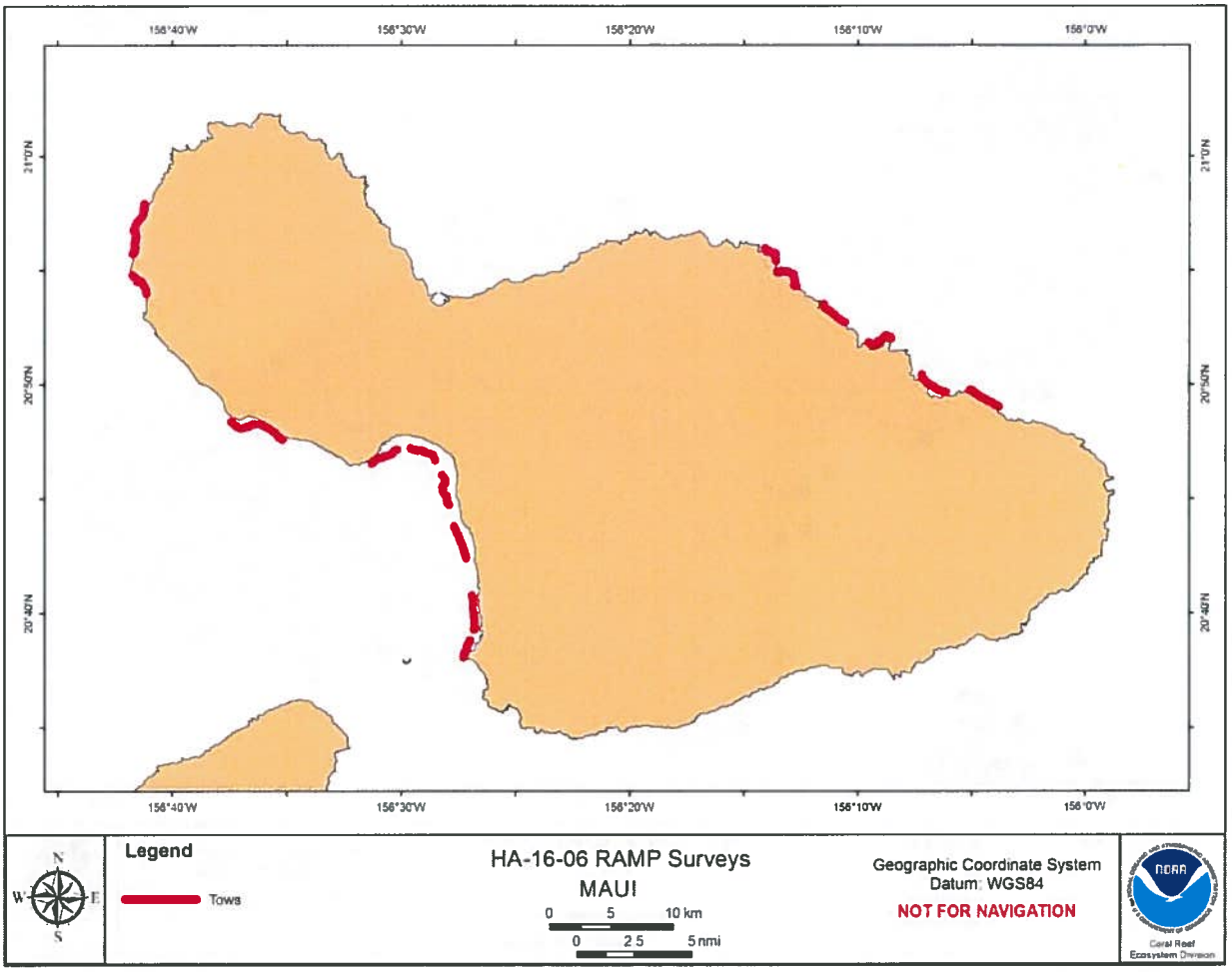

Figure F.2.2.--Track locations of towed-diver surveys conducted at Maui Island during the cruise HA-16-06.

F.3. Biological Monitoring: Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 29 REA sites at Maui Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig. F.3.1 and Table F.3.1). No fishes were collected during these surveys.

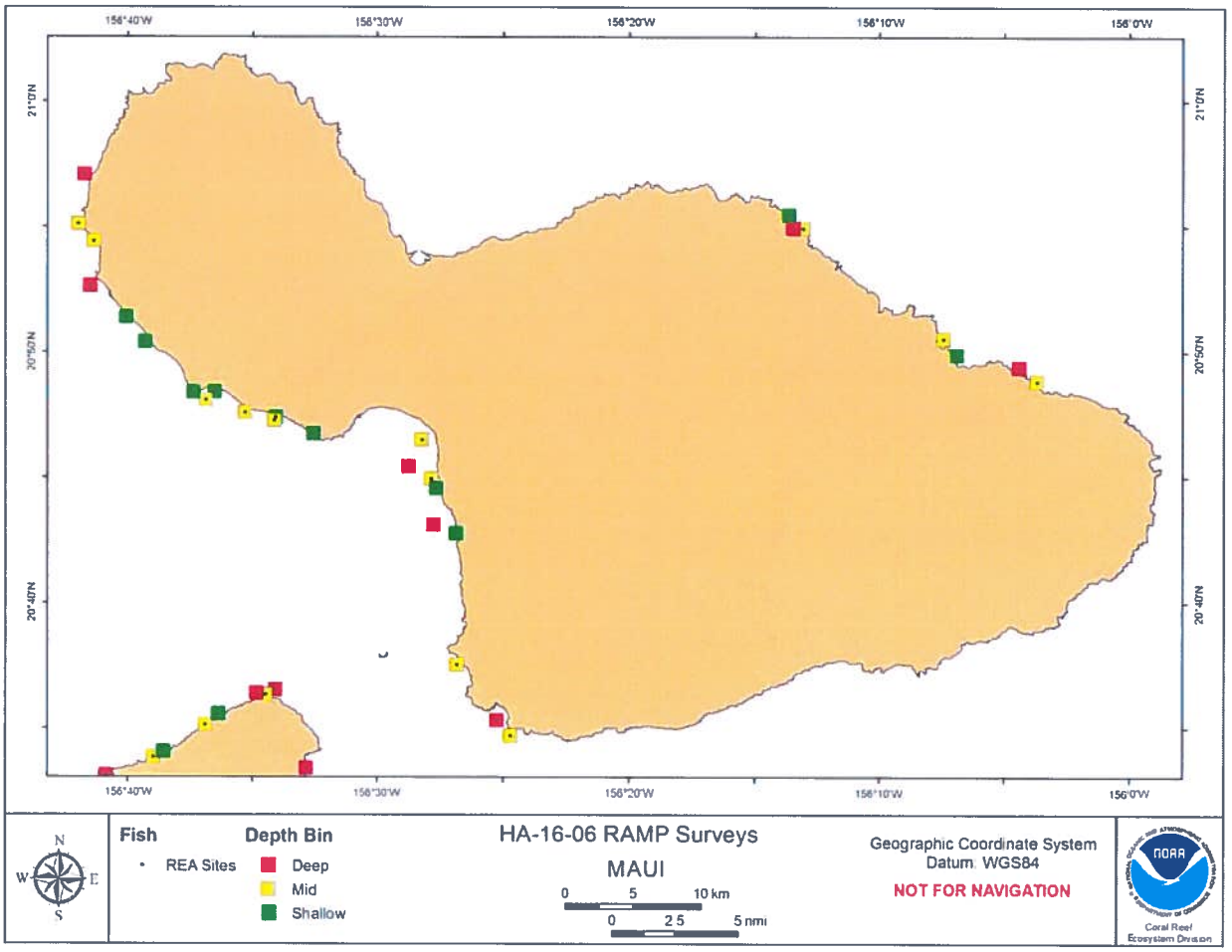

Figure F.3.1.--Locations of REA fish sites surveyed at Maui Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table F.3.1.--Summary of sites where REA fish surveys were conducted at Maui Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
MAI-1801	13-Jul-16	Deep	Forereef	23.3	20.71884	-156.46311
MAI-1805	13-Aug-16	Deep	Forereef	20.7	20.58863	-156.42045
MAI-1806	13-Aug-16	Deep	Forereef	23.6	20.75734	-156.479
MAI-1808	16-Jul-16	Moderate	Forereef	12	20.80144	-156.6139
MAI-1810	13-Jul-16	Moderate	Forereef	10.4	20.77497	-156.47006
MAI-1811	13-Aug-16	Moderate	Forereef	10.1	20.79306	-156.58809
MAI-1812	13-Aug-16	Moderate	Forereef	8.3	20.62573	-156.44655
MAI-1813	13-Aug-16	Moderate	Forereef	15.2	20.7878	-156.56889
MAI-1814	16-Jul-16	Shallow	Forereef	3	20.80704	-156.6082
MAI-1815	13-Aug-16	Shallow	Forereef	5.5	20.77889	-156.54271
MAI-1816	13-Aug-16	Shallow	Forereef	3.7	20.79006	-156.56788
MAI-1817	16-Jul-16	Shallow	Forereef	4.5	20.80658	-156.62249
MAI-1818	13-Jul-16	Shallow	Forereef	3.2	20.71256	-156.4472
MAI-1819	13-Jul-16	Shallow	Forereef	4.2	20.74268	-156.46043
MAI-1820	13-Jul-16	Moderate	Forereef	7	20.74887	-156.46389
MAI-1825	16-Jul-16	Deep	Forereef	23	20.95104	-156.69542
MAI-1827	16-Jul-16	Deep	Forereef	20.1	20.87718	-156.69154
MAI-1839	16-Jul-16	Moderate	Forereef	7	20.90672	-156.68927
MAI-1843	16-Jul-16	Shallow	Forereef	4.2	20.85641	-156.66774
MAI-1845	16-Jul-16	Shallow	Forereef	4.8	20.84001	-156.65504
MAI-1850	16-Jul-16	Moderate	Forereef	9	20.91832	-156.69946
MAI-1865	14-Jul-16	Deep	Forereef	21.3	20.9158	-156.224
MAI-1867	14-Jul-16	Deep	Forereef	23.6	20.82326	-156.07281
MAI-1870	14-Jul-16	Moderate	Forereef	13.3	20.91569	-156.21771
MAI-1878	14-Jul-16	Moderate	Forereef	16.6	20.81389	-156.0609
MAI-1880	14-Jul-16	Moderate	Forereef	12.8	20.84235	-156.12319
MAI-1882	14-Jul-16	Shallow	Forereef	6	20.92437	-156.22713
MAI-1883	14-Jul-16	Shallow	Forereef	4.7	20.83153	-156.11452
MAI-1897	13-Jul-16	Moderate	Forereef	13.6	20.57842	-156.41149

APPENDIX G: MOLOKA'I ISLAND

The island of Moloka'i located at 21°06′ N, 156°59′ W in the north Pacific, and is one of the main Hawaiian Islands. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: "Methods."

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

Oceanographic operations during the cruise HA-16-06 at Moloka'i Island a the retrieval and deployment of subsurface temperature recorders (STRs), calcification acidification units (CAUs), and near-shore water sampling, and conductivity-temperature-depth (CTD) casts at select NCRMP sites.

At nearshore locations around Maui Island, 10 shallow-water CTD casts were performed; 12 water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 6 water samples for nutrient analyses. In addition, 5 STRs were retrieved and 5 STRs were deployed; 23 CAUs were retrieved and 25 deployed at 5 locations around the island. (Fig. G.1.1and Table G.1.1).

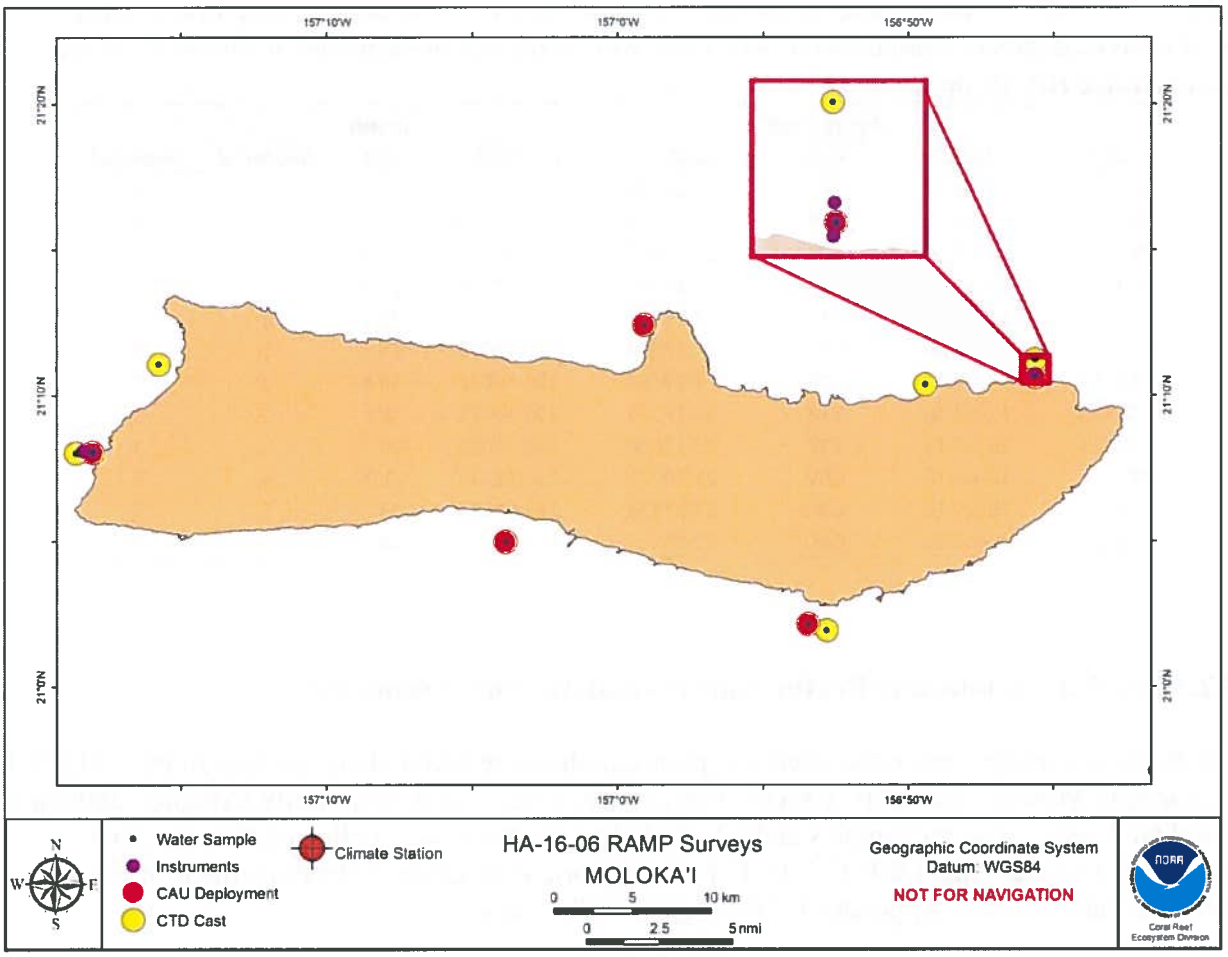

Figure G.1.1.--Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Moloka'i Island during cruise HA-16-06.

Table G.1.1.--Geographic coordinates and depths of the moored oceanographic instruments (STR) and biological installations (CAUs) that were retrieved or deployed at Moloka'i Island during cruise HA-16-06.

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
MOL-22	17-Jul-16	CAU	21.13409	-157.30026	14.6	4	5
MOL-22	17-Jul-16	STR	21.13409	-157.30026	16.2	–	1
MOL-22	17-Jul-16	STR	21.13486	-157.30590	25.6	–	1
MOL-22	17-Jul-16	STR	21.13409	-157.30026	16.2	1	–
MOL-22	17-Jul-16	STR	21.13486	-157.30590	26.2	1	–
MOL-23	19-Jul-16	CAU	21.17694	-156.76048	14.6	5	5
MOL-23	19-Jul-16	STR	21.17694	-156.76048	14.6	1	1
MOL-23	19-Jul-16	STR	21.17579	-156.76071	4.9	1	1
MOL-23	19-Jul-16	STR	21.17864	-156.76060	24.7	1	1
MOL-24	19-Jul-16	CAU	21.20705	-156.98474	0.0	4	5
MOL-20	20-Jul-16	CAU	21.03574	-156.89038	13.1	5	5
MOL-21	20-Jul-16	CAU	21.08299	-157.06424	16.2	5	5

G.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 11 REA sites around Moloka'i Island to assess benthic composition, coral community structure, and coral and algal disease; 4 water samples and 22 coral/algal biopsies were collected for microbial analyses (Fig. G.2.1 and Table G.2.1). For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

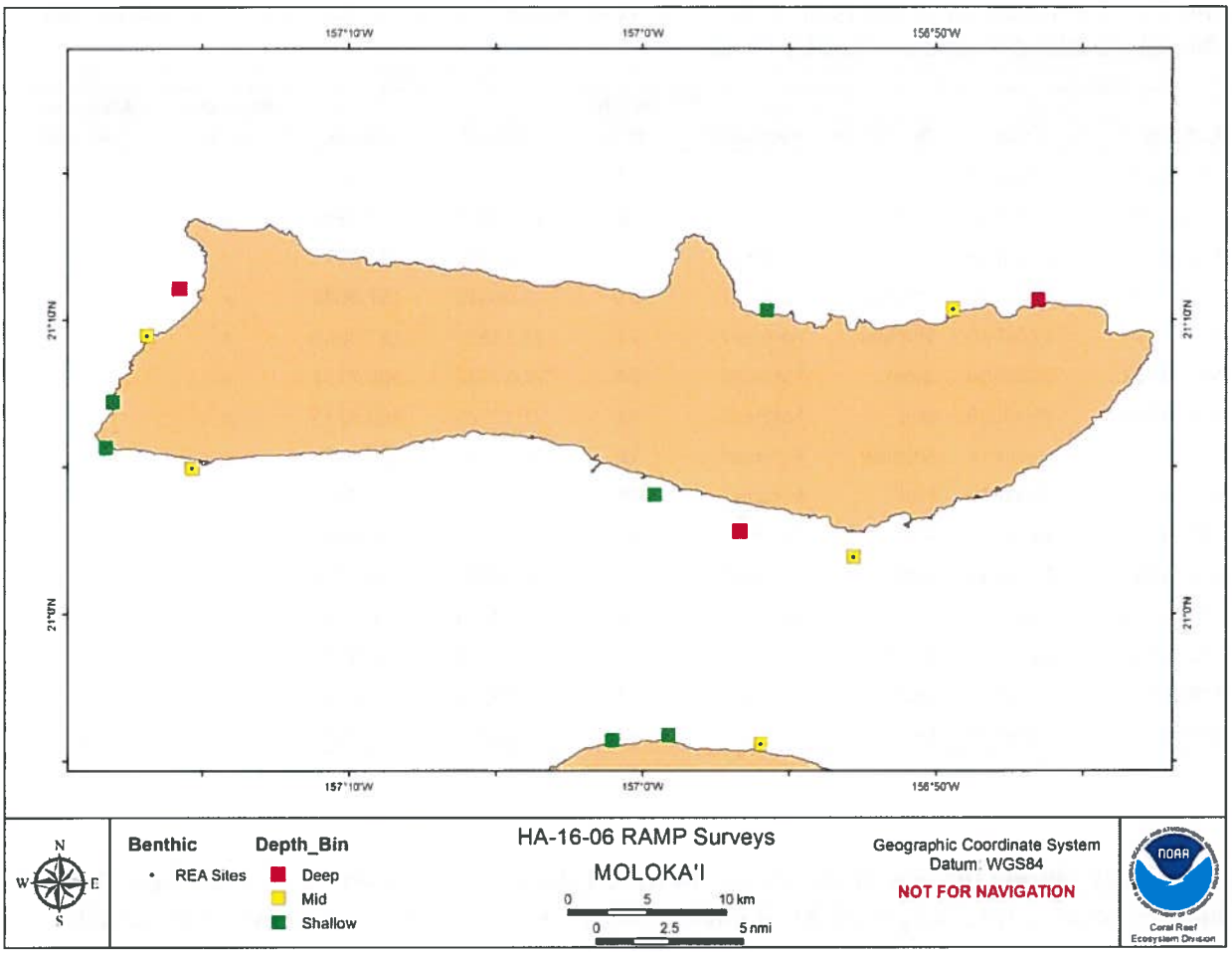

Figure G.2.1.--Locations of benthic REA sites surveyed at Moloka'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table G.2.1.--Summary of the benthic REA surveys and microbial water collections performed at Moloka'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
MOL-2099	17-Jul-16	Deep	Forereef	64	21.18461	-157.2626	x	
MOL-2105	17-Jul-16	Mid	Forereef	28	21.08267	-157.2556	x	
MOL-2115	17-Jul-16	Mid	Forereef	31	21.15766	-157.2811	x	
MOL-2116	17-Jul-16	Shallow	Forereef	21	21.09418	-157.3042	x	
MOL-2126	17-Jul-16	Shallow	Forereef	21	21.11992	-157.3003	x	
MOL-1939	19-Jul-16	Deep	Forereef	64	21.17782	-156.7752	x	
MOL-1953	19-Jul-16	Mid	Forereef	45	21.17276	-156.8235	x	
MOL-1977	19-Jul-16	Shallow	Forereef	18	21.17176	-156.9291	x	
MOL-23	19-Jul-16	Mid	Forereef	48	21.17694	-156.7605		x
MOL-24	19-Jul-16	Mid	Forereef	48	21.20705	-156.9847		x
MOL-1997	20-Jul-16	Deep	Forereef	74	21.04704	-156.9442	x	
MOL-2036	20-Jul-16	Mid	Forereef	51	21.03225	-156.8797	x	
MOL-2057	20-Jul-16	Shallow	Forereef	17	21.0674	-156.9931	x	
MOL-20	20-Jul-16	Mid	Forereef	43	21.03574	-156.8904		x
MOL-21	20-Jul-16	Mid	Forereef	53	21.08299	-157.0642		x

Additionally, during the HA-16-06 cruise, 14 towed-diver surveys were completed around Maui Island, covering a total length of 30.89 km (an area of 30.89 ha) of the ocean floor (Fig. G.2.2).

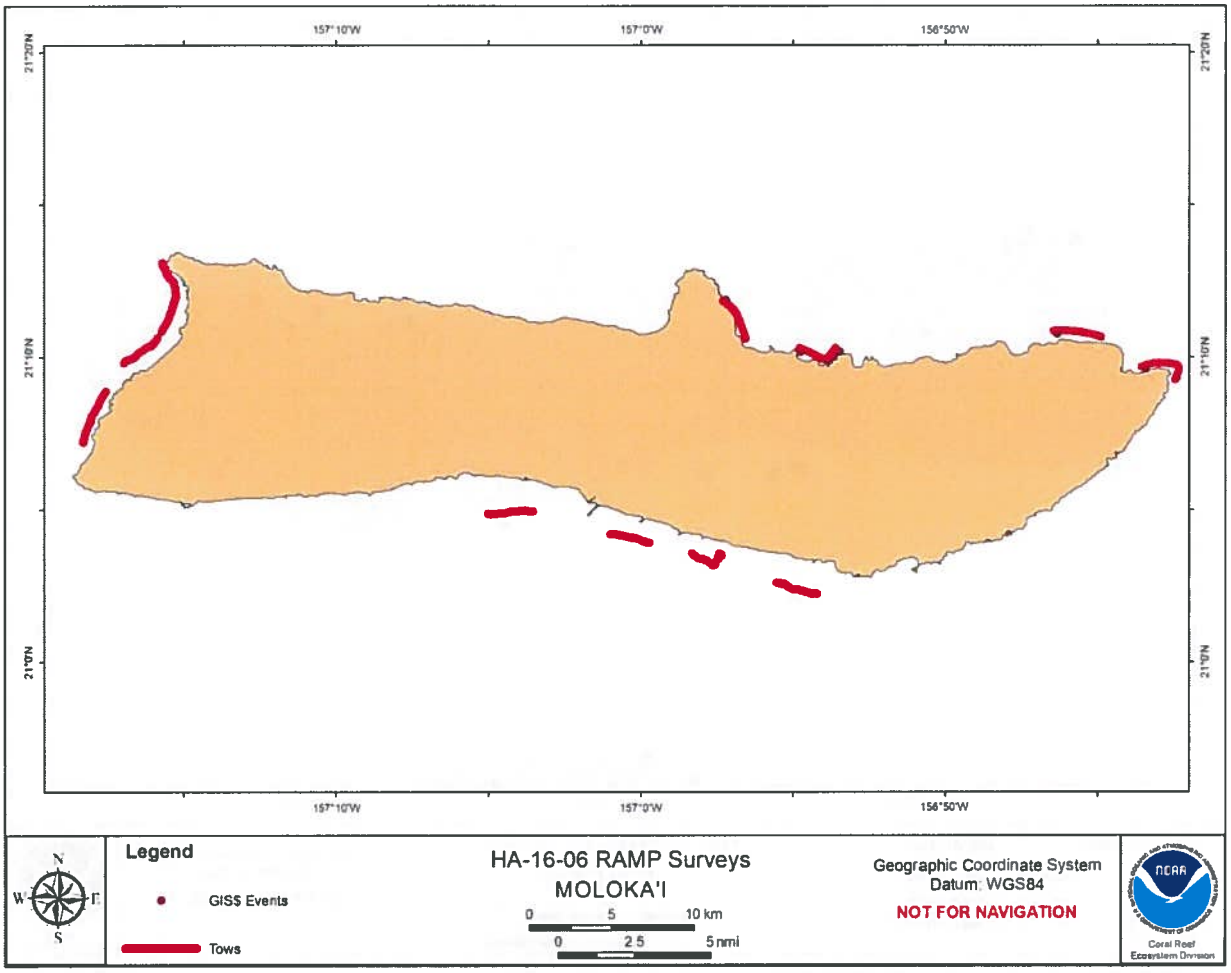

Figure G.2.2.--Track locations of towed-diver surveys conducted at Moloka'i Island during the cruise HA-16-06.

G.3. Biological Monitoring: Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 23 REA sites at Maui Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig. G.3.1 and Table G.3.1). No fishes were collected during these surveys.

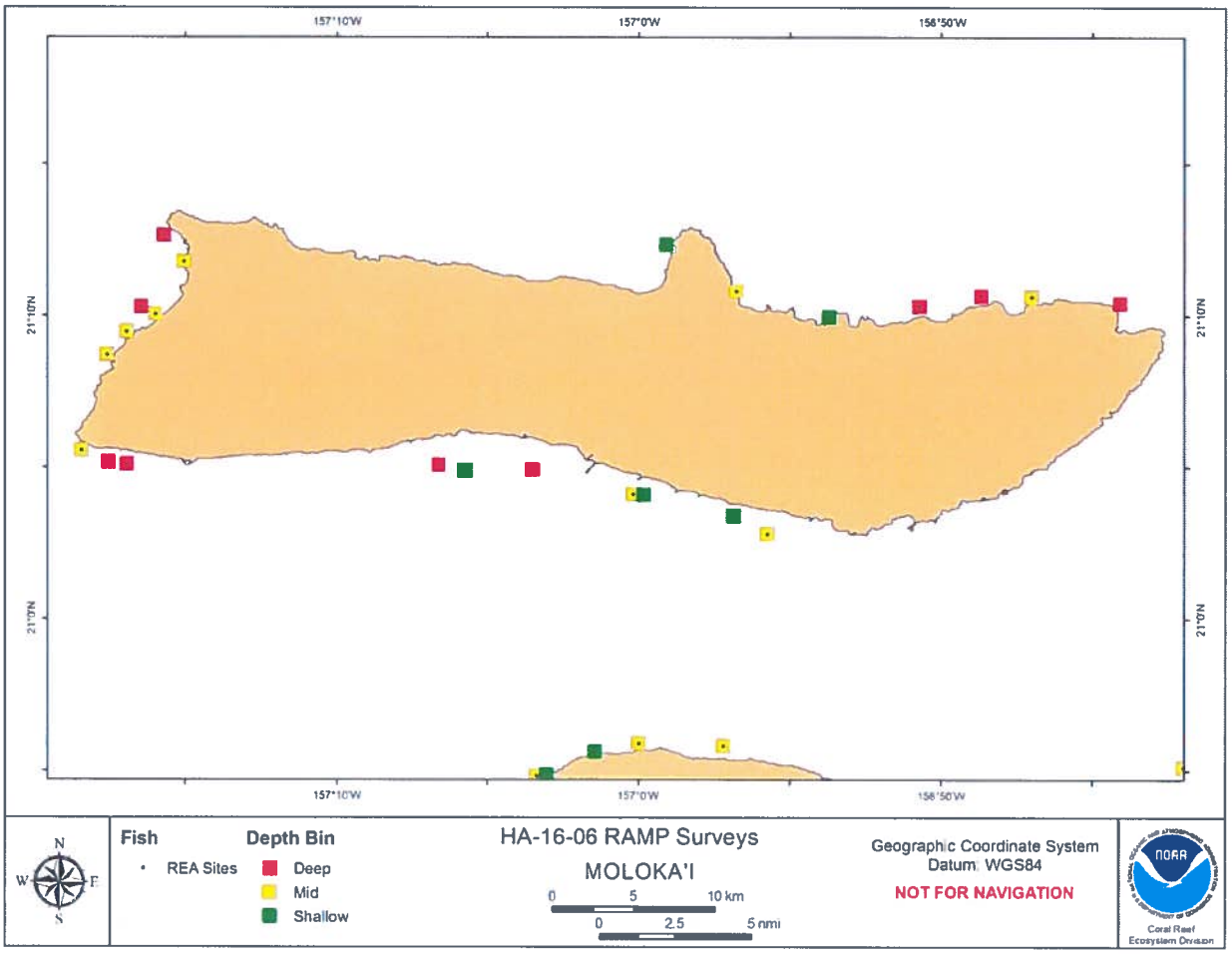

Figure G.3.1.--Locations of REA fish sites surveyed at Moloka'i Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table G.3.1.--Summary of sites where REA fish surveys were conducted at Moloka'i Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth_(m)	Latitude	Longitude
MOL-1665	19-Jul-16	Shallow	Forereef	4.3	21.20574	-156.98443
MOL-1711	19-Jul-16	Deep	Forereef	20	21.17751	-156.81099
MOL-1716	19-Jul-16	Deep	Forereef	22.9	21.1719	-156.84514
MOL-1721	19-Jul-16	Deep	Forereef	27.1	21.17362	-156.73443
MOL-1726	19-Jul-16	Moderate	Forereef	12.2	21.17701	-156.7835
MOL-1727	19-Jul-16	Moderate	Forereef	14.4	21.18018	-156.94554
MOL-1733	19-Jul-16	Shallow	Forereef	5.3	21.16608	-156.89478
MOL-1742	20-Jul-16	Deep	Forereef	22	21.08214	-157.05834
MOL-1746	20-Jul-16	Deep	Forereef	22.3	21.08444	-157.11011
MOL-1750	20-Jul-16	Moderate	Forereef	9	21.06847	-157.00265
MOL-1751	20-Jul-16	Moderate	Forereef	9.1	21.04668	-156.92863
MOL-1755	20-Jul-16	Shallow	Forereef	5.2	21.08181	-157.09545
MOL-1758	20-Jul-16	Shallow	Forereef	4.5	21.0681	-156.99697
MOL-1764	20-Jul-16	Shallow	Forereef	4.7	21.05702	-156.94734
MOL-1773	17-Jul-16	Deep	Forereef	19.6	21.08491	-157.2823
MOL-1776	17-Jul-16	Deep	Forereef	25	21.21069	-157.26159
MOL-1777	17-Jul-16	Deep	Forereef	20.4	21.17154	-157.27417
MOL-1778	17-Jul-16	Deep	Forereef	21.6	21.08606	-157.29291
MOL-1785	17-Jul-16	Moderate	Forereef	12.5	21.09256	-157.30717
MOL-1792	17-Jul-16	Moderate	Forereef	9.5	21.16761	-157.266
MOL-1794	17-Jul-16	Moderate	Forereef	15	21.1452	-157.29313
MOL-1799	17-Jul-16	Moderate	Forereef	11.8	21.15768	-157.28231
MOL-1800	17-Jul-16	Moderate	Forereef	7.8	21.19636	-157.25059

APPENDIX H: NI'IHAU ISLAND

The island of Ni'ihau located at 21°52′ N, 160°09′ W in the north Pacific, is one of the main Hawaiian Islands. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: "Methods."

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

Oceanographic operations during the cruise HA-16-06 at Ni'ihau Island a the retrieval and deployment of subsurface temperature recorders (STRs), calcification acidification units (CAUs), and near-shore water sampling, and conductivity-temperature-depth (CTD) casts at select NCRMP sites.

At nearshore locations around Maui Island, 5 shallow-water CTD casts were performed; 6 water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 3 water samples for nutrient analyses. In addition, 1 STR was retrieved and 1 STR deployed; 8 CAUs were retrieved and 10 deployed at 2 locations around the island. (Fig. H.1.1and Table H.1.1).

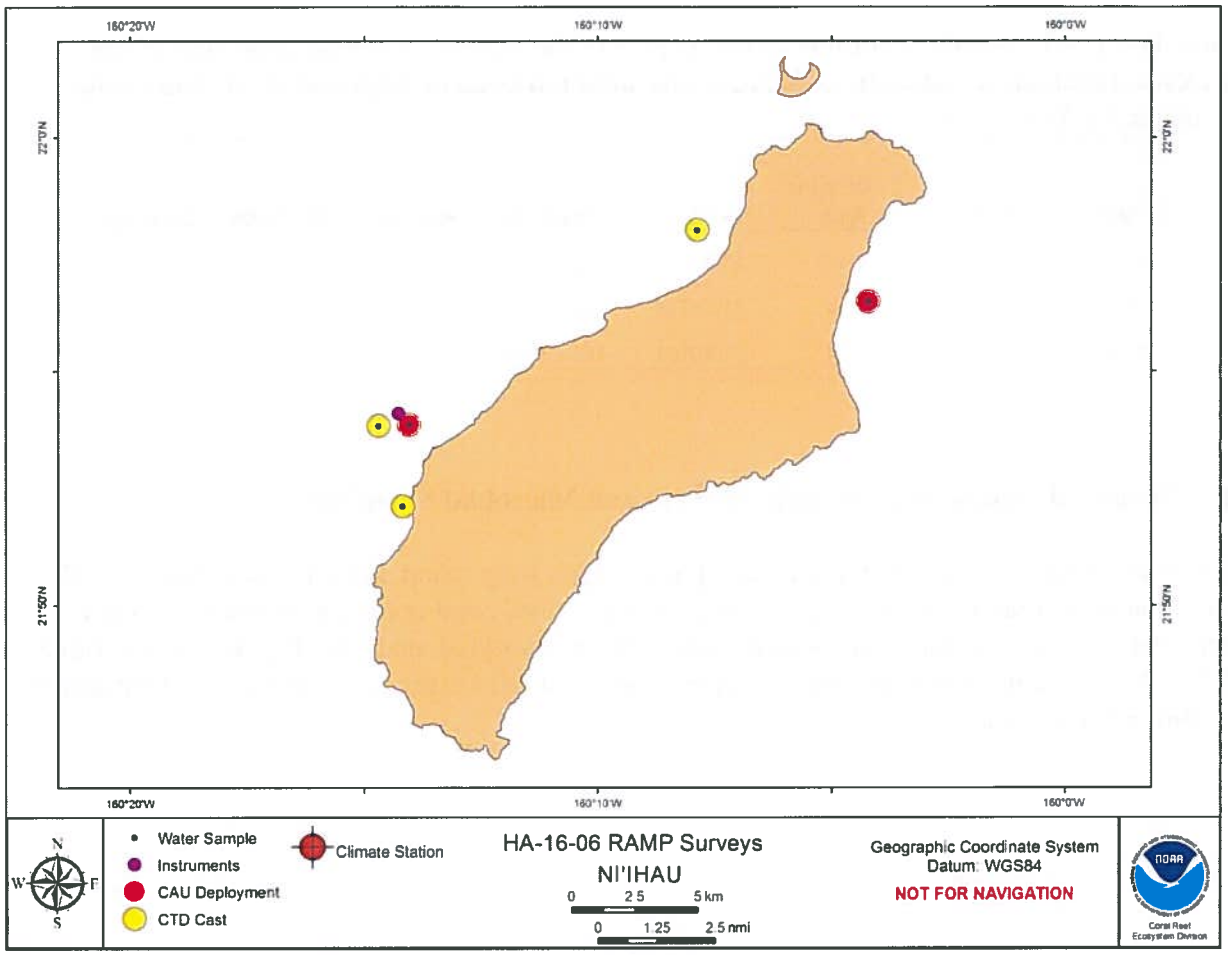

Figure H.1.1.--Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at Ni'ihau Island during cruise HA-16-06.

Table H.1.1.--Geographic coordinates and depths of the moored oceanographic instruments (STR) and biological installations (CAUs) that were retrieved or deployed at Ni'ihau Island during cruise HA-16-06.

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
NII-10	29-Jul-16	CAU	21.94135	-160.07004	15.9	5	5
NII-11	28-Jul-16	CAU	21.89758	-160.23390	15.9	3	5
NII-11	28-Jul-16	STR	21.90161	-160.23768	26.8	1	1

H.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 5 REA sites around Ni'ihau Island to assess benthic composition, coral community structure, and coral and algal disease; 4 water samples were collected for microbial analyses (Fig. H.2.1 and Table H.2.1). For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

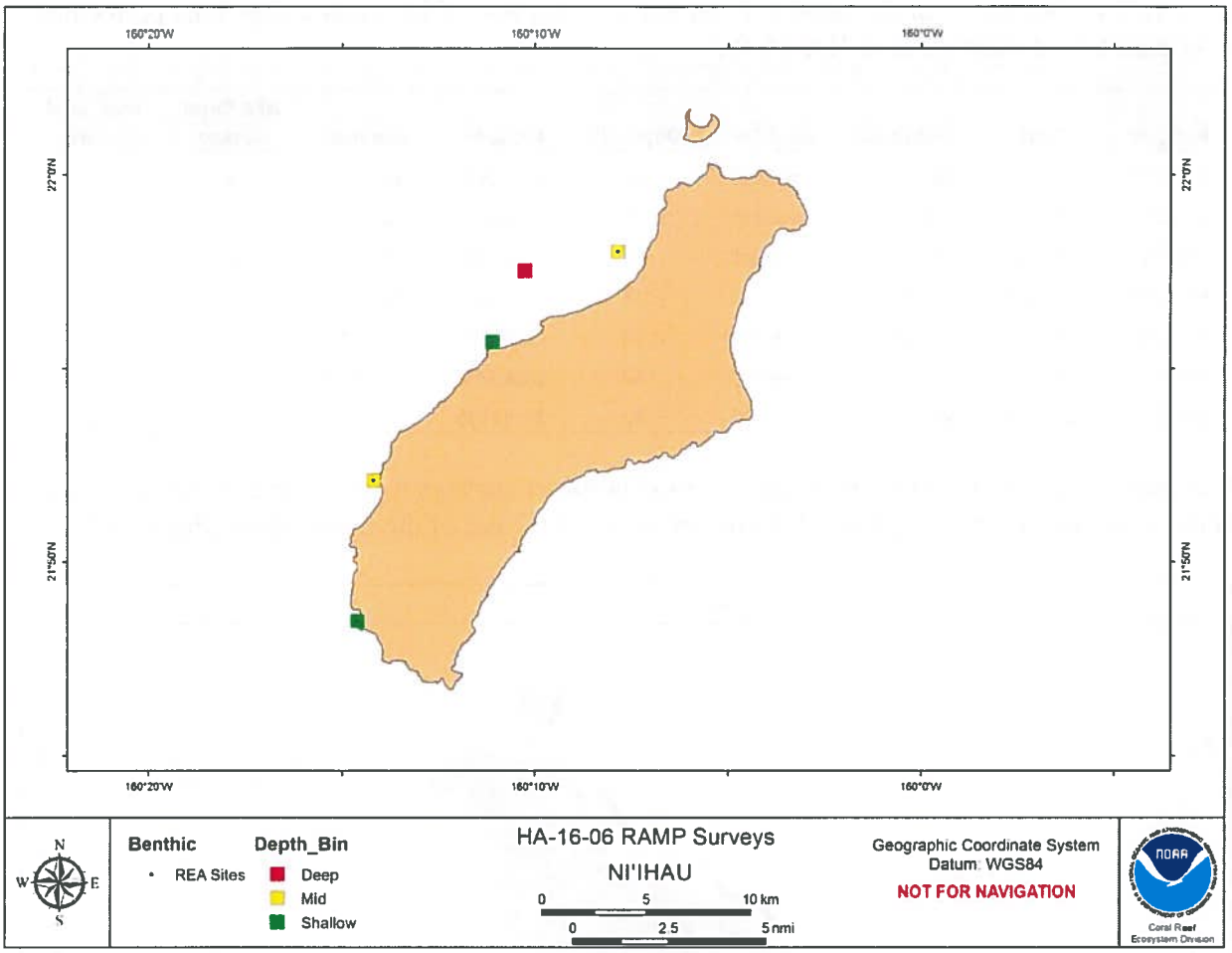

Figure H.2.1.--Locations of benthic REA sites surveyed at Ni'ihau Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table H.2.1.--Summary of the benthic REA surveys and microbial water collections performed at Ni'ihau Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
NII-1694	28-Jul-16	Deep	Forereef	82	21.95884	-160.1709	x	
NII-1719	28-Jul-16	Mid	Forereef	39	21.86845	-160.2363	x	
NII-1726	28-Jul-16	Mid	Forereef	51	21.96689	-160.1311	x	
NII-1736	28-Jul-16	Shallow	Forereef	18	21.9281	-160.1851	x	
NII-1745	28-Jul-16	Shallow	Forereef	18	21.80794	-160.2433	x	
NII-11	28-Jul-16	Mid	Forereef	52	21.89758	-160.2339		x
NII-10	29-Jul-16	Mid	Forereef	52	21.94135	-160.07		x

Additionally, during the HA-16-06 cruise, 5 towed-diver surveys were completed around Maui Island, covering a total length of 11.7 km (an area of 11.7 ha) of the ocean floor (Fig. H.2.2).

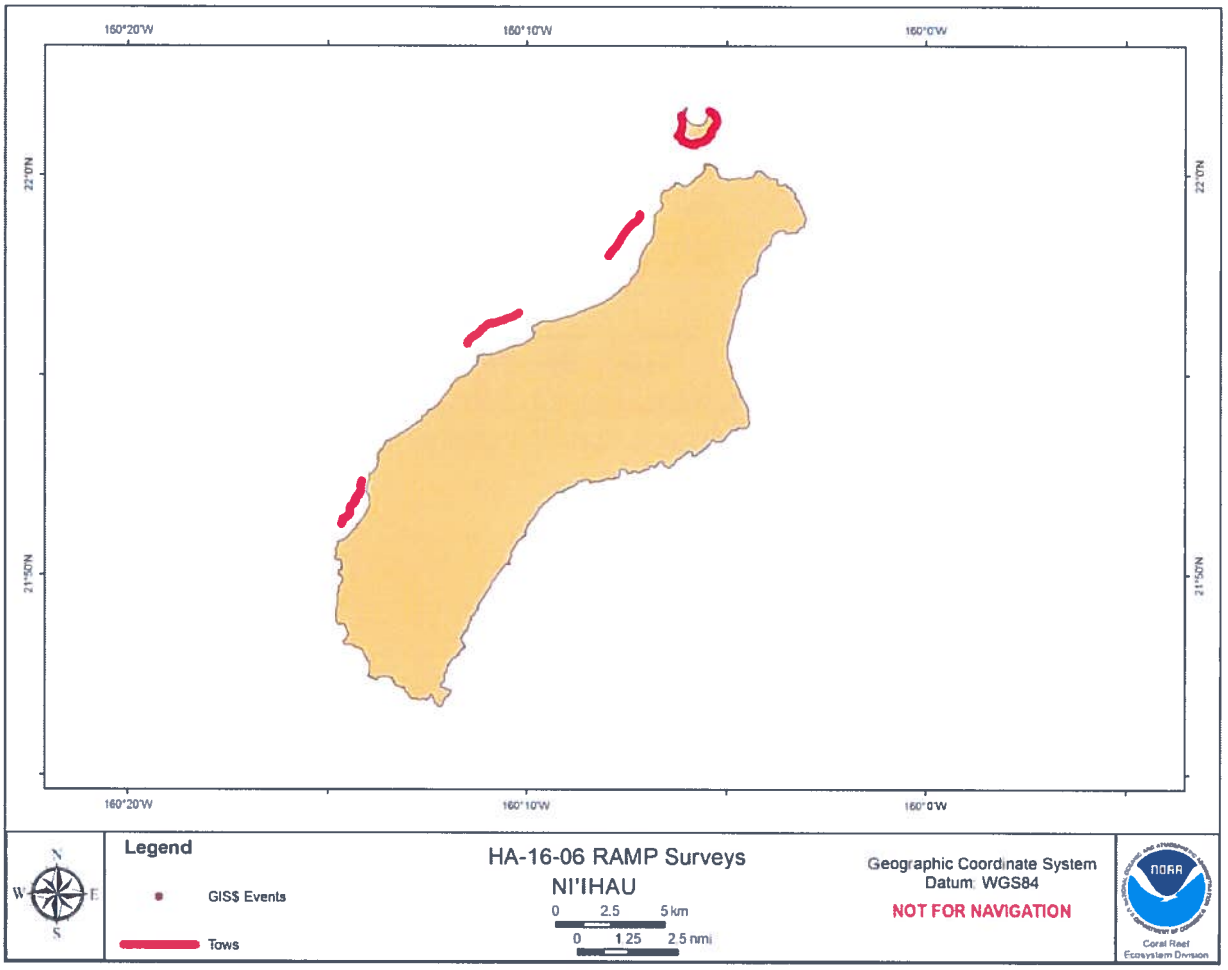

Figure H.2.2.--Track locations of towed-diver surveys conducted at Ni'ihau Island during the cruise HA-16-06.

H.3. Biological Monitoring: Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 12 REA sites at Ni'ihau Island and Lehua Rock over 3 different habitat strata: deep, moderate, and shallow forereef (Fig. H.3.1 and Table H.3.1). No fishes were collected during these surveys.

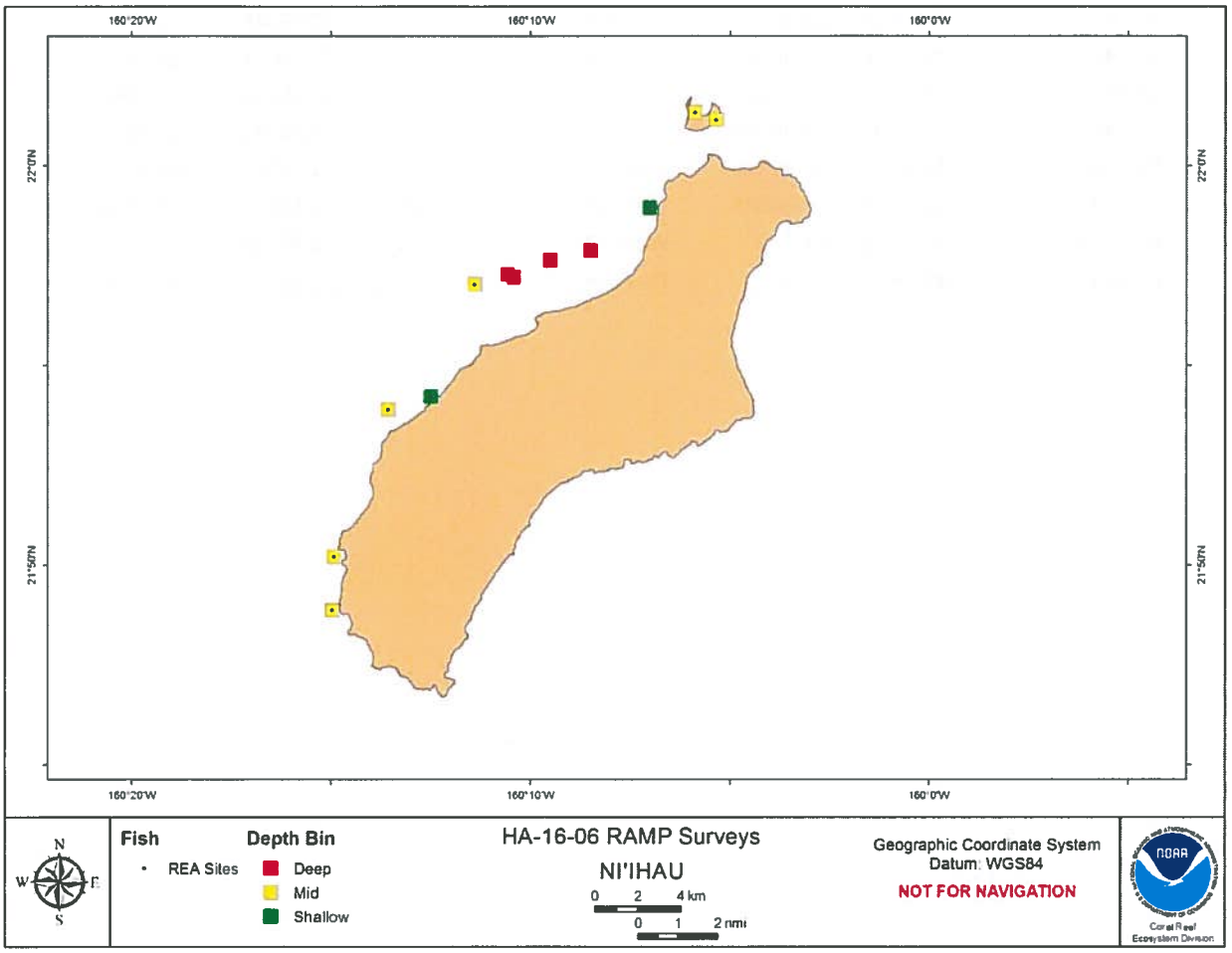

Figure H.3.1.--Locations of REA fish sites surveyed at Ni'ihau Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table H.3.1.--Summary of sites where REA fish surveys were conducted at Ni'ihau Island and Lehua Rock during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
NII-1462	28-Jul-16	Moderate	Forereef	15	22.01924	-160.08882
NII-1469	28-Jul-16	Moderate	Forereef	13	22.02234	-160.0978
NII-1476	29-Jul-16	Deep	Forereef	25.3	21.9606	-160.15813
NII-1479	28-Jul-16	Deep	Forereef	21	21.95368	-160.17312
NII-1481	28-Jul-16	Deep	Forereef	21.2	21.96449	-160.1414
NII-1486	28-Jul-16	Moderate	Forereef	12.3	21.81443	-160.2492
NII-1488	28-Jul-16	Shallow	Forereef	3.9	21.90363	-160.20821
NII-1489	28-Jul-16	Moderate	Forereef	15	21.89831	-160.22614
NII-1490	28-Jul-16	Moderate	Forereef	13	21.95062	-160.18964
NII-1493	28-Jul-16	Moderate	Forereef	8.8	21.83682	-160.2485
NII-1880	29-Jul-16	Shallow	Forereef	5.5	21.98248	-160.11685
NII-1881	29-Jul-16	Deep	Forereef	20.4	21.95482	-160.17575

APPENDIX I: O'AHU ISLAND

The island of O'ahu located at 21°25′ N, 157°59′ W in the north Pacific, is one of the main Hawaiian Islands. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: "Methods."

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

Oceanographic operations during the cruise HA-16-06 at O'ahu Island 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), near-shore water sampling, and conductivity-temperature-depth (CTD) casts at select NCRMP sites.

At nearshore locations around O'ahu Island, 20 shallow-water CTD casts were performed; 25 water samples were collected for analysis of dissolved inorganic carbon (DIC), total alkalinity (TA), and salinity, and 8 water samples for nutrient analyses. In addition, 8 STRs were retrieved and 9 STRs were deployed; 9 ARMS were recovered and processed for taxonomic analysis and 12 ARMS were deployed. Thirty-four CAUs were retrieved and 25 deployed at 5 locations around the island, and 20 BMUs were retrieved and 20 deployed collocated with CAUs at the NCRMP monitoring stations. (Fig. I.1.1and Table I.1.1).

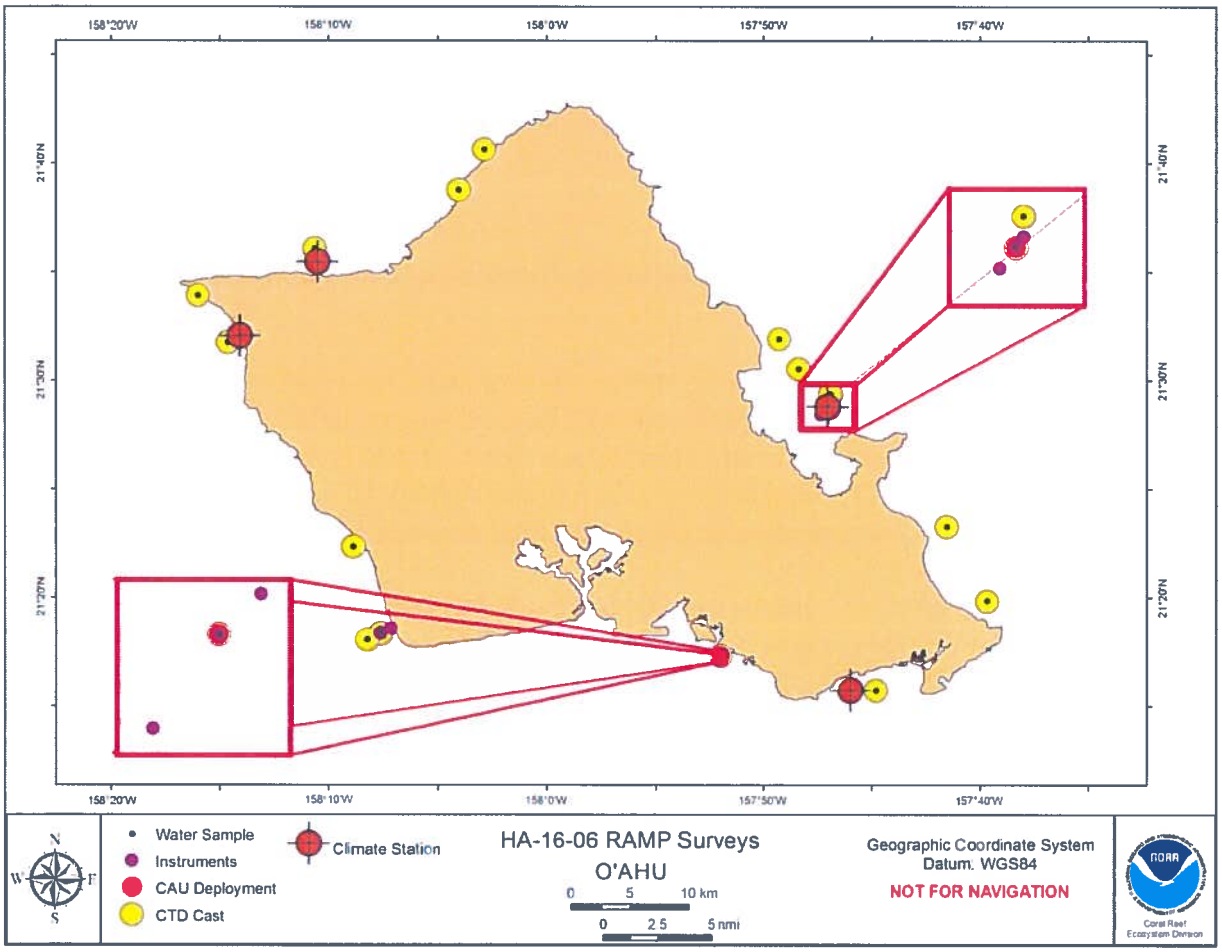

Figure I.1.1.--Mooring sites where oceanographic instruments and biological installations were retrieved or deployed and locations of near-shore CTD casts and water sampling performed at O'ahu Island during cruise HA-16-06.

Table I.1.1.--Geographic coordinates and depths of the moored oceanographic instruments (STR) and biological installations (ARMS, CAUs, and BMUs) that were retrieved or deployed at O'ahu Island during cruise HA-16-06.

Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
OAH-23	30-Jul-16	STR	21.28836	-157.86536	12.8	–	1
OAH-23	30-Jul-16	STR	21.28484	-157.86786	27.1	–	1
OAH-23	30-Jul-16	STR	21.28836	-157.86536	12.8	1	–
OAH-23	30-Jul-16	STR	21.28990	-157.86376	5.5	1	1
OAH-23	30-Jul-16	STR	21.28484	-157.86786	27.1	1	–
OAH-23	17-Aug-16	ARMS	21.28838	-157.86536	13.7	3	3
OAH-23	17-Aug-16	BMU	21.28838	-157.86536	13.7	5	5
OAH-23	17-Aug-16	CAU	21.28838	-157.86536	13.7	5	5
OAH-01	18-Aug-16	CAU	21.31183	-158.12737	10.7	5	–
OAH-21	18-Aug-16	ARMS	21.30557	-158.12621	14.6	3	–
OAH-21	18-Aug-16	BMU	21.30557	-158.12621	14.6	5	–
OAH-21	18-Aug-16	CAU	21.30557	-158.12621	14.6	5	–
OAH-21	18-Aug-16	STR	21.30950	-158.11833	5.2	1	–
OAH-21	18-Aug-16	STR	21.30577	-158.12653	25.9	1	–
OAH-21	18-Aug-16	STR	21.30557	-158.12621	14.6	1	–
OAH-04	19-Aug-16	CAU	21.53413	-158.23437	12.8	4	–
OAH-25	19-Aug-16	ARMS	21.53412	-158.23441	14.6	–	3
OAH-25	19-Aug-16	BMU	21.53412	-158.23441	14.6	–	5
OAH-25	19-Aug-16	CAU	21.53412	-158.23441	14.6	–	5
OAH-25	19-Aug-16	STR	21.53412	-158.23440	14.6	–	1
OAH-20	20-Aug-16	ARMS	21.59095	-158.17462	15.3	–	3
OAH-20	20-Aug-16	BMU	21.59095	-158.17462	15.3	–	5
OAH-20	20-Aug-16	CAU	21.59095	-158.17462	15.3	–	5
OAH-20	20-Aug-16	STR	21.59095	-158.17462	14.6	–	1
OAH-20	20-Aug-16	STR	21.59244	-158.17481	24.7	–	1
OAH-22	22-Aug-16	ARMS	21.47979	-157.78300	12.8	3	3
OAH-22	22-Aug-16	STR	21.47979	-157.78300	12.5	–	1
OAH-22	22-Aug-16	STR	21.48301	-157.78079	24.7	1	1
OAH-22	22-Aug-16	STR	21.47359	-157.78805	5.5	–	1
OAH-22	22-Aug-16	STR	21.47979	-157.78300	12.5	1	–
OAH-22	22-Aug-16	STR	21.47359	-157.78805	5.5	1	–
OAH-22	23-Aug-16	BMU	21.47971	-157.78301	12.5	5	5
OAH-22	23-Aug-16	CAU	21.47971	-157.78301	12.5	5	5
OAH-471	23-Aug-16	CAU	21.50842	-157.80524	14.6	5	–
OAH-24	24-Aug-16	BMU	21.26187	-157.76553	14.6	5	–
OAH-24	24-Aug-16	CAU	21.26187	-157.76553	14.6	5	5

I.2. Biological Monitoring: Benthic Surveys and Microbial Sampling

Belt-transect surveys were conducted and photographs were taken along transect lines at 32 REA sites around O'ahu Island to assess benthic composition, coral community structure, and coral and algal disease; 8 water samples and 22 coral/algal biopsies were collected for microbial analyses (Fig. I.2.1 and Table I.2.1). No towed-diver surveys were conducted around O'ahu. For more information about collections made at REA sites, see Table J.1.1 in Appendix J: "Biological Collections."

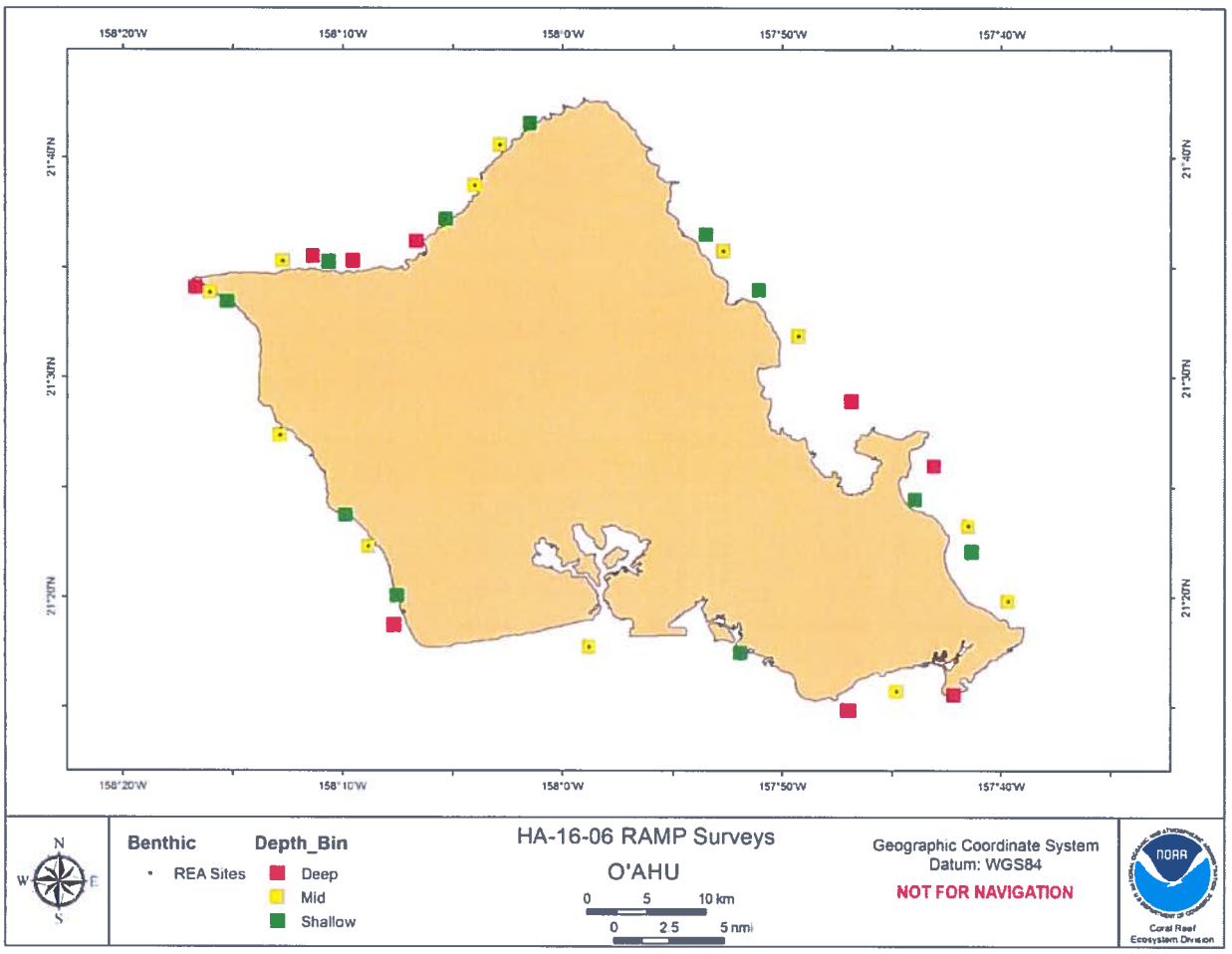

Figure I.2.1.--Locations of benthic REA sites surveyed at O'ahu Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table I.2.1.--Summary of the benthic REA surveys and microbial water collections performed at O'ahu Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (ft)	Latitude	Longitude	REA Coral Survey	Microbial Samples
OAH-2810	17-Aug-16	Deep	Forereef	63	21.24728	-157.7825	x	
OAH-2817	17-Aug-16	Shallow	Forereef	18	21.29099	-157.865	x	
OAH-2833	17-Aug-16	Mid	Forereef	44	21.29558	-157.9794	x	
OAH-2846	17-Aug-16	Mid	Forereef	51	21.26175	-157.7458	x	
OAH-23	17-Aug-16	Mid	Forereef	45	21.28838	-157.8654		x
OAH-23	17-Aug-16	Mid	Forereef	43	21.27915	-157.8705		x
OAH-2814	18-Aug-16	Deep	Forereef	67	21.31227	-158.1279	x	
OAH-2858	18-Aug-16	Mid	Forereef	46	21.37195	-158.1467	x	
OAH-2906	18-Aug-16	Shallow	Forereef	18	21.39559	-158.1645	x	
OAH-2909	18-Aug-16	Shallow	Forereef	16	21.33438	-158.1253	x	
OAH-2594	19-Aug-16	Deep	Forereef	71	21.56848	-158.2782	x	
OAH-2597	19-Aug-16	Shallow	Forereef	19	21.5575	-158.2542	x	
OAH-2605	19-Aug-16	Mid	Forereef	41	21.56482	-158.2672	x	
OAH-2843	19-Aug-16	Mid	Forereef	28	21.45644	-158.2143	x	
OAH-2588	20-Aug-16	Deep	Forereef	76	21.59221	-158.1892	x	
OAH-2621	20-Aug-16	Mid	Forereef	31	21.58847	-158.212	x	
OAH-2643	20-Aug-16	Shallow	Forereef	17	21.58785	-158.1772	x	
OAH-2749	20-Aug-16	Deep	Forereef	70	21.58887	-158.1594	x	
OAH-2758	20-Aug-16	Deep	Forereef	75	21.60362	-158.1108	x	
OAH-2766	20-Aug-16	Mid	Forereef	28	21.67683	-158.0476	x	
OAH-2781	20-Aug-16	Mid	Forereef	42	21.64586	-158.0669	x	
OAH-2794	20-Aug-16	Shallow	Forereef	16	21.69301	-158.0248	x	
OAH-2796	20-Aug-16	Shallow	Forereef	12	21.62052	-158.0887	x	
OAH-2518	22-Aug-16	Deep	Forereef	74	21.43288	-157.7176	x	
OAH-2521	22-Aug-16	Mid	Forereef	15	21.38737	-157.6906	x	
OAH-2538	22-Aug-16	Mid	Forereef	41	21.33058	-157.6603	x	
OAH-2556	22-Aug-16	Shallow	Forereef	17	21.3676	-157.6886	x	
OAH-2564	22-Aug-16	Shallow	Forereef	53	21.4074	-157.7322	x	
OAH-22	22-Aug-16	Mid	Forereef	42	21.47979	-157.783		x
OAH-2650	23-Aug-16	Deep	Forereef	70	21.48246	-157.7805	x	
OAH-2667	23-Aug-16	Mid	Forereef	41	21.59627	-157.8779	x	
OAH-2687	23-Aug-16	Mid	Forereef	43	21.53146	-157.8204	x	
OAH-2729	23-Aug-16	Shallow	Forereef	20	21.56703	-157.8518	x	
OAH-2739	23-Aug-16	Shallow	Forereef	20	21.60874	-157.8915	x	
OAH-2569	24-Aug-16	Deep	Forereef	83	21.2591	-157.7023	x	

I.3. Biological Monitoring: Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 54 REA sites at O'ahu Island over 3 different habitat strata: deep, moderate, and shallow forereef (Fig. I.3.1 and Table I.3.1). No fishes were collected during these surveys.

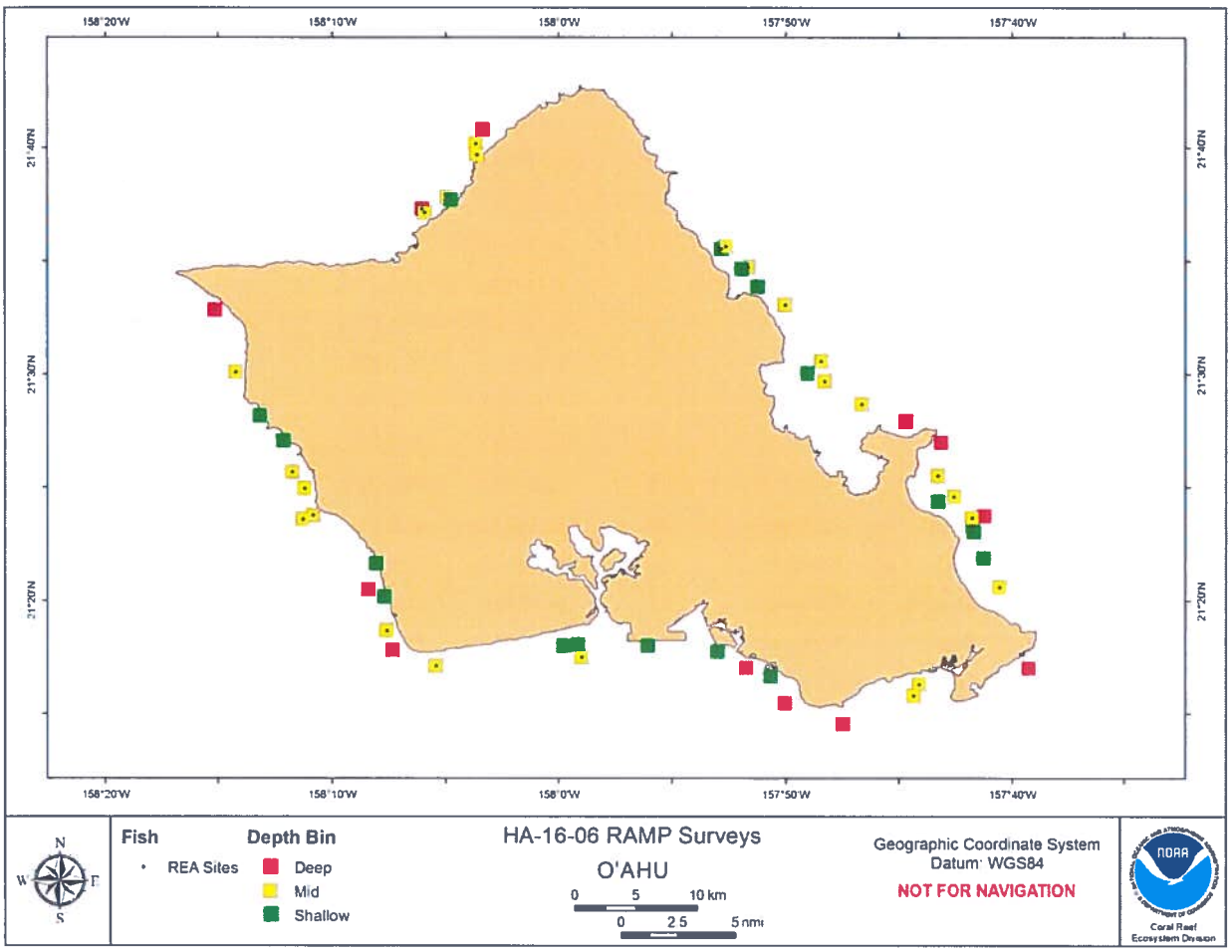

Figure I.3.1.--Locations of REA fish sites surveyed at O'ahu Island during cruise HA-16-06. All of these REA sites were selected using a stratified random design.

Table I.3.1.--Summary of sites where REA fish surveys were conducted at O'ahu Island during cruise HA-16-06.

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
OAH-2206	22-Aug-16	Deep	Forereef	19.8	21.28341	-157.65396
OAH-2214	22-Aug-16	Deep	Forereef	24.7	21.44967	-157.71846
OAH-2217	22-Aug-16	Deep	Forereef	25.5	21.39532	-157.68669
OAH-2223	22-Aug-16	Moderate	Forereef	13.4	21.40955	-157.70898
OAH-2235	22-Aug-16	Moderate	Forereef	15	21.42502	-157.7208
OAH-2236	22-Aug-16	Moderate	Forereef	12.8	21.3431	-157.67551
OAH-2237	22-Aug-16	Moderate	Forereef	12	21.39415	-157.69536
OAH-2239	22-Aug-16	Shallow	Forereef	6.1	21.38831	-157.6956
OAH-2251	22-Aug-16	Shallow	Forereef	3.6	21.40638	-157.72053
OAH-2264	22-Aug-16	Shallow	Forereef	5.5	21.38386	-157.69464
OAH-2270	22-Aug-16	Shallow	Forereef	4.9	21.36482	-157.68778
OAH-2276	23-Aug-16	Deep	Forereef	28.5	21.46566	-157.74437
OAH-2281	23-Aug-16	Moderate	Forereef	11.5	21.50954	-157.80633
OAH-2282	23-Aug-16	Moderate	Forereef	8.8	21.55116	-157.83326
OAH-2287	23-Aug-16	Moderate	Forereef	11.5	21.59396	-157.87692
OAH-2292	23-Aug-16	Moderate	Forereef	8.6	21.49481	-157.80389
OAH-2298	23-Aug-16	Moderate	Forereef	9.1	21.57877	-157.86042
OAH-2299	23-Aug-16	Moderate	Forereef	16.1	21.47787	-157.77684
OAH-2304	23-Aug-16	Shallow	Forereef	5.4	21.50069	-157.81689
OAH-2306	23-Aug-16	Shallow	Forereef	4.6	21.57734	-157.86554
OAH-2310	23-Aug-16	Shallow	Forereef	4.8	21.56441	-157.85343
OAH-2316	23-Aug-16	Shallow	Forereef	5.5	21.59202	-157.88025
OAH-2322	20-Aug-16	Deep	Forereef	22.1	21.62153	-158.10004
OAH-2330	20-Aug-16	Deep	Forereef	24.6	21.6807	-158.0564
OAH-2337	20-Aug-16	Moderate	Forereef	15.6	21.6614	-158.05996
OAH-2347	20-Aug-16	Moderate	Forereef	8.5	21.61876	-158.0982
OAH-2351	20-Aug-16	Moderate	Forereef	10.3	21.66982	-158.06085
OAH-2365	20-Aug-16	Moderate	Forereef	9.1	21.63004	-158.08193
OAH-2383	20-Aug-16	Shallow	Forereef	4.6	21.62812	-158.07916
OAH-2387	17-Aug-16	Moderate	Forereef	15.9	21.26314	-157.73876
OAH-2390	18-Aug-16	Moderate	Forereef	16	21.42802	-158.1955
OAH-2391	18-Aug-16	Moderate	Forereef	7.3	21.31121	-158.12583
OAH-2395	18-Aug-16	Moderate	Forereef	10.7	21.28493	-158.0899
OAH-2398	18-Aug-16	Moderate	Forereef	15	21.39294	-158.18765
OAH-2399	18-Aug-16	Moderate	Forereef	12.2	21.39602	-158.18
OAH-2405	17-Aug-16	Moderate	Forereef	15.2	21.29148	-157.98245
OAH-2406	19-Aug-16	Moderate	Forereef	11.6	21.50144	-158.23693
OAH-2407	17-Aug-16	Moderate	Forereef	12.5	21.27137	-157.73445

REA Site	Date	Depth Bin	Reef Zone	Depth (m)	Latitude	Longitude
OAH-2408	18-Aug-16	Moderate	Forereef	9.1	21.41568	-158.18632
OAH-2412	19-Aug-16	Shallow	Forereef	4.9	21.45102	-158.20233
OAH-2414	17-Aug-16	Shallow	Forereef	5.1	21.29569	-157.88285
OAH-2415	17-Aug-16	Shallow	Forereef	4.2	21.29994	-157.99609
OAH-2416	19-Aug-16	Shallow	Forereef	3.4	21.46914	-158.21944
OAH-2417	18-Aug-16	Shallow	Forereef	4.2	21.33605	-158.12787
OAH-2418	18-Aug-16	Shallow	Forereef	3.6	21.36039	-158.1337
OAH-2420	17-Aug-16	Shallow	Forereef	5.7	21.27756	-157.84376
OAH-2431	17-Aug-16	Shallow	Forereef	5.8	21.29991	-157.9341
OAH-2432	17-Aug-16	Shallow	Forereef	5.5	21.30093	-157.98561
OAH-2437	17-Aug-16	Deep	Forereef	25.8	21.28362	-157.86229
OAH-2445	17-Aug-16	Deep	Forereef	19.1	21.25794	-157.83388
OAH-2447	17-Aug-16	Deep	Forereef	24.1	21.24259	-157.79143
OAH-2456	18-Aug-16	Deep	Forereef	27	21.29703	-158.12244
OAH-2460	18-Aug-16	Deep	Forereef	23	21.34149	-158.13988
OAH-2461	19-Aug-16	Deep	Forereef	25.6	21.54716	-158.252

APPENDIX J: BIOLOGICAL COLLECTIONS

Biological and other samples were collected at Hawai'i, Kaho'olawe, Kaua'i, Lāna'i, Maui, Moloka'i, Ni'ihau, and O'ahu islands, and their surrounding waters for multiple research purposes. These collections are listed here in Table J.1.1.

Table J.1.1.--Samples collected at, Hawai'i, Kaho'olawe, Kaua'i, Lāna'i, Maui, Moloka'i, Ni'ihau, and O'ahu for microbial and ocean acidification analyses during cruise HA-16-06.

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
			MICROBIAL COLLECTIONS: WATER SAMPLES			
MAI-90	13-Jul-16	20.704847	-156.450523	2 L	2	8.5
MAI-30	14-Jul-16	20.86862	-156.14632	2 L	2	14.6
KAH-90	15-Jul-16	20.55276	-156.6794	2 L	3	9.1
KAH-90	15-Jul-16	20.55276	-156.6794	20 L	0.5	9.1
MAI-91	16-Jul-16	20.95183	-156.69183	2 L	3	6.1
MAI-91	16-Jul-16	20.95183	-156.69183	20 L	0.5	6.1
LAN-11	18-Jul-16	20.9265	-156.93851	2 L	3	13.7
LAN-11	18-Jul-16	20.9265	-156.93851	20 L	0.5	13.7
MOL-23	19-Jul-16	21.17694	-156.76048	2 L	3.5	14.6
MOL-23	19-Jul-16	21.17694	-156.76048	20 L	0.5	14.6
MOL-20	20-Jul-16	21.03574	-156.89038	2 L	2.5	13.1
MOL-20	20-Jul-16	21.03574	-156.89038	20 L	0.5	13.1
LAN-12	21-Jul-16	20.73726	-156.91579	2 L	4	14.9
LAN-12	21-Jul-16	20.73726	-156.91579	20 L	0.5	14.9
KAU-22	23-Jul-16	21.87666	-159.52551	2 L	4	14.6
KAU-22	23-Jul-16	21.87666	-159.52551	20 L	0.5	14.6
KAU-21	26-Jul-16	22.16847	-159.68564	2 L	1	14.6
KAU-21	26-Jul-16	22.16847	-159.68564	20 L	0.5	14.6
NII-11	28-Jul-16	21.89758	-160.2339	2 L	2.5	26.8
NII-11	28-Jul-16	21.89758	-160.2339	20 L	0.5	26.8
NII-10	29-Jul-16	21.94135	-160.07004	2 L	2.5	15.8
NII-10	29-Jul-16	21.94135	-160.07004	20 L	0.5	15.8
HAW-48	07-Aug-16	19.06071	-155.55237	2 L	8	14.9
HAW-48	07-Aug-16	19.06071	-155.55237	20 L	0.5	14.9
HAW-3204	08-Aug-16	19.64395	-154.981029	2 L	8	11.9
HAW-3204	08-Aug-16	19.64395	-154.981029	20 L	0.5	11.9
HAW-45	08-Aug-16	19.66466	-154.9747	2 L	8	13.7
HAW-45	08-Aug-16	19.66466	-154.9747	20 L	0.5	13.7
HAW-43	11-Aug-16	19.24436	-155.90028	2 L	8	24.4

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
HAW-43	11-Aug-16	19.24436	-155.90028	20 L	0.5	24.4
LAN-1681	12-Aug-16	20.817519	-156.801951	2 L	3	10.1
LAN-1681	12-Aug-16	20.817519	-156.801951	20 L	0.5	10.1
HAW-49	14-Aug-16	19.93087	-155.89211	2 L	8	14.6
HAW-49	14-Aug-16	19.93087	-155.89211	20 L	0.5	14.6
HAW-41	15-Aug-16	20.6824	-155.86038	2 L	8	15.2
HAW-41	15-Aug-16	20.6824	-155.86038	20 L	0.5	15.2
OAH-23	17-Aug-16	21.28838	-157.86536	2 L	3	11.9
OAH-23	17-Aug-16	21.28838	-157.86536	20 L	0.5	11.9
OAH-25	19-Aug-16	21.53412	-158.23441	2 L	3	14.6
OAH-25	19-Aug-16	21.53412	-158.23441	20 L	0.5	14.6
OAH-20	20-Aug-16	21.59095	-158.17462	2 L	3	15.2
OAH-20	20-Aug-16	21.59095	-158.17462	20 L	0.5	15.2
KAH-03	21-Aug-16	20.60048	-156.56042	2 L	1	11.0
KAH-03	21-Aug-16	20.60048	-156.56042	20 L	0.5	11.0
OAH-22	23-Aug-16	21.47970546	-157.783009	2 L	4	12.8
OAH-22	23-Aug-16	21.47970546	-157.783009	20 L	0.5	12.8
ALGAL COLLECTIONS: OCEAN ACIDIFICATION						
MAI-30	14-Jul-16	20.86862	-156.14632	CAU UNIT	4	15.2
MOL-22	17-Jul-16	21.13409	-157.30026	CAU UNIT	4	14.6
LAN-10	18-Jul-16	20.91534	-156.8864	CAU UNIT	5	14.0
LAN-11	18-Jul-16	20.9265	-156.93851	CAU UNIT	4	13.7
MOL-23	19-Jul-16	21.17694	-156.76048	CAU UNIT	5	14.6
MOL-24	19-Jul-16	21.20705	-156.98474	CAU UNIT	4	14.6
MOL-20	20-Jul-16	21.03574	-156.89038	CAU UNIT	5	13.1
MOL-21	20-Jul-16	21.08299	-157.06424	CAU UNIT	5	16.2
LAN-12	21-Jul-16	20.73574	-156.91551	CAU UNIT	5	15.2
KAU-22	23-Jul-16	21.87666	-159.52551	CAU UNIT	5	13.7
KAU-21	26-Jul-16	22.16847	-159.68564	CAU UNIT	5	14.6
NII-11	28-Jul-16	21.89758	-160.2339	CAU UNIT	3	15.8
NII-10	29-Jul-16	21.94135	-160.07004	CAU UNIT	5	15.8
HAW-48	07-Aug-16	19.06071	-155.55237	BMU UNIT	5	14.9
HAW-48	07-Aug-16	19.06071	-155.55237	CAU UNIT	3	14.9
HAW-45	08-Aug-16	19.66466	-154.9747	CAU UNIT	4	12.8
HAW-44	08-Aug-16	19.74694	-155.05806	CAU UNIT	5	13.1
HAW-46	09-Aug-16	19.48638	-154.81766	BMU UNIT	4	11.9
HAW-46	09-Aug-16	19.48638	-154.81766	CAU UNIT	4	11.9
HAW-43	11-Aug-16	19.24436	-155.90028	BMU UNIT	5	13.7
HAW-43	11-Aug-16	19.24436	-155.90028	CAU UNIT	5	13.7

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
HAW-49	14-Aug-16	19.93087	-155.89211	CAU UNIT	5	14.6
HAW-73	14-Aug-16	19.88451	-155.91393	CAU UNIT	5	14.6
HAW-41	15-Aug-16	20.6824	-155.86038	BMU UNIT	4	14.0
HAW-42	15-Aug-16	20.24916	-155.89093	BMU UNIT	5	13.7
HAW-42	15-Aug-16	20.24916	-155.89093	CAU UNIT	5	13.7
HAW-41	15-Aug-16	20.6824	-155.86038	CAU UNIT	3	14.0
OAH-23	17-Aug-16	21.28838	-157.86536	BMU UNIT	5	13.7
OAH-23	17-Aug-16	21.28838	-157.86536	CAU UNIT	5	13.7
OAH-21	18-Aug-16	21.30557	-158.12621	BMU UNIT	5	14.6
OAH-21	18-Aug-16	21.30557	-158.12621	CAU UNIT	5	14.6
OAH-01	18-Aug-16	21.31183	-158.12737	CAU UNIT	5	10.7
OAH-04	19-Aug-16	21.53413	-158.23437	CAU UNIT	4	12.8
OAH-22	23-Aug-16	21.47970546	-157.783009	BMU UNIT	5	12.5
OAH-22	23-Aug-16	21.47970546	-157.783009	CAU UNIT	5	12.5
OAH-471	23-Aug-16	21.50842	-157.80524	CAU UNIT	5	14.6
OAH-24	24-Aug-16	21.26187	-157.76553	BMU UNIT	5	14.6
OAH-24	24-Aug-16	21.26187	-157.76553	CAU UNIT	5	14.6
CORAL COLLECTIONS: MICROBIAL CORAL/ALGAL BIOPSIES						
MAI-90	13-Jul-16	20.70485	-156.45052	Cubic Centimeter	3	8.5
MAI-30	14-Jul-16	20.86992	-156.14526	Cubic Centimeter	9	25.3
MAI-91	16-Jul-16	20.95183	-156.69183	Cubic Centimeter	11	6.1
MOL-24	19-Jul-16	21.20705	-156.98474	Cubic Centimeter	11	14.6
MOL-21	20-Jul-16	21.08299	-157.06424	Cubic Centimeter	11	16.2
LAN-12	21-Jul-16	20.73726	-156.91579	Cubic Centimeter	11	5.5
KAU-22	24-Jul-16	21.88223	-159.52548	Cubic Centimeter	11	5.5
HAW-48	07-Aug-16	19.06071	-155.55237	Cubic Centimeter	11	14.9
HAW-44	08-Aug-16	19.74694	-155.05806	Cubic Centimeter	11	17.1
HAW-3326	10-Aug-16	19.73307	-156.05679	Cubic Centimeter	11	13.7
LAN-1721	12-Aug-16	20.74256	-156.97115	Cubic Centimeter	11	4.6
HAW-41	15-Aug-16	20.025	-155.86092	Cubic Centimeter	11	25.3
OAH-22	22-Aug-16	21.47979	-157.783	Cubic Centimeter	11	12.8
OAH-23	17-Aug-16	21.27915	-157.87053	Cubic Centimeter	11	13.1